Fall 2013

Epidemiology of Hospital Acquired Methicillin Resistant Staphylococcus Aureus in A Veterans Affairs Medical Center Spinal Cord Injury Unit: Fiscal Years 2008-2011

Rebecca B. Stone

EPIDEMIOLOGY OF HOSPITAL ACQUIRED METHICILLIN RESISTANT STAPHYLOCOCCUS AUREUS IN A VETERANS AFFAIRS MEDICAL CENTER SPINAL CORD INJURY UNIT: FISCAL YEARS 2008-2011

by

REBECCA B. STONE

(Under the Direction of John S. Luque)

ABSTRACT

The purpose of this retrospective case-control study was to assess risk factors contributing to hospital acquired methicillin *Staphylococcus aureus* (HA-MRSA) and gain a better understanding of the burden of HA-MRSA infection in patients with spinal cord injuries. The study was also conducted to see if new information would be found on HA-MRSA infections and validate or refute current research for patients in a dedicated spinal cord injury unit at a Veterans Affairs Medical Center. During the study period, the infection control department identified 95 cases of HA-MRSA. Additional data retrospectively collected were basic demographics, admitting diagnosis, presence of varying comorbidities, ASIA score, presence of indwelling medical device, BMI, LOS, MRSA colonization, and quarterly hand hygiene compliance. The patient population was described using appropriate univariate descriptive statistics and crude odd ratios (ORs) with 95% confidence intervals (CIs) calculated. The most common sources of infection for cases were ulcer related (31.6%), from skin and soft tissue infections besides pressure ulcers (23.2%), 14.7% were Foley catheter related, 8.4% were blood stream infections and 22.1% were from other sites/sources.

Assessment of risk factors for HA-MRSA for spinal cord injury patients in this study found that colonization (OR: 3), device use (Foley OR: 3.3, PICC OR: 39.4, use of both OR: 21.1) , paralysis (1.9), ASIA score A (OR: 4.5), amputee (OR: 3.5), decubitus ulcer (OR: 7.1), length of hospital stay > 30 days (OR: 17.1) and a hand hygiene compliance </= .89 (OR:1.88) were each significantly associated with acquiring a HA-MRSA infection. The significant risk factors were found to be similar to those described in previous studies supporting the need for the MRSA bundle currently in place. The study also affirmed that this population has special medical needs and that hand hygiene compliance is correlated with infection and transmission of MRSA. This information will aid in strengthening the design of the infection control program currently in place.

INDEX WORDS: MRSA, Hospital Acquired Infection, Spinal Cord Injury Unit, MRSA Bundle, Infection Control

EPIDEMIOLOGY OF HOSPITAL ACQUIRED METHICILLIN RESISTANT STAPHYLOCOCCUS AUREUS IN A VETERANS AFFAIRS MEDICAL CENTER SPINAL CORD INJURY UNIT: FISCAL YEARS 2008-2011

by

REBECCA B. STONE

B.S. Bluefield State College, 1982

M.Ed., Georgia Southern University, 2006

Submitted to the Graduate Faculty of Georgia Southern University in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF

PUBLIC HEALTH

STATESBORO, GEORGIA

2013

EPIDEMIOLOGY OF HOSPITAL ACQUIRED METHICILLIN RESISTANT STAPHYLOCOCCUS AUREUS IN A VETERANS AFFAIRS MEDICAL CENTER SPINAL CORD INJURY UNIT: FISCAL YEARS 2008-2011

by

REBECCA B. STONE

Major Professor: JOHN LUQUE
Committee: ROBERT VOGEL
CLAIRE ROBB
STEPHANIE BAER

Electronic Version Approved:
Fall 2013

DEDICATION

To my husband, Charlie, even in the face of doubt and uncertainty, thank you for your optimism and for never losing faith in me.

and

To Emily and Evan, as children you inspired me, I hope this accomplishment provides inspiration to you for whatever challenges you may encounter in life.

ACKNOWLEDGMENTS

I would like to thank my dissertation committee, Dr. John Luque, Dr. Robert Vogel, and Dr. Claire Robb, your guidance and support allowed me to persevere.

Dr. Vogel, I will always remember John Prine's Dear Abby, a new song I have since added to my playlist.

I would like to express my appreciation to Dr. Stephanie Baer at the VAMC for your guidance, knowledge, and commitment to see this project through. I am thankful to have met you. Thank you to Grace Hollingsworth, MRSA coordinator at the VAMC. At the beginning of this project I became your shadow; I appreciate your selflessness, teaching skills and above all how much I learned from you.

To my daughter, "sweet Em," your quick thinking opened the door for my research project. There is something to be said about "being in the right place at the right time." Also, what a great comfort it was to see your smile on the evenings I had class. To my son Evan, I am forever grateful for our long conversations on Friday nights; although you called me for advice about college and life in general, what you don't know is how much I learned from you.

And, finally, a special thanks to Dr. Jim Dias. You encouraged me from the start to pursue a doctoral degree. You followed me through this long process and were a mentor in the truest since of the word. You always made time for me and I am sincerely grateful for your contribution to this project. I would not have reached this milestone without your help.

"Don't be discouraged. It's often the last key in the bunch that opens the lock."

~Author Unknown

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

PURPOSE and SIGNIFICANCE

Introduction

Understanding the burden of healthcare-associated methicillin-resistant *Staphylococcus aureus* (HA-MRSA) in both healthcare and community settings is imperative for designing effective prevention programs and for the reduction of HA-MRSA infections (Centers for Disease Control and Prevention (CDC), 2011). Affecting certain populations disproportionately, such as individuals with low socioeconomic status and injection drug users; healthcare-associated infections are among one of the top ten leading causes of preventable deaths within hospitals in the United States. Hospitals acquired infections (HAIs) result in increased morbidity and mortality and are also responsible for a substantial increase in healthcare costs each year (Klevens, Morrison, Nadle, Petit & Gershman et al., 2007). Because of the increased costs, and morbidity and mortality related to HAIs, the reduction of HA-MRSA has been a top priority in the United States for major stakeholders in the public health, the medical, and infection prevention communities (Agency for Healthcare Research & Quality (AHRQ), 2009; Centers for Medicare & Medicaid, 2009; CDC, 2007; The Institute for Healthcare Improvement, (IHI) 2006; Platt, 2011; Association for Professionals in Infection Control and Epidemiology, (APIC) 2009). Several of the major stakeholders include the CDC, APIC, the Institute of Medicine (IOM), and the AHRQ. Considered an emerging issue and a threat to public health, *Healthy People 2020* created a new goal, "...Prevent, reduce, and ultimately eliminate healthcare-associated infections (HAIs) (US Department of Health and Human Services, 2010). Reflecting the commitment to reducing healthcare-associated infections, two supporting objectives were created by *Healthy People 2020*: (HAI-1) reduce healthcare-associated infections by reducing central line associated

bloodstream infections; and (HAI-2) to reduce invasive healthcare-associated methicillin-resistant *Staphylococcus aureus* infections by 75% nationwide (US Department of Health and Human Services, 2010).

Another initiative to reduce HAIs and led by the World Health Organization (WHO) is part of the First Global Patient Safety Challenge. This program was launched in 2005 and in 2009 added additional goals and programs with an emphasis on hand hygiene. These programs were developed to support healthcare workers and improve hand hygiene compliance and thus support the prevention of often life threatening HAI (WHO), 2009).

In the last two decades MRSA has become the most commonly identified multi-drug resistant pathogen in the United States causing invasive infections and a fifth of the hospital acquired infections often resulting in longer hospital stays, increased morbidity and mortality and increased costs (Cosgrove, Yi, Kaye et al., 2005; Fairclough, 2008; Gould, 2006; Reed, Friedman, Engemann et al., 2005; Shorr, 2007; Shorr, Tabak, Gupta et al., 2006). Invasive infections caused by MRSA also result in poorer outcomes, increased recovery time, and higher re-infection rates than non-invasive infections (Boucher & Corey, 2008; Chambers, 2005; Cosgrove, 2005; Klevens, Edwards, & Gaynes, 2008; Liebowitz, 2009; Sakoulas, Perencevich, Schwaber, Karchemer, & Caremeli, 2003).

Purpose of Study

Over the past 20 years, the incidence of infections caused by antimicrobial-resistant pathogens has increased dramatically, especially in vulnerable high-risk populations, such as those patients in the intensive care unit (ICU) and those who are immunocompromised and debilitated (Croft, Mejia, Barker, Maxwell & Dart, et al., 2009; Sarikonda, Micek, Doherty, Reichley & Warren et al., 2010; Weber, Huang, Oriola, Huskins & Noskin et al., 2007). The

CDC has estimated a direct medical cost per patient of MRSA to be $27,083 to $34,900, assuming 120,000 MRSA infections per year, (Rojas & Liu, 2005) and with an estimated annual direct hospital cost of MRSA for the United States of $3.2 billion to $4.2 billion (American Health and Drug Benefits (AHDB), 2009). This burden to the healthcare system does not take into account the indirect costs of MRSA to the patient and society, lost income and lost productivity (AHBD, 2009). In addition to the aforementioned costs, excess costs that are often associated with resistant pathogens may also be due to the necessity to use more expensive antibiotics, central venous access for prolonged infusion, additional laboratory monitoring, diagnostic testing and contact isolation for the patient (Shorr, 2007 ; Gould, 2010). This leads to substantial medical costs and also an increased use of medical and personnel resources.

Healthcare-associated infections, or HAIs, have become the most common complication of hospital care according to the CDC (CDC, 2007; Scott, 2009). Nearly 2 million patients suffer from infections annually with deaths resulting from HAI's estimated to be 99,000 and health care costs often exceeding $28 to $33 billion annually (CDC, 2007 & Scott, 2009). Such infections were long accepted by clinicians as an inevitable hazard of hospitalization; however, recent efforts have demonstrated that by understanding the burden of MRSA in specific populations and hospital settings, implementing relatively simple measures such as hand hygiene, a majority of such infections can be prevented (Berwick, Calkins, McCannon & Hackbarth, 2006**;** Institute for Healthcare Improvement, 2006; McCannon, Schall, Calkins & Nazem, 2006; Weber, Sickbert-Bennett, Brown & Rutala, 2007). As a result of these efforts and with present evidence showing healthcare-associated infections are preventable, hospitals and providers are under intense pressure to reduce the transmission and burden of these infections. Given the intense pressure upon hospitals to reduce HA-MRSA, predictors and risk factors for transmission and acquisition

of HA-MRSA have been addressed by a number of studies in hospital and community settings. Some of the predictors and risk factors addressed in these studies include such factors as MRSA colonization, previous hospitalization, and length of hospital stay (Croft et al., 2009; Klevens, Edwards, & Gaynes, 2008; Murthy & Frick, 2011; Ruhe et al., 2010; Santos, Machado, Camey, Kuchenbecker & Barth, 2010). Additional studies focused on other possible risk factors and predictors associated with MRSA, such as hemodialysis, malnutrition and trauma (Kaye et al., 2011).These risk factors have been used for surveillance purposes to target patient populations in different settings who may need specific interventions to prevent acquisition and transmission of HA-MRSA. Other variables that have been explored to be possible predictors and risk factors for infection and transmission of MRSA include invasive devices, age, chronic conditions such as hepatitis and HIV, and stays in long term care facilities (Evans, Hershow, Chin, Foulis & Burns et al., 2009; Garshick, Kelley, Cohen, Garrison, & Tun et al., 2005; Klevens, Edwards, & Gaynes, 2008). Comorbidities associated with MRSA infections and of interest because of an aging population include diabetes, decreased functional status and obesity (Chen et al., 2010; Eseonu, Middleton & Eseonu, 2011; Wang et al., 2010).

These infections are especially common in the intensive care unit (ICU) and acute care setting, therefore, recent studies have focused on preventing HAIs in these particular areas (Fortaleza, Melo, & Fortaleza, 2009; Kappel, Widmer, Geng, Arx & Frei et al., 2008; Rosenthal, Kyeremanteng, Hooper & Shojania, 2008; Scchweickert, Geffers, Farragher, Gastmeier, & Behnke et al., 2010). Because information is scarce and research has focused on preventing HAIs in these settings, a clear understanding of risk factors and predictors of MRSA transmission and acquisition is needed when attempting to translate this practice to patients with spinal cord injuries (Garcia, Moreno, Garrote & Cercenado, 2010; Kappel, Widmer, Geng, Arx & Frei et al.,

2008).

Patients with spinal cord injuries are a unique population requiring long-term specialized care. Many of these patients suffer from chronic pain resulting in depression, anxiety, anger and substance abuse. Physical impairment from spinal cord injuries often cause chronic urinary tract infections, pressure ulcers, amputation, pneumonia, infections, pulmonary emboli and development of co-morbidities such as diabetes and cardiovascular disease, each impacting the patient's engagement with treatment and motivation to recover and stay healthy. Therefore, understanding disease and infectious processes following this type of injury is necessary for customizing the appropriate treatment strategy as well as customizing infection control strategies for this population of patients (Evans et al., 2009). Addressing similarities and differences amongst different patient populations will also allow better patient care and improve patient safety.

Significance of the Study

Healthcare – associated infections with MRSA have been an increasing concern in acute care Veterans Affairs (VA) Medical Centers. Previous efforts to reduce MRSA transmission and acquisition have been attempted with varying degrees of success; however, in 2007 an MRSA "bundle" was implemented in acute care VA hospitals nationwide in an effort to further decrease healthcare – associated infections and transmission of MRSA. In 2008, this same "bundle" approach was implemented within the VA in the spinal cord injury unit (SCIU). The bundle consisted of universal nasal surveillance for MRSA, contact precautions for patients colonized or infected with MRSA, hand hygiene, and a change in the institutional culture whereby infection control would become the responsibility of everyone who has contact with patients.

Past research suggests that infection and transmission rates have been reduced following implementation of preventive measures (APIC, 2007; Berwick, Calkins, McCannon & Hackbarth, 2006; CDC, 2007; Institute for Healthcare Improvement, 2006; McCannon, Schall, Calkins & Nazem, 2006) making this study important for several reasons. First, understanding the burden of HA-MRSA in patients with spinal cord injuries is important to this medical center in order to design an effective infection program tailored to the specific needs of this population to help prevent the transmission of MRSA and reduce HA-MRSA infections. Second, researchers have studied the transmission and acquisition of MRSA in similar populations and settings generalizing their results; however, what remains to be fully explored is how these risk factors and predictors affect patients in a spinal cord injury unit where information is scarce. And third, this research will provide new information on the topic of MRSA and validate previous studies that have assessed risk factors and predictors for acquiring an MRSA infection within the hospital environment.

LITERATURE REVIEW

Brief History of MRSA

Prior to the advent of antibiotics, *Staphylococcus aureus* (*S. aureus*) emerged as a bacterial pathogen that was capable of causing a variety of significant human diseases leading to a high fatality rate (Gordon & Lowy, 2008; Chambers, 2005). Sir Alexander Fleming discovered penicillin in the early 1900s however it was not until the 1940s that penicillin was introduced into clinical care increasing survival rates for people with *Staphylococcal* disease and other bacterial pathogens. Shortly after the introduction of penicillin into clinical use, Kirby published a report in 1944 describing penicillinase-producing strains of *S. aureus* from hospital patients (Chambers, 2001 & Kirby, 1944).

Following World War II, penicillin became more readily available and used with increasing frequency within hospitals yielding a greater prevalence of penicillinase-producing strains of *S. aureus.* Within a few years most hospital strains of *S. aureus* were resistant to penicillin (Chambers, 2001). Penicillinase is an enzyme *S. aureus* is capable of producing which has the ability to interfere with the beta-lactam ring on penicillin. This renders it ineffective against Staphylococci and produces resistanc*e* (Barber, 1961; Diagnostic Microbiology, 2011). By the early 1950s most hospital strains of *S. aureus* were beta-lactamase producing or resistant yet penicillin continued to be the drug of choice and recommended in the medical community throughout the 1970s as an effective antimicrobial against *Staphylococcal* disease (Chambers, 2001). As these penicillin resistant strains emerged in the hospital setting -HA-MRSA, community strains of *S. aureus* continued to be sensitive to penicillin until the late 1990s.

Following the emergence of penicillin resistant strains of *S. aureus* in hospital settings, additional beta-lactam antimicrobials, or synthetic penicillins, were developed for the treatment of penicillin resistant *S. aureus* and included cloxacillin, methicillin, and nafcillin. The effectiveness of these antimicrobials was short lived - due to selective pressure of antibiotic exposure (Chambers, 2001) and by 1961 physicians in the United Kingdom reported seeing resistant strains to penicillin, streptomycin, tetracycline (Jevons, 1961), and methicillin (Barber, 1961). These particular bacteria resistant to beta-lactam antimicrobials were later classified as methicillin-resistant *Staphylococcus aureus* (MRSA) (Emmanuel, 2008; Heymann, 2008) and were first reported among patients in the United States in 1968 at Boston Hospital (Barrett, McGhee, & Finland, 1968).

Four decades later and after the first reports of MRSA at Boston Hospital, MRSA is now a major public health problem causing recurrent infections and serious sequelae in even the

healthiest of individuals. MRSA is a very difficult pathogen to treat and is consistently reported in hospitals and communities in the United States with an increasing prevalence worldwide causing substantial morbidity, mortality, and cost (Boucher & Corey, 2008; Chambers, 2001; Derenski, 2005; Diekema & Climo, 2008; Payman & Thierry, 2008).

Table 1. Timeline of *Staphylococcus aureus* Infection and Resistance

Year	Event
1940	Penicillin introduced
1942	Penicillin-resistant *Staphylococcus aureus* appears
1959	Methicillin introduced; most *S aureus* strains in both hospital and community settings are penicillin resistant
1961	Methicillin-resistant *S. aureus* appears
1963	First hospital outbreak of methicillin-resistant *S. aureus* (MRSA)
1968	First MRSA strain in U.S. hospitals
1970s	Clonal spread of MRSA globally, very high MRSA rates in Europe
1982	4% MRSA rate in the United States
1980s, early 1990s	Dramatic decreases in MRSA rates due to search-and- destroy; By 1999, <1% MRSA rate in the Netherlands; that rate has been sustained to date despite increasing MRSA rates in other parts of the world
1996	Vancomycin-resistant *S.aureus* (VRSA) reported in Japan
1997	Approximately 25% MRSA rate in US hospitals; vancomycin use increases; Serious community-acquired MRSA (CA-MRSA) infections reported; Pediatric deaths reported
2002	First clinical infection with VRSA in the United States
2003	MRSA rates continue to increase; approx. 60% MRSA rate in intensive care units; outbreaks of CAMRSA reported in numerous community settings and also implicated in hospital outbreaks; 2006 >50% of staphylococcal skin infections seen in emergency departments caused by CA-MRSA; HA-MRSA rate continues to increase; Distinction between HA-MRSA and CA-MRSA on epidemiological basis becomes increasingly difficult
2007	Report of active, population-based surveillance for invasive MRSA done in 2004-2005 estimates 95,000 invasive MRSA infections and 19,000 deaths from MRSA per year; Continued reports in the medical literature and media about severe CA-MRSA infections; Several states pass or are considering legislation regarding control of MRSA and public reporting of MRSA rates ; Strategies to control MRSA, including public reporting of MRSA infections, are hotly debated; “staph” and MRSA become household words

Mayo Clinic Proceedings, 2007

Community Acquired Methicillin-Resistant *Staphylococcus aureus*

In the last 10 years, MRSA has not only become a hospital pathogen, but also a community pathogen. CA-MRSA differs from HA-MRSA in that the infections may involve younger and healthier individuals without any known risk factors for infection or colonization (Boucher & Corey, 2008; CDC, 1999; Chambers, 2005; Kuehnert et al., 2005; Lui et al., 2008; Skov et al., 2005).

Gaining national attention, the first cases of community-acquired MRSA infections where no known risk factors could be found were first reported in the United States in the late 1990s. These cases were among four young children under the age of 5 in Minnesota and North Dakota, each case was fatal (Centers for Disease Control and Prevention, (CDC), 1999; Herold et al., 1998; Adcock et al., 1998). These children did not have any established risk factors such as recent hospitalization, prolonged antibiotic therapy or a relative working in a health-care setting. Subsequently these cases were treated with a beta-lactam antibiotic, cephalosporin, known to be an effective antibiotic for the treatment of *S. aureus* at the time. Laboratory reports confirmed MRSA, causing a delay in the use of appropriate antibiotic therapy and possibly contributing to the fatal outcomes of the children.

These cases represented a paradigm shift in the epidemiology of MRSA. Additional outbreaks followed these reported cases in other community settings and among diverse populations whom appeared to be at risk for infection but with no known risk factors. Reported infections initially involved skin and soft-tissue and were among prison inmates, injection drug users, men who have sex with men (MSM), military personnel, athletes, the medically underserved, and also children attending child-care facilities (Boucher & Corey, 2008; Gordon & Lowy, 2008; Klevens et al., 2006; Miller & Diep, 2008). Later, necrotizing pneumonia, fasciitis and sepsis were

reported as a result of CA-MRSA causing serious infections and fatalities (Francis et al., 2005); Miller et al., 2005; Mongkolrattanothai, Kahana, & Daum, 2003).

CA-MRSA has the ability to spread within households due to close confinement of family members. Those colonized with CA-MRSA often will experience repeated infections with CA-MRSA representing 15%-74% of skin and soft tissue infections presenting to the U.S. emergency departments and most often seen in healthy children and young adults (Mileno, 2008; Orlovic & Smego, 2009).

Colonization

Risk factors associated with MRSA colonization are well documented and include prolonged antibiotic exposure, previous or recent hospital admission or nursing home admission, recent outpatient visits, chronic illness, injection drug use or direct contact with an MRSA-colonized patient, healthcare worker or family member (Beam & Buckley, 2006; Chambers, 2001; Klevens et al., 2006; Orlovic & Smego, 2009).

Colonization for individuals with MRSA may be persistent or transient for months, with most patients remaining asymptomatic (Beam & Buckley, 2008; Sanford, Widmer, Bale, Jones & Wenzel, 1994). Colonization most often occurs within the nares or nostrils, as well as other body sites such as the axillae, groin, perineum and gastrointestinal tract (Gordon & Lowy, 2008). These bacteria do not pose a threat unless the integrity of the skin is breached, with a break in the skin, whether by shaving, surgery, aspiration, or through the insertion of a central line or catheter. Humans and animals are both natural reservoirs for MRSA (Chambers, 2001) with transmission of MRSA primarily through direct person to person contact; however, there are documented cases of animal to human and human to animal transmission (Juhasz et al., 2007; van Loo et al., 2007; Weese et al., 2005).

In 2004 a survey from the National Health and Nutrition Examination Survey (NHANES) estimated that greater than 4 million individuals in the United States or approximately 1.5% of U.S. residents are colonized with MRSA in the anterior nares (Gorwitz, 2008). Recently published studies have arrived at varying conclusions regarding colonization of MRSA and the association with MRSA infections.

Safdar and Bradley (2008) performed a systematic review and found in their study on patients with MRSA nasal colonization that the incidence and risk for subsequent infections with invasive MRSA is up to four times higher among carriers, particularly for patients in the Intensive Care Unit (ICU). Research by Croft et al. (2010) reported in their study that MRSA colonization was a predictor of subsequent infection among trauma patients and similarly, Schweitzer et al. (2008) found that previous MRSA colonization or infection was predictive of subsequent MRSA blood stream infections (BSIs). Datta & Huang (2008) studied the risk of infections and death due to MRSA in long-term carriers and found that individuals who are known to have "harbored MRSA for >1 year are at high risk for subsequent MRSA morbidity and mortality" (pg. 176). Accounting for 39% of the infections included pneumonia, soft tissue (14%), and central venous catheter infection (14%).

In 2003, Huang and Platt studied 209 adult patients colonized with MRSA and following review of infection-control records found that after discharge from the hospital, 29% developed infections over the next 18 months. The infections identified were bacteremia, pneumonia, soft tissue infection, and osteomyelitis. Eighty percent of the study patients with previous MRSA infection developed an MRSA infection in a new site with 49% developing an infection after hospital discharge. By contrast, Sarikonda et al. (2010) found that MRSA nasal colonization in

patients admitted to the ICU was a poor predictor for subsequent occurrence of MRSA lower respiratory tract infections and BSI. Klevens et al. (2006) reported identical findings.

Colonization and infection rates vary by setting such as the type of health-care facility, geographic location, and the population being studied (Davis, Stewart, Crouch, Florez & Hospenthal, 2004). Understanding prevalence of infection and colonization within one's own health-care facility is important for identifying high risk populations and for customizing successful infection control programs necessary to prevent acquisition and transmission of MRSA to patients, employees, and family members.

Transmission

Transmission of MRSA from environmental sources and hands is well documented in the literature. Microorganisms have the ability to live on human hands 2-60 minutes following contact with patients and/or a contaminated environment (WHO, 2009). Another portal of entry for bacteria is during the performance of high-risk patient care procedures such as surgery or the insertion of a central line. Each of these actions may contribute to the risk of HAIs and colonization.

Hospitals have long been known to harbor MRSA on fomites such as stethoscopes, bedside tables, pagers, charts, and beds (Huang, Mehta, Weed, & Price, 2006; Kassem, Sigler, & Esseili, 2007; Miller & Diep, 2008). Computer keyboards are also known reservoirs for contamination with MRSA not only in the hospital setting but also occurring in the community setting. In a pilot study examining the survival time of MRSA on hospital surfaces, Huang, Mehta, Weed, & Savor (2006) reported that MRSA has the ability to live on charts, bedside tabletops, and cloth curtains for 9-12 days. Any of these reservoirs can be sources for person to person transmission of MRSA resulting in infection and colonization.

Previous research provides substantiated evidence on the various ways transmission of MRSA may occur within the hospital environment. Therefore, the VAMC is following guidelines provided by the CDC to reduce such transmissions and understands the importance in using certain evidence based practice interventions.

MRSA Bundle

The Veterans Affair Medical Center implemented an "MRSA Bundle" consisting of universal nasal surveillance for MRSA, contact precautions for patients who are either colonized or infected with MRSA, a greater emphasis on hand hygiene compliance, and a change in employee behavior and organizational culture towards hospital acquired infections.

A bundle is characterized by the Institute for Healthcare Improvement (IHI) as a structured way of improving processes used for improving health outcomes based on evidence-based practices (Institute for Healthcare Improvement (IHI), 2006a). The VAMC implemented the MRSA bundle as a targeted infection control strategy to reduce methicillin-resistant *S. aureus* transmission and infection. Recent data supports the use of "bundles" of interventions to achieve successful reduction in MRSA transmission and infections (IHI, 2006b; Resar et al., 2005; Youngquist et al., 2007).

Prior to full implementation of the MRSA bundle, the VAMC introduced the concepts of the MRSA bundle to HCWs through the use of education, games, and contests. The VAMC also conducted focus groups to involve staff and determine how to implement the initiative using their ideas. Once full use of the MRSA bundle began, the MRSA coordinators collected the swabbing data and surveillance which was reported back monthly to the leadership. There were MRSA champions on each nursing unit to help move the initiative forward and disseminate information.

During the implementation of the MRSA Initiative, the infection control program also placed an emphasis on hand hygiene. In addition to the interventions of the National VA Initiative, all clinical personnel were involved in a collaborative, intensive, and self-monitoring of hand hygiene compliance. Each clinical unit had a hand hygiene champion trained by the Infection Control Department to observe and report quarterly. Non-staff volunteers were enlisted, trained by Infection Control staff, and often deployed on nights or weekends as independent observers of hand hygiene compliance. Patients and visitors were engaged in hand hygiene education and encouraged to practice hygiene.

Continuous improvement of these interventions is consistently being made within the VAMC to aid in the reduction of MRSA HAIs and colonization of patients during their hospital stay. The CDC recommends a bundle approach for the reduction of infections caused by multi-drug resistant organisms. For this strategy to be successful, it is important for the infection control department to have an understanding of their patient population, risk factors and prevalence of MRSA. This understanding will provide information to be used for educational purposes and improved infection control strategies.

Contact Precautions

Controlling the spread of MRSA within the hospital often requires a multi-modal approach. Literature suggests that quality improvement for the reduction of MRSA transmission and infection cannot be achieved by using a single intervention; therefore, a combination of improvement strategies is the approach many hospitals are using, to include contact precautions (Boyce, 2001).

The CDC recommends contact precautions when the facility deems MRSA to be of special clinical and epidemiologic significance. Following these recommendations, when single-patient

rooms are available, the VAMC will assign priority for these rooms to patients with known or suspected MRSA colonization or infection with highest priority given to those patients who have conditions that may facilitate transmission or infection, such as uncontained secretions or excretions. When single-patient rooms are not available, the VAMC will cohort patients with the same MRSA in the same room or patient-care area. When cohorting or grouping patients with the same MRSA is not possible, the VAMC will place MRSA patients in rooms with patients who are at low risk for acquisition of MRSA and associated adverse outcomes from infection and those who are likely to have short lengths of stay.

The CDC recommends healthcare workers wear gloves whenever touching the patient's intact skin or surfaces and articles in close proximity to the patient (e.g., medical equipment, bed rails). In addition to gloves, a gown is to be worn upon entry into the room and removed prior to leaving the room. Hand washing should then be performed before leaving the patient-care environment and upon leaving ensure that clothing and skin do not contact potentially contaminated environmental surfaces. This could result in possible transfer of microorganisms to other patients or environmental surfaces after leaving the room.

Contact precautions are used to reduce the risk of transmission of pathogens to the healthcare worker or conversely; to reduce the chance of the healthcare worker serving as a vector for transmission to patients. Contact precautions require patient cohorting or single-bed rooms for patients, and wearing gloves and gown simultaneously prior to contact with a patient. These guidelines are used by many hospitals and recommended by the CDC.

Hand Hygiene

Semmelweis' hypothesis in 1846 that the hands of healthcare personnel were the vector for spreading illness to some patients was initially rejected. However, hand hygiene is now widely

accepted today and is integral to the prevention of health care associated infections. Multidrug resistant organisms (MDROs) are transmitted by healthcare workers due to inadequate hand hygiene, poor technique, or contamination of the environment, equipment or supplies (Allegranzi & Pittet, 2009). Transmission sometimes results in health-care associated infections that cause approximately 80,000 deaths annually and significantly increase morbidity, mortality, and costs**.**

Many hospitals currently use core prevention strategies developed by the CDC when implementing clinical guidelines used to improve patient safety. In 2007 the Department of Veterans Affairs instituted a directive implementing the National VA MRSA Initiative which outlined a bundle methodology to decrease the rates of MRSA hospital-acquired infection. During the implementation of the MRSA initiative, the infection control department placed an emphasis on hand hygiene.

In 2001, Stone posited "that the treatment effect is so great that if hand hygiene were a new drug it would be used by all" (pg. 280). During patient care, healthcare worker's hands become progressively colonized with commensal flora as well as pathogens while interacting with patients (Pittet et al., 1999; WHO, 2009). In the event of ineffective hand hygiene, the longer the duration of care, the higher the degree of hand contamination. Healthcare workers are often busy and may not wash their hands for a sufficient amount of time or not use an adequate amount of antibacterial solution leading to poor hand decontamination. When infection control strategies break down during the care of a single patient and/or between patients' contact, microbial transfer is likely to occur.

Contamination of healthcare worker's hands has been associated with numerous hospital acquired outbreaks of multi-drug resistant organisms due to cross transmission to patients and also to the environment (Sartor et al., 2000; Shafie, Alishaq, & Garcia, 2004). Performing

proper hand hygiene during patient care is the most effective way and the simplest means in reducing and preventing HAIs. However, despite this simple measure, hand hygiene compliance among healthcare workers, especially physicians, remains suboptimal (Squires et al., 2013; Pincock, Bernstein, Warthman, & Holst, 2012). A number of studies have shown that HCWs compliance with hand hygiene is less than 50% and that of physicians often lower (Squires et al., 2013). Due to the complexities within the healthcare environment, hand hygiene compliance is often a difficult behavior to change and maintain over time.

Literature has documented a number of factors contributing to healthcare workers adopting hand hygiene or resisting change; however, barriers specific to physicians are not as well described. In a cross-sectional survey of physicians by Pittet and colleagues (2004), adherence for physicians showed an average of approximately 57% hand hygiene compliance, higher than the 50% norm but varied across medical specialties. Reasons for adherence to hand washing at the individual level was associated with an awareness of being observed, the belief of being a role model for others, a positive attitude toward hand hygiene after patient contact, and easy accessibility to hand –rub solution. However, a limitation to this study was the direct observation of the physician washing their hands and this may have influenced the increased compliance.

Pittet and colleagues (2004) found perceived environmental barriers for non-adherence for physicians to include high workload activities associated with high risk for cross-transmission. Additionally, certain medical specialties such as anesthesiology, emergency medicine and surgery were shown to have lower compliance rates due to time constraints and complexities in performing the job. Additional studies have shown a myriad of environmental barriers related to non-adherence to hand hygiene compliance for nurses and other HCWs to include lack of access to sinks, difficulty locating products, empty dispensers, and also time constraints (Boyle et al.,

2001; Squires et al., 2013).

On the individual or personal level, barriers described as risk factors for non-adherence included attitudinal beliefs, and skin irritation from repeated hand washing (Boyle et al., 2001; Squires et al., 2013). Another study focusing on nurses at the individual level and using a behavioral approach was described by Boscart and colleagues (2012) which identified motivational sources such as a person's personal safety and their families' safety to yield greater hand hygiene compliance. Additional motivational factors described in the study as important to nurses was to have individual feedback and self-monitoring to increase awareness and leading to greater compliance.

Good hand hygiene has for many years been considered the most important and cost effective means to help prevent the spread of HAIs, yet maintaining compliance over 50% continues to remain challenging for most hospital infection control departments.

Figure 1:
5 Moments for Hand Hygiene (2009).

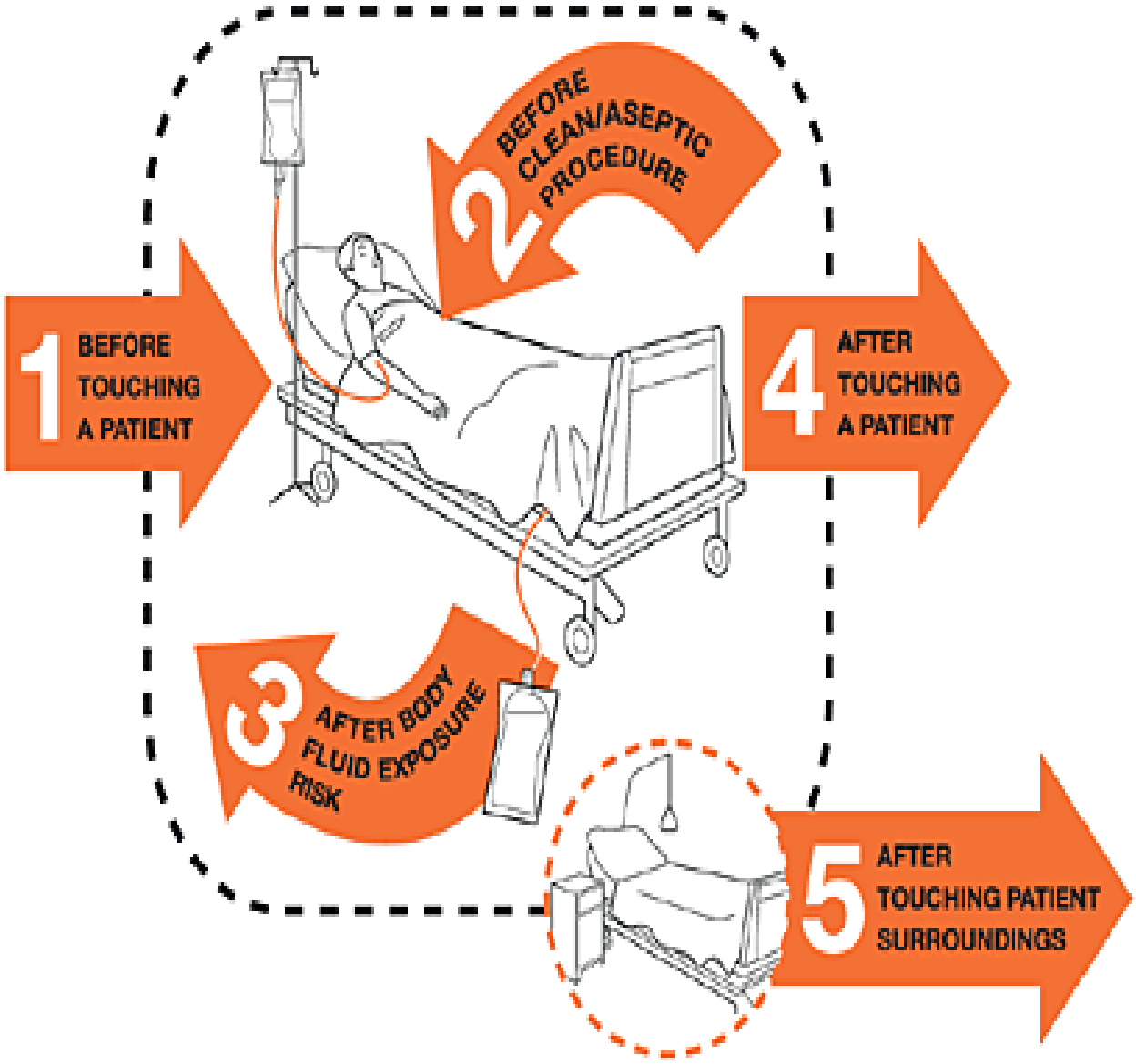


Figure 1: World Health Organizations' (WHOs') 5 Moments for Hand Hygiene (2009).

MRSA Active Surveillance

Active MRSA surveillance in the hospital setting may be helpful in the identification of patients at risk for developing MRSA infections; that is, screening all patients on admission for MRSA colonization to identify which patients need to be placed in contact precautions to reduce the spread to healthcare workers, patients, and family members (Bruce et al., 2010; Jain et al., 2011). Hospitals nationwide are facing declining reimbursement for HAIs and although MRSA surveillance is costly, studies show that successful programs can pay for themselves by reducing a patient's stay in the hospital. HAIs can double the length of stay for patients depending on complications and the facility (McCune, 2012).

Much attention has been focused on multi-drug resistant organism at the national and state levels and via public media. Some policy makers are calling for universal screening in hospitals to reduce HA-MRSA by identifying those colonized upon admission to the hospital or prior to a surgical procedure in hopes of reducing infection (Weber et al., 2007). Universal screening using a rapid Polymerase Chain Reaction (PCR) method for MRSA is expensive and remains controversial due to the variability in reducing HA-MRSA in the healthcare community (Murthy et al., 2010; Harbarth et al., 2008; Jeyaratnam et al., 2008; Keshtgar et al., 2008; Hardy et al., 2010; Robicsek et al., 2008).

Harbarth et al. (2008) conducted a prospective interventional cohort study at a Swiss teaching hospital using a rapid screening method for patients at admission in combination with conventional infection control measures compared to a control group using only standard infection control measures. This study showed no reduction in MRSA HAIs when using universal screening in combination with contact precautions in surgical patients. Another study, randomized and with high baseline MRSA infection rates by Jeyaratnam et al. (2008) also failed

to show a reduction in HA- MRSA infection rates. The investigators used a similar rapid molecular technique versus the conventional culture method.

Conversely, Robicsek et al. (2008) conducted an observational study in a 3-hospital, 850-bed organization with approximately 40,000 annual admissions comparing rates of MRSA during and after hospital admission in three consecutive time periods. After a baseline year, all patients admitted to the ICU were screened for MRSA colonization using PCR for twelve months and followed by screening for all hospital admissions. Patients testing positive for MRSA were placed in contact precautions. After three years, the prevalence density of aggregate hospital-associated MRSA disease per 10,000 patient-days at baseline and during ICU surveillance was 8.9, 7.4 the second year and 3.9 after the third year. The result of this intervention was associated with a large reduction in MRSA infection during admission and thirty days after discharge.

Keshtgar and colleagues (2008) conducted a study targeting surgical patients using PCR testing prior to undergoing emergency and elective surgery in a teaching hospital. MRSA positive patients were started on suppression therapy of mupirocin nasal ointment and undiluted chlorhexidine gluconate body wash. Comparing means to the previous year, MRSA bacteraemia fell by 38.5% and MRSA wound isolates fell by 12.7%. The reduction in MRSA infection was possibly related to the quick turnaround time for reporting of MRSA and the ability to administer the appropriate surgical prophylaxis prior to surgery.

Huang et al. (2011) in an effort to control MRSA spread in a neonatal intensive care unit (NICU) implemented several infection control measures. These included enhanced hand hygiene, alcohol-based handrubs, active MRSA surveillance, and contact precautions. This resulted in a significant decrease in all types of MRSA infections and colonization, especially blood stream infections.

Using a rapid molecular testing method for identification of patients colonized with MRSA upon admission is highly debated despite the quick turn-around time for the result. Using PCR is expensive, and results can vary depending on the facility, and adoption of the proposed method. Policymakers have tried to mandate the testing method, but with literature showing varying results in the value of the test and the reduction of HAIs, hospitals continue to have an option as to whether to continue to use conventional culture methods.

Culture Change

Another component of the MRSA bundle is the incorporation of institutional culture change throughout the hospital which integrates communication, teamwork, and leadership so that infection control and patient safety becomes the responsibility of everyone involved in the care of patients. This is to ensure that all persons within the facility take part in infection control and prevention practices reflecting the needs and desires of patients, whether this is through teaching and education, or through practice.

A result of the culture change is that everyone is responsible for infection control and prevention practices not just the department of hospital infection control and epidemiology. This additional component of the bundle can aid in the decrease in transmission of MRSA and a decrease in the MRSA bioburden in the environment within the healthcare facility.

Risk Factors for MRSA Infections

Age

Numerous factors predispose patients to MRSA and most studies have shown a strong association with age and infection. Kuehnert et al. (2005), using discharge data, reported MRSA rates for septicemia, pneumonia, and other infections increase with patient's age with most

diagnoses occurring in persons > 65 years of age. In the same study, patients <14 and 15-44 years of age had higher MRSA hospitalization rates when compared with patients age 45-64 and > 65 years of age. Overall, the MRSA rate increased with patient age. Klevens et al. (2008) also found an increase in MRSA infections among older adults aged > 65 years and in hospitals with < 200 beds. Blood stream infections increased significantly from 27.0% in the period 1990-1994 to 54.1% during the time period of 2000-2004. Among children during these same time periods aged 0-18 years, the proportion of infections due to antimicrobial resistant organisms did not change.

Fridkin et al. (2005) found that children less than two years of age were significantly more likely to be diagnosed with CA-MRSA infections when compared to children of differing ages. Another study, by Payman & Delorme, (2008) in a medical center also reported a significant increase in the incidence of MRSA among young patients 6-25 years of age, as well as patients 45-50, and the elderly, 86-90. No differences were found in males or females.

A study by Liu et al. (2008) found among San Francisco residents, persons aged 35-44 years of age and 45-54 years of age and older adults >85 years of age were at the greatest risk of infection caused by community onset of MRSA and with an annual incidence of hospital-onset MRSA infection to increase with age, especially the elderly. Men were 2.4 and 1.7 times more likely to have community-onset and hospital-onset MRSA than women, respectively. Again, combined hospital-onset and community-onset MRSA was three times higher in persons who were black versus white.

Numerous factors predispose patients to MRSA infections and most studies have shown a strong association with age and infection. Literature suggests those at highest risk include the young and the elderly with the chance of infection increasing as age increases.

Comorbidities and MRSA

Fridkin et al. (2005) identified underlying chronic conditions which increase a patient's contact with healthcare workers and length of stay within the hospital as predisposing factors for either colonization or infection with MRSA disease. The chronic conditions identified by Fridkin include diabetes, cardiovascular disease (CVD), smoking, HIV infection, and alcohol abuse. Yates et al. (2009) concluded in their study that wound chronicity, inpatient care, and chronic kidney disease each independently predisposed patients to MRSA infection. Malani, et al. (2008) also found diabetes to be associated with higher MRSA infections as well as chronic pulmonary disease, and hypertension.

Many patients with spinal cord injuries have poor functional status. In a nested case-control study in patients 65 and older, researchers found that a high Charlson comorbidity score, immobility, and wound class each were independent predictors of MRSA surgical site infections. Kaye et al. (2011) studied predictors for bloodstream infections in a retrospective case-control study on patients age 65 and older and found such comorbidity factors as obesity, presence of a central line on admission, and urinary incontinence to be predictive of an MRSA infection.

A prospective cohort study on patients admitted to an intensive care unit (ICU) and staying for a minimum of two days were studied for HA-MRSA. Variables excluded from the study were those that could be assessed within 24 hours of admission to the ICU because HA- MRSA infection is usually determined after 48 hours. Four variables found to be risk factors for MRSA infections in the ICU are intubation, open wound, antibiotic treatment, and steroid administration. These findings do not contradict other studies; however, intubation as a risk factor has not been fully explored (Yamakawa et al., 2011).

Wang and colleagues (2010) conducted a large one year prospective study in a tertiary care center in Taiwan differentiating between HA-MRSA and CA-MRSA using molecular typing to identify predictors of infection. Using univariate analysis, age, ICU onset, length of stay before index culture, diabetes mellitus, bedridden status, recent surgery, and catheter-related infection were associated with HA-MRSA. Community onset (CA-MRSA) was isolated from soft tissue infections and deep-seated infection, and not related to a surgical procedure. The study used patients with positive blood cultures, or bacteremia.

Comorbidities can play a central role in the acquisition of a hospital acquired infection resulting in longer hospital stays, increased cost to the patient and often debilitating effects, if not death. Older adults are at higher risk because of the presence of multiple comorbid conditions, functional impairment and a reduced immune response.

Invasive Devices

Invasive devices pose the greatest threat to patients for serious infections. The presence of an indwelling central venous catheter is the single strongest predictor of a bloodstream infection (Kaye et al., 2011), mechanical ventilators may cause serious respiratory infections and urinary catheters can result in catheter-associated urinary tract infections. 40% of the 2 million hospital associated infections reported each year are urinary tract infections and 80% of the infections are due to the presence of indwelling urinary catheters (Chen et al., 2013).

A retrospective case-control study was conducted by Kaye et al. (2011) to examine predictors of nosocomial bloodstream infections in older adults. In this study, of the 830 cases, 81% of the hospital-acquired blood stream infections were catheter related with 23% infected with MRSA, and MRSA was the most common pathogen isolated. Independent predictors of the catheter related blood stream infection (CRBSI) were male sex, obesity, the presence of a central line, a

gastrostomy tube, and urinary incontinence at the time of admission. The presence of the central line on admissions almost doubled the risk factor for a blood stream infection while the gastrostomy tube was associated with almost three times the risk. An unusual finding included an association with being male as an increased risk for infection however the reason for this was unclear and not discussed.

A prevalence study was conducted in patients with and without spinal cord injury to investigate the risk of hospital acquired infection by Girard, Mazoyer, Plauchu, & Rode (2006). The prevalence of infection was higher in the spinal cord injury group than in those without injury, 23.4% and 4.8% respectively, with most infections classified as urinary tract infection. Urinary catheterization is very common and significantly more frequent in spinal cord injury patients than non-spinal injury. The spinal cord injury group had a greater number of comorbidities; however, the only independent predictor of infection was having an indwelling urinary catheter. Other common infections found in this group included skin and soft tissue, often related to decubitus ulcers.

A retrospective case-control study by Yoon et al. (2010) from January 2006 to February 2009 looked at predictors of persistent methicillin-resistant *S. aureus* bacteremia. In this case-control study the researchers found independent factors associated with MRSA bacteremia to be long term use of medical devices, such as central lines, MRSA infection in more than one site, and long term vancomycin treatment.

Another problem with indwelling devices is the chance for the patient to become colonized with a multiple drug resistant organism, such as MRSA. Considered high risk for infection, Mody et al. (2007) studied the relationship between the use of indwelling devices and colonization in patients from a nursing home facility. Of the 100 patients in the device group, 55

were colonized with MRSA at various sites, compared with 23 in the control group. Literature has shown an association with colonization as a risk factor and predictor for subsequent MRSA infection.

Patients considered high risk, such as those with a spinal cord injury, may develop serious infections due to the use of indwelling devices. Many patients with spinal cord injuries use intermittent catheterization or have an indwelling urinary catheter, require central line placement for treatment due to infection, or require mechanical ventilation. The most effective way to prevent infections related to devices is to reduce the incidence of use, ensure the device is clinically indicated and use evidence based guidelines for insertion.

Hospital Length of Stay

Patients who remain in hospitals for extended lengths of time are exposed to longer antimicrobial use, invasive procedures and greater contact with healthcare workers. Past studies have suggested that each of these characteristics increases a patient's chance to acquire MRSA; therefore, length of stay is a possible risk factor (Santos et al., 2010; WHO, 2009). Barnett and colleagues (2009) studied the effect of MRSA infection on the length of stay in an intensive care unit and found that patients with MRSA infections had a relative risk of discharge when compared to staying that was approximately 20% lower than that for patients without MRSA. Contributing factors for the additional stay was found to be attributed to how ill the patient was, the number of comorbidities present, and if the infections were occurring early during their stay in the ICU. Prolonged stays in the ICU not only impacted the risk of infection but was shown to be associated with a slight risk in mortality.

Another study associated with poor outcomes related to MRSA and hospital length of study was conducted by Eseonu, Middleton, & Eseonu (2011). The study was conducted in a major

orthopedic trauma center in surgical patients over an 11 year study period. Length of stay for patients admitted was found to be significantly associated with an adverse outcome when the LOS was greater than 30 days. 62% of these patients suffered an adverse outcome compared to 24% that did not. Other studies have suggested a higher incidence of post-operative infections in males, yet this study with 38% of the cohort being male and 62% female, found no association between gender and outcomes. The mean age within the group with a good outcome was 71, while the mean age of the adverse outcome group was 69; this is contrary to the findings in previous work. Patients with diabetes and the site of the infection were not found to have a significant association with a poor outcome either.

Looking at trends in hospitalizations with antibiotic-resistant infections in the US, 1997-2006, Mainous et al. (2011) used national hospital discharge data to study the length of stay for infection related hospitalizations. From 1999-2000 the length of stay rose at first and then began a decline from 1997-2006, totaling an overall 40% decline with a median stay of 6.62 and 3.97 days, respectively. The study's results also suggested that length of stay in the hospital was closely related to the presence of health insurance. As the proportion of patients without insurance with infection-related hospitalizations with antibiotic resistance increased, the length of stay for those patients without insurance decreased, showing a median length of stay of 4.15 days. Patients with health insurance during the 10-year period had a median length of stay of 5.49 days; therefore suggesting the mean length of stay was shorter for patients without health insurance.

Patients who remain in hospitals for extended lengths of time are exposed to longer antimicrobial use, invasive procedures, greater contact with healthcare workers and the hospital

environment. Each of these factors may contribute to a patient acquiring a hospital related infection increasing a patient's morbidity and mortality.

Quality Improvement and Patient Safety Movement

Over the last ten years patient safety has become a top priority in hospitals, emphasizing the importance of effective surveillance and prevention activities performed by infection control programs. In the mid 1800s, Florence Nightingale emerged as the first infection prevention and control champion in the healthcare industry. Nightingale believed in preventive medicine resulting in the creation of standardized methods for cleaning hospitals. Around the same time, Dr. Ignaz Semmelweis discovered that simple hand washing could prevent the spread of bacteria from patient to patient, reducing infections and amputations, as well as deaths. Semmelweis' colleague, Oliver Wendell Holmes also made a similar discovery yet both physicians were criticized by their peers regarding their findings due to skepticism. Another milestone in reducing infections involved the surgeon, Joseph Lister, publishing ground breaking work on antisepsis and is credited as being the first person to use a sterilization process in the operating room and therefore reducing the spread of infection amongst patients (Smith, Watkins, & Hewlett, 2012).

In the 1960s, hospital surveillance began due in large to the emergence of *S. aureus* in hospitals. Surveillance has since evolved as an important component of infection control programs used for identifying the sources causing hospital outbreaks, identification of problem areas in the hospital environment, and for setting priorities for infection control activities. Surveillance data is also used to provide feedback to staff and physicians regarding infection rates and trends and can lead to action for reduction of hospital acquired infections.

In the 1970s, the National Nosocomial Infection Surveillance (NNIS) was created for the purpose of collecting, analyzing, and disseminating data on HAIs and to standardize definitions for infections. The SENIC project, which was a Study on the Efficacy of Nosocomial Infection Control, published in 1974, found that one third of HAIs could be prevented by effective infection control programs and by the 1990's, the Healthcare Infection Control Practices Advisory Committee (HICPAC) was formed by the CDC. This committee has been instrumental in establishing standardized guidelines used by infection control programs throughout U.S. hospitals resulting in improved quality processes and a reduction in HAIs.

In 1999, the Institute of Medicine published Today's Patient Safety and Quality Initiatives which reported on adverse events in hospitals, deaths, and the costs related to these adverse events. Recommendations resulting from this report included a proposal for hospital infection control programs to establish Patient Safety programs making the job of reducing HAIs and providing a safe work environment for all employees a top priority. A number of organizations are involved in the Patient Safety movement such as the Joint Commission on Accreditation of Healthcare Organizations and the Institute of Medicine. National Patient Safety Goals were developed by the Joint Commission and currently must be followed for hospital accreditation. Several examples of the goals infection control are responsible for overseeing include the monitoring of hand hygiene practices, development of methods for prevention of catheter related bloodstreams infections and eventually mandatory reporting of HAIs. A recent quality initiative developed by the Institute for Healthcare Improvement (IHI) is the "bundle." This type of measure is used by the VAMC for the reduction of MRSA HAIs. The bundle consists of improved hand hygiene, contact isolation, universal surveillance, and culture change within the hospital setting.

Improving the quality of patient care through surveillance and prevention activities is a valuable asset provided by infection control programs. Over the last ten years a greater emphasis has been placed on reducing such adverse events as HAIs caused by MRSA. Proposed guidelines can aid infection control programs in reducing infections, deaths, and the cost related to each of these.

Summary

Prior to 1970, infections resulting from MRSA were uncommon in hospital settings. By the 1980s and 1990s reports of HA-MRSA steadily increased, and by 1998 CA-MRSA was first reported among young children with no known risk factors (Mileno, 2008). Over the past 20 years, the incidence of infections caused by antimicrobial-resistant pathogens has increased dramatically, especially in vulnerable high-risk populations, such as those patients in the intensive care unit (ICU) and those who are immunocompromised and debilitated (Croft et al., 2009; Sarikonda et al., 2010; Weber et al., 2007). The CDC has estimated a direct medical cost per patient of MRSA to be $27,083 to $34,900. Assuming 120,000 MRSA infections per year, (Rojas & Liu, 2005) there is an estimated annual direct hospital cost of MRSA for the United States of $3.2 billion to $4.2 billion (American Health and Drug Benefits, 2009).

Because of the increased costs, and increased morbidity and mortality, the reduction of HA-MRSA has been a top priority in the United States for major stakeholders in the public health, medical, and infection prevention communities (Agency for Healthcare Research & Quality, 2009; Centers for Medicare & Medicaid, 2009; CDC, 2007; The Institute for Healthcare Improvement, (IHI) 2006; Platt, 2011; Association for Professionals in Infection Control and Epidemiology, 2009). As a result of these efforts by major stakeholders and with present

evidence showing healthcare-associated infections are preventable, hospitals and providers are under intense pressure to reduce the transmission and burden of these infections.

Individual interventions, such as universal surveillance or greater compliance with hand hygiene are unlikely to work alone as effective measures in reducing MRSA transmission and acquisition. Reduction in the number of HAIs and transmission of MRSA within the hospital setting requires a comprehensive approach for successful outcomes and sustainability, and for establishing guidelines and criteria for hospital infection control and quality improvement.

Use of Theory

The theories used in this study include the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB), frequently referred to as TRA/TPB. To provide specificity and to show the strength of the theory, each theory is discussed in detail with definitions of the constructs and examples related to infection control practice. The study was informed by theory for the development of research questions related to hospital acquired infections.

A theory that has received considerable attention in regards to health behavior change and proposes that the most important determinant of a person's behavior is a person's intent, is the Theory of Reasoned Action by M. Fishbein (Fishbein, 1967)**.** This theory was designed to study volitional behaviors or those behaviors that are performed at will (Luszczynska & Sutton, 2005). Along with Fishbein, Icek Ajzen proposed four constructs within this theory which helped them to develop the conceptual framework. These constructs include: intention, belief, behavior and attitude**.** Behavioral intention is defined by Fishbein and Ajzen as, "an indication of a person's readiness to perform a behavior and it is considered an immediate antecedent of behavior"(Ajzen, 2006). Behavioral belief is a person's intent to perform a behavior and the consequence that is related to performing the behavior and their subjective norms (social

pressures) associated with the behavior. Attitude toward the behavior is "the degree to which performance of the behavior is positive or negatively valued," (Ajzen, 2006). This is determined by a group of accessible behavioral beliefs linking the behavior to various outcomes**.** In the context of infection control practices, if a healthcare worker feels a strong commitment toward good patient care and to reduce infections through proper hand hygiene compliance, as a result, this person will have a positive attitude towards this task each time it needs to be performed. The opposite is true as well, negative beliefs about infection control practices, such as the need to wash hands repetitively and causing an irritation to the HCWs hands or a lack of understanding of the risk of infection, might yield low hand washing compliance.

Subjective norm "is the perceived social pressure to engage or not engage in a behavior" (Ajzen, 2006). A few examples of the type of social pressure a healthcare worker may experience which influences the behavior are social networks within the hospital and include peers, co-workers, physicians, or infection control managers. Therefore, if a person is concerned about what other people may think or are concerned about another person's perception of their job performance, this may provide motivation for a person to follow recommended guidelines for hand washing, and for insertion, cleaning, and maintenance of devices. This is a positive subjective norm and the person believes they are performing the appropriate behavior. The opposite of this thought process is true as well. An example of a positive subjective norm related to infection control practice may include healthcare workers who view co-workers or physicians as important people in their lives. They also believe these people, through observation, approve of their actions and participation in following appropriate infection control practices such as hand washing compliance. Each of the examples described above are behaviors that are purely volitional and may predict behavioral intention and the actual behavior.

In 1991 Ajzen expanded the Theory of Reasoned Action by adding an additional construct related to self-efficacy, perceived behavioral control, to create the Theory of Planned Behavior. These are not two different theories, rather a modification of the Theory of Reasoned Action reflecting those behaviors that are not fully under volitional control, or behaviors not performed at will. This modification reflects upon the perception by the healthcare worker as to whether or not an action, or job is within reason or difficult to perform. A person's behavior is strongly influenced by their confidence (self-efficacy) and their ability to perform a behavior. A healthcare worker may view a task as difficult and these difficulties are perceived as barriers when performing some infection control practices, such as hand washing. The reasons for these perceptions may include the thought of repetitive hand washing as very time consuming and taking away from other important patient care duties, or a lack of resources to perform the job.

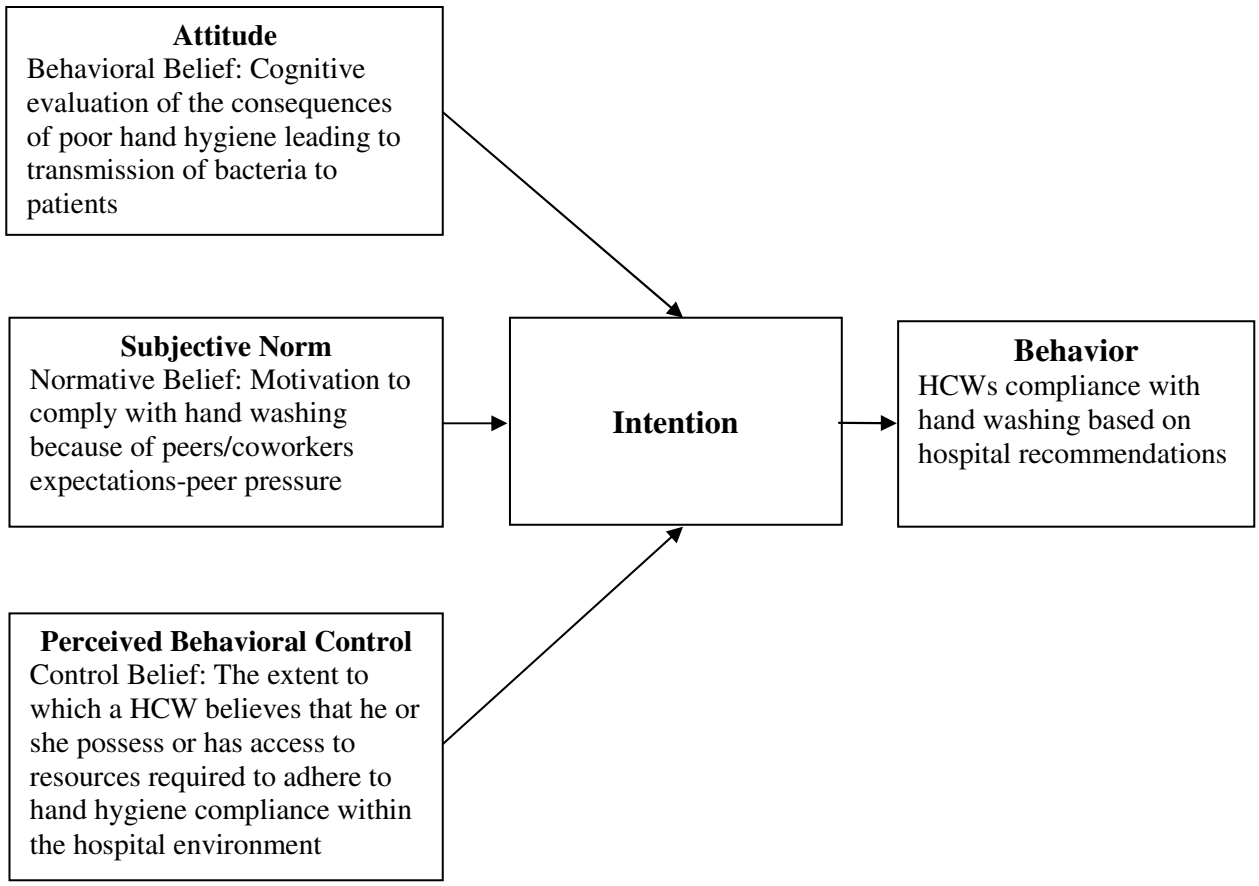
These theories inform the research to understand the behaviors of healthcare workers towards infection control measures, such as compliance with hand hygiene recommendations to aid in the reduction of HAIs (McLaws, Mahariouei, & Askarian, 2012; Pittet, 2004; O'Boyle, Henly & Larson, 2001).

Figure 2.
TRA/TPB Related to Hospital Acquired Infections

Intention	HCW's plan to adhere to hand hygiene in a variety of clinical settings for reduction of hospital acquired infections
Attitude	Affective/cognitive evaluation of the hand hygiene procedure itself
Beliefs about outcomes	Cognitive evaluation of the consequences of poor hand hygiene including transmission of the bacteria and professional behavior
Subjective norm	Overall evaluation of the extent to which important people in the lives of HCWs are thought to support or endorse hand hygiene compliance as recommended
Normative beliefs	Beliefs about expectations that specific other people hold for the HCW's person hand hygiene compliance
Perceived control	Overall evaluation of the degree to which a HCW believes that hand hygiene compliance can be performed as recommended
Control beliefs	The extent to which a HCW believes that he or she possesses or has access to resources required to adhere to hand hygiene compliance in a variety of clinical settings

Figure 2. Constructs of the TRA/TPB

Figure 3.
TRA/TPB & Hand Washing Compliance for Reduction of HA-MRSA Infections



DEFINITION OF TERMS

Adverse Outcome- An injury that was caused by medical personnel

American Spinal Injury Association (ASIA) Impairment Scale – Level of spinal cord injury, usually from A-D.

A=Complete: No motor or sensory function is preserved in the sacral segments S4-S5

B=Incomplete: Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5

C=Incomplete: Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3

D=Incomplete: Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more

E=Normal: Motor and sensory function are normal (www.asia-spinalinjury.org/)

Bioburden-The number of bacteria living on a surface before it is sterilized

Carrier – Organism that harbors an agent without clinical disease

Case – A patient meeting the defined hospital acquired infection definition as defined by CDC, VHA, APIC, or other national authority

Chromogenic Agar – An agar used for the isolation and identification of methicillin - resistant *Staphylococcus aureus*

Colonization – Microorganisms become established in a host without causing infection/disease

Cohort - Group of patients that share the same room or floor

Eschar– A thick leathery crust often covering an underlying necrotic process

Foley Catheter – A small flexible tube inserted into the urethra to the bladder to allow for the drainage of urine

Fomite – An inanimate object or material that is capable of transmitting infectious organisms from one individual to another

Hawthorne Effect – Phenomenon that produces an improvement in human behavior or performance as a result of increased attention from superiors or colleagues; a temporary modification of behavior

Incidence – Number of new cases of a disease a specific population has during a period of time

Infection – A condition whereby the bacterium has invaded body tissue and is multiplying and causing manifestations of disease, such as fever

Infection Control Measures – In addition to Standard Precautions, Transmission Based Precautions Contact Precautions for Methicillin Resistant *Staphylococcus aureus* or *Clostridium difficile*

Invasive – Characterized by a tendency to spread, infiltrate and intrude

Methicillin – An antibiotic in the penicillin class used in the past to treat infections from *Staphylococcus aureus*

Methicillin-Resistant *Staphylococcus aureus (MRSA)* – A gram positive bacteria that is resistant to methicillin or oxacillin and many other antibiotics

Methicillin-Sensitive Staphylococcus aureus (MSSA) – A gram positive bacteria that is sensitive to methicillin or oxacillin

MRSA Bundle – Consist of contact isolation, hand hygiene, universal surveillance, & culture change within the hospital setting

Nares – The nostrils (openings) of the nose which allow inhalation and exhalation of air

Nosocomial – Originating or taking place in a hospital

Pathogen – An agent such as bacteria capable of causing disease

Penicillinase – Producing *Staphylococcus aureus* – a bacterium resistant to beta-lactam antibiotics, particularly methicillin

PICC Line – A form of intravenous access that can be used for a prolonged period of time, such as for extended antibiotic therapy. It is inserted through a peripheral vein and advanced until the tip of the catheter reaches the Superior Vena Cava

Polysubstance abuse – Refers to a type of substance dependence disorder in which an individual uses at least three different classes of substances indiscriminately

Positive Deviance – Using one's own experiences to find solutions and solve problems while still following established hospital MRSA Infection Control Policies

Pressure Ulcer – Also known as decubitus ulcers or bedsores are localized injuries to the skin and/or underlying tissue usually over a bony prominence as a result of pressure, or pressure in combination with shear and/or friction. This most often occurs on the sacrum, coccyx, heels or the hips.

Prevalence – The total number of existing cases of a specified disease in a given population during a given period of time

Staphylococcus aureus – Bacterial species which can colonize or infect a person

Slough– Dead skin tissue that may have a yellow or white appearance

Surveillance – A system of collecting, consolidating, and analyzing resident data to determine incidence and prevalence of a disease in a facility

Transmission (MRSA) – The transfer of a disease from one person to another. The main mode of transmission of MRSA is person to person via hands.

ACRONYMS

APIC – Association of Practitioners of Infection Control

BSIs – Blood Stream Infections

CDC – Centers for Disease Control and Prevention

ICU – Intensive Care Unit

IOM – Institute of Medicine

IHI – Institute for Healthcare Improvement

LOS – Length of Stay

MDROs – Multidrug Resistant Organisms

MSSA – Methicillin-sensitive *Staphylococcus aureus*

MRSA – Methicillin resistant *Staphylococcus aureus*

NICU – Neonatal Intensive Care Unit

PICC Line – Peripherally Inserted Central Catheter Line

VAMC– Veterans Affairs Medical Center

VHA – Veterans Health Administration

WHO – World Health Organization

CHAPTER 2

RESEARCH QUESTIONS

Research Questions

Question 1 - What is the burden of HA-MRSA infection in patients with a spinal cord injury?

Question 2 - Is there an association with MRSA and age, race, weight, ASIA Score, decubitus ulcer, diabetes mellitus, anxiety/depression, Hepatitis C, polysubstance abuse, alcohol use, paraplegia, quadriplegia, amputee, device use, MRSA colonization, length of stay and hand hygiene compliance?

Question 3 - What evidence from this study will validate previous studies on MRSA risk factors?

Question 4 - What new information will emerge from this study?

CHAPTER 3

METHODS AND MATERIALS

Purpose of the Study

The purpose of this case-control study was to assess risk factors contributing to HA-MRSA and gain a better understanding of the burden of HA-MRSA in patients with spinal cord injuries. The case-control study was also conducted to see if new information would be found on HA-MRSA infections and validate or refute current research on the topic for patients in a dedicated spinal cord injury unit at a Veterans Affairs Medical Center.

Design of the Study

After obtaining Institutional Review Board approval from Georgia Regents University and the Veterans Affairs Medical Center, data were made available from the VHA Infection Control Department and permission granted for medical chart review.

The study was a retrospective chart review (case-control) study to gain a better understanding of trends in MRSA colonization and infection. The intent was to provide researchers and the VA Infection Control and Epidemiology Department with a better understanding of possible risk factors associated with the acquisition and transmission of MRSA in a dedicated spinal cord injury unit for fiscal years 2008-2011.

Inclusion and Exclusion Criteria

Those included in this study were male inpatients in the spinal cord injury unit 18 years of age and older. No minors were included in the study. Subject selection criteria were purely driven by the population of inpatients. It fairly distributes the burden, risk, and benefits of the research as it is generated by factors specific to the pathogen and the environment that are beyond the control of the researcher.

Patients may have diminished capacity due to advanced dementia or other advanced or end-stage medical problems. This same vulnerability is why they are susceptible to hospital acquired infections and why much care must be taken to try to prevent them. The potential benefit from lessons learned from surveillance and epidemiology outweighs the risk of the analysis and data gathering that will use the medical records of these patients.

Data Source

The Veterans Affair Medical Center implemented a "MRSA Bundle" consisting of universal nasal surveillance for MRSA, contact precautions for patients who were either colonized or infected with MRSA, hand hygiene, and a change in the institutional culture using positive deviance. The goal of positive deviance was to foster cultural change so that HCWs would help find solutions to solve problems and therefore infection control and prevention became the responsibility of everyone involved in the care of patients.

The electronic medical record for this study was initially established when a patient was admitted to the hospital and followed until the patient was discharged or the patient expired. "The Veterans Health Administration (VHA) utilizes a sophisticated electronic health information system called the Veterans Health Information Systems and Technology Architecture (VISTA). This system is a comprehensive clinical and administrative repository of all veteran health information including laboratory, radiology and pharmacy. The computerized patient record system (CPRS) is a system that provides a user interface for information captured in VISTA. Health care providers use the CPRS & VISTA to update patient medical history, place clinical orders, review laboratory results, medical images and current medications. Microbiological culture data and relevant patient information are obtained from VISTA via a

Clinical Informatics Service in the VA, which is responsible for extracting data from VISTA into a relational database (SQL server)." (VHA, 2007)

Collection of MRSA Nasal Swabs

Samples of nasal secretions are obtained by hospital staff with a swab from both anterior nares of patients within 24 hours after their admission to the hospital. Swabs are also obtained from patients who are not known to be colonized or infected with MRSA when they are transferred or discharged from units within the VA. The VA clinical microbiology laboratory processes the nasal swabs with the used of standard or selective chromogenic agar for the isolation of MRSA or with polymerase chain-reaction (PCR) based tests by rapid molecular detection for the detection of the organism. Positive results are reported to the patient's nursing unit and recorded in the electronic medical record.

Study Population

The study population included male adults 18 years of age and older who had a hospital admission to the Spinal Cord Injury Unit between fiscal years 2008-2011 at a Veterans Affair Medical Center in the southeastern U.S. No minors were included in the study. Racial/ethnic composition did not limit enrollment. Subject selection criteria were purely driven by the population of inpatients. It fairly distributed the burden, risk, and benefits of the research as it was generated by factors specific to the pathogen and the environment and are beyond the control of the researcher.

Analysis and Interpretation of the Data

Data Collection

A retrospective case-control study was conducted. Hospital acquired MRSA infections were identified by the Infection Control Department through routine surveillance. Once the case

definition was met a line-list of cases was made which was added to a spreadsheet with name and SSN and kept on a protected department network drive in the Infection Control Department. Validation of the MRSA cohort and collection of variables was performed on these cases using the computerized patient record system (CPRS) and the Veterans Health Information Systems and Technology Architecture (VISTA). Database managers extracted the CNVAMC control-group subjects from the spinal cord injury unit for years 2008-2011 using the last 4 digits of the SSN, name and birth year. For every MRSA case, 2 controls were randomly chosen and stratifying on birth year. This 2:1 selection was used to improve the power of the study. All data was de-identified before analysis. We extracted the following variables for both cases and controls: demographic information (gender, race/ethnicity, birth year), reason for visit (admitting diagnosis), length of stay, presence of comorbidities, ASIA score, CA-MRSA on admission and discharge, and infection source and type. All personally identifiable information was deleted before entry into a spreadsheet for analysis of the data. A new ID was created for this purpose for each patient that had no link to the SSN or name and transferred to a disc by the CNVAMC data managers. Data was not stored on the hard drive of a PC and no mobile devices were used.

Collection of Hand Hygiene Data

Hand hygiene records were collected per routine surveillance by the Infection Control Department. Hand hygiene data for HCWs is reported quarterly and kept protected on the access limited committee or department network drive in the Infection Control and Epidemiology Department.

Collection of hand hygiene data for HCWs in the Spinal Cord Injury Unit was observational and used both staff and independent monitors. The data was reported quarterly to the Infection Control Department as part of routine surveillance. A minimum of ten opportunities to wash

hands or use alcohol-based hand rub was observed by each department/unit and reported as a percentage for the quarter.

Coding for this variable was entered in the following way: the four quarters in the year were coded as 1-4 respectively; each patient was assigned a percentage based on the hand hygiene compliance for the quarter the patient was admitted.

Collection of MRSA Case Subjects

MRSA cases were identified as part of routine surveillance by the Infection Control Department. Once the case definition of MRSA-HAI infection, CA-MRSA infection or colonization was met as defined by the CDC & the National Health Safety Network (NHSN), a line-list of cases was made which was kept on protected department network drives. The data was then de-identified before entry into a spreadsheet by VA Infection Control Practitioners and was kept protected on the access limited committee drive or department network drive. Data was further protected by keeping electronic information password protected and access limited and other documents locked in filing cabinets in the PI's research office. Investigators had access to these materials.

Data Analysis

Prior to the data analysis, time was spent in "cleaning" the data and performed in several stages. In the first step, variables were reviewed by looking at variances and frequencies, outliers, coding errors, missing data, typing errors and subsequently checked with the medical records. Also, the number of cases and controls were reviewed to make sure the number of cases matched the number of controls. In the second stage, corrections were made, and the analysis performed.

The patient population of interest was described using appropriate univariate descriptive statistics: frequencies and percentages for categorical variables and means, medians and range and standard deviation for continuous variables and crude odd ratios (ORs) and 95% confidence intervals (CIs) were calculated. All statistical analyses were done using IBM SPSS Statistics (IBM Corp. Released 2011. IBM SPSS Statistics for Mac, Version 20.0. Armonk, NY: IBM Corp.).

CHAPTER 4

RESULTS

The purpose of this case-control study was to assess risk factors contributing to HA-MRSA and gain a better understanding of the burden of HA-MRSA in patients with spinal cord injuries. The case-control study was also conducted to see if new information would be found on HA-MRSA infections and validate or refute current research on the topic for patients in a dedicated spinal cord injury unit at a Veterans Affairs Medical Center.

This chapter is organized into the following sections to present study results: (1) descriptive analysis for variables of interest, and; (2) analysis of research questions.

Descriptive Statistics for Variables of Interest

During the study period, the infection control department identified 95 cases of HA-MRSA using standard surveillance methods and criteria for HAIs as defined by the CDC and the NHSN. All cases were validated by the researcher using these criteria and a data collection tool was constructed before study initiation. Culture information collected by the Infection Control Department included the source, type and date of infection. Additional data that were retrospectively collected were basic demographics, admitting diagnosis, presence of varying comorbidities, ASIA score, presence of indwelling medical device, BMI, LOS, MRSA colonization on admission and discharge, and quarterly hand hygiene compliance.

Ninety-five cases of HA-MRSA were identified and 190 uninfected control patients were chosen using a random number generator. The mean age of the cohort on admission was 59.81 (+/- 11.77 S.D.), had a mean BMI of 26.56 (+/- 6.521 S.D.) and had a mean length of stay of 83.17 days (+/- 123 S.D.) (Table 2). Note that amputees were excluded from all BMI calculations because of the questionable significance of the value.

Table 2. Quantitative Variable Descriptive Statistics Overall and by Group

		Cases	Control	Overall
Age on Admission				
	N Valid	93	190	283
	N Missing	2	0	2
	Mean	59.89	59.77	59.81
	Median	61.00	61.00	61.00
	Std. Dev.	11.818	11.775	11.768
	Minimum	25.000	26.000	25.000
	Maximum	84.00	84.00	84.00
BMI[1]				
	N Valid	76	168	244
	N Missing	2	11	12
	Mean	25.99	26.82	26.56
	Median	26.00	27.00	26.00
	Std. Dev.	5.992	6.748	6.521
	Minimum	15.000	15.000	15.000
	Maximum	46.000	53.000	53.000
LOS[2]				
	N Valid	94	190	284
	N Missing	1	0	1
	Mean	165.77	42.31	83.17
	Median	128.50	10.00	29.00
	Std. Dev.	152.497	78.481	123.056
	Minimum	4.000	1.000	1.000
	Maximum	934.000	549.000	934.000
Hand Hygiene	N Valid	95	189	284
	N Missing	0	1	1
	Mean	.607579	.664603	.645528
	Median	.670000	.890000	.860000
	Std. Dev.	.3832385	.4167471	.406028
	Minimum	.0000	.0000	.0000
	Maximum	1.0000	1.0000	1.0000

[1]Body Mass Index (Amputees Excluded)
[2]Length of Stay (Days)

Primary causes of spinal cord injury varied across cases and controls with the majority of injuries caused by vehicular (Approx. 25.0 % for cases and controls), and motorcycle accidents (9.5% for cases vs. 4.7% for controls), falls (24.2% for cases vs. 15.3% for controls), other types of accidents (10.5% for cases vs. 15.3% for controls), gunshot wounds (8.4% for cases vs. 9.5% for controls), spinal related injury (4.2% for cases vs. 13.2% for controls) and followed by other causes (13.7% for cases vs. 9.5% for controls). The same variance was found for cases and controls for admitting diagnosis. An admitting diagnosis for annual evaluation accounted for 49.5% of controls while an admitting diagnosis of decubitus ulcer accounted for 51.6% of the cases. Urinary tract infection (7.4% for cases vs. 6.8% for controls) and other causes followed with similar results for both cases and controls (Approx. 28.0%) (Tables 3 and 4).

Table 3. Cause of Injury

			Group		Total
			0 Control	1 Case	
Reason for Injury	1 Car Accident	Count	53	24	77
		% within Group	27.9%	25.3%	27.0%
	2 Fall Accident	Count	29	23	52
		% within Group	15.3%	24.2%	18.2%
	3 Motorcycle Accident	Count	9	9	18
		% within Group	4.7%	9.5%	6.3%
	4 Other Accident	Count	29	10	39
		% within Group	15.3%	10.5%	13.7%
	5 Gun Shot Wound	Count	18	8	26
		% within Group	9.5%	8.4%	9.1%
	6 Spinal Related	Count	25	4	29
		% within Group	13.2%	4.2%	10.2%
	7 Other	Count	18	13	31
		% within Group	9.5%	13.7%	10.9%
	8 Unknown	Count	9	4	13
		% within Group	4.7%	4.2%	4.6%
Total		Count	190	95	285
		% within Group	100.0%	100.0%	100.0%

Table 4. Admitting Diagnosis by Group

			Group		Total
			0 Control	1 Case	
Admit Dx	1 Annual Evaluation	Count	94	12	106
		% within Group	49.5%	12.6%	37.2%
	2 Ulcer	Count	24	49	73
		% within Group	12.6%	51.6%	25.6%
	3 UTI	Count	13	7	20
		% within Group	6.8%	7.4%	7.0%
	4 Other	Count	59	27	86
		% within Group	31.1%	28.4%	30.2%
Total		Count	190	95	285
		% within Group	100.0%	100.0%	100.0%

As displayed in Table 5, cases (61.6%) were more likely than controls (39.2%) to have an ASIA score of A (complete impairment). Cases (80%) were more likely than controls (36%) to have a pressure ulcer on admission (Table 6). Cases (56.7%) were more likely than controls (30.2%) to have a positive nasal culture for MRSA on admission (Table 7). Cases (59.6%) were more likely than controls (32%) to have a positive nasal culture for MRSA on discharge (Table 8).

Table 5. ASIA Score by Group

			Group		Total
			0 Control	1 Case	
ASIA Score	0 D	Count	60	11	71
		% within Group	36.1%	12.8%	28.2 %
	1 C	Count	30	16	46
		% within Group	18.1%	18.6%	18.3 %
	2 B	Count	11	6	17
		% within Group	6.6%	7.0%	6.7%
	3 A	Count	65	53	118
		% within Group	39.2%	61.6%	46.8 %
Total		Count	166	86	252
		% within Group	100.0%	100.0%	100.0 %

Table 6. Decubitus Ulcer by Group

			Group		Total
			0 Control	1 Case	
Ulcer Decubitis	0 No	Count	121	19	140
		% within Group	64.0%	20.0%	49.3%
	1 Yes	Count	68	76	144
		% within Group	36.0%	80.0%	50.7%
Total		Count	189	95	284
		% within Group	100.0%	100.0%	100.0%

Table 7. MRSA Colonization on Admission by Group

			Group		Total
			0 Control	1 Case	
MRSA Admit	0 Negative	Count	125	39	164
		% within Group	69.8%	43.3%	61.0%
	1 Positive	Count	54	51	105
		% within Group	30.2%	56.7%	39.0%
Total		Count	179	90	269
		% within Group	100.0%	100.0%	100.0%

Table 8. MRSA Colonization at Discharge by Group

			Group		Total
			0 Control	1 Case	
MRSA DC	0 Negative	Count	121	36	157
		% within Group	68.0%	40.4%	58.8%
	1 Positive	Count	57	53	110
		% within Group	32.0%	59.6%	41.2%
Total		Count	178	89	267
		% within Group	100.0%	100.0%	100.0%

Research by Eseonu, Middleton and Eseonu (2011) found in their study that a length of hospital stay greater than 30 days was significantly associated with a MRSA infection; therefore, the cut-points for length of hospital stay were calculated using </= 30 days and > 30 days. There were a greater proportion of cases showing longer lengths of stay with 88.3% staying > 30 days as compared to 30.5% of controls staying > 30 days (Table 9). Medical device use varied across groups with catheter use being 24.2% in cases and 38.9% in controls, PICC use 11.6% in cases and 1.6% in controls, and use of a catheter and PICC simultaneously 55.8% in cases and 14.2% in controls (Table 10).

Table 9. Length-of-Stay by Group

			Group		Total
			0 Control	1 Case	
LOS	0 </= 30 Days	Count	132	11	143
		% within Group	69.5%	11.7%	50.4%
	1 > 30 Days	Count	58	83	141
		% within Group	30.5%	88.3%	49.6%
Total		Count	190.00	94.00	284.00
		% within Group	100.0%	100.0%	100.0%

Table 10. Device Use by Group

			Group		Total
			0 Control	1 Case	
Device Use	0 None	Count	86	8	94
		% within Group	45.3%	8.4%	33.0%
	1 Foley	Count	74	23	97
		% within Group	38.9%	24.2%	34.0%
	2 PICC	Count	3	11	14
		% within Group	1.6%	11.6%	4.9%
	3 Both	Count	27	53	80
		% within Group	14.2%	55.8%	28.1%
Total		Count	190	95	285
		% within Group	100.0%	100.0%	100.0%

The most common sources of infection for cases were ulcer related (31.6%) and from skin and soft tissue infections besides pressure ulcers (23.2%), 14.7% were Foley catheter related, 8.4% were blood stream infections and 22.1% were from other sites/sources (Table 11).

Table 11. Infection Source for Cases (N=95)

			Group	Total
			1 Case	
Infection Source	1 Blood	Count	8	8
		% within Group	8.4%	8.4%
	2 SST	Count	22	22
		% within Group	23.2%	23.2%
	3 Ulcer	Count	30	30
		% within Group	31.6%	31.6%
	4 Catheter	Count	14	14
		% within Group	14.7%	14.7%
	5 Other	Count	21	21
		% within Group	22.1%	22.1%
Total		Count	95	95
		% within Group	100.0%	100.0%

SST-Skin & Soft Tissue

The percentages varied in cases and controls; 67.6% of cases showed </= 89% compliance for hand washing for HCWs and 52.4% of controls were </= 89% compliance with hand washing for HCWs. Compliance also varied for the > 90% compliance group, case subjects showed 32.6% compliance with hand washing for HCWs and HCWs compared to 47.6% for control subjects (Table 12).

Table 12. Hand Hygiene Compliance by Group

			Group		Total
			0 Control	1 Case	
Hand Hygiene	0 </= 0.89	Count	99	64	163
		% within Group	52.4%	67.4%	57.4%
	1 >/= 0.90	Count	90	31	121
		% within Group	47.6%	32.6%	42.6%
Total		Count	189	95	284
		% within Group	100.0%	100.0%	100.0 %

Analysis of Research Questions

Research Question #1

What is the burden of HA-MRSA in patients with a spinal cord injury?

A prevalence study was conducted in patients with and without spinal cord injury to investigate the risk of hospital acquired infection by Girard, Mazoyer, Plauchu, & Rode (2006). The prevalence of infection was higher in the spinal cord injury group than in those without injury, 23.4% and 4.8% respectively, with most infections classified as urinary tract infection. Urinary catheterization is very common and significantly more frequent in spinal cord injury patients than non-spinal injury. The spinal cord injury group had a greater number of comorbidities; however, the only independent predictor of infection was having an indwelling urinary catheter. Other common infections found in this group included skin and soft tissue, often related to decubitus ulcers.

In the current study, the most common source of infection for cases were from decubitus ulcers (31.6%) and from skin and soft tissue infections (besides decubitus ulcers) (23.2%),

14.7% were Foley catheter related, 8.4% were blood stream infections and 22.1% were from other sites/sources (Table 13).

Table 13. Infection Source for Cases (N=95)

			Group	Total
			1 Case	
Infection Source	1 Blood	Count	8	8
		% within Group	8.4%	8.4%
	2 SST	Count	22	22
		% within Group	23.2%	23.2%
	3 Ulcer	Count	30	30
		% within Group	31.6%	31.6%
	4 Catheter	Count	14	14
		% within Group	14.7%	14.7%
	5 Other	Count	21	21
		% within Group	22.1%	22.1%
Total		Count	95	95
		% within Group	100.0%	100.0%

SST-Skin & Soft Tissue

Research Question #2

Is there an association with HA-MRSA and age, race, weight, ASIA score, decubitus ulcer, diabetes mellitus, anxiety/depression, hepatitis C, polysubstance abuse, alcohol use, paraplegia, quadriplegia, amputee, device use, MRSA colonization, length of stay, and hand hygiene compliance?

The unadjusted odds ratios (ORs) of MRSA-HAI were calculated for the following risk factors: Age at Admit (median split: </= 61 vs. > 61), Race (White vs. Black), Weight Status (Underweight or Normal: BMI < 25 vs. Overweight: BMI 25 - 29 vs. Obese: BMI > 29), ASIA Score (D vs. C vs. B vs. A), Decubitus Ulcer (No vs. Yes), Diabetes Mellitis (No vs. Yes), Anxiety-Depression (No vs. Yes), Hepatitis C (No vs. Yes), Poly-substance Abuse (None vs.

History vs. Current), Alcohol Abuse (None vs. History vs. Current), Paraplegia (No vs. Yes), Quadriplegia (No vs. Yes), Amputee (No vs. Yes), Device Used (None vs. Foley Only vs. PICC Only vs. Both Foley and PICC), MRSA Colonization on Admit (Negative vs. Positive), MRSA Colonization at Discharge (Negative vs. Positive), Length of Stay (median split: </= 30 Days vs. > 30 Days, and Hand Hygiene (median split: > 0.90 vs. </= 0.89). It should be noted that all calculations concerning Weight Status, as defined by BMI, excluded amputees since BMI is not relevant for amputees.

The unadjusted ORs (Table 14) showed that the use of a Foley catheter increased the univariate odds of HA-MRSA 3.3 fold, use of a PICC increased the odds 39.4 fold, and use of both a Foley and PICC increased the odds 21.1 fold. A hospital length-of-stay greater than 30 days increased the univariate odds of HA-MRSA 17.1 fold. MRSA Colonization on admission and MRSA colonization at discharge increased the univariate odds of HA-MRSA approximately 3 fold. Having a decubitis ulcer increased the univariate odds of HA-MRSA 7.1 fold. Having an ASIA score of A (Complete Impairment) increased the univariate odds of HA-MRSA 4.4 fold. Having an ASIA score of B or C (Incomplete Impairment) increased the univariate odds of HA-MRSA approximately 2.9 fold. Having an amputation increased the univariate odds of HA-MRSA 3.5 fold. Paraplegia increased the univariate odds of HA-MRSA 1.9 fold. Hand hygiene compliance for HCWs of </= 0.89 increased the univariate odds of HA-MRSA 1.88 fold.

Table 14. Unadjusted Odds Ratios for MRSA Hospital Acquired Infection (n = 190 Controls; n = 95 Cases)

Variable[1]	Categories	0 Control	1 Case	Odds Ratio	P-Value
Age at Admit	0 </= 61	101 (52.3%)	48 (51.6%)		
	1 > 61	89 (46.8%)	45 (48.4%)	1.064	0.807
Race	0 White	107 (59.1%)	46 (52.3%)		
	1 Black	74 (40.9%)	42 (47.7%)	1.320	0.288
Weight Status (Amputees Excluded)	0 Underweight or Normal (BMI < 25)	65 (38.7%)	30 (39.5%)		
	1 Overweight (BMI 25 - 29)	53 (31.5%)	29 (38.2%)	1.186	0.594
	2 Obese (BMI > 29)	50 (29.8%)	17 (22.4%)	0.737	0.392
ASIA Score	0 D	60 (36.1%)	11 (12.8%)		
	1 C	30 (18.1%)	16 (18.6%)	2.909	0.018
	2 B	11 (6.6%)	6 (7.0%)	2.975	0.071
	3 A	65 (39.2%)	53 (61.6%)	4.448	< 0.001
Decubitis Ulcer	0 No	121 (64.0%)	19 (20.0%)		
	1 Yes	68 (36.0%)	76 (80.0%)	7.118	< 0.001
Diabetes Mellitis	0 No	141 (74.6%)	72 (75.8%)		
	1 Yes	48 (25.4%)	23 (24.2%)	0.938	0.828
Anxiety-Depression	0 No	132 (69.5%)	74 (77.9%)		
	1 Yes	58 (30.5%)	21 (22.1%)	0.646	0.136
Hepatitis C	0 No	168 (88.4%)	83 (87.4%)		
	1 Yes	22 (11.6%)	12 (12.6%)	1.104	0.796
Poly-substance Abuse	0 None	148 (82.2%)	74 (82.2%)		
	1 History	22 (12.2%)	11 (12.2%)	1.000	1.000
	2 Current	10 (5.6%)	5 (5.6%)	1.000	1.000
Alcohol Use	0 None	131 (72.4%)	64 (72.7%)		
	1 History	28 (15.5%)	11 (12.5%)	0.804	0.573
	2 Current	22 (12.2%)	13 (14.8%)	1.210	0.618
Paraplegia	0 No	115 (64.6%)	45 (48.9%)		
	1 Yes	63 (35.4%)	47 (51.1%)	1.907	0.013

Quadriplegia	0 No	91 (50.0%)	55 (59.8%)		
	1 Yes	91 (50.0%)	37 (40.2%)	0.673	0.126
Amputee	0 No	179 (94.2%)	78 (82.1%)		
	1 Yes	11 (5.8%)	17 (17.9%)	3.547	0.002
Device Used	0 None	86 (45.3%)	8 (8.4%)		
	1 Foley Only	74 (38.9%)	23 (24.2%)	3.341	< 0.001
	2 PICC Only	3 (1.6%)	11 (11.6%)	39.417	< 0.001
	3 Both Foley and PICC	27 (14.2%)	53 (55.8%)	21.102	< 0.001
MRSA Colonization on Admit	0 Negative	125 (69.8%)	39 (43.3%)		
	1 Positive	54 (30.2%)	51 (56.7%)	3.027	< 0.001
MRSA Colonization at Discharge	0 Negative	121 (68.0%)	36 (40.4%)		
	1 Positive	57 (32.0%)	53 (59.6%)	3.125	< 0.001
Length of Stay	0 </= 30 Days	132 (69.5%)	11 (11.7%)		
	1 > 30 Days	58 (30.5%)	83 (88.3%)	17.172	< 0.001
Hand Hygiene	0 >/= 0.90	90 (47.6%)	31 (32.6%)		
	1 </= 0.89	99 (52.4%)	64 (67.6%)	1.88	0.017

[1]Note: The reference category for each variable is the first-listed category for that variable.

Research Question #3

What evidence from this study will validate previous studies on HA-MRSA risk factors?

Assessment of risk factors for HA-MRSA for spinal cord injury patients in this study found that colonization, device use, paralysis, ASIA score, amputation, decubitus ulcer, length of hospital stay and hand hygiene compliance were each associated with acquiring a HA-MRSA infection. These risk factors are similar to those described in previous studies in other hospital populations besides those in a spinal cord injury unit.

In addition to confirming the risk factors, this study also confirms that current efforts targeting the reduction of MRSA in the SCIU at the VAMC are necessary due to the associated risk factors; in particular, colonization, the number of patients admitted with decubitus ulcers and device use. The study also affirms current assumptions about this population having special medical needs and being at high risk for MRSA disease.

Lastly, the analysis of the data also confirms the long standing assertion that hand hygiene is correlated with infection and transmission of MRSA.

Research Question #4

What new information on MRSA will emerge from this study?

The current study was able to provide a descriptive analysis to this hospital for patients within a dedicated spinal cord injury unit, address specific risk factors associated with HA-MRSA and the burden of infection. This has not been done before at this hospital for this particular population and providing baseline characteristics to the hospital is important when making decisions on designing and implementing an effective infection control program. The information from this research can be used as an educational tool for patients and family and can provide teaching points regarding contact precautions, colonization, and the importance for hand

washing compliance. This study affirms that current efforts targeting the reduction of MRSA in the SCIU at the VAMC, such as the MRSA bundle, are readily needed due to the associated risk factors and characteristics of the population admitted to the spinal cord injury unit.

Due to limited information on this patient population, understanding risk factors and the burden of MRSA in the past were generalized from data on patients in the acute care setting or the ICU. Quality improvement processes should not always be a "one size fits all" approach and patient populations, the organisms and site of infection are often unique to the hospital and its environment and community. The current study found 80% of the case subjects were admitted with decubitus ulcers, and this was the most common source of HA-MRSA infection. Some studies have shown catheter associated urinary tract infections as the primary source of infection in spinal cord injury patients due to the increased use of Foley catheters; however, catheter associated infections were next to last as a source of infection in the current study.

The current study found that risk factors associated with HA-MRSA are similar to patients in hospital populations that have been previously studied; however, univariate statistics from the study provided a rich description of the population which will give infection control a better understanding of their patient population being admitted. This information will aid in strengthening the design of the infection control program currently in place or allow for the tailoring of a needed intervention to the specific needs of the patients in the spinal cord injury unit.

Additionally, the study also provided the basis for future analysis and to further contribute to the knowledge base by identifying the need to study interactions/effect modifiers within the potential risk factors previously described (e.g., age, race or device use).

CHAPTER 5

SUMMARY, DISCUSSION, AND CONCLUSION

Summary

The purpose of this case-control study was to gain a better understanding of the burden of HA-MRSA and to assess risk factors associated with the acquisition and transmission of HA-MRSA in a dedicated spinal cord injury unit (SCIU) at a Veterans Affairs Medical Center. The case-control study was also conducted to see if new information would emerge on HA-MRSA infections and validate current research.

Research Question #1: What is the burden of HA-MRSA in patients with a spinal cord injury?

Patients with spinal cord injuries or disorders due to trauma, spinal stenosis, vertebral osteomyelitis, and other causes often have a neurogenic bowel and bladder, decubitus ulcers, frequent hospitalizations, as well as having experienced numerous surgeries. Decubitus ulcers (pressure ulcers) often do not resolve readily and may become chronic wounds requiring frequent dressing changes. Also, patients with a neurogenic bowel and bladder often require digital stimulation of the bowel and urinary catheterization (Evans et al., 2012). Each of these practices requires frequent contact with contaminated body fluids by HCWs and may lead to the development of a HAI.

During fiscal years 2008-2011, 95 cases of MRSA were identified by the Infection Control and Epidemiology department at the VAMC with the average age of the cohort on admission being 59.81 years, and with a greater proportion of males vs. females. The cohort was predominately white (52.3% cases vs. 59.1% controls).

Case infections were identified through the application of the CDC/NHSN surveillance definitions by specific definition. Infections were divided into the following categories: (1)

blood; (2) skin and soft tissue (SST) (cellulitis, soft tissue/wound infection); (3) skin and soft tissue (decubitus ulcer); (4) catheter associated urinary tract infection, and; (5) other causes of infection.

Case-control analysis of the data showed that having a decubitus ulcer upon admission increased the univariate odds of HA-MRSA 7.1 fold ($p < 0.001$). Patients with decubitus ulcers upon admission comprised 80% of the case subjects and of the 95 cases identified with HA-MRSA, 31.6% subsequently acquired an infection from a decubitus ulcer site. Decubitus ulcers were located in areas such as the sacral, ischial, trochanter, femur, and hip areas. Skin and soft tissue infections were the second most prevalent infection comprising 23.2% of the case subjects. Skin and soft tissue infections, causing cellulitis, were cultured from areas such as the shoulder, inguinal region, abdomen, ankle, leg, and arm. Of the 95 MRSA cases identified, 24.2% had indwelling Foley catheters increasing the likelihood of a HA-MRSA infection by 3.341 fold; and subsequently, almost 15% of those patients developed a catheter associated urinary tract infection with MRSA. Other sources such as bone-joint infection, deep tissue, lower respiratory and ventilator associated infections, and epidural abscess accounted for 22.1% of the HA-MRSA infections. These types of infections were collapsed into one category due to sparse numbers of each of these in the cases. And, lastly, blood stream infections accounted for 8.4% of the HA-MRSA infections and were defined as either a lab confirmed blood stream infection or associated with a central line. In this study, a patient with a central line or PICC had a 39.42-fold increase for a HA-MRSA infection.

Research Question #2: Is there an association with HA-MRSA and age, race, weight, ASIA score, decubitus ulcer, diabetes mellitus, anxiety/depression, hepatitis C, polysubstance abuse,

alcohol use, paraplegia, quadriplegia, amputee, device use, MRSA colonization, length of stay, and hand hygiene compliance?

The average age of the cohort on admission was 59.81 years with no significant difference occurring between cases and controls. The cohort was predominately white (52.3% cases vs. 59.1% controls), had a mean length of stay of 83.2 days and a mean hand-hygiene compliance of 65% for HCWs. The majority of the case subjects had an admitting diagnosis of decubitus ulcer (51.6%) with the majority of controls having an admitting diagnosis of annual evaluation (49.5%). Decubitus ulcer was the most common infection identified in the case subjects comprising 51.6% of the group, other skin and soft tissue infections (not including decubitus ulcers) accounted for 23.2% of the infections, Foley catheter followed with 14.7%, blood stream infections 8.4%, and other causes of infection were 22.1%.

Case-control analysis of the data showed that having a decubitus ulcer upon admission increased the univariate odds of HA-MRSA 7.1 fold ($p < 0.001$). Patients with decubitus ulcers comprised 80% of the case subjects, and 36% of the control subjects. A hospital length-of-stay greater than 30 days increased the univariate odds of HA-MRSA 17.1 fold ($p < 0.001$). Cases showed a greater percentage at 88.3% vs. 30.5% in control subjects. The unadjusted odds ratio showed that the use of a Foley catheter increased the univariate odds of HA-MRSA 3.3 fold ($p < 0.001$), use of a PICC line increased the odds 39.4 fold, ($p < 0.001$) and use of both a Foley catheter and PICC line increased the odds 21.1 fold ($p < 0.001$). Case subjects showed a Foley catheter use of 24.2% vs. 38.9% in control subjects, PICC line use was 11.6% in cases vs. 1.6% in controls, and use of a Foley catheter and PICC line together comprised 55.8% of case subjects and 14.2% of control subjects.

An ASIA score of A (complete impairment) increased the univariate odds of HA-MRSA 4.4 fold and having an ASIA score of B or C (incomplete impairment) increased the univariate odds approximately 2.9 fold. An ASIA score of A accounted for 61.6% of case subjects and an ASIA score of B or C accounted for approximately 6.6% and 18.0% respectively.

Other factors associated with a significantly increased univariate odds ($p < 0.05$) for HA-MRSA were colonization on admission (OR: 3.0) and discharge (OR: 3.1), having an amputation (OR: 3.5), being paraplegic (OR: 1.9), and having a HCW with a hand-hygiene compliance of </= 0.89 (OR: 1.88).

Comorbidities can play a central role in the acquisition of a hospital acquired infection resulting in longer hospital stays, increased cost to the patient and often debilitating effects, if not death. Older adults are at higher risk because of the presence of multiple comorbid conditions, functional impairment and a reduced immune response. Several comorbidities included in the study but showing no significance for increased odds of HA-MRSA included anxiety/depression, having diabetes mellitus, hepatitis C, and poly-substance abuse.

A number of studies have shown a strong association with age and infection; however, in the current study age was not significantly associated with infection. Kuehnert et al. (2005), using discharge data, reported MRSA rates for septicemia, pneumonia, and other infections increased with patient's age with most diagnoses occurring in persons > 65 years of age. The study also reported that the overall MRSA rate increased with patient age. Klevens et al. (2008) also found an increase in MRSA infections among older adults aged > 65 years and in hospitals with < 200 beds. Another study, by Payman & Delorme, (2008) in a medical center reported a significant increase in the incidence of MRSA among young patients 6-25 years of age, as well as patients 45-50, and the elderly, 86-90. In the current study, 48% of HA-MRSA infections occurring in the

case subjects were diagnosed in patients > 61 years of age and unlike the previous studies, slightly over half (52%) of HA-MRSA infections in the case subjects were diagnosed at </= 61 years of age. The difference in age associated infections from the general hospital population when compared to the current population under study may be related to the multiple comorbities associated within the spinal cord injury population.

Discussion of Major Findings

The theory informing this research, The Theory of Planned Behavior, was previously described and provided the reader with an understanding of the behavior associated with the HCW's intent and their adherence, or not, to hand hygiene recommendations and compliance. Proper hand hygiene compliance has been cited in the literature as one of the most important functions a HCW can perform to prevent the spread of infection. Due to the nature of the injury in spinal cord patients most have had frequent hospitalizations and surgeries, many are colonized with MRSA and have multiple decubitus ulcers, and often require use of multiple devices; each predisposing the patient to infection. Each of these factors lead to frequent contact by HCWs and unless adherence to hand hygiene compliance is maintained, infection may occur.

The purpose of this case-control study was to assess risk factors contributing to HA-MRSA and gain a better understanding of the burden of HA-MRSA in patients with spinal cord injuries. The case-control study was also conducted to see if new information would be found on HA-MRSA infections and validate or refute current research on the topic for patients in a dedicated spinal cord injury unit at a Veterans Affairs Medical Center.

This case-control study was also undertaken to better understand the risk factors associated with MRSA in this population and setting due to limited information and to support needed recommendations and efforts currently being used to reduce infections at the VAMC. Such

efforts include: 1) PCR testing for patients admitted and transferred to the spinal cord injury unit, 2) contact isolation for patients colonized with MRSA and with an ongoing MRSA infection, 3) increased hand washing awareness through education for HCWs and family members, and; 4) use of gown and gloves for all having direct contact with patients colonized and infected with MRSA. This study provides evidence to aid in the design of an effective infection control program tailored to the specific needs of patients in the spinal cord injury unit. After analyzing a number of variables that are well documented in the literature as risk factors in this patient population, this study found device use, colonization with MRSA on admission, hospital length-of-stay over 30 days, hand hygiene compliance, amputation, decubitus ulcer, ASIA score and paraplegia as being significantly associated as risk factors for HA-MRSA.

Invasive devices pose the greatest threat to patients for serious infections. A case-control study by Kaye, et al. (2011) found indwelling central venous catheters to be a primary cause for HA-MRSA bloodstream infections. In the current study, of the 95 case subjects with MRSA, 11.6% had a PICC inserted upon admission increasing the odds of HA-MRSA 39.4-fold. In contrast, the study by Kaye, et al. (2011) found the presence of a central line on admission almost doubled the risk factor for a blood stream infection. Both studies indicate a patient is at high risk for infection; however, spinal cord injury patients may be at a greater risk because of being colonized with MRSA, the presence of multiple comorbidities and frequent contact by HCWs.

The same study by Kaye, et al. (2011) and another study by Girard, Mazoyer, Plauchu, and Rode (2006) found indwelling Foley catheter use an independent predictor for infection. The current study found indwelling Foley catheter use increased the odds of HA-MRSA 3.3-fold. The current research also found if both a Foley catheter and PICC line were both being used

simultaneously, the odds increased 21.1-fold. Simultaneous use of these devices accounted for 55.8% of the MRSA case subjects vs. 14.2% of the control subjects. Due to the nature of the injury sustained by this population of patients, many require use of an indwelling Foley catheter as well as the use of the PICC line simultaneously for long term antibiotic therapy due to infection or other therapeutic treatment. Although, 24.2% of cases had an indwelling Foley catheter, and 55.8% had both a indwelling Foley and PICC line, catheter associated urinary HA-MRSA were not the primary or secondary source of HA-MRSA infections.

Patients who remain in hospitals for extended lengths of time may be exposed to longer antimicrobial use, invasive procedures, and greater contact with healthcare workers. Past studies have suggested that each of these healthcare characteristics may increase a patient's chance to acquire MRSA (Santos, et al., 2010; WHO, 2009). Eseonu, Middleton, & Eseonu (2011) conducted a study in an orthopedic trauma center and found hospital length-of-stay greater than 30 days to be significantly associated with a HAI. Similarly, a hospital length-of-stay greater than 30 days in the current study also demonstrated a significant association with a 17.2-fold increase in the odds for acquiring HA-MRSA. In the current study, a large proportion of the case subjects, 88.3%, remained in the hospital greater than 30 days when compared to 30.5% of the control subjects. A prospective study by Kappel and colleagues (2008) in patients with spinal cord injuries found a mean duration of stay of 147 days for patients with MRSA infection compared to 63 days for MRSA negative patients. The study associated the longer hospitalization time due to an interruption in treatment and rehabilitation because of isolation due to the infection and also the high percentage of patients admitted with decubitus ulcers. The study also found that MRSA positive patients had a greater frequency of ulcers on admission when compared to MRSA negative patients. The same was true in the current study.

The high-risk nature of the spinal cord injury patient, how sick the patient was upon admission, when the infection occurred during the patients stay, decubitus ulcers on admission, surgery, and the number of comorbidities present are considered possible reasons for the differences in the length-of-stay. Estimating a true value for hospital length of stay created a statistical challenge in this study in that MRSA infection may have increased the length of stay and simultaneously may have increased the chance of infection (Barnett et al., 2009). Due to the sparse sample size in the study, confounders and effect-modifiers that may have been associated with increasing hospital length of stay were not considered in the current analysis and will provide the basis for a future study.

Colonization and infection rates vary by setting; such as the type of health-care facility and the population being studied (Davis, Stewart, Crouch, Florez, & Hospenthal, 2004). Recently published studies have arrived at varying conclusions regarding colonization with MRSA and the association with subsequent MRSA infections. Safder & Bradley (2008) found in their study that MRSA nasal colonization increased the risk for subsequent infections four times among carriers, particularly for patients in the ICU. Results from the current study found similar results in that colonization with MRSA on admission would likely increase the risk for infection three fold among carriers. Univariate statistics showed that over 56.7% of the case subjects were colonized with MRSA on admission while only 30.2% of control subjects were colonized. By contrast, Sarikonda, et al. (2010) and Klevens, et al. (2009) did not find colonization to be a strong predictor for subsequent occurrence of infection. The increased colonization for case subjects may be due to increased exposure to the hospital environment from frequent hospitalizations and increased contact with HCWs.

Indeed, hand hygiene is the single most effective and inexpensive way to reduce or eliminate infections from occurring; yet, in most hospitals, the compliance rate among HCWs rarely exceeds 50% (Gilbert, Stafford, Crosby, Fleming, & Gaynes, 2010). A study was conducted among ICUs in hospitals that were members of the National Nosocomial Infection Surveillance System. The study was initiated following the publication of the CDC Hand Hygiene Guide. Forty hospitals were recruited and following the study period hand hygiene rates for HCWs were low, resulting in a mean compliance of 56.6%. (Larson, Quiros, & Lin, 2007).

Another study, conducted by Gilbert and colleagues (2010) at a VAMC in Atlanta, GA found similar results for hand hygiene compliance among HCWs as the previous study. The study was conducted in the medical and surgical intensive care units using a trained observer to collect hand hygiene compliance by the type of room (contact precaution vs. noncontact precautions). The overall hand hygiene compliance for the surgical intensive care unit was 50.7% in contact precaution rooms vs. 51.7% compliance in the noncontact precaution rooms. The medical intensive care unit had similar hand hygiene compliance rates, 45.1% in contact precaution rooms vs. 50.8% in noncontact precaution rooms. One third of patients hospitalized at the Atlanta VA were on contact precautions, and approximately half of the patients on contact precautions were placed under these precautions because of the implementation of the MRSA bundle.

To match the VA's criteria, the cut point used for hand hygiene compliance was either </=.89 or >/=.90.The current analysis showed that having a hand hygiene compliance of </= 0.89 among HCWs increased the odds for infection 1.88-fold. Hand hygiene compliance for HCWs caring for case and control subjects varied whereas 67.6% of HCWs caring for MRSA case subjects demonstrated </= 89% compliance and 52.4% compliance for control subjects. Compliance also

varied for HCWs in the >/= 90% compliance group, whereas HCWs caring for MRSA case subjects showed 32.6% compliance and 47.6% compliance in the control subjects.

Collection of hand hygiene data for HCWs in the Spinal Cord Injury Unit was observational and used both trained staff and independent monitors. The data were reported quarterly to the Infection Control Department as part of routine surveillance. A minimum of ten opportunities to wash hands or use alcohol-based hand rub was observed by each department/unit and reported as a percentage for the quarter.

Providing the unit with a staff monitor may correlate with an increased exposure of the unit to hand hygiene education since it involves educating both the staff monitor performing the hand hygiene observations and the manager on the unit who interprets the results. The act of performing the hand hygiene observation may also create a Hawthorne effect, that is, artificially improving hand hygiene temporarily.

Hand hygiene compliance is unlikely to be homogeneous across all shifts on all days of the week, and the staff performing the observation may not be sensitive enough to indicate small aberrations. However, for units where the staff monitor is consistently present and used, it may best correlate with the overall culture of safety, receipt of education and interest in performance improvement. Additionally, more accurate data about hand hygiene compliance may be provided using the staff monitor because of reasons mentioned previously.

The other mechanism to track compliance is the independent monitor. This monitor often provides more objective data with a higher volume of observations per period; however, this method may also be subject to the Hawthorne effect.

Due to the Hawthorne effect, when HCWs know other people are observing them they become more conscious and vigilant with hand washing procedures and compliance. This may

have inflated the hand washing compliance and data reported to the Infection Control Department in the quarterly report during the period of study.

Decubitus ulcer was significantly associated as a risk factor for HA-MRSA with a 7.18-fold increased likelihood for infection. This was the most common infection site identified for this population of patients with 80% of the case patients admitted to the spinal cord injury unit with a decubitus ulcer. Yates, et al. (2009) conducted a prospective study in patients with diabetes-related foot infections and found that wound chronicity independently predisposed patients to MRSA infections. A prevalence study was conducted in patients with and without spinal cord injury to investigate the risk of hospital acquired infection by Girard, Mazoyer, Plauchu, & Rode (2006). The prevalence of infection was higher in the spinal cord injury group than in those without injury, 23.4% and 4.8% respectively. And, unlike the population of patients in the current study, most infections were classified as urinary tract infection. Although the prevalence of infection was higher in the spinal cord injury group, differences may occur in the prevalence based on type and site of infection emphasizing the importance for understanding a patient population in individual hospital settings.

Through the identification of risk factors for MRSA, strategies may be put in place to prevent the spread of resistant organisms with an emphasis on early detection of at-risk patients and use of aggressive hand hygiene compliance and isolation.

Several other patient characteristics found to predispose a patient to HA-MRSA in this study included having an amputation (OR: 3.54), having an ASIA score A (OR: 4.48) (complete impairment) and paraplegia (OR: 1.9). These characteristics are related to a decrease in a patient's ability to walk, bathe, eat, and perform normal bathroom functions. These limitations with daily functional activities require frequent patient contact by HCWs and may predispose

patients to MRSA infection and colonization. A nested case-control study by Chen et al. (2011) with elderly patients found that poor functional status and requiring assistance with three or more activities an independent risk factor for MRSA surgical site infections (OR:2.73). Another study, conducted by Kaye et al. (2011) found an association between urinary incontinence, an important aspect of functional status in patients with spinal cord injury, and MRSA blood stream infection. This increased risk of infection may have been related to a patient's severity of illness, a greater frequency of contact by HCWs, a greater likelihood of having an indwelling catheter, and possibly related to poorer hygiene than patients without urinary incontinence. These patient characteristics are associated with immobility and poor functional status often requiring increased contact by HCWs and family members.

Study Strengths

One of the major strengths of this study is that it is the first attempt to describe the population admitted to a dedicated spinal cord injury unit at this VAMC providing new information to the hospital infection control department. Also, because of a lack of current information in general on this population regarding the burden of MRSA and the associated risk factors for the disease, the analysis provided current information for use at this hospital and the data may be of value to other VAMCs for benchmarking within spinal cord units. This analysis will be helpful to the Infection Control Department in tailoring their interventions, strengthening existing measures, and to justify a need for increased funding to promote preventive efforts to reduce HAIs, such as the MRSA bundle. Education can also be tailored for patients, medical personnel, and family based on information obtained from this study such as characteristics of the population and risk factors specifically associated with this population for HA-MRSA**.**

The study also identified a need to further explore interactions and effect modifiers within the potential risk factors such as ASIA score and decubitus ulcer and PICC line and Foley catheter.

Study Limitations

There were several limitations identified in this study primarily associated with having a sparse sample size and missing data. Data were not available for MRSA cases for fiscal year 2008 and were not included in the study. The number of cases present in that year may have improved the statistical power of the analysis. Data were missing for multiple quarters on hand hygiene compliance which are observational and self-reported and may have contributed to study bias.

Additionally, the VAMC is largely comprised of male patients. No females were included in the study due to having only one female case identified over the period under study. Due to the use of this VAMC population, it is not fully representative of the overall U.S. population given that it is mostly male, over 50 years of age and at high risk for infection.

Another major limitation of the study was a sparse data set found in case subjects. This resulted in the removal of "other" races from the study. Additionally, the sparse data set did not allow for further analysis to be conducted for interactions/effect modifiers within the potential risk factors. Therefore, the odds ratio for using a PICC line and a Foley catheter simultaneously showed reduced odds for acquiring HA-MRSA when compared to using a PICC line or Foley catheter alone.

Suggestions for Future Research

Additional research using a larger sample size for analysis of interactions and effect modifiers within the potential risk factors may prove to show beneficial data. Also, the current study explored healthcare associated risk factors for HA-MRSA; however, less is known about

socioeconomic factors, as well as how living in a rural vs. an urban area may contribute to MRSA infection and colonization. Also, comparing patients in the acute care setting to the spinal cord injury population may provide interesting results.

Each of these ideas are important areas for further study in this population of patients and for public health.

Implications for Public Health and the VAMC

Considered an emerging issue and a threat to public health, *Healthy People 2020* created a new goal, "...Prevent, reduce, and ultimately eliminate healthcare-associated infections (HAIs) (US Department of Health and Human Services, 2010). Reflecting the commitment to reducing healthcare-associated infections, two supporting objectives were created by *Healthy People 2020*: (HAI-1) reduce healthcare-associated infections by reducing central line associated bloodstream infections; and (HAI-2) to reduce invasive healthcare-associated methicillin-resistant *Staphylococcus aureus* infections by 75% nationwide (US Department of Health and Human Services, 2010). The basis of this study was to gain a better understanding of risk factors associated with HA-MRSA infection and address the burden of MRSA. The case-control study was also conducted to see if new information would be found or refute current literature on HA-MRSA. This information would be used to aid in the reduction and eventually the elimination of HA-MRSA within the VAMC.

The results of this research can be used to better inform physicians, healthcare workers, patients, and infection control practitioners about HA-MRSA infection and transmission. Providing a descriptive analysis to this hospital for patients with a spinal cord injury, associated risk factors for HA-MRSA and the burden of infection is important when designing and implementing an effective infection control program.

The VAMC had appreciated the preponderance of MRSA infections in decubitus ulcers, and had implemented a screening program on admission to identify wounds already infected or colonized with MRSA on admission in 2012. From the current research, the VAMC had not appreciated the quantity of HA-MRSA for skin and soft tissue (SSTIs) infections. The VAMC will take a closer look at what these SSTIs are and identify if there are ways to intervene. For example, if they are surgical site infections, perhaps bolstering the pre-operative regimen to be more efficient against MRSA will help to decrease these types of infections. If the infections are associated with central line sites, perhaps line placement and maintenance will be reviewed. Also, if the skin and soft tissue infections are related to boils or furuncles and in those attending the physical therapy gym, the equipment may need more thorough cleaning.

Device use and length of stay have often been associated with increased infection rates; however, it is interesting that the ASIA score was also associated with an increased risk for HA-MRSA. Perhaps the cohorting methodology, which already gives preference to neutropenic or immunocompromised patients for private rooms should consider the ASIA score as well to reduce the exposure of these patients to other patients with MRSA.

Also, due to the number of HA-MRSA infections in this population, the VAMC will look to focus interventions back on patients with decubiti and not as much on those with Foley catheters, although important. A multivariate analysis would also be informative for a future study by exploring potential confounders within the potential risk factors.

The evidence based information from this research can also be used as an educational tool for patients and family and can provide teaching points regarding contact precautions, colonization, and the importance for hand washing compliance. The VAMC certainly recognizes the need to change the culture to increase the self-efficacy of the patients and the staff to believe they can

achieve hand hygiene compliance. And although awkward, the VAMC encourage their patients to remind staff to wash their hands and will continue to do so. In the future, and as nursing competencies become more integrated into their evaluation system, it is hopeful that hand hygiene becomes a competency that their managers evaluate them on. There is currently no administrative oversight for hand hygiene compliance and if the individual nurse managers address it, it is of their own volition. Once consistent hand hygiene becomes the subjective norm and there is peer pressure, managerial pressure, and patient advocacy pressure to be consistent in the discipline of hand hygiene, then the hand hygiene results should improve. The current method for achieving cultural change is through education. This research will allow the VAMC to educate staff and patients using their own data, rather than national studies to drive the importance of their hand hygiene compliance.

The results found in this study also support the importance of the prevention strategies currently being used at the VAMC in this population and already proven effective in acute care or long term care. It supports the need for adhering to guidelines for each of the components of the MRSA bundle because of such risk factors as colonization and decubitus ulcers, both associated with HA-MRSA in this at-risk population.

Adhering to guidelines can be expensive and time consuming for healthcare workers. Information from this study may also provide needed justification for allocation of resources and funding to continue, strengthen, or add prevention strategies and improve quality processes as mentioned previously.

Following these guidelines and tailoring prevention strategies based on data relative to the spinal cord injury population allow this hospital to reflect their commitment towards the reduction of HA-MRSA infections and can lead to a reduction in hospital and patient costs, a

reduction in readmission rates, morbidity and mortality. Each is an important aspect in public health.

Conclusion

The purpose of this case-control study was to assess risk factors contributing to HA-MRSA and gain a better understanding of the burden of HA-MRSA in patients with spinal cord injuries. The case-control study was also conducted to see if new information would be found on HA-MRSA infections and validate or refute current research on the topic for patients in a dedicated spinal cord injury unit at a Veterans Affairs Medical Center.

In 2007 the VAMC implemented a MRSA bundle consisting of universal nasal swabbing for colonization of MRSA, contact precautions for all colonized patients with MRSA, increased hand hygiene washing to include education and monitors, and a change in institutional culture in that infection control became the responsibility of everyone who had contact with patients. The success for reduction in HA-MRSA infections and transmission relies heavily on HCWs following proper hand washing guidelines recommended by the CDC with each of the components of the prevention "bundle" working synergistically. Evidence suggests that interventions that are theory driven are more effective than those without a theoretical background (Glanz & Bishop, 2010). The theory informing this research, the TRA/TPB, helped explain the behavior and relationship between the HCWs intent and their adherence to hand hygiene recommendations, in particular, the HCWs perceived control. To achieve greater hand washing compliance the VAMC hopes to change the culture in the hospital and promote self-efficacy for staff. This will be achieved through education and use of the data from this research to drive home the importance of their hand hygiene compliance.

Infection control strategies should be tailored to a specific population as infection prevention and quality improvement processes should not be a "one size fits all" approach. The current study was able to provide a descriptive analysis to this hospital for patients within a dedicated spinal cord injury unit, address specific risk factors associated with HA-MRSA, and address the burden of HA-MRSA. This study confirms that current efforts targeting the reduction of MRSA in the SCIU at the VAMC are justified in their use because of such risk factors as colonization and the number of patients with decubitus ulcers on admissions. The study also affirms current assumptions about this population being at risk for MRSA disease. And, although not generalizable in most hospital settings, this study may be of value to other VA hospitals with spinal cord injury units and rehabilitation settings.

Improving the quality of patient care through surveillance and prevention activities is a valuable asset provided by infection control programs. Therefore, understanding the patient population in the hospital setting is valuable in providing information which can help strengthen the overall program. The current research will help the VAMC justify aggressive infection control strategies, such as hand washing, cohorting of patients based on their ASIA score, and adjusting the focus of interventions on patients with decubiti and not as much on those with Foley catheters.

Over the last ten years a greater emphasis has been placed on reducing such adverse events as HAIs caused by MRSA. Proposed guidelines, such as the MRSA bundle can aid infection control programs in reducing infection and transmission by MRSA, deaths, and the cost related to each of these. The current research will allow the VAMC to educate staff using their own data, not national studies to drive home the importance of their hand hygiene. The data from this study

will also provide information to help refocus interventions in other areas. Future research efforts may focus studying other modifiable risk factors that predict HA-MRSA infection.

REFERENCES:

Adcock, P.M., Pastor, P., & Medley, F., et al (1998). Methicillin-resistant *Staphylococcus aureus* in two child-care centers. *Journal of Infectious Disease, 38,* 273-281.

Affif, W., Huor, P., & Loo, V.G. (2002). Compliance with methicillin-resistant *Staphylococcus aureus* precautions in a teaching hospital. *American Journal of Infection Control, 30,* 7, 430-433.

Agency for Healthcare Research & Quality (2009). AHRQ projects to prevent healthcare-associated infections, fiscal year 2011. Retrieved from http://www.ahrq.gov/qual/haify11.pdf.

American Health and Drug Benefits, (2009). Methicillin-resistant *Staphylococcus aureus*: Economic and clinical impact. *American Health & Drug Benefits, 2(suppl),* S74-S78.

Association of Professionals in Infection Control and Epidemiology (APIC). (2009). Guide to the elimination of methicillin-resistant *Staphylococcus aureus* (MRSA) in hospital settings. Retrieved from http://www.apic.org/Resource_/EliminationGuideForm/08b12595-9f92-4a64-ad41-4afdd0088224/File/APIC-MRSA-in-Long-Term-Care.pdf.

Barber, M., (1961). Methicillin-resistant staphylococci. *Journal of Clinical Pathology, 14*, 385.

Barnett, A.G., Rahul, B., Graves, N., Edgeworth, J., Robotham, J. & Cooper, B. (2009). Using a longitudinal model to estimate the effect of methicillin-resistant *Staphylococcus aureus* infection on length of stay in an intensive care unit. *American Journal of Epidemiology, 170*, 9,1186-1194.

Barrett, F.F., McGhee, R.F., & Finland, M. (1968). Methicillin-resistant Staphylococcus aureus at Boston city hospital. *New England Journal of Medicine, 279,* 448.

Beam, J.W., & Buckley, B. (2006). Community-acquired methicillin-resistant *Staphylococcus aureus:* Prevalence and risk factors. *Journal of Athletic Training, 41,* 3, 337-340.

Berwick, D., Calkins, D., McCannon, C. & Hackbarth, A. (2006). The 100,000 lives campaign. *Journal of the American Medical Association, 295,* 324-327.

Boyce, J.M. (2001). MRSA patients: Proven methods to treat colonization and infection. *Journal of Hospital Infection, 48,* (Suppl. A), S9-S14.

Centers for Disease Control and Prevention (CDC). (1999). Four pediatric deaths from community acquired methicillin-resistant *Staphylococcus aureus* – Minnesota and North Dakota, 1997-1999, *Morbidity and Mortality Weekly Report, 48,* 707-712.

Centers for Disease Control and Prevention (CDC). (2006). Management of multidrug-resistant organism in healthcare settings.

Centers for Disease Control and Prevention (CDC). (2007). Estimates of healthcare associated infections. Retrieved from http://www.cdc.gov/ncidod/dhqp/hai.html.

Centers for Medicare & Medicaid Services (2009). American Recovery and Reinvestment Act of 2009, Pub. L. No 111-5, 42 U.S.C. 241(a).

Centers for Disease Control and Prevention (CDC), (2011). MRSA statistics. Retrieved from http://www.cdc.gov/mrsa/statistics/index.html.

Chambers, H.F., (2001). The changing epidemiology of *Staphylococcus aureus. Emerging Infectious Diseases, 7*, 2, 178-182.

Cosgrove, S.E., Qui Y., Kaye, K.S., et al. (2005). The impact of methicillin resistance in *Staphylococcus aureus* bacteremia on patient outcomes: mortality, length of stay, and hospital charges. *Infection Control and Hospital Epidemiology, 26,* 166-174.

Croft, C.A., Meijia, V.A., Barker, D.E., Maxwell, R.A., & Dart, B.W., et al. (2009).

Methicillin-resistant *Staphylococcus aureus* in a trauma population: Does colonization predict infection? Presented at the Annual Scientific Meeting and Postgraduate Course Program, Southeastern Surgical Congress, Atlanta, GA, February 7-10, 2009.

Datta, R. & Huang, S.S. (2008). Risk of infection and death due to methicillin-resistant *Staphylococcus aureus* in long-term carriers. *Clinical Infectious Diseases, 47,* 176-181.

Davis, K.A., Stewart, J.J., Crouch, H.K., Florez, C.E., & Hospenthal, D.R. (2004). Methicillin-resistant *Staphylococcus aureus* (MRSA) nares colonization at hospital admission and its effect on subsequent MRSA infection. *Clinical Infectious Diseases, 39*, 15, 776-782.

Davis, K.A., Stewart, J.J., Crouch, H.K., Florez, C.E., & Hospenthal, D.R., (2008). Methicillin-resistant *Staphylococcus aureus* (MRSA) nares colonization at admission and its effect on subsequent MRSA infection. *Clinical Infectious Diseases, 39*, 6, 776-782.

Deresinksi, S. (2005). Methicillin-resistant *Staphylococcus aureus*: An evolutionary, epidemiologic, and therapeutic odyssey. *Clinical Infectious Diseases, 40,* 562-573.

Dikema, D.J. & Climo, M. (2008). Preventing MRSA infections: Finding it is not enough. *Journal of the American Medical Association, 299,* 1190-1191.

Evans, C. Hershow, R., Chin, A. Foulis, P., Burns, S. & Weaver, F. (2009). Bloodstream infections and setting of onset in persons with spinal cord injury and disorder. *Spinal Cord, 47*, 610-615.

Eseonu, K.C., Middleton, S.D., & Eseonu, C.C. (2011). A retrospective study of risk factors for poor outcomes in methicillin-resistant *Staphylococcus aureus* (MRSA) infection in surgical patients. *Journal of Orthopaedic Surgery and Research, 6*, 25, 1-6.

Evans, M., Kralovic, S., Simbartl, L., Obrosky, D., Hammond, M., & Evans, C., et al. (2012).

Prevention of methicillin-resistant *Staphylococcus aureus* in spinal cord injury units. American Journal of Infection Control, 6,

Fairclough, S.J., (2006). Why tackling MRSA needs a comprehensive approach? *British Journal of Nursing, 15,* 2, 72-75.

Fishbein, M. (ed.) (1967). Reading in Attitude Theory and Measurement. New York: Wiley.

Fortaleza, C.R., Melo, E.C., & Fortaleza, CMCB. (2009). Nasopharyngeal colonization with methicillin-resistant *Staphylococcus aureus* mortality among patients in an intensive care unit. *Latino-am Enfermagem, 17,* 5, 677-682.

Forster, A.J., Kyeremanteng, K., Hooper, J., Shojania, K.G. & van Walraven, C. (2008). The impact of adverse events in the intensive care unit on hospital mortality and length of stay. *BMC Health Service Research,* 259-266.

Francis, J.S., Doherty, M.C., & Lopatin, U., et al. (2005). Severe community-onset pneumonia in healthy adults caused by methicillin-resistant Staphylococcus aureus carrying the Panton-Valentine leukocidin. *Clinical Infectious Diseases,40*, 100-107.

Garshick, E., Kelley, A., Cohen, S., Garrison, A., Tun, C. & Gagnon, D. et al. (2005). A prospective assessment of mortality in chronic spinal cord injury. *Spinal Cord, 43,* 408-416.

Gilbert, K., Stafford, C., Crosby, K., Fleming, E., & Gaynes, R. (2010). Does hand hygiene compliance among health care workers change when patients are in contact precaution rooms in ICUs? *American Journal of Infection Control, 38*, 515-517.

Girard, R., Mazoyer, M.A., Plauchu, M.M., & Rode, G. (2006) High prevalence of nosocomial infections in rehabilitation units accounted for by urinary tract infections in patients with spinal cord injury. *Journal of Hospital Infection, 62*, 473-479.

Glanz, K., Lewis, F. & Rimer, B. (2002). Health behavior and health education: Theory, research and practice. 3rd edition , San Francisco, CA. Jossey-Bass.

Glanz, K., & Bishop, D.B. (2010). The role of behavioral science theory in development and implementation of public health interventions. *Annual Review of Public Health, 31*, 399-418

Gordon, R., & Lowy, F. (2008). Pathogenesis of methicillin-resistant Staphylococcus aureus infection. *Clinical Infectious Diseases, 1,* 46(Suppl 5): S350-S359.

Gorwitz, R., Kruszon-Moran, D., McAllister, S., McQuillan, G., McDougal, L., & Fosheim, G,. et al. (2008). Changes in the prevalence of nasal colonization with *Staphylococcus aureus* in the United States, 2001-2004. *The Journal of Infectious Diseases, 1,* 197(9), 1226-1234.

Gould, I.M., Reilly, J., Bunyan, D., & Walker, A. (2010). Costs of hospital-acquired methicillin-resistant *Staphylococcus aureus* (MRSA) and its control. *Clinical Microbiology and Infection, 16,* 1721-1728.

Groom, A.V., Wolsey, D.H., Naimi, T.S., Smith, K., & Johnson, S., et al (2001). Community-acquired methicillin-resistant *Staphylococcus aureus* in a rural American Indian community. *Journal of the American Medical Association, 286,* 10, 1201-1205.

Harbarth, S., Frankhauser, C., Schrenzel, J., Christensen, G. J., & Clerc, P. et al. (2008). Universal screening for methicillin-resistant *Staphylococcus aureus* at hospital admission and nosocomial infection in surgical patients. *Journal of the American Medical Association, 299,* 10, 1149-1157.

Hardy, K., Price, C., Szczepura, A., Gossain, S., Davies, R., & Stallard, N., et al. (2010). Reduction in the rate of methicillin-resistant *Staphylococcus aureus* acquisition in surgical wards by rapid screening for colonization: a prospective, cross-over study. *Clinical*

Microbiology and Infection, 16, 4, 333-339.

Herold, B.C., Immergluck, L.C., & Maranan, M.C., et al (1998). Community-acquired methicillin-resistant *Staphylococcus aureus* in children with no identified predisposing risk. *Journal of the American Medical Association, 279*, 593-598.

Huang, S.S. & Platt, R. (2003). Risk of methicillin-resistant *Staphylococcus aureus* infection after previous infection or colonization. *Clinical Infectious Diseases, 36*, 281-285.

Huang, Y., Lien, R., Su, L., Chou, Y., & Lin, T. (2011). Successful control of methicillin-resistant *Staphylococcus aureus* in endemic neonatal intensive care units-A 7-year campaign. *PLos OnE, 6,*8, 1-7.

Hugonnet, S., Sax, H., Eggimann, P., Chevrolet, J.C., & Pittet, D. (2004). Nosocomial bloodstream infection and clinical sepsis. *Emerging Infectious Diseases, 10*, 76-81.

Institute for Healthcare Improvement (2006a). 5 million lives campaign: An initiative of the Institute for Healthcare Improvement. Retrieved from http://www.ihi.org/about/Documents/5MillionLivesCampaignCaseStatement.pdf/.

Institue for Healthcare Improvement (2006b). How to guide: Improving hand hygiene: A guide for improving practices among healthcare workers. Retrieved from http://www.ihi.org/HH/Topics/CriticalCare/IntensiveCare/Tools/HowtoGuideImproving HandHygiene.htm.

Jeyaratnam, D., Whitty, C.J., Phillips,K., Liu, D., Orezzi, C., Ajoku, U., & French, G. (2008). Impact of rapid screening tests on acquisition of methicillin-resistant *Staphylococcus aureus*: cluster randomized crossover trial. *British Medical Journal, 336,* 927-930.

Jevons, M.P. (1961). Celbenin-resistant staphylococci. *British Medical Journal, 1,* 124-125.

Juhasz-Kaszanyitzky, E., Janosi, S., Somogyi, P., Dan, A., van dre Graaf-van Bloois, L. van

Duijkeren, E., et al. (2007). MRSA transmission between cows and humans. *Emerging Infectious Diseases, 13,* 630-632.

Kaplan, S.L., Hulten, K.G., Gonzalez, B.E., Hammerman, W.A., Lamberth, L. Versalovic, J., et al. (2005). Three-year surveillance of community-acquired *Staphylococcus aureus* infections in children. *Clinical Infectious Disease, 40,* 1785-1791.

Kaye, K.S., Marchaim, D., Chen, T.Y., Chopra, T., Anderson, D.J., & Choi, Y., et al. (2011). Predictors of nosocomial bloodstream infections in older adults. *The American Geriatrics Society, 59,* 622,627.

Kappel, C. Widmer, A. Geng, V., Arx, V, Frei, R., & Koch, H-G, et al. (2008). Successful control of methicillin-resistant *Staphylococcus* in a spinal cord injury center: A 1-year prospective study including molecular typing. *International Spinal Cord Injury Society, 46,* 438-444.

Kirby, W.M., (1944). Extraction of a highly potent penicillin inactivator from penicillin resistant *Staphylococci*. *American Association for the Advancement of Science, 99*(2579), 452-453.

Klevens, M.R., Morrison, M.A., Fridkin, S.K., Reingold, A., Petit, S., & Gershman, S., et al. (2006). Community-associated methicillin-resistant *Staphylococcus aureus* and healthcare risk factors. *Emerging Infectious Diseases, 12*, 1991-1993.

Keshtgar, M., Khalili, A.,Coen, P.,Carder, C. Macrae, B., & Jeanes, A., et al. (2008). Impact of rapid molecular screening for methicillin-resistant *Staphylococcus aureus* in surgical wards. *British Journal of Surgery, 95,* 381-386.

Klevens, M., Edwards, J., & Gaynes, R. (2008). The impact of antimicrobial-resistant, healthcare-associated infections on mortality in the United States. *Clinical Infectious*

Disease, 47, 927-930.

Kuehnert, M.J., Hill, H., Kupronis, B.A., Tokars, J.I., Solomon, S.L. & Jernigan, D.B. (2005). Methicillin-resistant Staphylococcus aureus hospitalizations, United States. *Emerging Infectious Diseases, 11*, 6, 868-872.

Larson, E.L., Quiros, D. & Lin, S.X. (2007). Dissemination of the CDC hand hygiene guideline and impact on infection rates. *American Journal of Infection Control, 35*(10), 666-675.

Lee, B.Y., Bailey, R.R., Smith, K.J., Muder, R.R., Strotmeyer, E.S. & Lewis, J., et al. (2010). Surveillance for adults at hospital admission: An economic model and analysis. *Infection Control Hospital Epidemiology, 31*, 6, 598-606.

Liebowitz, L.D. (2009). MRSA burden and interventions. *International Journal of Antimicrobial Agents, 34*, S3; S11-S13.

Luszczynska, A., & Sutton, S. (2005). Attitudes and expectations. In J. Kerr, R. Weitkunat, & M. Moretti (Eds.), ABC of behavior change: A guide to successful disease prevention and health promotion, (pp. 77-84). Edinburgh: Elsevier.

Mainous, G.A., Diaz, V.A., Matheson, E.M., Gregorie, S.H., & Hueston, W.J. (2011). Trends in hospitalizations with antibiotic-resistant infections: US, 1997-2006. *Public Health Reports,* May-June, vol. 126, 354-360.

McCannon, Schall, Calkins & Nazem (2006). Saving 100,000 lives in U.S. hospitals. *British Medical Journal, 332,* 1328-1330.

McClaws, M.L., Maharlouei, N., Yousefi, F., & Askarian, M. (2012). Predicting hand hygiene among Iranian health care workers using the theory of planned behavior. *American Journal of Infection Control, 40, 4*, 336-339.

Mileno, M.D. (2008). MRSA in the United States and beyond. *Travel Medicine Advisor,* 129-

131.

Miller, L.G., Perdreau-Remington, F., & Rieg, G., et al. (2005). Necrotizing fasciitis caused by community-associated methicillin-resistant *Staphylococcus aureus* in Los Angeles. *New England Journal of Medicine, 352,* 1445-1453.

Mongkolrattanothai, K., Boyle, S., Kahana, M.D., & Daum, R.S. (2003). Severe *Staphylococcus aureus* infections caused by clonally related community-acquired methicillin-susceptible and methicillin-resistant isolates. *Clinical Infectious Diseases, 37,* 1050-1058.

Murthy, A., De Angelis, G., Pittet, D., Schrenzel, J., Uckay, I., & Harbarth, S. (2010). Cost-effectiveness of universal MRSA screening on admission to surgery. *Clinical Microbiology and Infectious Diseases, 16*, 1747-1753.

Murthy, A. & Frick, K. (2011). Economics of nosocomial MRSA infection in Europe: Measuring direct cost of infection, with an economic evaluation of rapid screening on admission to hospital surgical wards. *Clinical Microbiology and Infection*, DOI....

National Nosocomial Infection Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004(2004). *American Journal of Infection Control, 32,* 470-485.

O'Boyle, C.A., Henly, S.J., & Larson, E. (2001). Understanding adherence to hand hygiene recommendations: *The theory of planned behavior. American Journal of Infection Control, 29,* 6, 352-360.

Obritsch, M.D., Fish, D.N., MacLaren, R., & Jung, R. (2004). National surveillance of antimicrobial resistance in *Pseudomonas aeruginosa* isolates obtained from intensive care unit patients from 1993 to 2002. *Antimicrobial Agents & Chemotherapy, 48,* 470-485.

Orlovic, D., & Smego, R.A., (2009). Emerging community-acquired methicillin-resistant *Staphylococcus aureus* pneumonia. *International Journal of Collaborative Research on Internal Medicine & Public Health, 1,* 2,73-82.

Payman, N. & Delorme, T. (2008). Methicillin-resistant *Staphylococcus aureus* among younger population in northeastern Ohio. *Ohio Journal of Science, 108*, 3, 50-52.

Pittet, P., Hugonnet, S., Silva-Pessoa, C.L., Sauvan, V., & Permeger, T.V. (2004). Hand hygiene among physicians: Performance, beliefs, and perceptions. *Annual Internal Medicine, 141*, 1-8.

Platt, R. (2011).Time for a culture change? *The New England Journal of Medicine, 364, (15),* 1464-1465.

Reed, S.D., Friedman, J.Y., Engemann, J.J., et al (2005). Costs and outcomes among hemodialysis-dependent patients with methicillin-resistant or methicillim-susceptible *Staphlococcus aureus* bacteremia. *Infection Control and Hospital Epidemiology, 26,* 175-183.

Resar, R., Pronovost, P., Haraden ,C., Simmonds ,T., Rainey,T. & Nolan, T. (2005). Using a bundle approach to improve ventilator care processes and reduce ventilator-associated pneumonia. *Joint Commission Journal on Quality and Patient Safety, 31, 5,* 243-248.

Robicsek, A., Beaumont, J.L., Paule, S.M., Hacek, D.M., Thomson Jr., R.B., & Kaul, K.L. (2008). Universal surveillance for methicillin-resistant Staphylococcus aureus in 3 affiliated hospitals. *Annals of Internal Medicine, 148,* 409-418.

Rojas, E.G., & Liu, L. Z. (2005). Annual cost for the treatment of patients hospitalized with methicillin-resistant Staphylococcus aureus in the United States. *Value Health, 8,* 308.

Ruhe, J., Guzman, L., Moss, M., Riley, W., Mildvan, D., & Perlman, D., et al, 2011. Methicillin-susceptible *Staphylococcus aureus* nasal colonization and the risk of subsequent methicillin-resistant *Staphylococcus aureus* infections among hospitalized patients. *Diagnostic Microbiology and Infectious Diseases, 71,* 163-166.

Sakoulas, G., Perencevich, E.N., Schwaber, M.J., Karchemer, A.W., & Caremeli, Y. (2003). Comparison of mortality associated with methicillin-resistant *Staphylococcus aureus* bacteremia: A meta analysis. *Clinical Infectious Disease, 36,* 53-59.

Salomao, R., Rosenthal, V.D., Grimberg, G., Nouer, S., Blecher, S., & Ferreira, S.B. (2008). Device-associated infection rates in intensive care units of Brazilian hospitals: Findings of the International Nosocomial Infection Control Consortium. *American Journal of Public Health, 24,* 3, 195-202.

Sampathkumar, P., (2007). Methicillin-resistant *Staphylococcus aureus*: The latest health scare, *Mayo Clinic Proceedings, 82, 12*, 1463-1467.

Sanford, M.D., Widmer, A.F., Bale, M.J., Jones, R.N., & Wenzel, R.P. (1994). Efficient detection and long-term persistence of the carriage of methicillin-resistance *Staphylococcus aureus. Clinical Infectious Diseases, 19,* 1123-1128.

Santos, H., Machado, D., Camey, S., Kuchenbecker, R. Barth, A. & Wagner, M. (2010). Prevalence and acquisition to a tertiary-care hospital in Brazil. *Infectious Diseases, 10*, 328, 1-7.

Sarikonda, K., Scott, M., Doherty, J., Reichley, R., Warren, D. & Kollef, M. (2010). Methicillin-resistant *Staphylococcus aureus* nasal colonization is a poor predictor of intensive care unit-acquired methicillin-resistant *Staphylococcus aureus* infections requiring antibiotic treatment. *Critical Care Medicine, 38,* 10, 1991-1995.

Sartor, C., Veronique, J., Duvivier, C., Dupont, H., Sambuc, R., & Drancourt, M., et al. (2000). Nosocomial *Serratia marcescens* infections associated with extrinsic contamination of a liquid nonmedicated soap. *The Society for Healthcare Epidemiology of America, 21*, 3, 196-199.

Schweickert, B., Geffers, C., Farragher, T., Gastmeier, P., & Behnke, M., et al. (2011). The MRSA-import in ICUs is an important predictor for the occurrence of nososcomial MRSA cases. *Clinical Microbiology and Infection, 17*, 6, 901-906

Scott, R.D. (2009). The direct medical costs of healthcare-associated infection in U.S. hospitals and the benefits of prevention, 2009. Divisions of Healthcare Quality Promotion, National Center for Preparedness, Detection, and Control of Infectious Diseases, Coordinating Center for Infectious Diseases, Centers for Disease Control and Prevention, February, 2009.

Shafie, E., Alishaq, M., & Garcia, L. (2004). Investigation of an outbreak of multidrug-resistant *Acinetobacter baumannii* in trauma intensive care unit. *Journal of Hospital Infection*, *56*, 2, 101-105.

Shorr, A.F., Tabak, Y.P., Gupta, V. et al (2006). Morbidity and cost burden of methicillin-resistant *Staphylococcus aureus* in early onset ventilator-pneumonia. *Critical Care, 10*, R97.

Shorr, A.F., (2007). Epidemiology and economic impact of methicillin-resistant *Staphylococcus aureus:* Review and analysis of the literature. *Pharmacoeconomics, 25,* 751-768.

Siegel, J.D., Rhinehart, E., Jackson, M., Chiarello, L. (2007) The Healthcare Infection Control Practices Advisory Committee: Centers for Disease Control & Prevention (CDC).

Guidelines for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings Centers for Disease Control and Prevention (CDC). Retrieved from http://www.cdc.gov/hicpac/pdf/isolation/Isolation2007.pdf.

Skov, R., Kolmos, H.J., Peltonen, R., Vuopio-Varkila, J., Hardardottir, H., Gudlaugsson, O.,et al. (2005). MRSA infections increasing in the Nordic countries. Eurosurveillance, *10*, 31.

Smith, P., Watkins, K., & Hewlett, A. (2012). Infection control through the ages. *American Journal of Infection Control, 40,*1*,* 35-42. (doi:10.1016/j.ajic.2011.02.019)

Stein, R.A., Goetz, R.M., & Ganea, G.M. (2009). Ceftobiprole: A new beta-lactam antibiotic. *The International Journal of Clinical Practice, 63*, 6, 930-943.

U.S. Department of Health and Human Services (USDHHS) (2020). *Healthy People 2020: Understanding and Improving Health, Volumes I and II.* Washington, DC: U.S. Government Printing Office.

Van Loo, I., Huijsdens, X., Tiemersma, E., de Neeling, A., van de Sande-Bruinsma, N., Beaujean, et al. (2007). Emergence of methicillin-resistant *Staphylococcus aureus* of animal origin in humans. *Emerging Infectious Diseases, 13,* 1834-1839.

Weber, D., Sickbert-Bennett, E., Brown, V., & Rutala, W. (2007). Comparison of hospitalwide surveillance and targeted intensive care unit surveillance of healthcare-associated infections. *Infection Control and Hospital Epidemiology, 28*, 12, 1361-1366.

Weber, S.G., Huang, S.S., Oriola, S., Huskins, W.C., Noskin, G.A., & Harriman, K., et al. (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,* 73-

85.

Witte, W., Strommenger, B., Stanek, C., & Cuny, C. (2007). Methicillin-resistant *Staphylococcus aureus* ST398 in humans and animals, Central Europe. *Emerging Infectious Diseases, 13*, 255- 258.

World Health Organization (WHO). (2009). WHO guidelines on hand hygiene in healthcare: A summary. Retrieved from http://www.who.int/gpsc/5may/background/en/

Yamakawa, K., Tasaki, O., Fukuyama, M., Kitayama, J., Matsuda, H., & Nakamori, Y., et al. (2011). Assessment of risk factors related to healthcare-associated methicillin-resistant *Staphylococcus aureus* infection at patient admission to an intensive care unit in Japan. *Infectious Diseases, 11,* 303, 1-7.

Yates, C., May, K., Hale, T., Allard, B., Rowlings, N., & Freeman, A. (2009). Wound chronicity, inpatient care, and chronic kidney disease predispose to MRSA infection in diabetic foot ulcers. *Diabetes Care, 32,* 10, 1907-1909.

Chen, Y.Y., Chi, M.M., Chen, Y.C., Chan, Y.J., Chou, S.S., & Wang, F.D. (2013). Using a criteria-based reminder to reduce use of indwelling urinary catheters and decrease urinary tract infections. *American Association of Critical-Care, 22*, 2, 105-114.

Young, Y., Kim, J., Park, D., Sohn, J., & Kim, M. (2010). Predictors of persistent methicillin-resistant *Staphylococcus aureus* bacteraemia in patients treated with vancomycin. *Journal of Antimicrobial Chemotherapy, 65*, 1015-1018.

Youngquist, P., Carroll, M., Farber, M., Macy, D., Madrid, P., Ronning, J., & Susag, A. (2007). Implementing a ventilator bundle in a community hospital. *Joint Commission Journal on Quality and Patient Safety, 33*, 4, 219-25.

APPENDICES

A. Protocol: Epidemiology of Hospital Acquired Methicillin-Resistant *Staphylococcus aureus* in a Veterans Affairs Medical Center Spinal Cord Injury Unit: Fiscal Years 2008-2011

Chart Reviewer: Rebecca B. Stone
Date of Review: _____

Data Capture Form

Patient ID	Case	Control #1	Control #2
Birth Year			
Race			
Gender			
Ethnicity			
Height			
Weight			
BMI (Calculated)			
Antibiotics: Y/N (If yes, list)			
Wound Consult: Y/N			
Infection Source/Type			
CA-MRSA on Admission: Y/N			
CA-MRSA on Discharge: Y/N			

Device Use: (If yes, type.e.g. central line, etc.)			
Cause of Injury:			
ASIA Score			
Admission Date			
Area of Service			
Admission Diagnosis			
Cause of death/underlying cause of death			
Discharge Date			
Length of Stay			
Neurogenic Bladder			
Neurogenic Bowel			
Sexual Dys. 2ndary			
Diabetes Mellitus II			
Hypertension			
Chronic Neuropathic Pain			
Anxiety/Depression			
Annual Spinal Cord Eval.			
Hepatitis			
HIV			
Decubitus Site/ Stage			
Hemorrhoids			

AKA			
Cholecystitis			
Cholelithiasis			
Hypotension			
Spasms			
Osteomyelitis			
Anxiety/Depression/PTSD			
Smoking History			
Drug History			
Alcohol History			

B. MRSA Validation Tool for Spinal Cord Injury Patients Age 18 & Older

Protocol: Epidemiology of Hospital Acquired Methicillin-Resistant *Staphylococcus aureus* in a Veterans Affairs Medical Center Spinal Cord Injury Unit: Fiscal Years 2008-2011

Chart Reviewer: Rebecca B. Stone

Date of Validation of MRSA Cases: _____

(Adapted from CDC/NHSN Surveillance Definitions)

Infection (Body Site)	**Clinical Criteria**	**Yes**	**No**
SSI- Surgical Site Infection (superficial, primary or secondary site)	Must meet the following criteria:		
	Infection occurs w/I 30 days after operative procedure *and* involves only skin and subcutaneous tissue of the incision *And* at least 1 of the following: a. purulent drainage from incision b. organisms isolated from an aseptically obtained culture of fluid or tissue from incision c. at least 1 of the following signs and symptoms of infection: a. pain or tenderness b. localized swelling c. redness or heat d. incision deliberately opened by surgeon & is culture positive or not cultured (culture negative finding does not meet this criterion) e. diagnosis of infection by surgeon or attending physician		
SSI- (deep incisional- primary or secondary site)	Must meet the following criteria:		
	Infection occurs w/I 30 days after operative procedure if no implant is left in place or w/I 1 yr. if implant is in place and the infection appears to be related to the operation *a*nd involves deep soft tissue of the incision		

	And at least 1 of the following: a. purulent drainage from incision but not the organ space b. deep incision spontaneously dehisces or deliberately opened by the surgeon and is culture positive or not cultured when the patient has at least 1 of the following signs and symptoms: a. pain or tenderness b. fever c. abscess or evidence of infection involving the deep incision on direct examination/reoperation or by histopathology or radiology exam d. diagnosis of infection by surgeon or attending physician		
SSI- (Organ/Space)	Must meet the following criteria:		
	Infection occurs w/I 30 days after the operation if no implant is left in place or w/I 1 yr. if implant is in place and the infection appears to be related to the operation *and* infection involves any part of the body, excluding the skin incision, fascia, or muscle layers that is opened during the operation *and* patient has at least 1 of the following: a. purulent drainage from a drain placed through a stab wound into the organ/space b. organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space c. abscess or other evidence of infection found on direct exam, during reoperation, histopathologic or radiologic exam d. diagnosis by surgeon or attending physician		
BSI-Blood Stream Infection(LCBI-Laboratory-confirmed bloodstream)	Must meet at least 1 of the following criteria		
	1. Recognized pathogen cultured from 1 or more blood cultures *and* organism is not related to an infection at		

	another site 2. At least 1 of the following signs & symptoms: a. fever b. chills c. hypotension d. signs and symptoms and positive culture are not related to an infection at another site e. common skin contaminant cultured from 2 or more blood cultures drawn on separate occasions		
Central Line-Associated Blood Stream Infection (CLABSI)	1. A laboratory-confirmed bloodstream infection (LCBI) where central line (CL) or umbilical catheter (UC) was in place for >2 calendar days when all elements of the LCBI infection criterion were first present together, with day of device placement being Day 1, *AND* 2. A CL or UC was in place on the date of event or the day before. If the patient is admitted or transferred into a facility with a central line in place (e.g., tunneled or implanted central line), day of first access is considered Day1.		
	Comments: 1. Neither the insertion site nor the type of device may be used to determine if a line qualifies as a central line. The device must terminate in one of the great vessels or in or near the heart and be used for one of the purposes outlined above, to qualify as a central line. 2. An introducer is considered an intravascular catheter, and depending on the location of its tip and use, may be a central line. 3. Pacemaker wires and other nonlumened devices inserted into central blood vessels or the heart are not considered central lines.		
BJ-Bone & Joint Infection (osteomyelitis)	≥ 1 of the following criteria:		
	1. Organism cultured from bone 2. Evidence of osteomyelitis on direct exam of bone during a surgical operation or histological exam 3. ≥2 of the following signs and symptoms		

	with no other recognized cause: a. fever (>38º C) b. localized swelling c. tenderness d. heat e. drainage at suspected site *And at least 1 of the following:* a. organism cultured from blood b. radiographic evidence of infection		
BJ- (Joint or Bursa)	≥ 1 of the following criteria:		
	1. Organism cultured from joint fluid or synovial biopsy 2. Evidence of joint or bursa infection seen during a surgical operation or histological exam 3. ≥2 of the following a. joint effusion b. swelling c. tenderness d. heat e. evidence of effusion f. limitation of motion *And at least 1 of the following:* a. organisms and WBCs seen on Gram's stain of joint fluid b. positive antigen test on blood, urine, or joint fluid c. cellular profile and chemistries of joint fluid consistent w/infection and not rheumatologic disorder d. radiographic evidence of infection		
Disc Space Infection	Must meet at least 1 of the following criteria:		
	1. Patient has organisms cultured from vertebral disc space obtained during a surgical procedure or aspiration 2. Evidence of disc infection during a surgical operation or histopathological exam 3. Signs and symptoms: a. fever b. pain at the disc space *and* c. radiographic evidence of infection 4. Signs and symptoms: a. fever b. pain at the involved disc space		

CNS-Central Nervous System (intracranial infection-brain abscess, sub or epidural infection, encephalitis)	At least 1 of the following must be met:		
	1. Patient has organisms cultured from brain tissue or dura. 2. Patient has an abscess or evidence of intracranial infection seen during a surgical operation or histopathologic examination. *3.* Patient has at least 2 of the following signs or symptoms with no other recognized cause: a. headache b. dizziness c. fever d. localizing neurologic signs e. changing level of consciousness, or confusion *and at least 1 of the following:* a. organisms seen on microscopic examination of brain or abscess tissue obtained by needle aspiration or by biopsy during a surgical operation or autopsy b. positive antigen test on blood or urine c. radiographic evidence of infection *and* if diagnosis is made antemortem, physician institutes appropriate antimicrobial therapy.		
CNS-(meningitis)	At least 1 of the following must be met:		
	1. organism cultured from CSF 2. At least1 following S&S: a. fever (>38 ºC) b. headache c. stiff neck d. meningeal signs e. cranial nerve signs f. irritability AND ≥1 of the following: a. increased white cells, elevated protein, and/or decrease glucose in CSF b. organism seen on Gram's stain of CSF c. organism cultured from blood		

	AND if diagnosis is antemortem, physician institutes antimicrobial therapy		
CNS - (spinal abscess w/o meningitis			
	Abscess of the spinal epidural or subdural space w/o involvement of the CSF or adjacent bone 1. Organism cultured from abscess in the spinal epidural or subdural space 2. Abscess in spinal epidural or subdural space seen during surgery or histo exam 3. ≥1 following signs and symptoms a. fever (38 ºC) b. back pain c. focal tenderness d. radiculitis e. paraparesis f. paraplegia AND ≥1 of the following: a. organism cultured from blood b. radiographic evidence of spinal abscess AND if diagnosis is antemortem, Physician institutes antimicrobial therapy		
CVS-Cardiovascular System Infection(arterial or venous)	At least 1 of the following must be met:		
	1. Organism cultured from arteries or veins removed during surgical operation and, blood culture not done or no organism cultured from blood 2. Evidence of arterial or venous infection seen during a surgical operation on histological exam 3. ≥1 of following S&S a. fever (>38 deg C) b. pain c. erythema d. heat at involved vascular site and more than 15 colonies cultured from intravascular cannula tip and BC not done or no organisms cultured from blood 4. Purulent drainage at involved vascular site 5. ≥1 of the following S&S: a. fever (>38 deg C)		

	b. hypothermia (<37 deg C) c. apnea d. bradycardia e. lethargy f. pain g. erythema h. heat at vascular site and more than 15 colonies cultured from intravascular cannula tip and BC not done or no organisms cultured from blood and more than 15 colonies cultured from intravascular cannula tip and BC not done or no organisms cultured from blood		
CVS - (endocarditis, valve disease, due to a device, implant or graft)	At least 1 of the following must be met:		
	1. organism cultured from valve or vegetation 2. ≥2 of the following S&S: a. fever (>38 ºC) b. new or changing murmur c. embolic phenomena d. skin manifestations (for example: petechiae, splinter hemorrhages, painful subcutaneous nodules) e. CHF f. cardiac conduction abnormality and ≥1 of the following: a. organism cultured from ≥2 blood cultures b. organism seen on Gram's stain of valve when culture is negative or not done c. valvular vegetation seen during a sx procedure or autopsy d. evidence of new vegetation seen on echo and ≥1 of the following: if diagnosis is made antemortem, or physician institutes appropriate antimicrobial treatment		
CVS - (myocarditis/pericarditis)	At least 1 of the following must be met:		
	1. Organism cultured from pericardial tissue or fluid 2. ≥2 of the following S&S: a. fever b. chest pain		

	c. paradoxical pulses d. increased heart size *and at least 1 of the following:* a. abnormal EKG consistent with myocarditis or pericarditis b. evidence of myocarditis or pericarditis on histo exam c. pericardial effusion		
CVS- (mediastinitis)	At least 1 of the following must be met:		
	1. organisms isolated by culture during surgical procedure or needle aspiration 2. evidence of infection seen during operation or histopathological examination 3. ≥1 of the following S&S: a. fever b. chest pain c. sterna instability *and at least 1 of the following:* a. purulent discharge b. positive culture from blood or discharge from mediastinal area c. mediastinal widening on x-ray		
EENT- Eye, Ear, Nose, Throat, or Mouth Infection	At least 1 of the following must be met:		
	1. pathogens cultured from purulent exudates 2. pain or redness of conjunctiva *and at least 1 of the following:* a. WBC's and organisms seen on Gram stain b. purulent discharge 3. Infection of eye other than conjunctivitis: a. physician diagnosis of eye infection b. organism cultured from blood		
EENT - (ear mastoid)	At least 1 of the following must be met:		
	Otits externa: 1. pathogen isolated from purulent drainage from ear canal 2. and ≥1 of the following S&S: a. fever b. pain c. redness d. drainage from ear canal		

	and a. organisms seen on gram stain from drainage Otitis media: 1. pathogen isolated from fluid from middle ear 2. and ≥2 of the following S&S: a. fever b. pain c. inflammation d. retraction or decreased mobility of eardrum e. fluid behind eardrum Otitis interna: 1. pathogen isolated from inner ear 2. physician diagnosis Mastoiditis: 1. pathogen isolated from purulent drainage of mastoid 2. and ≥2 of the following S&S: a. fever b. pain c. tenderness d. erythema e. headache f. facial paralysis *and at least 1 of the following* a. organism seen on gram stain		
EENT - (oral cavity-mouth, tongue, gums)	At least 1 of the following must be met:		
	1. pathogen isolated from tissues in oral cavity 2. abscess or evidence or oral cavity infection on examination 3. and ≥1 of the following S&S: a. abscess b. ulceration *and at least 1 of the following* a. organisms seen on gram stain b. physician diagnosis and treatment		
EENT- (Sinusitis)	At least 1 of the following must be met:		
	1. organisms isolated by culture from purulent drainage 2. at least 1 of the following S&S:		

	a. fever b. pain c. tenderness over sinus d. purulent exudates e. nasal obstruction *and at least 1 of the following:* a. positive transillumination b. positive radiographic exam		
GI-Gastrointestinal Infections (gastroenteritis)	At least 1 of the following must be met:		
	1. acute onset of diarrhea with or w/o vomiting or fever, and not likely noninfectious cause 2. At least 2 of the following S&S: a. nausea b. vomiting c. abdominal pain d. fever e. headache		
IAB – Intraabdominal Infection (gallbladder, bile ducts, liver, spleen, pancrease)	At least 1 of the following must be met:		
	1. organism cultured from purulent material from IAB space 2. Abscess or other evidence of IAB infection 3. ≥2 of the following S&S: a. fever (>38 ºC) b. nausea c. vomiting d. abdominal pain e. jaundice AND ≥1 following: a. organism from drainage from surgically placed drain b. organism seen on Gram's stain of drainage or tissue c. organism cultured from blood or radiographic evidence of infection		
UR – Upper Respiratory Tract (pharyngitis, laryngitis, epiglottitis)	At least 1 of the following must be met:		
	1. ≥2 of the following S&S: a. fever b. erythema of pharynx c. sore throat		

	d. cough e. hoarsenss f. purulent throat exudates *and at least 1 of the following:* a. organisms isolated from the specific site b. organisms isolated from blood c. physician diagnosis of infection 2. abscess seen on direct examination		
LRI-Lower Respiratory Tract Infection, Other than Pneumonia (bronchitis, bronchiolitis, tracheitis, w/o evidence of pneumonia)	Must meet at least 1 of the following:		
	1. no clinical or radiographic evidence of pneumonia *and at least 2 of the following S&S:* a. fever b. cough c. new or increased sputum production d. rhonchi e. wheezing *and at least 1 of the following:* a. positive culture obtained by deep tracheal aspirate or bronchoscopy		
OREP-Reproductive Tract Infection (other infections of the reproductive tract)	Must meet at least 1 of the following:		
	1. organisms isolated from the affected site 2. abscess or evidence of infection 3. at least 2 of the following S&S: a. fever b. nausea c. vomiting d. pain e. tenderness f. dysuria *and* a. organisms cultured from the blood b. physician diagnosis		
SST-Skin & Soft Tissue Infection (cellulitis/soft tissue/wound infection)	Must meet at least 1 of the following:		
	1. Purulent draining, pustules, vesicles, or boils 2. ≥2 of the following with no other		

	recognized cause: a. pain or tenderness b. localized swelling c. redness d. heat *AND ≥1 of following:* a. organism cultured from site b. organism cultured from blood		
Soft Tissue (necrotizing fascitis, infectious gangrene, necrotizing cellulitis, infectious myositis, lymphadenitis, or lymphangitis)	One of the following must be met:		
	1. Organism cultured from site 2. Purulent drainage at site 3. Abscess or other signs of infection observed during surgical operation or histological exam 4. ≥2 of the following characteristics a. organism cultured from blood		
SST-Decubitus ulcer, including superficial and deep infections	At least 2 of the following signs and symptoms with no other recognized causes:		
	1. redness 2. tenderness 3. swelling of decubitus wound edges *And ≥1 of the following*: a. organism cultured from properly collected fluid or tissue b. organism cultured from blood *Purulent drainage alone is not sufficient Evidence of decubitus ulcer. Properly collected specimen involves needle aspiration of fluid or biopsy of tissue from ulcer margin.*		
SYS-Systemic Infection			
	Involves multiple organs or systems w/o an apparent single site infection.		
Urinary Tract Infection-UTI			
Symptomatic Urinary Tract Infection-SUTI	Patient must meet at least 1 of the following criteria:		
	1. Patient has at least 1 of the following signs		

	or symptoms with no other recognized cause: fever (>38C), urgency, frequency, dysuria, or suprapubic tenderness *And* Patient has a positive urine culture, greater than 100,000 microorganisms per cc of urine with no more than 2 species of microorganisms. 2. Patient has at least 2 of the following signs or symptons with no other recognized cause: fever (>38C), urgency, frequency, dysuria, or suprapubic tenderness *AND at least 1 of the following:* a. positive dipstick for leukocyte esterase and/nitrate b. pyuria (urine with >10WBC high power field of unspun urine) c. organisms seen on Gram's stain of unspun urine d. at least 2 urine cultures with repeated isolation of the same uropathogen (gram negative bacteria or *Staphylococcus saprophyticus*) with >20,000 colonies/ml in non-voided specimens e. < 100,000 colonies/ml of a single uropathogen (gram negative or Staphylococcus saprophyticus) in a patient being treated with an effective antimicrobial agent for a urinary tract infection f. physician diagnosis of a urinary tract infection g. physician institutes appropriated therapy for a urinary tract infection		
OUTI-Other Infection of the UTI (kidney, ureter, urethra, tissue surrounding the retro-peritoneal)	Patient has at least 1 of the following criteria:		
	1. Positive culture from fluid other than urine or tissue from affected site 2. An abscess or other evidence of infection on examination during surgical operation or histopathologic examination 3. ≥ 2 of the following signs		

	and symptons: a. fever (>38 deg C) b. localized pain c. localized tenderness at the involved site *And* at least 1 of the following: a. purulent drainage from site b. organisms cultured from blood that are compatible with suspected site of infection c. radiographic evidence of infection d. physician diagnosis of infection of the kidney, urethra, or tissues surrounding the retroperitoneal or perinephric space e. physician begins appropriate therapy for infection of the kidney, ureter, bladder, utethra, or tissues surrounding the retroperitoneal or perinephric space		
Asymptomatic Bacteriuria-ASB	Patient has at least 1 of the following criteria:		
	1. Patient has had an indwelling urinary catheter within 7 days before the culture *AND* Patient has a positive urine culture, that is, >100,000 organisms per cc of urine with no more than 2 species of organisms *AND* Patient has no fever (>38C), urgency, frequency, dysuria, or suprapubic tenderness. 2. Patient has not had an indwelling urinary catheter within 7 days before the first positive culture *AND* Patient has had at least 2 positive urine cultures, that is, >100,000 organisms per cc of urine with repeated isolation of the same microorganism and no more than 2 species of microorganisms *AND* Patient has no fever (>38C), urgency, frequency, dysuria, or suprapubic tenderness. Comments: A positive culture of a urinary catheter tip is not an acceptable laboratory test to diagnose a urinary tract infection.		

C. IRB Approval Letter

Date:	10/18/2012
HAC File #:	Pro00000773 , Stone Epidemiology of Hospital Acquired Methicillin-Resistant Staphylococcus aureus in a Veterans Affairs Medical Center Spinal Cord Injury Unit: Fiscal Years 2008-2011
Protocol Title	Epidemiology of Hospital Acquired Methicillin-Resistant Staphylococcus aureus in a Veterans Affairs Medical Center Spinal Cord Injury Unit: Fiscal Years 2008-2011
PI Name	Rebecca Stone
Approval Date	10/16/2012
Expiration Date	10/15/2013

The Human Assurance Committee (HAC) chairperson or designee reviewed and approved the referenced study and enclosed document(s) by the expedited procedure in accordance with the Department of Health and Human Services (DHHS) policy and the Institutional Assurance on file with the DHHS under the following criteria:

(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for nonresearch purposes (such as medical treatment or diagnosis). (Note: Some research in this category may be exempt from the HHS regulations for the protection of human subjects, 45 CFR 46.101(b)(4). This listing refers only to research that is not exempt.)

Approval has been granted for waiver of consent and waiver of HIPAA Authorization in accordance with the Department of Health and Human Services DHHS) policy, the Institutional Assurance on file with the DHHS and the Health Insurance Portability and Accountability Act (HIPPA) policy because:

1. The research involves no more than minimal risks to subjects.
2. The alteration or waiver of consent will not adversely affect the privacy rights and welfare of the individuals.
3. The research could not practicably be carried out without access to and use of the protected health information.
4. The research could not practicably be carried out without the waiver or alteration.
5. The privacy risks to individuals whose protected health information is to be used or disclosed are reasonable in relation to the anticipated benefits, if any, to the individuals, and the importance of the knowledge may reasonably be expected to result from the research.
6. There is an adequate plan to protect the identifiers from improper use and disclosure.
7. There is an adequate plan to destroy identifiers at the earliest opportunity consistent with the conduct of the research unless there is a health or research justification for retaining the identifiers, or such retention is required by law.
8. There are adequate written assurances that the protected health information will not be reused or disclosed to any other entity or person except as required by law, for authorized oversight of the research project, or for other research for which the use of disclosure of the protected information will be permitted.

The approval includes the following supporting documents

MRSA Data Collection Form.pdf 10/16/2012 0.01

The Committee calls your attention to the following obligations as Principal Investigator of this study. Under the terms of our approved Institutional Assurance to the Department of Health and Human Services, you must provide the HAC with a progress report at the termination of the study, or prior to the expiration of this approval, whichever comes first. If the study will continue beyond the initial approval term, review by the Human Assurance Committee is required, with a progress report constituting an important part of the review.

Failure to submit a Continuation Request by its due date will result in an automatic termination of this study. Reinstatement will only be granted following resubmission of the study to the HAC.

The HAC has determined that the interval of continuing review as noted by the approval and approval expiration dates above is appropriate to the degree of risk for this protocol.

If Veterans Affairs (VA) patients or facilities will be involved in this study, a letter of approval from the VA Research & Development Committee must also be obtained prior to involvement of VA patients or facilities. You must also contact the VA regarding their disclosure reporting requirements.

Please feel free to contact our office at 706-721-3110 if you have any questions.

Human Assurance Committee (HAC)
Georgia Health Sciences University
1120 15th St., CJ-2103
Augusta GA 30912-7621
HAC@georgiahealth.edu
Office 706-721-3110http://www.georgiahealth.edu/research/ohrp/irb/hac/index.html

D. VAMC R&D Approval Letter

Department of Veterans Affairs

Memorandum

Date: November 26, 2012

From: Associate Chief of Staff For Research & Development (ACOS/R&D) (24)

Subj: R&D Approval of Research Project

To: Rebecca Stone, Dr.PHo

1. At the November 19, 2012 meeting the below listed actions were taken by the Committee on your project entitled *"Epidemiology of Hospital Acquired Methicillin-Resistant Staphylococcous Aureus in a Veterans Affairs Medical Center Spinal Cord Injury Unit: Fiscal Years 2008-2011"*.

a. Concurred with the approval of the Institutional Review Board (IRB) dated 10/16/2012.

b. Noted that the project is a retrospective chart review and is exempt from review by the Subcommittee on Research Safety (SRS).

c. Approved the project to be conducted at the Charlie Norwood Veterans Affairs Medical Center. The approval period of this project is November 19, 2012 – November 18, 2013.

2. This letter is clearance to initialize your approved research project.

3. Mandatory annual progress reports/continuing review are due to the R&D by October 18, 2013.

4. All Principal Investigators will be held responsible for ethical breaches in the conduct of their research and these problems may affect the investigator's ability to do research with the VA in the future.

5. Questions regarding the conduct of research may be directed to the R&D Coordinator at extension 2509.

Thomas J. Hartney, MD