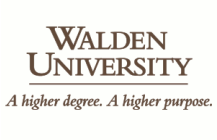

1-1-2011

Analysis of Risk Factors Associated With Asymptomatic Colonization of Methicillin Resistant Staphylococcus aureus (MRSA) Among Community College Students

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This is to certify that the doctoral dissertation by

Marilynn Kish-Molina

has been found to be complete and satisfactory in all respects,
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the review committee have been made.

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2012

Abstract

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M.S., Wayne State University, 1980

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Dissertation Submitted in Partial Fulfillment

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Abstract

The bacterium *Staphylococcus aureus* has been an important human ailment for centuries, and with the overuse of antibiotics, methicillin resistant *Staphylococcus aureus* (MRSA) has emerged as a deadly, costly pathogen worldwide. Healthy carriers can become sick or can spread MRSA without symptoms. The amount of asymptomatic colonization among healthy college students and risk factors for colonization by MRSA are not well understood. According to the epidemiologic triangle model, the host (students who take antibiotics or have a history of skin infections), the infectious agent (MRSA) and the environment (direct contact with people, animals, or objects that may harbor MRSA) all play an important role in this disease. This study explored MRSA colonization rates among healthy students at a community college and explored the possibility that students exposed to sources of MRSA might have a higher colonization rate. Using a cross-sectional quantitative design with stratified sampling, risk factors to include student's discipline, gender, race, work, and leisure exposure were surveyed. In tandem, Mannitol Salt Agar and MRSA Select Agar were inoculated from nasal swabs to identify students colonized by MRSA. The data were analyzed using contingency tables and Chi Squares. Significant risk factors identified included students who had a major that involved touching shared equipment and/or those who were in majors such as nursing, students who had close contact with animals, and students who had a skin infection. The implication for positive social change include improved awareness of MRSA colonization and risk factors which can lead to better prevention strategies and increased awareness among the student population.

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Dedication

I would like to dedicate this dissertation to my loving husband, Mario Molina, and my precious daughter, Ashley Molina, for their unwavering support during this long process and their unconditional love. I would also like to dedicate this dissertation to my parents, the late Captain Emil Kish and Inez Kish, for all their support through the years and for instilling in me the can-do spirit that has allowed me to overcome many obstacles and persevere and succeed.

Acknowledgments

I would like to acknowledge my dissertation chair, Dr. Nancy Rea, for her knowledge and kind words along the way, and Dr. Chad Moretz for his encouragement and statistical expertise. I would also like to acknowledge Dr. Rodney Rohde, from Texas State University, for his support and encouragement along the way. I especially want to acknowledge my husband Mario Molina for all the emotional and economic support he gave and my daughter Ashley Molina for picking up the slack at home. I also thank God, and realize through Him, all things are possible.

A special thanks goes to the Academic Vice-Presidents, past and present, Dr. James Templer and Dr. Amy Locklear, for their support and allowing me to work with the students and for allowing me to have a partial sabbatical for a year to focus on the coursework and dissertation. Science and Math Department Faculty were always supportive from giving feedback to helping me find students to checking on my progress and giving words of encouragement. I would especially like to thank Dr. Chris Allen, Ms. Tami Allison, Ms. Emmeline Dodd, Mr. Tom English, Dr. Greg Johnson, Dr. Tom Johnson, Mr. Tracy Orr, Dr. Ali Ravandi, Mr. Leslie Richardson, Ms. Asha Stephens, Mr. Herman Trivilino, and Dr. Renate True. Last, but certainly not least, I would like to thank all of the students who participated in my study, which was about one fourth of the student body, and all the faculty that let me survey and test students during the last few minutes of their classes.

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Chapter 1: Introduction to the Study

Introduction

Although *Staphylococcus aureus* has been a common source of infections in people throughout history (Heymann, 2008), the epidemiology of *Staphylococcus aureus* is changing. *Staphylococcus aureus* is a hardy Gram-positive bacterium that usually causes boils, skin infections, blood infections, and wound infections. Some strains release toxins that can cause such diverse problems as food poisoning and toxic shock syndrome (Nelson, 2007). With the discovery of antibiotics, staph infections were reduced, but, with years of abuse and overuse of antibiotics, antibiotic-resistant strains have become increasingly common (Germs-Go-Global, 2008). About 30% of the people in the United States are colonized with *Staphylococcus aureus*, commonly in the nostrils, and self-infection is common in carriers, but they can also spread this bacterium to others mainly through contact with their hands (Heymann, 2004). Penicillin resistance is very common in *Staphylococcus aureus*, but overtime, many strains have become resistant to methicillin and oxacillin as well and are referred to as methicillin-resistant *Staphylococcus aureus*, or MRSA (Leung-Chen, 2008). MRSA is resistant to all the beta-lactam antibiotics. Two different types of MRSA have evolved, one being hospital or health care associated, which is known as HA-MRSA, and the other being community-associated or CA-MRSA. The HA-MRSA has become increasingly resistant to many antibiotics, and even the last resort drug, vancomycin, is proving ineffective against a few strains (Leung-Chen, 2008). The CA-MRSA has emerged more recently, infecting healthy people and causing significant mortality and morbidity in people with no health

care exposure. Both HA-MRSA and CA-MRSA are very hard to treat and very costly to treat with costs running in the billions of dollars each year in the United States alone (Germs-Go-Global, 2008). Intravenous vancomycin is the usual treatment in severe cases, but there were seven cases in the United States between 2000-2006 that were completely resistant to vancomycin (Germs-Go-Global, 2008).

Asymptomatic colonization by MRSA can occur in healthy individuals, but how frequently this occurs and what factors may lead to colonization have not been fully studied. There is very little data on college student colonization rates and risk factors (Rohde et al.,2009). My study focused on colonization among healthy community college students and explored possible factors that may increase colonization rates. As some community college students pursue degrees that involve clinical contact with people, such as nursing, they may be at higher risk of colonization. As MRSA is hardy and can live outside the body for weeks on inanimate objects, students who use shared equipment in some degree plans may also be at increased risk to become colonized by MRSA. There is a significant gap in the literature on a student's major and the incidence of MRSA colonization. Chapter 2 includes a detailed literature review and further explores MRSA, including sources and risk factors, in greater detail.

Background of the Study

Asymptomatic colonization of MRSA in a healthy person may develop into an infection or it may spread to another person, especially after close contact (source, publication date). A better understanding of who is asymptomatically colonized could prove critical in controlling the spread of MRSA through the community. People who

work in direct contact with others such as beauticians or nurses may be an unsuspecting source of MRSA (Heymann, 2008). Programs that involve training nurses or cosmetologists could also put the students at increased risk by their exposure to direct contact with many other people. These students may have an increased risk of becoming colonized with MRSA, and then graduate and actively practice their profession while increasing the spread of MRSA. There is a lack of knowledge about colonization rates among community college students who are trained in fields such as nursing, cosmetology, and fire technology and their possible increased likelihood of exposure. Community college students are an understudied group when it comes to MRSA colonization, and because of the diversity found among community college students, a study targeting this group could be a rich source of information about the colonization and spread of MRSA.

Although there have been a few studies of MRSA carriage among healthy college students, the studies have variable results. A study at Texas State University had found 7.4% MRSA colonization rate among students (Rohde et al., 2009), whereas a study of Baylor University students in the fall 2009 revealed less than 1% colonized, and a study at McMurry University demonstrated a 5.7% colonization rate of MRSA. The CDC (2007) estimated MRSA rates in the U.S. population at about 0.8%. The Baylor campus is similar to the CDC estimate, whereas the other two are significantly higher. There is a gap of how much of the MRSA is CA-MRSA (Pursell, 2003), and looking at a community college with commuting students would be an informative additional study. Morita et al. (2007) found a 3% colonization rate in students at Kapi'olani Community

College in Hawaii. There is no evidence that anyone has looked at the types of MRSA among college students at either the community college or four year college setting.

Close contact with people and fomites increases the chances of picking up Staph including MRSA (Heymann, 2008), so studying students who have different majors and different degrees of contact with people and with fomites should increase the understanding of who might carry MRSA. Other risk factors might include employment outside of college in a healthcare or daycare facility. Risk may also come from leisure activities like working out, going to the beach, getting a tattoo, getting a pedicure or a waxing. Risk may come from having children or pets or being treated for a health condition. Chapter 2 provides the reader with greater depth into known and possible risk factors.

Problem Statement

MRSA infections are an emerging, costly problem in healthcare as well as in the community (Germs-Go-Global, 2008). The prevalence of asymptomatic carriage among healthy adults is not well understood (Romano et al., 2006). Although a few studies have been conducted on college students (Morita et al., 2007; Rhode et al., 2009), no studies exist that specifically look at a student's college major and the possible exposure risk with different curricula, such as nursing clinicals. With increased understanding of the prevalence of asymptomatic colonization and which factors might increase the prevalence, the approach to control and prevention of the spread of MRSA will be improved. This study looks at the prevalence of MRSA colonization among healthy community college students with no previous history of a MRSA infection, and focuses

on differences between majors in college, leisure and work exposures, and other risk factors. Risk factors that were studied by survey include all of the following that were relevant in the last 12 months: pets or close contact with animals, have young children, work out regularly or participate in sports, surf, swim, or frequent the beach regularly, work in a daycare, work in a healthcare facility (including a nursing home), had a skin infection, boil, or sore, been told one had a skin infection called "mersa", MRSA, or antibiotic resistant Staph, been a patient in a hospital, had surgery, had a tattoo, had a professional manicure or pedicure or waxing, or taken antibiotics.

Purpose of the Study

The purpose of this cross-sectional quantitative study was to determine the prevalence of asymptomatic colonization of MRSA among community college students and to further explore the impact of a student's college major on colonization rates. Other risk factors that were explored were exposure to children, pets or other animals, exposure through leisure or work activities, or exposure through treatments for health issues. As MRSA, especially CA-MRSA, is emerging as a disease, knowing the prevalence of asymptomatic carriage may help in control and prevention. Finding out if colonization status increases in students that pursue hands-on careers, such as nursing or cosmetology, may increase the awareness in these disciplines and may aid in control or prevention. As there is no medical intervention when a healthy person carries MRSA, the students were not given the laboratory results from the study unless students requested their results (Rhode et al., 2009).

Nature of the Study

This quantitative study sampled community college students for asymptomatic carriage of *Staphyloccous aureus* and MRSA. I administered a questionnaire to students at the same time they were screened for *S. aureus* and MRSA. The questionnaire included a query of risk factors and some basic demographic questions.

The research questions and hypotheses of my study determined the prevalence of asymptomatic carriage of MRSA among a sample of community college students, and also determined if there were significant differences in carriage between students with different college majors, and with different possible risks from exposure through vocations, avocations, or health care treatments. These are discussed further in the next section. See Chapter 3 for more details of the methods, media, and techniques used.

Research Questions and Hypotheses

Considering the gap in knowledge of asymptomatic colonization of MRSA among community college students, the following research questions were studied in this dissertation:

1. How prevalent is asymptomatic colonization of MRSA in healthy adult college students in a community college?

$H_0$1: There will be no significant difference between the rate of asymptomatic colonization of MRSA among healthy adult community college students and among healthy adults in the United States, which is about 0.8% (CDC, 2007).

H_A1: There will be a significant difference between the rate of asymptomatic colonization of MRSA among healthy adult community college students and among healthy adults in the United States.

2. Is there a difference in colonization between different majors, such as those that have hands-on portions for part of their training involving touching other people, like nursing and cosmetology students, and those that use shared equipment, like process technology and computer science majors, and those that have no formal hands-on training or shared equipment?

H_02: There will be no significant difference between asymptomatic colonization rates of MRSA between community college students who have majors that have training that involves touching other people, like nursing or cosmetology, or students who have training that involves touching shared equipment, like process technology and fire technology, or students that have no hands on component in their training.

H_A2: Students who have majors that have training that involves touching other people, like nursing or cosmetology or students who have training that involves touching shared equipment, like process technology and fire technology will have a significantly higher rate of asymptomatic colonization of MRSA compared to students that have no hands on component in their training.

3. Is there a higher incidence in community college students who have been exposed to possible risk factors for MRSA within the last 12 months that include: (a) having pets or close contact with animals, (b) having young children, (c) working out regularly or participating in sports, (d) surfing , swimming, fishing, or frequenting the

beach regularly, (e) working in a daycare, (f) working in a healthcare facility (including a nursing home), (g) having a skin infection, boil, or sore, (h) having been told they have a skin infections called “mersa”, MRSA, or antibiotic resistant Staph, (i) having been a patient in a hospital or having surgery, (j) getting a tattoo, (k) having a professional manicure or pedicure or waxing, or (l) taking antibiotics.

$H_0$3: There will be no significant difference between asymptomatic colonization rates of MRSA between community college students who have been exposed to risks and those who have not been exposed.

H_A3: There will be a significant difference between asymptomatic colonization rates of MRSA between community college students who have been exposed to risk factors from their leisure activities, work activities, or healthcare treatments and those who have not been exposed.

4. Is there a difference in prevalence in community college students based on demographic differences such as age, gender, or race?

$H_0$4: There will be no significant difference between asymptomatic colonization rates of MRSA between community college students based on demographic differences such as age, gender, or race.

H_A4: There will be a significant difference between asymptomatic colonization rates of MRSA between community college students based on demographic differences such as age, gender, or race.

Theoretical Base

The theoretical base of this study utilizes the epidemiologic triangle model. This model is based on the interactions of the infectious agent, the host, and environment and is very appropriate for an endemic disease. This model can be thought of as a who, what, and where representation where *Staphylococcus aureus* or MRSA are the "what" or agents, students at College of the Mainland are the "who" or hosts, and the "where" or environment would be the students' contact with people, animals, and objects that all may harbor MRSA. This model helps in the understanding of how the infectious agent spreads. With increased understanding, discovered routes of spreading can be disrupted and reduction in the spread of MRSA could be realized.

Definition of Terms

Beta-Lactam Antibiotics: A group of antibiotics that include all the penicillins and cephalosporins. They contain a very reactive ring that contains 3 carbons and one nitrogen that interfers with cell wall synthesis in bacteria (Talaro, 2008).

CA-MRSA: Community acquired methicillin-resistant *Staphylococcus aureus*, a strain of antibiotic resistant bacteria that is frequently found in the community, such as schools and daycares (Talaro, 2008).

HA-MRSA: Hospital acquired methicillin-resistant *Staphylococcus aureus*, a strain of antibiotic resistant bacteria that is frequently found in hospitals as a hospital acquired or nosocomial infection (Huang, 2006).

MRSA: Methicillin-resistant *Staphylococcus aureus,* a strain of bacteria that is resistant to antibiotics, primarily the beta lactam antibiotics (Talaro, 2008).

MRSASelect: a special type of media that is selective for identifying methicillin resistant *Staphylococcus aureus*. It is manufactured by a company called BIO-RAD (Nonhoff et al., 2009).

MSA: Mannitol salt agar, a type of media that is selective for identifying the bacterium *Staphylococcus aureus* (Leboffe & Pierce, 2006).

Nosocomial: a hospital acquired infection, which develops in patients after 48 hours of admission (Mirza, 2012)).

PFGE: Pulsed-field gel electrophoresis, a method for detecting different types of bacteria by separating their DNA (Talaro, 2008), and used to detect different types of MRSA, particularly differentiating between CA-MRSA and HA-MRSA.

S. aureus: *Staphylococcus aureus*, a common bacterium found on skin and in the nostrils (Heymann, 2008)).

Assumptions

The cross-sectional study took place during the end of the spring semester, 2011, the summer semester, 2011, and the first part of the fall semester, 2011, with the assumption that the hands-on students had been in a program for at least a full semester and had enough exposure to patients or clients in clinical settings to increase their exposure to MRSA if it is going to increase.

Another assumption was that students were honest and accurate when they answered the questions on the questionnaire they filled out when they had their nasal swabbing done.

Limitations

The ideal design would have been a prospective study with a cohort of students with different majors tested in the fall and then again at the end of the spring semester. Because of the attrition of students from the fall semester to spring semester and the sample size needed for significance being 1,000, this was not possible. A cross-sectional study was performed over the course of the late spring semester, summer, and through the first part of the fall semester due to the time involved of testing 1,000 subjects.

Scope and Delimitations

The study only sampled community college students that were enrolled during the spring, summer, and/or fall, 2011 at a small community college in Texas. The student population is racially diverse, but most of the students come from low socioeconomic backgrounds. The population may not be reflective of all community college students in the United States. The sampling occurred in the latter part of the spring semester, over the summer, and in the early part of the fall semester so if there is a seasonal component of MRSA colonization or a temporal component as a student progresses through a program in school, that was not detected in this study. The study was funded solely by the student for the purpose of completing the dissertation, therefore a prospective cohort study was not feasible.

Significance of the Study

This study provided valuable information about who is colonized with MRSA among the healthy adult population, and shed further light on who might be more likely to be colonized with MRSA based on exposure level to other people as well as known

risk factors. MRSA, particularly CA-MRSA, is an emerging problem in many communities. Knowing the risk when one gets a pedicure or goes to a gym or a healthcare facility and further knowing what to look for during the early stages of infection can reduce the morbidity and mortality. An increase in awareness in how to prevent infections can benefit everyone. For example, not shaving the legs 24 hours before a pedicure dramatically decreases the risk of bacteria from entering the body, and would reduce the chances of a MRSA infection (Vanderhelden, 2008) Making the public aware of such simple steps to avoid infections would promote positive social change. Professions, such as cosmetology and nursing, could be more careful about infection control. Students going through such programs should be protected from infection from their contacts with people and should learn the importance of prevention and should strictly adhere to guidelines for prevention of the spread of diseases. If all professionals adhered to the infection control guidelines religiously and the consumer was aware of what they could do to reduce infections such as MRSA, the health of the community would benefit.

Summary and Transition

In summary, staph infections are common and have been common in people for centuries and have been a challenge for healthcare just as long. With the use and abuse of antibiotics, there has been the emergence of MRSA, which has added an even more daunting challenge to healthcare, and in even more recent years, the spread of MRSA through the community with no known risk from prolonged exposure through a healthcare facility has made this even more of an enigma. How common this occurs

without symptoms in healthy adults is not well understood, but some risk factors that may increase the chances of a MRSA infection are playing contact sports, close contact with animals, poor hygiene, overcrowding, and taking antibiotics, especially multiple times (Romano et al., 2006).

This study looked at the asymptomatic colonization of a sampling of healthy college students. The students were sampled from assorted majors, with three major strata. The strata included those students who have a major that involves touching lots of other people, such as nursing, those students that have a major that involves touching shared equipment that many students touch, such as process technology, and those who just come to class and leave and do not have exposure risks associated with their major. Additionally, students were also given a questionnaire that looked at some known risk factors and basic demographics. As one of the risk factors for having CA-MRSA is close contact with people, students with increased contact with people in their academic experience may be more likely to be colonized with MRSA. This study sheds some more light on who might be more at risk in the population to carry MRSA, and this could in turn help with better preventions. Implementation of preventions could begin in the academic career if it is found that certain majors are more likely to carry MRSA, and this could improve the health of the students as well as circumvent subsequent exposure to unexposed patients or clients in the future.

A comprehensive look at *Staphylococcus aureus*, as well as MRSA, including the variants CA-MRSA and HA-MRSA, and gaps in the literature is addressed in Chapter 2. The intricate details of the research design, including further discussion of the media and

techniques, are explored in Chapter 3. The actual results of this study including statistical analyses are found in Chapter 4. The summary, conclusions, and recommendations including implications for social change are found in Chapter 5.

Chapter 2: Literature Review

Introduction

The main intent of this literature review is to compile the current literature on the epidemiology of *Staphyloccus aureus*, focusing primarily on Methicillin-resistant *Staphylococcus aureus*, and to further explore the differences between Community-acquired *Staphylococcus aureus* (CA-MRSA) and Hospital-acquired *Staphylococcus aureus* (HA-MRSA). The epidemiology of the more recently emerging CA-MRSA is researched in greater depth with special emphasis on prevalence, mechanisms of spread, and detection.

The search strategy started with the Walden University Library databases including Proquest Health & Medical Complete, Nursing and Allied Health Source, Journal of the American Medical Association, MEDLINE, and Ovid Nursing Journals Full Text. Initial search terms included: *Staphylococcus* infections, *Staphylococcus* infections AND drug resistance, *Staphylococcus* infections AND public health, MRSA, CA-MRSA, and HA-MRSA. Government websites, including the Center for Disease Control and Prevention (CDC), were also utilized as well as Google. The articles that were used yielded further sources from the cited references. *Control of Communicable Diseases Manual* (Heymann, 2004) and *Foundations in Microbiology* (Talaro, 2008) were also used for general background information on *S. aureus.*

The Epidemiology of *Staphylococcus aureus*

Staphylococcus aureus (S. aureus) has been causing problems for people for many years, even before the drug resistant strains were present. The genus

Staphylococcus can live in high salt conditions, which make it a likely inhabitant on the skin and nostrils, and two common genera are frequently found in humans, *Staphylococcus aureus* and *Staphylococcus epidermidis* (Talaro, 2008). *Staphylococcus epidermidis* rarely causes problems (Talaro, 2008), whereas *S. aureus* can be problematic. There are many virulence factors and toxins that different strains of S. aureus possess and these make this bacterium one of the most common sources of infections in people (Talaro, 2008, pp. 536-538). Most strains of *S. aureus* are coagulase positive, where they cause fibrin to be deposited around the bacterial cell and may allow it to hide from the host's defenses (Talaro, 2008)). Some strains release lipases that allow them to digest oils on the skin and colonize the skin. Some strains release hyaluronidase, which digests the glue that holds the cells together, and allows them to invade into deeper tissues (Talaro, 2008). Another virulence factor that allows some strains to invade is an enzyme called staphylokinase (Talaro, 2008). This helps them digest through blood clots and invade deeper in the host.

Many strains of *S. aureus* release hemolysin that causes red blood cells to burst. This is problematic if the bacteria get into the blood. A few strains release leukocidins that lyse neutrophils and macrophages, which are the body's best defense at getting rid of *S. aureus* (Talaro, 2008, p.537). Most *S. aureus* infections are local, causing an infection of a hair follicle or gland in the skin, and it is usually a draining wound that spreads the infection, although an asymptomatic carrier may be a culprit in transmission as well (Talaro, 2008). Infections can spread from the skin to underlying bone and cause osteomyelitis, or they can become systemic, and cause blood infections, heart valve

damage, pneumonia, septic arthritis, meningitis, and kidney infections (Talaro, 2008, pp. 538-540). Because this bacterium is very tough, and resists drying, and can be viable on surfaces for weeks, it can also be spread by fomites. Long before MRSA, *S. aureus* was a problem in hospitals causing nosocomial infections because it is common in the nostrils, skin, nasopharynx, and sometimes even in the intestines, and it can contaminate a surgical site or be introduced in a colonized catheter or shunt as many are very good at forming biofilms (Talaro, 2008, p. 538-539).

Some strains of *S. aureus* release exotoxins that cause problems in the host (Talaro, 2008). A few strains release an exfoliative toxin that causes the skin to peel, which results in scalded skin syndrome in newborns and contributes to some of the peeling look of impetigo (Talaro, 2008, p. 538-541). Another rare toxin produced by some strains is toxic shock syndrome toxin. The bacteria builds up in gauze packings or tampons, and if the strain can release this toxin, the host develops toxic shock syndrome, which can lead to a rash, dropping blood pressure, and even death (Heymann, 2008). The rash can look like a sun burn, and the palms and soles of the feet can peel (Heymann, 2004, p. 506). The super-absorbent tampons were the worst for promoting overgrowth of *S. aureus* and were removed from the market, but tampons, contraceptive sponges, nasal packaging, and such all need to be changed frequently (Talaro, 2008, p. 540). Another toxin that is released by *S. aureus* is an enterotoxin, and it causes food poisoning. This happens when food is contaminated with a strain of *S.aureus* that can produce this toxin, and it sits off temperature for several hours (Talaro, 2008, p. 539). This is a very common type of food poisoning, with rapid onset of vomiting and/or diarrhea and usually

rapid recovery. The fact that *S. aureus* thrives in salty environments makes this even more problematic since salty foods, like ham, are still subject to growth by this bacterium (Talaro, 2008, pp. 539, 820, 821).

Staphylococcal infections are common all over the world, and are more common in areas where good hygiene may be challenging to achieve. People who lack adequate access to soap are at risk as are people who live in crowded conditions (Heymann, 2004, p. 499). Young children, babies, anyone compromised such as diabetics, the elderly, burn patients, drug users, and anyone with a chronic disease like cystic fibrosis are all at increased risk (Heymann, 2004). Warmer weather has also been linked with increasing infections (Heyman, 2004, p. 499). Spread can be from fomites as well as a draining pustule, hands, or—rarely—through the respiratory system. People as well as some animals can be a reservoir for *S. auerus*, which will be further discussed with CA-MRSA (Heymann, 2004, p. 499). Good hygiene helps with prevention of infections as does not sharing razors and towels and such (Heyman, 2004, p. 499). Regular hand washing is very important in prevention, and this should be emphasized for everyone, especially for those in health care where this is a major cause of nosocomial infections. Incision and drainage may be sufficient to treat boils and similar infections, but if antibiotics are used, they should be sensitivity tested and the patient should be compliant in their usage (Heymann, 2004, p. 505). Additionally, everything should be cleaned thoroughly because this bacterium can live for weeks on the surface of fomites, and IVs should be changed every 48 hours due to the ability of this bacterium to colonize via biofilms (Heymann, 2004, p. 505).

An Overview of HA-MRSA and CA-MRSA

As stated earlier, with the overuse and abuse of antibiotics, MRSA was born (source, publication date). Now, there are two different types of MRSA, HA-MRSA and CA-MRSA with different characteristics and some distinctive differences in their epidemiology. HA-MRSA has been around longer, causing problems for hospital patients since the 1960s (Klevens et al., 2007). In fact, by 2003 in the United States, over 64% of staph infections in hospitals were HA-MRSA, up from about 36% in 1992 (Klevens et al., 2006). CA-MRSA was first discovered in drug users in Detroit in 1981 (Klevens et al., 2007) and has been an increasing problem in the United States and Canada since then (Nicolle, 2006). This is distinguished from hospital-acquired methicillin-resistant *Staphylococcus aureus* (HA-MRSA), as they have different virulence factors (Giffard & Warner, 2006). Within the last 20 years, CA-MRSA has become an emerging disease worldwide with the potential to become endemic (Kluytmans-Vandenbergh, 2006).

Although there is overlap with hospital or outpatient exposure, CA-MRSA may occur among healthy individuals with no apparent risk factors (Beam & Buckley, 2006). People with poor living conditions, use intravenous drugs, or are incarcerated have a higher incidence, but so do athletes and children attending day care (Gilbert et al., 2006). Other risk factors identified by Tisinger (2008) include being female, being of a race other than European American, having a roommate with CA-MRSA, being a member of the military, having diabetes or a skin disease or current cancer, taking antibiotics within the last 6 months, and having a family member or friend that is employed in health care.

More factors pointed out by Leung-Chen (2008) are being young or old, or having HIV because all of these groups may lack the antibodies needed to resist infection. Leung-Chen (2008) also pointed out the risk of sharing personal items like a towel or a razor. Huang et al. (2006) suggested injection drug users may be an important reservoir for CA-MRSA because they found almost half of the people in their study who had CA-MRSA were injection-drug users. CA-MRSA can be distinguished from HA-MRSA by testing for antibiotic resistance and pulsed-field gel electrophoresis (Talaro, 2008). CA-MRSA normally is resistant to only the beta-lactam antibiotics and erythromycin and using pulsed-field gel electrophoresis (PFGE), demonstrates patterns of USA 300 and USA400, the main clones in the United States (King et al., 2006). USA1000 and USA 1100 have also been associated with CA-MRSA (Klevens et al., 2007). HA-MRSA shows much more diverse multidrug resistance, and patterns on PFGE are USA100, USA 200, and sometimes USA500 (Klevens, et al., 2007). In addition, many of the CA-MRSA strains have a gene for Panton-Valentine leukocidin, which codes for a toxin that destroys white blood cells (King et al., 2006).

HA-MRSA is more common in older people, especially over age 65 (Klevens et al., 2006). Major risk factors for HA-MRSA are recent hospitalization or surgery, undergoing hemodialysis, having an implanted medical device, living in a long-term care facility like a nursing home within the last 12 months, taking antibiotics recently, or having a family member with HA-MRSA (Tisinger, 2008). One study found viable MRSA on the outside of a sterile package after more than 38 weeks (Dietz et al., 2001).

The hardiness of this bacterium combined with compromised hosts makes this a challenging adversary in a hospital environment.

According to Beam and Buckley (2006) one problem with studying CA-MRSA is the lack of a standardized definition. There are up to eight different definitions, and the term *community associated* is sometimes used. Molecular typing may help with the development of a consistent definition. Another area that needs attention is the transmission of MRSA between healthy people and what the risk factors are for transmission (Beam & Buckley, 2006). The incidence of carriers in the community at large is unknown according to Romano et al. (2006). Normally, the CA-MRSA cases are identified when someone enters a hospital or goes to a clinic with a soft-tissue infection (King et al., 2006). King et al. looked at demographic factors such as age, gender, and race, hospitalization within the past year, HIV status, history of MRSA, and antibiotic therapy, but did not look at incarceration or day care attendance, stating that these need to be explored. Purssell (2003) further identified chronic disease, surgery, endotracheal intubation, and household contact with someone with MRSA as additional risk factors. Interestingly, Tacconelli et al. (2004) studied 254 patients with MRSA and none of these turned out to have true CA-MRSA.

In a study by Collignon et al. (2005) in Australia, they found that bacteremia caused by *Staphylococcus aureus* was common. Even before MRSA, in young patients without antibiotic intervention, the mortality was over 80%. Even with antibiotic intervention, the median mortality rate for MRSA bacteremia is 34% (Collignon et al., 2005). The median mortality is still 25% for strains of *S. aureus* that are sensitive to the

beta-lactams (MSSA). This demonstrates how serious an infection with any version of *S. aureus* can be if it spreads to the bloodstream. Collignon et al. (2005) found that in Australia, about 25% of all bacteremia due to *S. aureus* was a MRSA strain, and further discovered about 77% of these were associated with HA-MRSA whereas 23% were CA-MRSA. Collignon et al. also pointed out the Panton-Valentine leukocidin gene is in the CA-MRSA strains in Australia, and how this is associated with abscesses that are subcutaneous as well as the necrotizing pneumonia seen in the United States. They reiterated the long hospital stays (average of over 26 days) and the high cost of treating these patients.

There is also an overlap of CA-MRSA that is finding its way into hospitals. Klevens et al. (2006) found an increasing amount of CA-MRSA strains showing up in nosocomial infections. They found a decrease in the amount of antibiotics to which these strains were resistant compared to the traditional HA-MRSA strains at several hospitals. One thing Klevens et al. pointed out is that regardless of the strain, hospitals need to be more aggressive about identifying and treating patients that are colonized with MRSA, and perhaps make decolonization mandatory. This approach has been successful in a couple of European countries.

The Epidemiology of CA-MRSA as Seen In Actual Studies

As CA-MRSA has been increasing steadily and many diverse risk factors are emerging, a review of several case studies to show how varied the epidemiology of this type is follows. The first cases that were an enigma to the medical profession were four cases of CA-MRSA that proved fatal for four youngsters in Minnesota and North Dakota

(MMWR, 1999). According to a MMWR report (1999), a 7-year-old African American girl died in an urban Minnesota hospital after 5 weeks of being infected. She was originally admitted in July, 1997, with a high fever and pain in the right groin, which turned out to be an infected hip joint. On her third day, MRSA was cultured from her blood and synovial fluid, and she was started on vancomycin. She died from bronchopneumonia, and she had a history of being healthy, and her family members had no employment in healthcare or no one resided in a long term care facility (MMWR, 1999). The next case was a 16-month-old American Indian girl who lived in rural North Dakota. She was admitted to a hospital in January, 1998, with a high temperature, rash, and seizures. She died within just 2 hours of being admitted, and her autopsy revealed MRSA that was also susceptible to other classes of antibiotics, and she had abscesses on the brain, heart, liver, kidneys, and MRSA in the meninges, lungs, and blood (MMWR, 1999). She also had no family members who worked in healthcare, lived in a long term care facility, or had been hospitalized in the previous year. The next case was a 13-year-old European American girl who lived in rural Minnesota (MMWR, 1999). She was admitted to the hospital in January, 1999, with a fever, respiratory distress, and blood in her sputum. She died within 7 days after being moved to a pediatric hospital and put on vancomycin. She too, had MRSA that was sensitive to other classes of antibiotics, had been healthy, and had no family members that worked in health care or lived in a long term care facility. The last case was a one-year-old European American boy who lived in rural North Dakota. He was admitted to the hospital in February, 1999, for bronchiolitis, vomiting, dehydration, high fever, and rash (MMWR, 1999). He also was started on

vancomycin after being transferred to ICU, but he died from pneumonia the next day, and multidrug-susceptible MRSA was cultured from blood after he died, and it was discovered he had necrotizing pneumonia. He, too, was healthy, and no family members had risk factors for MRSA, but his 2-year-old sister had been treated for a skin infection 3 weeks before which was confirmed as MRSA (MMWR, 1999). The MRSA was identical in both of the siblings. Up to this point, most MRSA cases were nosocomial (MMWR, 1999), and the ones that did show up in the community were seen in injection drug users or people that lived in long term care facilities (MMWR, 1999). These were unusual, in that they all involved healthy children with no known risk factors and proved fatal. Because the cases showed diversity in race and rural/urban locals, CA-MRSA colonization may be widespread (MMWR, 1999). Perhaps the wide-spread use of beta-lactams and cephalosporins in young children may be a factor in the evolution of this strain of MRSA.

Baggett et al. (2004) did a study of a CA-MRSA outbreak in southwestern Alaska. The population was mostly Eskimo, and the outbreak began in May of 1999. Thirty-four cases were studied from one village, and they all had CA-MRSA. Twenty-four of these had no healthcare exposure in the preceding year, and the other 10 had been either hospitalized or underwent surgery. All had CA-MRSA from the outbreak proven by pulsed-field gel electrophoresis, and the regional hospital had not had a nosocomial MRSA infection in the 3 years before the investigation. Risk factors included being colonized by MRSA or having a family member colonized by MRSA, use of a sauna that was used by someone with MRSA, and using antibiotics within the last year. Apparently,

MRSA can form a biofilm on the wood in the sauna, which allows it to survive the extreme heat and it can be transmitted to other hosts. More than half of the skin infections in this outbreak occurred below the waist, with 20% infecting the buttocks (Baggett et al., 2004). Contributing to this outbreak was the use of antibiotics that select for strains that have the PantonValentine Leukocidin gene. A response to this was the education of medical staff to only use antibiotics for severe infections and reduce overall use of antibiotics. The interaction of MRSA possessing the Panton-Valentine Leukocidin cytotoxin and antibiotic use is probably a contributing factor in other outbreaks as well.

Another environmental source for MRSA recently discovered was salt water (Laino, 2009). Studies of beaches in South Florida and Puget Sound in Washington revealed samples containing *Staphylococcus aureus* including some MRSA strains (Laino, 2009). This was unexpected but plausible because *S. aureus* can tolerate salty environments. The bacteria was also in the sand, so suggestions to avoid infections include getting all the sand off skin, showering after a swim in the ocean, and keeping cuts bandaged if playing in the sand (Laino, 2009). Any sign of infection in an abrasion after a trip to the beach warrants a follow-up with the doctor. The MRSA strains identified were normally those associated with HA-MRSA (Laino, 2009).

Someone can get CA-MRSA from an unhygienic tattoo, which Long et al. (2006) supported in their study of the role of unlicensed tattooists in the spread of Community-associated Methicillin resistant *Staphylococcus aureus.* The authors went through an introduction of where CA-MRSA is usually found and went through a study of three states where MRSA is reportable and where clusters were linked to unlicensed tattooists.

The cases were all reported to the local health departments by hospital infection-control practitioners in six communities in three states. There were 34 primary cases and 10 secondary cases, which were well-defined. The patients were split out as to age, gender, race, and underlying risk factors. Only one had a known risk factor, hepatitis C. They also studied the severity of the infection, with most being mild to moderate, and four requiring hospitalization with intravenous vancomycin. The 34 who were primary cases, contracted at or near a new tattoo site, were interviewed. The personal interviews were revealing. All tattoos were done by unlicensed tattooists, using home-made tattoo equipment, and they did not follow standard sterile procedures. Several patients recalled seeing sores on the tattooist's hands, and several of the tattooists had recently been incarcerated (but none of the patients had been), which is a risk factor for contracting CA-MRSA. The evidence was clear that getting a tattoo from an unlicensed tattooist is risky, and contracting CA-MRSA is one of the risks. The bacteria were confirmed to be CA-MRSA in four out of the six clusters by using Pulsed-field gel electrophoresis (PFGE). The ones that were confirmed were all a strain known as USA300. The other two clusters were tested using antibiotic sensitivities. The authors also pushed for increased education on the risk of using an unlicensed tattooist.

Hinkley and Allen (2008) reviewed a case study of a boy, 4, and his bout with CA-MRSA that had persisted through several treatments with antibiotics, exacerbated by his noncompliance with taking the medicine to treat his infection. His parents also became infected from his lesions, and he was finally hospitalized and put on IV antibiotics. Hinkley and Allen (2008) also did an extensive literature review and further

studied 1,100 MRSA cases, and they noticed CA-MRSA affected a younger population (average age 23 years), and was more common in non-White individuals with lower incomes (than the more well known HA-MRSA). Some of the risk factors that they identified for CA-MRSA were use of antibiotics, especially used multiple times, playing contact sports, abrasions on skin and skin-to-skin contact, poor hygiene, overcrowding, contact with fomites, institutionalized, and being indigenous. They summarized that many of these cases were children seeking help from their pediatricians with skin infections, and the pediatrician should culture the bacteria and test for sensitivity, and realize it could be CA-MRSA. Education on hygiene and hand-washing are important in controlling this as well as follow-ups for the patients.

Cook et al. (2007) discovered heterosexual transmission of CA-MRSA in Manhattan. Prior to this, sexual transmission was thought to be exclusively associated with men who had sex with other men. Initially, a random phone survey was done with 1,142 individuals, and 476 households agreed to complete a survey and submit a nasal swab, which found less than 1% carried CA-MRSA. This was inconsistent with local findings, so an additional study was done using 114 households that had a person diagnosed with CA-MRSA. They were studied longitudinally at 3 month intervals, and discovered that the nasal areas were free of CA-MRSA but the pubic area was colonized by CA-MRSA and it could be transmitted to a heterosexual partner. They were all USA300 strains, which is consistent with CA-MRSA. This study brought up the important point that colonization may not be all over the body, and CA-MRSA strains may prefer the pubic area to the nasal passages. Traditionally, the nasal passages are

tested, and this may not provide the overall colonization. Two other important issues brought up by Cook et al. were the facts that some people are colonized by CA-MRSA and have no health problems but still pass on the bacteria to others, and if one patient is treated for CA-MRSA, their sexual partner also needs to be treated because they saw several cases of patients passing it back and forth when both were not treated. This was the first study that linked transmission in heterosexual couples.

Another source of CA-MRSA is contact with animals. Tisinger (2008) stated that transmission can be from people to animals or vice versa, and can be from the family pets, such as dogs, cats, rabbits, and horses. This is yet another risk factor for CA-MRSA. In a study in England by Baptiste et al. (2005), they found dogs carried MRSA in nares and in feces, and they documented MRSA transmission between dogs and people, and it was identified as EMRSA-15, a human epidemic strain. This implies dogs can be a reservoir for MRSA. Furthermore, dog owners and veterinarians and their staff may become infected by dogs. Veterinarians also should be aware that antibiotic choices for this infection are limited. Dogs with pyoderma, external ear infections, recurring urinary tract infections, any implanted device, or postsurgical wound infections may have MRSA, with rates being as high as 38% (OSU, n.d.). Lefebvre and Weese (2009) discovered that pet therapy dogs picked up MRSA from patients in a long-term care facility in Ontario, Canada. Cats also may carry MRSA and it may be spread from the cat to the owner, or vice versa. One study found a cat and the owner both infected with the USA 300 strain of MRSA, a common CA-MRSA strain (AVMA, 2009).

Another study in Canada demonstrated that horses and people could carry a rare Canadian MRSA clone, which was seen at a thoroughbred farm and the equine hospital they used (Weese et al., 2005). In the study by Baptiste et al. (2005), they found five different equine MRSA strains, which implies MRSA occurs in the horse population, and could represent another reservoir of MRSA that could be spread to people. Even zoo animals can get MRSA (AVMA, 2009). An elephant calf tested positive for USA 300 MRSA when it had skin pustules, but three of the zoo workers also were colonized with USA 300 MRSA, and the transmission was an example of a reverse zoonotic transmission (AVMA, 2009).

Huijsden et al. (2006) investigated the family of a baby who tested positive for CA-MRSA. They actually tested the family, coworkers (the family had a pig-farm), and 10 pigs. Three family members, three people who worked on the farm, and eight pigs tested positive for CA-MRSA, and it was all the same strain. A further study done in the Netherlands by van Belkum et al. (2008) revealed one strain of MRSA, ST398, that was found in nares of pigs in slaughterhouses also overlapped with MRSA that was carried by pig farmers when they were tested in the hospital. This strain appears to be porcine, but can easily spread to people and cause invasive as well as superficial infections. This could spread to the community at large (source, publication date). Khanna et al. (2008) studied pigs and pig farmers in Ontario and found a respective colonization rate of 25% and 20% respectively. In this case, the strains were ST398 and USA 100. USA 100 is another common CA-MRSA strain. In two U.S. facilities results were dichotomous. One older facility had colonization of pigs at 70% and workers at 64% whereas a newer

facility with pigs from a different source had both swine and humans testing negative for MRSA colonization (AVMA, 2009). The type found in the U.S. facility that had MRSA was ST398, and some of these pigs came from Canada, which may have been the source.

Another study involved the spread of CA-MRSA from a beauty salon (Huijsdens et al., 2008). This study was done in the Netherlands, where MRSA rates are low (2%) and MRSA is not mandatorily reportable. A woman beautician had a reoccurring MRSA infection first identified in December, 2004. She had recurrent infections on her lower body, and MRSA was identified on a swab of an abscess on the genital area in July, 2005. She was treated, declared MRSA-free in December, 2005, but was found to test positive for MRSA in March, 2006. At that time, she also had eczema and was advised to stop servicing customers.

Two customers, now both MRSA positive, were linked back to the beautician, at a time when the beautician had an infected axillary hair follicle (Huijsdens et al., 2008). Both the customers had wax treatments, so infection control came to the salon, reviewed the importance of disinfecting tools and cleaning the rooms, and also tested the wax, waxing tools, and the waxing room. They also tested six employees and 22 regular customers. Interestingly, all six employees, 19 of the regular customers, and all environmental swabs were free of MRSA. Upon observation of the beautician actually waxing a customer, one source of transmission was discovered. The beautician removed her gloves, touched the skin to feel for remaining hairs but did not wash her hands before touching the customer. This newly waxed, tender skin would be an opportune site for MRSA to colonize.

After the initial investigation, more contacts, including family members, roommates, and secondary contacts were screened. Of a total of 45 tested with either direct or indirect contact with the index case beautician, 11 were found to be MRSA positive, including the beautician and the two customers (Huijsdens et al., 2008). Others included a family member of the beautician, a roommate, partners of a roommate as well as a customer, someone who worked out with one of the customers and his partner. They all had the same strain. The average age was 29 years, which is consistent with CA-MRSA occurring in younger people. From this, it could be concluded that CA-MRSA could be spread within a household as well as between heterosexual partners.

CA-MRSA can also be spread at nail salons. According to Watson (2006), MRSA that can be found in nail salons can be very aggressive and cause open sores, and even death. This may take months of antibiotics to control, if it is controlled. One 46 year-old woman from Fort Worth died after having a pedicure (Watson, 2006). She had mentioned to a friend while receiving the pedicure that she saw blood in the whirlpool after she cut her foot on the pumice stone. She was then treated for 7 months with antibiotics, both orally and intravenously, and then she died. Shaving the legs before a pedicure also puts one at risk for a staph infection because this causes tiny abrasions on the skin (Vanderhelden, 2008). As many women shave their legs before a pedicure, this makes them more vulnerable to infection. The state of California started a new law that requires salons to clean and then disinfect whirlpools used for foot treatments for 10 minutes between customers (McGreevy, 2008). According to McGreevy (2008), inspectors have found salons in noncompliance, and they are fined and put on probation.

As there are 18 inspectors and 40,000 salons in the state of California, the inspectors have a challenging job ensuring the safety of consumers by enforcing the compliance of disinfection of whirlpools for the needed time.

Changing the rules to make reporting of MRSA mandatory could help identify outbreaks earlier and intervention may be more successful. Jobs where people touch other people and have a MRSA infection may be one source of the spread of this disease (Heymann, 2008). Making sure all equipment is sterilized or disinfected and any surfaces where customer's skin comes in contact with it should be cleaned. As people and some of these professions become more aware of the risks of MRSA, more precautions will be taken to prevent the spread.

MRSA and College Students

MRSA, particularly CA-MRSA, is more likely to occur in healthy young adults where crowding is common (Weiner, 2008). Dormitories and other aspects of the college experience, such as increased sexual activity, crowding, lapses in cleanliness, and increased exposure to contaminated surfaces, may increase the risk of exposure and subsequent colonization by CA-MRSA (Weiner, 2008). College athletes particularly football players, wrestlers, and fencers, are vulnerable to outbreaks of MRSA (Weiner, 2008). Although the U.S. population in general has a colonization rate of MRSA at less than 1%, a couple of studies looking at MRSA colonization rates among healthy college students have found higher percentages (CDC, 2007; Morita et al., 2007; Rohde et al., 2009).

Morita et al. (2007) tested 95 healthy community college students and five healthy faculty members for *S. aureus* and MRSA at a Hawaiian community college, and the participants were also surveyed for risk factors. After testing, 33 were positive for *S. aureus* colonization (33%) and of those, three (3%) carried MRSA (Morita et al., 2007). Risk factors that were explored by Morita et al. (2007) were ethnicity, gender, prior *Staphylococcus aureus* infections, recent antibiotic use, pets, and exposure to saltwater. There were no significant findings between risk factors and colonization (Morita et al., 2008), but they suggested a need to test a larger sample size and include strain typing.

Rohde et al. (2009) tested 203 healthy four-year college students at a senior university, Texas State University, and these participants were also surveyed for risk factors. After testing, 60 tested positive for *S. aureus* (30%) and of those, 15 (7.4%) carried MRSA (Rohde et al., 2009). Risk factors that were explored by Rohde et al. 2009) were gender, ethnicity, skin infections in the last 12 months, hospitalized or surgery in the last 12 months, antibiotics use in the last 3 months, intravenous drug use in the last 12 months, currently living in a dorm or lived in a dorm in the last 6 months, been in jail in the last 12 months, and participated in athletics in the last 12 months. The two risk factors that proved statistically significant were recent skin infections and hospitalization in the past 12 months (Rohde et al., 2009) and they also pointed out the need to make university personnel aware of the possibility of outbreaks of MRSA and the gap in knowledge that still exists concerning the epidemiology of MRSA.

Two other Texas universities were studied with mixed results. A study done at Baylor led by Adair explored 736 students, and found 149 (20.2 %) were colonized by *S.*

aureus, and of those, 7 (0.95%) carried MRSA ("Study Measures Staph," 2009). In a study by Rawls et al. (2010) at McMurry University, 105 students were studied, and 5.7% were colonized with MRSA. The significant risk factors in this case were playing intramural sports, being a male under 25, and living in the dormitory (Rawls et al., 2010).

A study exploring risk factors for football players was done by Begier et al. (2004). Sports teams, especially football, have seen a rise in CA-MRSA in recent years. In this study, risk factors were closely analyzed among players infected and those that were not. There were 10 cases of CA-MRSA among 100 college football players from August 6 to October 1, 2003. All of the cases were males between the ages of 17 and 22. Two cases had to be hospitalized, and all cases either had abscesses or cellulitis. All were confirmed as MRSA USA300. Players who had turf burns from artificial turf were 7 times more likely to be infected. Body shaving for cosmetic reasons also played a role, and interestingly the players that shaved the genitals or groin were at much higher risk for picking up an infection versus shaving other areas of the body. Furthermore, when players were swabbed for colonization, the axillae and groin grew MRSA in some when the nostrils showed no presence of MRSA. The groin colonization supports other studies that suggest the possibility of spread through sexual activity. The player position was also a risk factor with positions such as defensive backs and cornerbacks being more at risk due to the most direct contact during scrimmages. Use of the whirlpool two or more times a week increased the risk as well, and upon closer investigation, it was discovered the whirlpool was not disinfected properly or drained regularly. It was treated with a little povidone-iodine in the morning and drained at the end of the day. Other

contributing factors were no soap in the showers, towels washed in water that was not hot and not with bleach, and wound coverage left up to the players. After antibacterial soap dispensers were made available in the showers, towels were washed at or above 71 degrees C, and players were advised to shower and attend to any turf burns and cuts right after practice the MRSA infections stopped. The outbreak ended with implementation of these suggestions with the strongest correlation being the addition of soap dispensers.

Recommendations for Management of Staph and MRSA in the Community

In response to the escalating problem of *Staphylococcus aureus* infections, including MRSA, the CDC (2008) has made numerous recommendations. Many of these are common sense and include covering an infection with a bandage and washing hands regularly with soap and water or alcohol-based sanitizer, which should be done every time a bandage is changed or someone touches infected skin. Surfaces that someone is likely to come in contact with skin should be the focus of cleaning and disinfecting. If equipment can not be cleaned due to damage like in a locker room, it should be discarded. Objects should be cleaned and disinfected in areas where staph could be a problem. Disinfectants usually do not work as cleaners also, so the directions on a disinfectant should be followed. Some require a contact time for a given length of time, and this should be adhered to for maximum effectiveness. Disinfectants are potentially hazardous and may cause skin, eye or respiratory irritations. Therefore, when they are used, the eyes and skin should be protected and the area should be well-ventilated. Disinfectants are not designed to be used to treat a skin infection; they are designed for inanimate objects (Talaro, 2008). EPA-registered disinfectants are the best choice, but

household bleach can be used, but follow the directions on the container. Bleach should not be used full strength and should not be mixed with other cleaning products, like ammonia, which can create dangerous gases (Talaro, 2008). Some surfaces, like electronic equipment surfaces, may be damaged by disinfectants (Talaro, 2008). Therefore, ideally computer keyboards and similar potential fomites should have a cleanable thin cover over them that can be cleaned if they are used by numerous people.

If an individual is coming in contact with a surface of questionable cleaning and disinfecting history like surfaces in a gym, it is best to shower right after surface exposure or direct-contact exposure with another person (Beam & Buckley, 2006). Hands should be cleaned regularly. Many health clubs have added the gel-sanitizers for easier compliance. Any kind of sports equipment should be cleaned according to the manufacturer's guidelines and allowed to dry. The CDC (2008) recommended laundering in water as warm as the clothing or detergent label instructs. However, after reading the study by Begier et al. (2004), it could be concluded that towels and such should be washed in hot water, and not shared, and not probably reused without washing. Additionally, not sharing personal items that contact the skin like razors was also suggested. Further suggestions for prevention found in Leung-Chen (2008) include washing gym clothes after each use and towels and bed linens with bleach if possible and using a hot dryer, getting medical attention quickly when a skin infection has draining pus or does not heal, and using antibiotics as prescribed, which means not stopping a few days after starting when someone feels better or not sharing the antibiotics, because this promotes antibiotic resistance in bacteria.

Recommendations for Clinical Management of MRSA

A panel of more than 30 MRSA experts came up with the following recommendations to control MRSA in the clinical setting (Gorwitz et al., 2006). First, patients that have mild to moderate skin infections should be treated with incision and drainage, without using antibiotics. Antimicrobial therapy may be appropriated for infections that can not be controlled by incision and drainage, but clinicians should consider sensitivity test results and the susceptibility of local MRSA strains. Intravenous vancomycin is usually the drug of choice for HA-MRSA but there are some hospitals with vancomycin-resistant *S. aureus* strains. Other antibiotics may be good choices for CA-MRSA, like trimethroprim-sulfamethoxazole, minocycline, doxycycline, and clindamycin. Currently, there are no guidelines for someone who is colonized by MRSA, but when infection is spreading to members of the same household or someone has a reoccurring infection, then treatment with mupirocin ointment in the nasal cavity and an antiseptic like chlorhexidine bath as a body wash may be advisable. In a healthcare environment, adhering to strict infection control measures is critical because MRSA spreads from contaminated hands or fomites. Fomites can include patient charts and even curtains, so cleaning and disinfecting everything is important. Good hand washing and disinfecting of medical equipment between patients is critical (Gorwitz et al., 2006).

Siegel et al. (2006) pointed out how important administrative support is in the controlling of the spread of MRSA and other multidrug-resistant organisms. Reduction of MRSA has been seen in healthcare facilities that use aggressive and sustained control interventions like preemptive use of contact precautions as soon as a patient is admitted

until there is a proven negative culture (Siegel et al., 2006)There needs to be economic and personnel support for the needed surveillance, education, enhanced cleaning of the facility, and improved communication between facilities and between the facility and the patient. A challenge for this is the overcrowding and understaffing that is seen in many facilities in the United States and worldwide, which makes MRSA infections harder to contain.

Discussion of Methods

Methods for detecting *Staphlyococcus aureus*

Mannitol Salt Agar was used to detect *Staphylococcus aureus* colonization. Mannitol Salt Agar contains 7.5% sodium chloride that inhibits bacteria except the genus *Staphylococcus* (Leboffe & Pierce, 2006). Mannitol Salt Agar also contains mannitol, a carbohydrate, and phenol red, a pH indicator. Pathogenic *Staphylococcus aureus* ferments the mannitol and turns the media bright yellow, where nonpathogenic strains of *Staphylococcus*, like *Staphylococcus epidermidis*, do not ferment mannitol, and the colonies grow, but look pink (Leboffe & Pierce, 2006).

Kateete et al. (2010) compared Mannitol Salt Agar, DNase agar, and coagulase tests for sensitivity and specificity. These methods are all methods of choice when economic resources are limited. Kateete et al. (2010) found Mannitol Salt Agar (MSA) the most sensitive (94% sensitivity), while the tube coagulase test had a sensitivity of 91% for human plasma, and the DNase test had a sensitivity of 75%. The results for specificity were best for the DNase test (96%), while the MSA showed 79% specificity, and the coagulase test using human plasma was 11%. MSA was the best single identifier

with a sensitivity of 94% and a specificity of 79%, and was chosen as the method of choice for this study. MSA plates were inoculated with nasal swabs and incubated for 48 hours at 37 degrees Celsius. Bright yellow plates and colonies were assumed to be *Stapylococcus aureus*.

Methods for Detecting MRSA Colonization

MRSA*Select* media is a type of chromogenic media that detects MRSA with excellent sensitivity (Nonhoff et al., 2009). Nonhoff et al. (2009) compared three chromogenic media, chromID MRSA, MRSA-Screen, and MRSA*Select*. All three media had sensitivities greater than 95%, and results on all three were improved when enrichment broth media was used first. MRSA-Select had 85% specificity when enrichment was used first (Nonhoff et al., 2009). MRSA*Select* plates were inoculated with nasal swabs and incubated for 48 hours at 37 degrees Celsius. Plates that exhibited the characteristic mauve colonies were assumed to be MRSA.

van Loo et al. (2007) compared MRSA*Select* with the traditional screening method for the detection of MRSA including a Columbia agar plate with 5% sheep blood and 2 micrograms of ciprofloxacin per milliliter, an MSA agar plate with 4 micrograms of oxacillin per milliliter, and an enrichment broth containing Mueller-Hinton broth, 6 micrograms of oxacillin per milliliter and 6 micrograms of aztreonam per milliliter. The MRSA*Select* showed a sensitivity of 78.6% and specificity of 99.5% whereas the traditional screening showed a sensitivity of 78.6% and a specificity of 100%. The MRSA*Select* agar was chosen for the clarity of interpreting results.

Summary

Staphylococcus aureus with all its virulence factors has been a burden for healthcare for years, and with the development of the MRSA strains, healthcare and public health have a serious challenge facing them. Now, the community, including college students, may be the next target. MRSA infections can make the cost of a hospital stay escalate to $14,000 from the average $7,600 (Thomas, 2009). Serious MRSA infections lead to about 19,000 deaths in the United States annually (CDC, 2007). Healthcare workers should take infection control to heart, especially changing gloves and hand-washing between every patient. According to Leung-Hen (2008), in 2007, there were 1.2 million MRSA infections among hospital patients in the United States. Timely detection is critical for healthcare personnel so an effective antibiotic can be used in the early stages of disease. Responsible use of antibiotics, including in healthcare and in the agricultural industry, will need to be implemented.

Because there is such a strong link between healthcare and MRSA, college students that work in healthcare, have had recent surgical or hospitalization history, or have educational components that expose them to hospitals and patients through nursing clinicals may be at increased risk for becoming colonized with MRSA. Those students who have taken antibiotics recently or have had a skin infection in the recent past may also be at risk for MRSA colonization.

A large gap in knowledge is the extent CA-MRSA is found in the community, including among college students, and how it is transmitted (Morita et al., 2007; Pursell, 2003; Rohde et al., 2009). The CDC (2007) estimated that about 32% of the U.S. population is colonized with *Staphylococcus aureus* and about 0.8% are colonized with

MRSA. College students appear to have a significantly higher colonization rate, as high as 7.5% (Rohde et al., 2009). Beam and Buckley (2006) suggested that to help control CA-MRSA among college athletes, more studies determining risk factors and prevalence among athletes need to be done. *Staphylococcus aureus* is a hardy bacterium that may live for days to weeks on fomites, so this may be an important source of transmission.

In addition to healthcare related risks, other logical risks to explore among college students were their involvement in sports. Beach activities were also considered because of the recent link between MRSA and beaches, and the college in this study is only 15 miles from Galveston, and some of the student body surfs or frequents the beaches there. College curricula is different between majors with different exposures to shared equipment and exposure to handling other people, so this too was explored to see if there was a difference in MRSA colonization between college majors. Specifically, college majors involving touching people, or touching shared equipment, or not doing either of these as part of their curricula, were compared. Because MRSA is more common in young people, exploring risks that are more popular among young adults were also explored including pedicures and manicures and tattoos. Pets and small children have also been implicated as possible reservoirs for MRSA, so these were also included in risk factors.

This study involved sampling the healthy student population at a small community college in Texas and detecting the prevalence of asymptomatic *S. aureus* and MRSA colonization. By studying asymptomatic MRSA colonization in healthy college students, I hoped to bridge the gap that exists in the knowledge of the prevalence of

MRSA colonization as well as the potential spread of MRSA. By surveying risk factors ranging from curricula exposure, to work and recreational exposure, this study revealed risk factors that are associated with MRSA colonization in college students that have not been previously detected.

Education programs on the importance of good hygiene should be emphasized, with a special push for regular hand-washing. Hand-washing and good hygiene are an important prevention in the community as well as the hospital, and may be an excellent tool in the prevention of MRSA among college students. Given all the potential reservoirs and how hardy this bacterium is, control is more realistic than eradication, but even control will be arduous.

Chapter 3: Research Method

Introduction

This chapter explains the methodology used in this study of determining colonization rates among healthy community college students for *S. aureus* and MRSA and surveying and analyzing risk factors that may be linked with colonization. The section will begin with discussion of why a cross-sectional design was chosen. The setting for the study as well as how sampling was conducted will be explained next. The actual sampling techniques including specialized microbiological media used to identify *S. aureus* as well as MRSA will be described. How the data was analyzed as well as how participants were protected will be further explored. Plans for dissemination of the results of this study will also be shared, followed by a summary.

Research Design and Approach

This study used a cross-sectional quantitative design. In a cross-sectional design, the prevalence of a condition across a sample of the student body is compared with respect to exposure to risk factors (Checkoway et al., 2004). This design is well suited to this study and when performed on students with a semester or more of college, captured data on students who have been exposed to risk factors from curricula after at least a semester of exposure. In comparable studies by Morita et al. (2007) and Rohde et al. (2009), this was also the research design of choice. The drawback of this design is that it may reveal an association between MRSA colonization and a risk factor, but a causal relationship is better determined by a cohort study (Checoway et al., 2004). Additionally,

considering the attrition rate of students and the time factor for a dissertation research project, the cross-section design was found more suitable to this study.

Setting and Sample

The study took place at a community college in Texas. This college had a student enrollment of approximately 4,000 students for the spring semester, 2011. The enrollment represents a mix of academic and work force students, with about 30% of the students being full-time. The average age of the student is about 25 years, with about 60% of the students being female. The student population is ethnically diverse, with about 57% European American, 20% Hispanic, and 20% African American. I am a full-time biology professor at the college and was granted permission by the administration to recruit students who were willing to participate.

Students were sampled over the course of the late spring semester, the entire summer sessions, and through the mid-fall semester, 2011. Instead of recruiting individual students, different classes that are in different disciplines were asked to participate. Faculty were asked for permission to conduct the study at the end of the class, and students agreeing to participate were sampled for *S. aureus* and MRSA and surveyed. The courses were chosen according to college majors, with three different groups being chosen. One group was drawn from classes where students have a clinical or hands on component touching other people. Classes that were included here were the nursing classes, the cosmetology classes, and the emergency medical services classes.

A second group was drawn from classes where students have frequent contact with equipment shared with other students. Classes that were included in this group were

process technology classes, fire academy classes, art classes (mainly sculpting), drafting classes, and welding classes.

The third group was drawn from classes where students do not have a hands-on component touching people or equipment. This group was the more traditional liberal arts majors, and classes that were included in this group were some of the chemistry, English, government, humanities, biology, physics, physical education, mathematics, history, geology, and history classes. Students were recruited that were 18 years of age and older. Students in programs that may increase their risk of exposure to MRSA were only recruited for sampling if they had spent at least one full semester in the program and had already touched either equipment or people as part of their training. This eliminated students who had just started a program and allowed adequate exposure to possible sources of colonization in some of the college disciplines. This study used a stratified sampling method with three strata or subgroups: students who have hands on exposure to other people in their major, students who have hands on exposure to shared equipment in their major, and students who do not have hands on exposure to people or shared equipment in their major. The amount of exposure to other people or equipment may have been a predictor or a confounder, and stratification allowed me to decide after looking at the data and the variables (Hulley & Cummings, 1988).

A sample size of 1,000 was used, in an effort to detect any significant effect of the independent variables. The sample size is based on a multiple regression model. The Alpha level or *p*-value for probability was set at 0.05. The value is used by convention to determine statistical significance. The total number of predictors for this model was 16.

This was determined by considering college major and the other surveyed values. The anticipated effect size (f^2) was set at 0.02 by convention. The statistical power level was set at 0.8. The sample size was then determined using a statistical program from Daniel Soper (2010). The minimum sample size was determined to be 974. I rounded the sample size up to 1,000. Because I used a stratified sampling method with three strata of unequal numbers, I needed to weigh the samples accordingly. Out of the 1,000 sample size, there were 130 from hands on disciplines, 191 from disciplines with shared equipment, and 679 students from disciplines that do not have a hands-on component with people or equipment. This reflects a proportionate sample from each of the strata taking into account the unequal numbers between the strata.

Students were sampled for *S. aureus* and MRSA by using sterile swabs sampling both anterior nares. At the same time, they were also administered a survey to collect demographic and risk factor data (see Appendix). If students were suffering from any type of skin infection or Staph infection, they were excluded from the study.

Instrumentation and Materials

Method for detecting *Staphlyococcus aureus*

Mannitol Salt Agar was used to detect *Staphylococcus aureus* colonization. Mannitol Salt Agar contains 7.5% sodium chloride, which inhibits bacteria except the genus *Staphylococcus* (Leboffe & Pierce, 2006). Mannitol Salt Agar also contains mannitol, a carbohydrate, and phenol red, a pH indicator. Pathogenic *Staphylococcus aureus* ferments the mannitol and turns the media bright yellow, whereas nonpathogenic strains of *Staphylococcus*, like *Staphylococcus epidermidis*, do not ferment mannitol, and

the colonies grow, but look pink (Leboffe & Pierce, 2006). Mannitol Salt Agar (MSA) has been used since 1945 as a selective medium for *S. aureus*, and is well accepted for isolation of *S. aureus* from numerous body sites, including the nares (Kampf et al., 1998).

Method for detecting MRSA

MRSA*Select* agar plates are manufactured by BIO-RAD and used routinely by hospitals and laboratories for the rapid identification of MRSA. MRSA*Select* media is a type of chromogenic media that detects MRSA with excellent sensitivity (Nonhoff et al., 2009). MRSA*Select* agar is cream colored and MRSA colonies will grow as distinct reddish-purple colonies usually within 24 hours. Nonhoff et al. (2009) compared three chromogenic media, chromID MRSA, MRSA-Screen, and MRSA*Select*. All three media had sensitivities greater than 95%, and results on all three were improved when enrichment broth media was used first. MRSA*Select* had 85% specificity when enrichment was used first (Nonhoff et al., 2009). MRSA*Select* agar was also evaluated by Carson et al. (2009), and they looked at 1071 MRSA-positive and 2733 MRSA-negative cultures and found that at 24 hours the MRSA*Select* Agar had excellent sensitivity and specificity for MRSA, and longer incubations were not necessary.

Procedure for using MSA and MRSA*Select* agar

Sterile swabs were used to collect samples in the anterior nares. These were plated onto Mannitol Salt Agar and MRSA*Select* Agar, and grown at 37 degrees Celsius for 48 hours to detect *Staphylococcus aureus* and Methicillin-Resistant *Staphylococcus aureus* (MRSA). On the Mannitol Salt Agar, prolific colonies that grew bright yellow and turned the media bright yellow were assumed to be *S. aureus*. Colonies that exhibit

the characteristic reddish purple colonies on MRSA-Select plates were assumed to be MRSA. Funding for the MRSA select plates, the Mannitol Salt Agar plates, and the sterile swabs were provided by the researcher, using personal funds.

Demographic and Risk Factor Survey

The questionnaire the students completed was a survey of demographic information and additional risk factors. This included demographic information such as age, gender, and ethnicity. Risk factors that were included on this survey included all of the following that were relevant in the last 12 months: pets or close contact with animals, have young children, work out regularly or participate in sports, surf, swim, fish, or frequent the beach regularly, work in a daycare, work in a healthcare facility (including a nursing home), had a skin infection, boil, or sore, been told you have a skin infections called "mersa," MRSA, or antibiotic resistant Staph, been a patient in a hospital, had surgery, had a tattoo, had a professional manicure or pedicure or waxing, or taken antibiotics. Part of the survey was developed and used by Rohde et al. (2009) in a previous study of MRSA and college students and part of the survey was developed by the researcher incorporating questions concerning college majors, pet/animal exposure, exposure to children, leisure activities of surfing and going to the beach, as well as exposure through tattoos, professional manicures, pedicures or waxings. The survey that was used may be found in the Appendix. The data collected can be found in Chapter 4.

Data Collection and Analysis

Each of the research questions with the associated hypotheses from Chapter 1 will be revisited as data collection and analysis techniques are revealed. This will clarify the

sampling and surveying of the students as well as explain analysis for each research question. Each of the variables were tested against MRSA cases using Epi Info software, and were used to answer the research questions 2, 3 and 4 that follow (see Table 1).

Table 1

Variables, Type of Test and Level of Measurement

Variable	Type of Test	Level of Measurement
S. aureus colonization in nostrils	Mannitol Salt Agar	Yes or No
MRSA colonization in nostrils	MRSA Select Agar	Yes or No
Student's College Major	Recruited by enrollment in a course for a variety of disciplines	Major involves touching other people, touching shared equipment, or neither
Student's age	Survey Question	18 and over
Student's gender	Survey Question	Male or Female
Student's race/ethnicity	Survey Question	African-American Asian Caucasian Hispanic Other
Have pets or close contact with animals	Survey Question (All Survey Questions are based on self-reporting are for the last year)	Yes or No
Have young children	Survey Question	Yes or No
Work out regularly or participate in sports	Survey Question	Yes or No
Surf, swim,fish, or frequent the beach	Survey Question	Yes or No
Work in a daycare	Survey Question	Yes or No
Work in a healthcare facility, including a nursing home	Survey Question	Yes or No
Have a skin infection, boil or sore within the last year	Survey Question	Yes or No
Have MRSA or antibiotic resistant Staph	Survey Question	Yes or No
Been a patient in a hospital or had surgery	Survey Question	Yes or No
Taken antibiotics	Survey Question	Yes or No
Had a professional manicure or pedicure or waxing	Survey Question	Yes or No
Had a tattoo	Survey Question	Yes or No

Research question 1: "How prevalent is asymptomatic colonization of MRSA in healthy adult college students in a community college?" was answered by the testing for MRSA by sampling the nasal flora of the students, and growing the bacteria on Mannitol Salt Agar and MRSA*Select* Agar. The results were reported as a percentage of MRSA compared with the total sample, and compared with the average carriage rates in the United States for healthy adults. These data then allowed the ability to reject or fail to reject the null hypothesis. In this case, the dependent variable was MRSA colonization and the independent variable was being a healthy adult community college student.

$H_0$1: There will be no significant difference between the rate of asymptomatic colonization of MRSA among healthy adult community college students and among healthy adults in the United States, which is about 0.8% (CDC, 2007).

H_A1: There will be a significant difference between the rate of asymptomatic colonization of MRSA among healthy adult community college students and among healthy adults in the United States.

Research question 2: "Is there a difference in colonization between different majors, such as those that have hands-on portions for part of their training involving touching other people, like nursing and cosmetology students, and those that use shared equipment, like process technology and computer science majors, and those that have no formal hands-on training or shared equipment?" This question was investigated by comparing colonization rates in these three groups. EpiInfo was used, and a contingency table was used on the inputted data looking at majors that touch other people as part of their training, majors that touch shared equipment as part of their training, and students

who have majors that do not traditionally touch other people or shared equipment as part of their training. The hands-on majors were grouped together because the hands-on people subset had much overlap with shared equipment. The results allowed the researcher to reject or fail to reject the null hypothesis (See Chapter 4) In this case, the dependent variable is MRSA colonization and the independent variable is college major, looking at how much contact a student has with other people and fomites during the training associated with different majors.

$H_0$2: There will be no significant difference between asymptomatic colonization rates of MRSA between community college students that have majors that have training that involves touching other people, like nursing or cosmetology, or students that have training that involves touching shared equipment, like process technology and fire technology, or students who have no hands on component in their training.

H_A2: Students who have majors that have training that involves touching other people, like nursing or cosmetology or students that have training that involves touching shared equipment, like process technology and fire technology will have a significantly higher rate of asymptomatic colonization of MRSA compared to students who have no hands on component in their training.

The research question 3: "Is there a higher incidence in community college students that have been exposed to possible risk factors for MRSA within the last twelve months that include: (a) having pets or close contact with animals, (b) having young children, (c) working out regularly or participating in sports, (d) surfing , swimming, fishing, or frequenting the beach regularly, (e) working in a daycare, (f) working in a

healthcare facility (including a nursing home), (g) having a skin infection, boil, or sore; (h) having been told they have a skin infections called "mersa", MRSA, or antibiotic resistant Staph; (i) having been a patient in a hospital or having surgery, (j) getting a tattoo, (k) having a professional manicure or pedicure or waxing, or (l) taking antibiotics." Were tested using the survey instrument (See Appendix) when the students are surveyed. Each of the questions were inputted into EpiInfo with the other data and linear regressions as well as Chi squares were run with the independent variables to see if any show significance in MRSA colonization. This allowed me to reject or fail to reject the following null hypothesis. In this research question, the dependent variable was MRSA colonization and the independent variables were work exposure, leisure exposure, or other common risk factors listed above in a through l.

$H_0$3: There will be no significant difference between asymptomatic colonization rates of MRSA between community college students that have been exposed to risks and those that have not been exposed.

H_A3: There will be a significant difference between asymptomatic colonization rates of MRSA between community college students that have been exposed to risk factors from their leisure activities, work activities, or healthcare treatments and those that have not been exposed.

Research question, 4: "Is there a higher incidence in community college students based on demographic differences such as age, gender, or race?" This question was tested using the survey instrument (See Appendix) when the students were surveyed. Each of the demographic questions was inputted into EpiInfo with the other data and linear

regressions and contingency tables were run with the independent variables to see if any showed significance in MRSA colonization. This allowed me to reject or fail to reject the following null hypothesis. In the last research question, the dependent variable is MRSA colonization and the independent variables are age, gender, and race.

$H_0$4: There will be no significant difference between asymptomatic colonization rates of MRSA between community college students based on demographic differences such as age, gender, or race.

H_A4: There will be a significant difference between asymptomatic colonization rates of MRSA between community college students based on demographic differences such as age, gender, or race.

Protection of Human Participants

Participation was voluntary and participants signed a consent form. Students were at least 18 years of age to participate and no students were recruited from any of the classes that I taught. The survey and nasal samples were collected at the same time on campus, and were kept confidential. Questionnaires and agar plates were only identified by a number, and no student identifiers were used. As there is no medical intervention when healthy people carry MRSA (Rohde et al., 2009), the study did not include the name or any identifying information on the students that participated. No research was undertaken until I received Walden University IRB approval (#222444555).

Dissemination of Findings

The results were shared at an open seminar at the college during the spring semester, 2012. All students as well as faculty were invited to attend the seminar. I hope

to present a poster during Walden poster sessions that overlap with Walden University commencement, winter of 2012. I plan on collaborating with Dr. Rodney Rohde from Texas State University and share the findings in the Journal of Clinical Laboratory Science.

Summary

The methodology described in this chapter explains the choice of research design and further explains the choice of setting and sample. *S. aureus* and MRSA were detected by the specialized media, Mannitol Salt Agar and MRSA*Select*, respectively. The survey instrument designed for risk factors developed by the researcher was also discussed. Colonization rates as well as analysis of risk factors using various statistical methods were achieved from the study, and some interesting statistically significant factors were identified. Chapter 4 will reveal the results of the inquiry of students at the college under study and their colonization rates of MRSA as well as risk factors.

Chapter 4: Results

Introduction

This study was designed to gain a better understanding of the frequencies and risk factors associated with MRSA colonization among healthy college students. The study involved community college students in Texas who were legal adults who volunteered to answer a short questionnaire as well as swab both nasal passages. The swabs were then used to inoculate Mannitol Salt Agar plates and MRSA Select plates, which are diagnostic for *Staphylococcus aureus* and *Methicillin-Resistant Staphylococcus aureus*, respectively. The media were incubated for 48 hours at 37 degrees Celcius, and the results were then recorded. The questionnaires included basic demographic data along with potential risk factors. The students were sampled from the end of the spring semester, 2011 through the middle of the fall semester, 2011. Over 200 classes from assorted disciplines were solicited with a total of 1,000 students being sampled.

Descriptive Statistics and Analyses

I sampled 1,000 community college students from Texas. The student population that the sample was drawn from was 4,000 students, and the sample was recruited from assorted classes over the course of the end of the spring semester, through the summer, and into the fall semester, 2011. I described the study in classes during the last 10 minutes of class where the professor was agreeable to a allow participation of the class. The participation was strictly voluntary, students filled out a consent form and they had to be at least 18 years of age. No classes that I taught participated. The students were diverse regarding majors and demographic characteristics, with a mix of academic and

workforce students. The student population is 60 % female with an average age of 25– years-old. The student population is racially varied with 57% European American, 20% Hispanic, and 20% African American. About 30% of the students are full-time students.

Research Question 1

How prevalent is asymptomatic colonization of MRSA in healthy adult college students in a community college?

$H_0$1: There will be no significant difference between the rate of asymptomatic colonization of MRSA among healthy adult community college students and among healthy adults in the United States, which is about 0.8% (CDC, 2007).

H_A1: There will be a significant difference between the rate of asymptomatic colonization of MRSA among healthy adult community college students and among healthy adults in the United States.

The asymptomatic colonization rate for the adult community college students was 10.4%, which was considerably higher than the predicted 0.8% (CDC, 2007). Using a Chi Square analysis using the observed values of MRSA compared to expected values using the CDC predicted frequency, the incidence of MRSA among the community college students was significantly higher, with Chi-Square of 85.36, df of 1and $P < 0.0001$. A summary of these results can be found in Table 2. Therefore, I reject the null hypothesis for research question 1. There is a significant difference between the MRSA colonization rate among College of the Mainland students and the MRSA colonization rate among healthy adults in the United States in general. Healthy students in this study have a 14 times greater odds of being colonized by MRSA than the rate predicted for

healthy adults in the United States in general according to the CDC (OR=14.393, 95% CI 6.472-29.711, P<0.0001).

Table 2

Overall frequency of Staphylococcus aureus Colonization and MRSA Colonization Among Students and Predicted Values for Healthy Adults (CDC)

Colonization	Frequency	Percentage	P Value	Odds Ratio
By *Staphylococcus aureus*			0.655	1.022
Healthy Students	511	51.1%		
Predicted Value	300-500	30-50%		
By MRSA			<0.0001*	14.393
Healthy Students	104	10.4%		
Predicted Value	8	0.8%		

Note. *N*=1,000 students *Statistically significant at p<0.01

Research Question 2

Is there a difference in colonization between different majors, such as those that have hands-on portions for part of their training involving touching other people, like nursing and cosmetology students, and those that use shared equipment, like process technology and computer science majors, and those that have no formal hands-on training or shared equipment?

$H_0 2$: There will be no significant difference between asymptomatic colonization rates of MRSA between community college students who have majors that have training that involves touching other people, like nursing or cosmetology, or students that have training that involves touching shared equipment, like process technology and fire technology, or students that have no hands on component in their training.

H_A2: Students who have majors that have training that involves touching other people, like nursing or cosmetology or students that have training that involves touching shared equipment, like process technology and fire technology will have a significantly higher rate of asymptomatic colonization of MRSA compared to students that have no hands on component in their training.

Students who have training touching equipment or other people were categorized together because many of the students who touch people also share common equipment, so it was not possible to separate that effect. The results for colonization among students with different majors can be found in Table 3. Students who had touched shared equipment and/or other people as part of their educational experience had a significantly higher risk of being colonized by MRSA than the students who did not have a formal hands-on component of touching shared equipment or other people. The Chi-Square was 4.09 with 1 degree of freedom and p = 0.0431. Therefore, I reject the null hypothesis for Research Question 2. There is a significant difference between MRSA colonization rates among students who have a hands-on component involving shared equipment and /or people in their formal college training and those students who do not. Students who are in a career path with a component than involves a hands-on component with people or shared equipment have 57% greater odds of MRSA Colonization than majors that do not have the hands-on component (OR=1.567, 95% CI 1.035-2.374, P=0.043.

Table 3

Frequency of MRSA Colonization by Major

Major	n	Frequency of MRSA	Percentage	P Value	Odds Ratio

Hands-on Equipment & Hands-on People	321	43	13.4%	0.023*	1.567
Not Hands-on	679	61	9.0%		
Total	1000	104	10.4%		

*Statistically significant and $p<0.05$

Research Question 3

Is there a higher incidence in community college students who have been exposed to possible risk factors for MRSA within the last 12 months that include: (a) having pets or close contact with animals, (b) having young children, (c) working out regularly or participating in sports, (d) surfing , swimming, fishing, or frequenting the beach regularly, (e) working in a daycare, (f) working in a healthcare facility (including a nursing home), (g) having a skin infection, boil, or sore, (h) having been told they have a skin infections called “mersa”, MRSA, or antibiotic resistant Staph, (i) having been a patient in a hospital or having surgery, (j) getting a tattoo, (k) having a professional manicure or pedicure or waxing, or (l) taking antibiotics.

$H_0$3: There will be no significant difference between asymptomatic colonization rates of MRSA between community college students who have been exposed to risks and those that have not been exposed.

H_A3: There will be a significant difference between asymptomatic colonization rates of MRSA between community college students who have been exposed to risk factors from their leisure activities, work activities, or healthcare treatments and those that have not been exposed.

The risk factors with actual n values, frequencies for the risk factors, and frequencies and percentages of those that carried MRSA are listed in Table 4. Not everyone answered all the questions on the survey, so the *n* value is a little less than 1,000 in each case. The data were analyzed using 2X2 contingency tables for each factor, since they were presumed independent. The risk factors that were statistically significant were close contact with animals and having a skin infection within the last 12 months. Having MRSA was close to being statistically significant but this cell was very small. Therefore, I reject the null hypothesis for Research Question 3. Students who had close contact with animals and students who had a skin infection in the last 12 months had a higher rate of MRSA colonization than students that did not have close contact with animals or a skin infection. Students who had close contact with animals in the last year had 92% greater odds of MRSA colonization than students that did not have close contact with animals (OR=1.920, 95% CI 0.295-0.920, P=0.013). Students who had a skin infection in the last 12 months had 83% greater odds of MRSA colonization than students who did not have a skin infection (OR=1.825, 95% CI 1.161-2.869, P=0.008). Although not statistically significant, students that had a MRSA infection in the last 12 months had 132 % greater odds of MRSA colonization rate than students that did not have MRSA(OR=2.321, 95% CI 0.922-5.840, P=0.072).

Table 4

Frequency of MRSA Colonization by Possible Risk Factors (Exposure was for the last 12 months)

Risk Factor	n (for the question based on responses)	Frequency of Risk Factor	Frequency of MRSA and Percentage	P Value Fisher Exact	Odds Ratio
Close contact with	971	742	88 (11.9%)	0.012**	1.920

animals					
Close contact with children	996	389	43 (11.1%)	0.372	1.094
Work out regularly in a gym / Participate in sports	992	483	47 (9.8%)	0.258	0.855
Surf, swim, fish, or walk on the beach	996	228	26 (11.4%)	0.333	1.189
Work in a daycare	990	24	2 (8.3%)	0.543	0.787
Work in a healthcare facility	994	138	15 (10.9%)		
Have a skin infection	994	199	31 (15.6%)	0.007*	1.825
Have MRSA	979	29	6 (20.1%)	0.072	2.321
Been a patient in the hospital or had surgery	995	254	26 (10.2%)	0.545	0.998
Taken antibiotics	997	544	57 (10.5%)	0.521	1.011
Had a professional manicure, pedicure, or waxing	992	580	53 (9.1%)	0.065	0.728
Had a tattoo	996	145	10 (6.9%)	0.088	0.604

Note. *statistically significant at p<0.01 ** P<0.05

Research Question 4

Is there a difference in prevalence in community college students based on demographic differences such as age, gender, or race?

$H_0$4: There will be no significant difference between asymptomatic colonization rates of MRSA between community college students based on demographic differences such as age, gender, or race.

H_A4: There will be a significant difference between asymptomatic colonization rates of MRSA between community college students based on demographic differences such as age, gender, or race.

Table 5 is a summary of MRSA colonization by demographic data including gender, race, and age. All of these factors proved to be statistically insignificant when they were run as Chi Squares. Therefore, I failed to reject the null hypothesis for Research Question 4. There is no significant difference between students of different genders, races, or ages for MRSA colonization rates. Females had 25% less odds of being colonized by MRSA than males (OR=0.751, 95% CI 0.495-1.137, P=0.101). Students 18 though 24 had 27% greater odds of being colonized by MRSA than students that were 25 years of age or older (OR=1.274, 95% CI 0.844-1.923, P=0.147).

Table 5

Frequency of MRSA Colonization by Demographic Data

Demographic variable	# in Sample	Colonized by MRSA # (%)	P value	Odds Ratio
Gender				
Females	654	62 (9.5%)	0.107	0.751
Males	343	42 (12.2%)		
Race				
African American	163	14 (8.6%)	0.245	
Asian	37	3 (8.1%)		
European American	540	66 (12.2%)		
Hispanic	204	19 (9.3%)		

Other	53	2 (3.8%)		
Age				
18-24	518	59 (11.4%)	0.147	1.274
25 and older	480	44 (9.2%)		

Summary of the Findings

The MRSA colonization rate among this study of healthy students was 10.4 %, which was significantly higher and about 10 times the MRSA colonization rate predicted by the CDC, which was 0.8%. Several other studies that have looked at healthy college students from both community colleges and four-year colleges found the colonization rate higher than the rate for the healthy U.S adult population (CDC, 2007, Morita et al., 2007, Rohde, et al., 2009). The rates found varied between 3% and 7.4% in the previous studies. This study showed a higher rate, but the sample size was much larger in this study.

In this study, three factors were shown to be statistically significant. If the student had a major such as hands on exposure to people and/or equipment, if the student had close contact with animals during the preceding 12 months, and if the student had a skin infection in the last 12 months, the student had a statistically higher risk for being colonized with MRSA. Contingency tables and Chi squares were used to determine statistical significance in all cases. Table 6 summarizes the statistical analysis of the statistically significant risk factors. The other risk factors that were explored that did not statistical significance include gender, race, age, working in healthcare or a daycare, taking antibiotics, having close contacts with small children under the age of 5, working

out in a gym or playing organized sports, swimming, surfing, fishing, or walking on the beach, having a tattoo, or having professional manicures, pedicures, or waxing. Having MRSA in the last 12 months was a very small sample, even out of the 1,000 students who were samples, and the *p*-value was close to being significant with a *p* value = 0.072 and an odds ratio of 2.321. This may have been significant with a higher sample size.

Table 6

Factors Demonstrating Statistical Significance for Increased Risk of MRSA Colonization

Independent Variables	Chi-Square	P-Value Fisher Exact	Odds Ratio	95% Confidence Interval for Odds Ratio	
				Lower	Upper
Major Hands-on Not Hands-on	4.55	0.023	1.567	1.035	2.374
Close Contact with Animals In the Last Year Yes No	5.20	0.012	1.920	1.087	3.391
Skin Infection in the Last Year Yes No	6.95	0.008	1.825	1.161	2.869

Note. P value is statistically significant at <0.05 for Chi Square

In the other studies involving college students, being hospitalized or having a recent skin infection were significant (Rohde et al., 2009) and playing intramural sports, being a male under 25, and living in the dormitory were also found to be significant for increased MRSA colonization (Rawls et al., 2010). Students' exposure to animals or major with respect to touching shared equipment or touching people were not considered in the other studies. However, there have been studies involving different populations

that have found a link between animal exposure and MRSA colonization among people (AVMA, 2009; Baptiste et al., 2005; Lefebvre & Weese, 2009; OSU, n.d.; Tisinger, 2008). Other studies have tied exposure to fomites and people to increased MRSA colonization (Gorwitz et al., 2006; Siegel et al., 2006). These factors as well as recommendations for the disciplines that have a hands-on component will be addressed in Chapter 5.

Chapter 5: Discussion, Conclusions, and Recommendations

Overview and Summary of Results

Staphylococcus aureus is a formidable enemy causing much morbidity in the human and animal population. Subsequently MRSA, an antibiotic resistant strain, evolved with the overuse and abuse of antibiotics. MRSA is a significant problem in healthcare and in the general population worldwide (Germs-Go-Global, 2008). In the United States, MRSA hospitalizations are estimated at 100,000 yearly (Schaffer 2010), and those hospitalized can have problems ranging from skin infections to pneumonia. MRSA infections can lead to death, as many as 19,000 yearly (Sexton & Reynolds 2010).

The source of *Staphylococcus aureus* and MRSA is in part from healthy individuals who are colonized by these bacteria as well as animals that are colonized by these bacteria. There is a gap in the knowledge of how frequent asymptomatic colonization by MRSA occurs and what some of the underlying risk factors are (Rohde, et al., 2009). This study was done to address this lack of knowledge. In this study, 1,000 healthy students were tested for *Staphylococcus aureus* and MRSA colonization by using nasal swabs which were then swabbed onto Mannitol Salt Agar, a diagnostic medium for *Staphylococcus aureus*, and MRSA*Select* agar, a diagnostic medium for MRSA. The samples were collected from students who volunteered to be part of the study at a Texas community college from late April to mid October, 2011. The students who participated also answered a brief questionnaire at the time the nares were swabbed. Of the many factors that were explored, four proved to be statistically significant. The healthy student population had a statistically higher incidence of MRSA colonization (10.4%) than what

was expected among healthy adults (0.8%) according to the CDC (2007). Students who were enrolled in a program that had a hands-on component either with shared equipment or handled people in their training such as nursing students participating in clinical rotations, had a statistically higher incidence of MRSA colonization than students who did not have this exposure in their formal college education. Additionally, students who had close contact with animals, either as pets or as livestock, had a statistically higher incidence of MRSA colonization as did students who reported having a skin infection in the last 12 months. Other factors did not prove significant, but all are further discussed in greater detail in the next section.

Interpretation of Findings

Research Question 1: How prevalent is asymptomatic colonization of MRSA in healthy adult college students in a community college? This study found a higher incidence of colonization (10/4%) of healthy college students at the college under study, than what would be expected using the colonization rates (0.8%) from the CDC (2007). Several other studies that have looked at healthy college students from community colleges and four-year colleges found the colonization rate higher than the rate for the healthy U.S. adult population (CDC, 2007; Morita et al., 2007; Rohde, et al., 2009). The rates found varied between 3% and 7.4% in the previous studies. This study shows a higher rate, but the sample size was much larger than in the other college studies. The college that was part of this study is a community college with no dormitories, so some of the other studies that attributed the higher rates to dormitory living would not be a factor here. Also, at the time of the study, the college did not have any athletic teams. The

samples were taken over the late spring though mid-fall, so perhaps there would be a seasonal effect. This study overlapped with the hottest, driest summer on record for Texas. The other college studies that looked at college students in general were all done in Texas or Hawaii, both having mild climates (Morita et al., 2007; Rawls et al., 2010, Rohde et al., 2009). Milder climates may be more conducive to touching shared surfaces with more bare skin. Shorts, t-shirts, and tank tops are common attire for the students most of the year, so students come in contact with chairs, tables, lab benches, and other shared surfaces with exposed skin the largest part of the year. College students are also more likely to come in contact with contaminated surfaces and increase intimate contact with others as part of the college experience (Weiner, 2008).

Research Question 2: Is there a difference in colonization between different majors, such as those that have hands-on portions for part of their training involving touching other people, like nursing and cosmetology students, and those that use shared equipment, like process technology and computer science majors, and those that have no formal hands-on training or shared equipment? Students who had touched shared equipment and/or other people as part of their educational experience had a significantly higher risk of being colonized by MRSA than the students that did not have a formal hands-on component of touching shared equipment or other people. The Chi-Square was 4.09 with 1 degree of freedom and $p = 0.0431$. This demonstrates the increased risk to students if they have exposure to shared surfaces and/or lots of handling of people during their college training. Initially, I was trying to separate exposure to fomites and exposure to people, but it was not possible because much of the training experience in disciplines

such as nursing and cosmetology involve both. There are protocols for hand-washing and disinfecting surfaces as well as masks for students that are sick, and gloves for some procedures, but the compliance rate is another unknown variable.

Research Question 3: Many of these risk factors did not prove to be statistically significant but there were a few that did and others that were close (See Table 4 in Chapter 4 for all factors with *p*-values and odds ratios). One of the risk factors that was statistically significant was close contact with animals within the last 12 months (*p* value = 0.012 and odds ratio = 1.920). The risk factor that was explored in this study was close contact with animals in the last 12 months, with no distinction made between pets and livestock. Mostly, students have pets, but there are some students that are from rural areas where they have cattle, horses, and other livestock. Numerous other studies have also found a link between MRSA colonization and contact with animals, either pets (AVMA, 2009; Lefebve & Weese, 2009; OSU, n.d.) or livestock (Baptiste et al., 2005; Khanna et al, 2008; Weese et al., 2005). Animals may be an important reservoir for MRSA.

Another statistically significant risk factor was having a skin infection within the last 12 months (*p* value = 0.007 and odds ratio = 1.825). Having a skin infection called MRSA within the last 12 months was close to being statistically significant but this cell was very small (*p* value = 0.072 and odds ratio = 2.321). Since *Staphylococcus aureus* and MRSA both commonly manifest as a skin infection, this was not surprising. Rohde et al. (2009) also found statistical significance between MRSA colonization and a recent skin infection among the students at Texas State University. Rohde et al. (2009) also

found a hospitalization in the last 12 months to be significant for increasing MRSA colonization, but this was not found in this study.

The risk associated with getting a tattoo or a professional manicure, pedicure, or waxing was also close to being statistically significant, but this had a reduced risk. The odds ratio for getting a tattoo was 0.604 with a *p* value of 0.088 and the odds ratio associated with getting a professional manicure, pedicure, or waxing was 0.728 with a p value of 0.065. Other studies (Huijsdens et al., 2008, Long et at., 2006; Watson, 2006,) have found these activities to increase the risk of MRSA colonization, but in this study, these were associated with lowered risks. Perhaps students who had professional manicures, pedicures, or waxing were more diligent about hygiene, which has a protective effect. The risk factor explored for getting a tattoo was getting one in the last 12 months, but no distinction was made as to where. Professional tattoo parlors and salons are very common in the area surrounding the college, and they are checked regularly by the health department for cleanliness. Perhaps this and the competitive nature and word of mouth from clients actually make for a cleaner environment, lowering the risk for MRSA colonization. Some tattoo parlors locally also recommend clients use Gold Dial soap, which has an effective antimicrobial ingredient. Regular use of antibacterial soaps may also reduce the incidence of MRSA colonization.

Research Question 4: Is there a difference in prevalence in community college students based on demographic differences such as age, gender, or race? There is no significant difference between students of different genders, races, or ages for MRSA colonization rates. Rawls et al. (2010) found being a male under 25 to be a significant

risk factor, but this was not the case here. Rawls study was done at McMurray University, which is a senior university with dormitories. This study was done at a commuting two-year institution. Tisinger (2008) looked at the population at large and found being female and being a race other than European American were some of the risk factors for being colonized with CA-MRSA, but this was not seen in this study.

Implications for Social Change

This study provided valuable information about who is colonized with MRSA among the healthy student population at a community college in Texas, and the analysis shed further light on who might be more likely to be colonized with MRSA based on exposure level to other people, fomites, and other known risk factors like close contact with animals. MRSA, especially CA-MRSA, is a budding problem in many areas. Knowing the risk when one gets a pet or goes to a healthcare facility or starts a college program with a clinical or hands-on component and further knowing what to look for during the early stages of infection can reduce the morbidity and mortality. An education blitz concentrating on MRSA and how it spreads could benefit everyone. Making the faculty and students aware of fundamental steps to avoid infections would promote positive social change. Professions, such as cosmetology, firefighting, emergency medical services, and nursing, could be more aggressive with infection control. Students participating in such curricula should be safeguarded from infection from their contacts with people and shared paraphernalia. The education team as well as the student should learn the importance of deterrence and should strictly adhere to guidelines for prevention of the proliferation of microbes. If all professionals adhered to infection control

procedures consistently and the average person was aware of what they could do to decrease infections such as MRSA, the wellbeing of society would improve.

Recommendations for Action

An awareness campaign aimed at students would be an appropriate first recommendation. Incoming freshman are required to take a mandatory incoming student success class, and a short segment on communicable diseases, including MRSA, could be incorporated into this class. A pamphlet could be designed for a general student audience and be distributed to incoming students in the class. Periodic open seminars addressing MRSA could be offered at College Hour, an hour blocked out midday on Tuesdays and Thursdays at the college for student activities, club meetings, and seminars.

I would also meet with the areas with higher incidences of MRSA and see what the current protocols are for infection control. Based on this, I would make recommendations of additional practices that are known to reduce the incidence of MRSA.

Recommendations for Further Study

This study has revealed several areas that need further study. As there was an increase in MRSA Colonization among students who had a clinical or hand-on equipment or people exposure, a further study comparing MRSA colonization rates among a cohort of students in hands-on programs as they progress through the program could be informative as to when increased colonization by MRSA occurs. Additionally, studying how many preventive measures are in place in a program and how high compliance to them could be useful. Adding new protocols for prevention in different programs as well

as adding an education/awareness campaign and studying the efficacy would be an informative study. A further study that focuses on animal exposure would also shed more light on this link. Anecdotally, I have seen changes in exposure to animals change MRSA colonization of the anterior nares. One individual was tested over the course of a couple of years, and when the person worked around horses he was positive, but with no exposure to the horses, tested negative. This suggests that colonization changes with time and exposure. Tracking healthy people who test positive for a couple of years and tracking changes in exposure to risk factors would also clarify temporal changes and exposure factors for MRSA colonization.

Pulse-field gel electrophoresis studies of the MRSA colonization would be the main way to determine specific strains and determine whether students carried HA-MRSA or CA-MRSA. The main clones in the US of CA-MRSA are USA 300 and USA400 and the main clones of HA-MRSA are USA 100, USA 200, and USA 500, but others have also been identified (King et al., 2006; Klevins et al., 2007). As new strains emerge from other countries and other sources, this would be a very useful further study to see which strains were prevalent among students. HA-MRSA if more prevalent in older people (Klevens et al., 2006), so it would be a very interesting follow-up to see if the students that were colonized with MRSA had CA-MRSA or HA-MRSA, and if there was more of one type associated with a certain subgroup, like HA-MRSA more common among nursing students.

As hygiene is an important part of prevention, a follow-up study could be to see if there is decreased incidence of colonization of MRSA among people that are very careful

about hygiene and hand-washing. As this study took place in the warm months between April and mid-October, another follow-up study could look at possible differences in colonization rates of MRSA in the winter months.

Summary

Public health and all of society have a momentous burden with antibiotic resistant microorganisms. *Staphylococcus aureus* with all its virulence factors has always been a tribulation, but with the discovery and requisite use of antibiotics, an even more formidable enemy, MRSA, has emerged. In 2007, there were 1.2 million MRSA infections among hospital patients in the United States (Leung-Hen 2008) and MRSA infections can make the cost of a hospital stay escalate to $14,000 from the average $7,600 (Thomas, 2009). Serious MRSA infections lead to about 19,000 deaths in the United States annually (CDC, 2007).

The college campus is not immune to this threat. Asymptomatic colonization is an important reservoir for *Staphylococcus aureus* and MRSA. At the college in this study, of 1,000 students sampled, 51.1 % were colonized by *Staphylococcus aureus* and 10.4 % were colonized by MRSA. The CDC (2007) estimates that about 32% of the U.S. population is colonized with *Staphylococcus aureus* and about 0.8% are colonized with MRSA. College students appear to have a significantly higher colonization rate, as seen this study as well as others (Morita et al., 2007; Rawls et al., 2010; Rohde et al., 2009). Perhaps this discrepancy is due to college students having more contact with other people and fomites in general, such as shared computer keyboards, or the rate of colonization is underestimated in the general population.

Significant findings from this study show a higher incidence of MRSA colonization among students that had contact with other people or shared surfaces as part of their formal college training, such as EMT students, than students who did not have this same contact with their college major, such as English majors. Healthcare workers are at higher risk of exposure to MRSA, so the students who a clinical component of their formal education is logical. In addition to healthcare related risks, touching other people or shared equipment increased the chances of MRSA colonization. Another significant risk for the student population at large was having a skin infection in the last 12 months. As Staph infections usually manifest as a skin infection, this seems very plausible. Rhode et al. (2009) also found this to be an increased risk factor among college students. Pets and small children have also been implicated as possible reservoirs for MRSA, and in this study, close contact with animals, either as pets or livestock, showed to be another significant risk factor for being colonized by MRSA. This study does help bridge the gap that exists in the knowledge of the prevalence of MRSA colonization as well as the potential spread of MRSA.

Everything considered, instructive programs on the importance of good hygiene including regular hand-washing should be implemented. Meticulous hand-washing and conscientious hygiene are important preventative measures in the college as well as the general public and among healthcare personnel. Additionally, any program using shared equipment should be vigilant about regularly disinfecting surfaces. Any safety protocols in place should be followed religiously, and gloves should be used in situations where contamination risks are elevated. Recognizing all the budding reservoirs and how robust

this microbe is, control is more realistic than eradication, but even control will be daunting.

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Appendix: Questionnaire: MRSA Survey at College of the Mainland

QUESTIONNAIRE NUMBER _____

Age _____

Gender ___ Male
___ Female

College Major (Completed by Researcher)
____ Not Hands-on
____ Hands-on Equipment
____ Hands-on People

Race / Ethnicity (Choose the closest match)
___ African-American
___ Asian
___ Caucasian
___ Hispanic
___ Other

For the following questions, consider them within the last 12 months:

Close contact with pets or other animals at least weekly? Yes / No

Do you have young children under the age of 5 that live with you or that you see at least weekly? Yes / No

Do you exercise regularly in a gym or participate in sports at least once a week? Yes / No

Do you fish, surf, swim, or walk on the beach at least once a week? Yes / No

If yes, circle all that apply:

surf walk on beach swim in saltwater swim in pools swim in freshwater fish

Do you work in a daycare? Yes / No

Do you work in a healthcare facility, including a nursing home? Yes / No

If yes, what type of a facility? _____

Have you had a skin infection, boil, or sore? Yes / No

Have you had a skin infection called “mersa”, MRSA, or antibiotic resistant staph? (Yes / No)

Have you been a patient in a hospital or had surgery? Yes / No

If yes, what type of surgery or in what capacity as a patient?

_____

Have you taken antibiotics (in the last year)? Yes / No

If yes, circle how many times you were prescribe antibiotics in the last year:

1 2-3 4 or more

Have you had a tattoo in the last year? Yes / No

Have you had a professional manicure, pedicure or waxing within the last year? Yes / No

If yes, circle how many times you have had any of these procedures in the last year:

1-2 3-6 7-12 13 or more

You have completed the student portion on the survey. Thank you for your participation.

To be completed by researcher after incubation of nasal swab:

Does the student carry *S. aureus* in the nares? Yes / No

Does the student carry MRSA in the nares? Yes / No

Curriculum Vitae

Marilynn M. Kish-Molina
MKMolina@com.edu
409-933-8328

Education

Ph.D. in Public Health specializing in Epidemiology, Walden University, August 2012 GPA 4.00

MPH in Public Health, Walden University, November 2008 GPA 4.00

Ph.D. Candidate in Zoology (A.B.D.), University of Texas, Austin, Texas, Spring 1991 GPA 3.95

M.S. in Biology, Wayne State University, Detroit, Michigan, March, 1980 GPA 4.00

B.S. in Biology, Wayne State University, Detroit, Michigan, September, 1977 GPA 3.73

(3.85 for major)

Teaching Experience

Professor - [redacted] TX - 6/94 to present. Duties have included teaching laboratory and lecture sections in General Biology I & II, Human Anatomy and Physiology (a two-semester sequence), and Microbiology; and teaching lecture sections in Nutrition and Medical Terminology. Science Team Leader (equivalent to the position of Chairperson) for the 1996/97 Academic Year, 2001/2002 Academic Year, and 2002/2003 Academic Year. Faculty Council President for Fall 1999. Founder of the Honors Program, and served as the Co-Director until 2003. Report Coordinator for the Continuing Education Committee for the S.A.C.S. visit Spring 2003. Cofounder of the Biology Club started Fall, 2005. Supplemental Instruction Supervisor for Science as of Fall, 2010. Full-time tenured faculty member.

Secondary Teacher - Houston Independent School District, Houston, TX - 1993-1994. Alternative Certification Program - admitted to program in Spring 1993, hired at Patrick Henry Middle School, Houston, TX - 8/93 to 6/94. Duties included teaching seventh grade life science using the scope and sequence method developed by Baylor College of Medicine. This position was full-time.

Instructor - Austin Community College - Rio Grande Campus/Northridge Campus/Cypress Creek Campus, Austin, TX - 8/90 to 8/91 and 1/92 to 8/92. Duties included teaching laboratory and lecture sections in Introductory Microbiology, Cellular and Molecular Biology and Anatomy and Physiology, and teaching laboratory/field studies and lectures in Oceanography. This position was part-time.

Assistant Instructor - University of Texas - Department of Zoology, Austin, TX 8/87 - 7/90 and 1/92 to 5/92. Duties included teaching laboratory

sections in Human Anatomy, discussion sections in Introductory Biology for majors and non-majors, field studies/laboratory sections in Limnology/Oceanography and laboratories in Basic Ecology and Entomology. This position was part-time.

Teaching Assistant - University of Texas - Department of Microbiology, Austin, TX 1/87 to 5/87. Duties included teaching laboratory sections for Public Health Bacteriology. This position was part-time.

Assistant Professor - Bacone College - Math/Science/Computer Science Department, Muskogee, OK - 8/83 to 7/86. Duties included teaching lecture and laboratory sections in Human Anatomy and Physiology, Microbiology, General Zoology, General Ecology and Special Studies in Biology. I was also sponsor of the Science Club (1983 - 1986), sponsor of the Student Senate (Fall 1984) and President of the Bacone Professional Association (1985-1986). This position was full-time.

Instructor - Schoolcraft College - Science Department, Livonia, MI - 1/83 to 7/83. Duties included teaching lecture and laboratory sections in Human Anatomy & Physiology (a two-semester sequence). This position was part-time.

Associate Instructor - Central Texas College - Science Department, Killeen, TX - 9/80 to 5/82. Duties included teaching lecture and laboratory sections in Physical Geology, Historical Geology, General Biology and Physical Geography. In addition, I taught extension courses at the Gatesville Unit, Texas Department of Corrections. This position was full-time.

Graduate Teaching Assistant - Wayne State University - Department of Biology, Detroit, MI - 9/78 to 6/79. Duties included teaching laboratory and discussion sections in Comparative Anatomy, Introductory Biology and Microbiology. This position was part-time.

Research

Prevalence of Asymptomatic Colonization of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Among Community College Students: Variances Between Majors and Possible Risk Factors (Dissertation). Walden University 2012 Dr. Nancy Rea was my chair.

Comparison of the Russian MIR and the proposed ISS Resistance Exercise Device for the Junior College KC-135 Program at NASA, 2000.

Environmental Consultant - for Paul Price and Associates, Austin, TX 10/91 to 2/92. Duties included identifying aquatic invertebrates, primarily insects. They were identified to genus using biological keys. This position was part-time.

Graduate Research Assistant - University of Texas - Department of Zoology 8/90 to 1/91. Duties included collecting and maintaining colonies of fire ants as well as assisting Dr. E. Vargo with research on fire ant pheromones and queen fecundity. This position was part-time.

Research in Tropical Studies, Corcovado, Costa Rica - Summer, 1988. I focused primarily on insects, but I did get a broad overview of the rainforest community. Dr. L. E. Gilbert was my supervising professor.

Research in Ecological Problems - Wayne State University, Detroit, MI 6/79 to 3/80. I worked primarily with *Drosophila* and heritability of senescence. Dr. L. Luckinbill was my supervising professor.

Honors/Awards/Professional Societies/Community Activities

Attended Oxford Round Table on Global Nutrition and Obesity, March, 2008
Who's Who Among America's Teachers - 1998, 2000, 2002, 2003, 2004
Faculty Council President, College of the Mainland - 1999
Teacher of the Year, College of the Mainland - 1998
Finalist for Teacher of the Year, College of the Mainland - 1996
Human Anatomy & Physiology Society, Inc. (1997-2010)
National Association of Biology Teachers (1999-2009)
American Society of Microbiology (1996-2012)
TCCTA Member (1994-2012), TCCTA Campus Representative (2000-2012)
Frank & Fern Blair Fellowship in Field Ecology (1990-1991 & 1991-1992)
University of Texas
Phi Kappa Phi - elected as a member in 1988
Scholarship for Summer/1988 to study in Corcovado, Costa Rica
The Sierra Club (1981-1992)
Chairperson - Pesticide Committee (1989-1991) Austin Chapter
Bacone Professional Association (1983-1986)
President (1985-1986)
Wayne State Merit Scholarship for 3 years (total time as undergraduate)
Phi Beta Kappa - elected as a member in 1977
Phi Sigma Biological Honor Society