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A Systematic Review of the Efficacy of Environmental Decontamination and Personal Hygiene Practices in Reducing Methicillin Resistant Staphylococcus aureus Acquisition

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Abstract

BACKGROUND

Staphylococcus aureus is the leading cause of hospital acquired infections. Methicillin Resistant *Staphylococcus aureus* (MRSA) is the second most common healthcare associated infection in the healthcare system. A bacterium resistant to the antibiotic drug, methicillin, MRSA can make treatment for serious chronic illnesses difficult, leading to morbidity and mortality.

OBJECTIVE

The primary purpose of this study is to provide a systematic review of all research articles pertaining to the effectiveness of personal hygiene and environmental decontamination in controlling the transmission of methicillin-resistant *Staphylococcus aureus* (MRSA).

METHODS

Databases PubMed, Global Health, and Medline were searched for research articles relevant to reducing MRSA acquisition using personal hygiene practices or environmental decontamination procedure. The keywords MSRA, MDRO, decontamination, hygiene, prevention, and clean were used to assist in identifying these articles. Full text articles were assessed to ensure they met inclusion criteria. Data was collected from each article regarding study time, location, outcome of interest, statistical result, and study design.

RESULTS

Of the articles included in this systematic review, 9 of 10 reported a significant decrease in MRSA acquisition in a healthcare or correctional facility setting after

implementation of improved personal hygiene practices or environmental decontamination. There is an increased need for compliance with appropriate hygiene practices in a healthcare setting by healthcare workers. Further research needs to be conducted on the cost effectiveness of decontamination processes and educational programs to encourage compliance with MRSA policies that are already set in place by hospitals worldwide.

Keywords: MRSA, intervention, prevention, cleaning, hygiene, decontamination

**A SYSTEMATIC REVIEW OF THE EFFICACY OF ENVIRONMENTAL
DECONTAMINATION AND PERSONAL HYGIENE PRACTICES IN REDUCING
METHICILLIN RESISTANT *STAPHYLOCOCCUS AUREUS* ACQUISITION**

**BY
RHE'A GREEN
BACHELOR OF SCIENCE, SAVANNAH STATE UNIVERSITY**

**A CAPSTONE SUBMITTED TO THE GRADUATE FACULTY OF GEORGIA STATE
UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
MASTER OF PUBLIC HEALTH**

**ATLANTA, GEORGIA
30303**

Approval Page

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By

Rhe'a Green

Approved:

Dr. Richard Rothenberg, MD, MPH - Committee Chair

Dr. Lisa Casanova, PhD, MS-Committee Member

April 21, 2016

Date

Author's Statement Page

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Rhe'a Green
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INTRODUCTION

Overview/Background

Staphylococcus aureus, commonly known as staph, is a bacterium that causes serious systemic and localized infections. Owing to natural bacterial evolution (National Institute of Health, 2011) more than 80% of *S. aureus* became resistant to penicillin, the antibiotic drug for treatment, in the 1950s (Klein, E., Smith, D., & Laxminarayan, R, 2007). Methicillin was then introduced as an alternative antibiotic drug to treat the newly penicillin resistant bacterium. Over time, British scientists discovered that *Staphylococcus aureus* had become resistant to methicillin (National Institute of Health, 2011) and identified the bacterium as a hospital acquired pathogen in the late 1960s (Fridkin, S., Hageman, J., Morrison, M., Sanza, L., Como-Sabetti, K. et al, 2005). Natural bacterial evolution, amplified by the response of the bacterium to effective antibiotics, continues to occur and *Staphylococcus aureus* is now resistant to a group of antibiotics, called beta-lactams, including penicillin, methicillin, amoxicillin, and oxacillin to name a few (National Institute of Health, 2011).

Methicillin resistant *Staphylococcus aureus* (MRSA) is the second most common hospital acquired infection (HAI) in the healthcare system (Hidron, A., Edwards, J., Patel, J., Horan, T., Sievert, D., et al, 2008). Approximately 1-2% of people carry MRSA on their skin or in their nose. The diagnosis of MRSA requires laboratory testing that a doctor may recommend after seeing a wound that appears to be infected or is not healing properly (Virginia Department of Health, 2013). Between 1980 and 1994, the National Nosocomial Infection Surveillance System (NNIS) reported that the proportion of methicillin resistant *Staphylococcus aureus* increased from 2% to 29% in NNIS hospitals

(Jernigan, J., Titus, M., Groschel, D., Getchell-White, S., & Farr, B, 1996). By 2008, 65% of all hospital acquired *S. aureus* infections in the United States were due to MRSA (Wenzel, R., Bearman, G., & Edmond, M., 2008). The rate of morbidity and mortality (Jernigan, J., Titus, M., Groschel, D., Getchell-White, S., & Farr, B, 1996) caused by the pathogen has made MRSA a serious public health problem. Compared to patients with methicillin susceptible *S. aureus*, those with MRSA have twice the mortality rate, significantly longer hospital stays, and higher median hospital costs (Calfée, D., Salgado, C., Classen, D., Arias, K., Podgorny, K., et al, 2008). Surgical site infections caused by MRSA have a 3.4 times higher risk of mortality and 2 times higher median hospital costs. These high morbidity and mortality rates are associated with delays in initiation of effective antimicrobial therapy, less effective antimicrobial therapy for infection due to resistant strains, and higher severity of underlying illness among persons with infection due to resistant strains (Calfée, D., Salgado, C., Classen, D., Arias, K., Podgorny, K., et al, 2008).

Methicillin resistant *Staphylococcus aureus* can be categorized into two types: Community acquired MRSA (CA-MRSA) and hospital acquired MRSA (HA-MRSA) (National Institute of Health, 2011). The Society for Healthcare Epidemiology of America's (SHEA) time-based definition of hospital acquired MRSA is MRSA that is identified from a specimen obtained after a third calendar day of hospitalization, with the day of admission being counted as calendar day one (Calfée, D., Salgado, C., Classen, D., Arias, K., Podgorny, K., et al, 2008).

Hospital acquired MRSA has been associated with healthcare related risk factors since its discovery. Community associated MRSA has become an important public

health issue because CA-MRSA is growing among persons without traditional healthcare related risk factors, and can also be acquired in a hospital setting (Calfee, D., Salgado, C., Classen, D., Arias, K., Podgorny, K., et al, 2008). The definition of community-acquired MRSA varies between public health organizations and researchers. Calfee, Salgado, & Classen et al define CA-MRSA as MRSA that is acquired from the community or another healthcare facility (2008), while Salgado, Farr, & Calfee, defines CA-MRSA as MRSA that is present or incubating during the time of admission and acquired by factors other than previous healthcare exposure (2003). Due to MRSA colonization, the presence of the bacteria with undetectable signs of infection (Virginia Department of Health, 2013), which can persist for months to years, Salgado, Farr, & Calfee suggest that CA-MRSA is the detection of MRSA colonization. This in the community due to patients that are colonized with MRSA in hospital settings and later acquire (2003). The time-based definition of community acquired MRSA is MRSA that is identified from a specimen obtained on or before the third calendar day of a patient's hospitalization, with the day of admission being counted as calendar day number one (Calfee, D., Salgado, C., Classen, D., Arias, K., Podgorny, K., et al, 2008). Community associated MRSA strains are an emerging cause of HA-MRSA and has increased concerns for infection control because of perceived differences in the epidemiology of the strains (Wenzel, R., Bearman, G., & Edmond, M., 2008). Hospital acquired MRSA and community acquired MRSA are further differentiated by clinical differences, including the patients' clinical history and exposure to healthcare (Calfee, D., Salgado, C., Classen, D., Arias, K., Podgorny, K., et al, 2008).

Purpose of the Study

Since the discovery of MRSA as a hospital acquired pathogen, the rates of MRSA acquisition have fluctuated due to its ability to also spread throughout community settings. The Infectious Disease Society of America issued a call to action in 2008 for the medical community to take measures to reduce MDRO transmission. Since 2008, 91% of all hospitals reported using some form of MRSA control. Some of these preventive measures may include hand hygiene, active surveillance testing, isolation practices, and/or environmental decontamination. The recommendations made by public health organizations including the Center for Disease Control and Prevention and the Society for Healthcare Epidemiology of America have proven to be successful in reducing the acquisition of MRSA. These organizations have contributed to the understanding of MRSA control in the healthcare system; if in compliance, the prevalence of MRSA in the healthcare setting is expected to be significantly low. The primary purpose of this study is to provide a systematic review of all research articles pertaining to the effectiveness of personal hygiene and environmental decontamination in controlling the transmission of methicillin-resistant *Staphylococcus aureus* (MRSA). The effectiveness of active surveillance testing for MRSA has been evaluated in past years, but there is little research on the most recommended method of prevention, personal and environmental hygiene. This study seeks to examine whether personal and environmental hygiene in hospital and community settings can independently reduce MRSA acquisition by evidence of a significant risk reduction or a reduced number of cases post intervention.

LITERATURE REVIEW

Risk Factors

The frequency of CA-MRSA is increasing among persons without typical health care associated risk factors for MRSA acquisition (Salgado, C., Farr, B., & Calfee, D., 2003). These healthcare associated risk factors include recent hospitalization, injection drug use, antimicrobial use, history of underlying illnesses and chronic disease (Gorak, E., Yamada, S., & Brown, J., 1999), length of hospital stay, the presence of foreign bodies, and frequent contact with healthcare personnel (Calfee, D., Salgado, C., Classen, D., Arias, K., Podgorny, K., et al, 2008). Age is also a risk factor of MRSA acquisition due to its correlation with pressure ulcers as age increases (Coello, R., Glynn, J., Gaspar, C., Picazo, J., & Fereres, J., 1997). The Salgado, Farr, & Calfee study documented the health care associated risk factors among community members with MRSA and the prevalence of MRSA colonization in community settings among healthy persons who did not have health care associated risk factors for acquisition (2003). Assessment of risk factors for MRSA acquisition included one or more healthcare associated factors including recent hospitalization, recent outpatient visit, recent nursing home admission, recent antibiotic exposure, chronic illness, injection drug use, and close contact with a person with risk factors for MRSA acquisition. Among these risk factors, recent hospitalization and chronic illnesses that required health care visits were the most common. Those having household contact with MRSA colonized patients were 14 times more likely to be colonized in comparison to members of the community without a known MRSA contact (Salgado, C., Farr, B., & Calfee, D., 2003). The main way that MRSA is spread from one person to another is hand contact, contact with contaminated

items, close skin-to-skin contact, openings in the skin, and poor hygiene (Virginia Department of Health, 2013). Acquisition of MRSA, whether it occurs in the hospital setting or in the community, frequently goes unnoticed unless clinical infection develops. Given the lengthy duration for which colonization with MRSA can persist, an infection may develop in a setting different from that in which the organism was initially acquired (Salgado, C., Farr, B., & Calfee, D., 2003). Calfee, Selgado, & Classen et al's study revealed the risk of developing a MRSA infection within 18 months after detection of MRSA colonization was 29% (2008). Without results of surveillance cultures documenting acquisition time, whether an infection was acquired in a hospital or community setting is not certain (Salgado, C., Farr, B., & Calfee, D., 2003). The Salgado, Farr, & Calfee analysis found that even when minimal risk factor assessments were done, at least 85% of hospital patients who met the time based definition for CA-MRSA and 47.5% of healthy community members that were colonized with MRSA had one or more health care associated risk factors for acquisition (2003). This suggests that the prevalence of MRSA among persons without typical risk factors remain relatively low and most MRSA colonization and infection develops among those who have health care associated risk factors or contact with other persons who have such risks. When patients known to be colonized with HA-MRSA are discharged from a healthcare facility into the community, close contact occurs and the pathogen can be passed on to those in the community (Salgado, C., Farr, B., & Calfee, D., 2003). Salgado, Farr, & Calfee suggests that the large population of patients colonized with HA-MRSA who were never recognized as such while in the healthcare facility contribute to the spread of MRSA in the community (2003).

Prevention

There is no treatment needed for colonization but it is important that preventive measures be taken to reduce the spread of the pathogen (Virginia Department of Health, 2013). Methicillin resistant *S. aureus* has been acknowledged as a public health concern by the Society for Healthcare Epidemiology of America (SHEA), CDC, Dutch Working party on Infection Prevention (WIP), and the Joint Working Party. These public health organizations have recommended education, hand hygiene, environmental decontamination, compliance with cleaning and contact precautions, and active surveillance testing (Calfee, D., Salgado, C., Classen, D., Arias, K., Podgorny, K., et al, 2008) as screening and preventative measures in the control of MRSA.

Due to the lack of interest in patients that are colonized with MRSA while in a healthcare facility and discharge of these patients with the risk of spreading the pathogen, the best way to control MRSA within the community is to control MRSA within healthcare settings (Salgado, C., Farr, B., & Calfee, D., 2003). By 2008, the proportion of MRSA isolates increased from 30% in 1990 to 65% (Wenzel, R., Bearman, G., & Edmond, M., 2008). Methicillin resistant *S. aureus* acquisition has reduced significantly as proven by a large number of studies examining the effectiveness of these suggested screening procedures and prevention methods.

The Center for Disease Control and Prevention (CDC) has proposed a number of strategies to reduce the spread of organisms among patients such as hand hygiene and isolation precautions (Climo, M., Yokoe, D., Warren, D., Perl, T., Bolon, M., 2013). Some studies have found a decrease in incidence of MRSA infection and colonization after adopting barrier isolation procedures and some have failed to demonstrate a change

in incidence using similar measures (Jernigan, J., Titus, M., Groschel, D., Getchell-White, S., & Farr, B, 1996). Jernigan, Titus, Groschel, and Getchell-White compared the rate of transmission of MRSA from patients that were not isolated with the rate of transmission from patients who had been placed in contact isolation during a seven (7) month outbreak in a neonatal intensive care unit in Virginia (1996). Transmission of MRSA was sixteen (16) times more frequent in patients that were not isolated during the outbreak than from patients in contact isolation (Jernigan, J., Titus, M., Groschel, D., Getchell-White, S., & Farr, B, 1996). Murray-Leisure, Geib, Graceley, et al found that contact isolation alone failed to control an epidemic in their hospital (1990). Rao, Jacobs, & Joyce observed that contact isolation failed to limit the spread of a MRSA outbreak, but strict isolation was successful (1988). Reboli, John, & Levkoff reported that contact isolation failed to control a MRSA epidemic in a neonatal intensive care until the initiation of hexachlorophene handwashing (1989). A two year randomized control trial from 2007 to 2009 evaluated the effectiveness of bathing with chlorhexidine gluconate to minimize risks of acquiring multi-drug resistant organisms (MDRO) among healthcare associated infection (HAI) risk patients. Chlorhexidine gluconate is an antiseptic agent that acts against organisms including *S. aureus* by decreasing the microbial burden on skin and prevents secondary environmental contamination. The rate of MRSA acquisition decreased by 19% (1.89 vs 2.32 cases per 1000 patient days, $p=0.29$) when chlorhexidine gluconate was used in comparison to the control group, however, the result was not significant (Climo, M., Yokoe, D., Warren, D., Perl, T., Bolon, M., et al, 2013).

While many studies have concluded the reduction of incident MRSA cases after implementing infection control intervention methods, in 1999, Ellingson, Muder, Jain,

Kleinbaum, & Feng, et al were of the first to evaluate whether reductions in MRSA acquisition could be achieved on a large scale and sustained over a 7 year period (2011). Ellingson, Muder, Jain, Kleinbaum, & Feng, et al study consisted of three elements for the MRSA prevention intervention: (1) use of behavioral change strategies to promote infection control adherence (2) Emphasis on hand hygiene and disinfection (3) surveillance testing of anterior nares and open wounds within 48hours after admission to identify patients with colonized MRSA for prompt contact precautions (2011). These strategies resulted in a 21.8% decrease in incidence of MRSA colonization from 2.40 cases per 1000 patient days at risk to 1.88 cases per 1000 patient days at risk (Ellingson, K., Muder, R., Jain, R., Kleinbaum, D., Feng, P., et al, 2011). A survey of US hospital epidemiologists found that 91% of epidemiologist used some kind of MRSA control in their hospitals (Jernigan, J., Titus, M., Groschel, D., Getchell-White, S., & Farr, B, 1996). Compliance with the control methods that have been implemented in the healthcare setting has been successful in reducing MRSA acquisition and colonization.

METHODS

The systematic review process began by constructing the research question, “Can personal hygiene and environmental decontamination practices independently reduce the acquisition of MRSA?” Personal hygiene in this study is defined as the cleanliness of the external body. Literature searches were performed using the A-Z databases made available to Georgia State University students by the university library. PubMed, Global Health, and the MedLine databases were most appropriate. Based on the purpose of the study the keywords MRSA and prevention or intervention, and cleaning or hygiene or decontamination were used to search for relevant articles. After reviewing these databases, additional articles were selected from systematic reviews. The flowchart below (Figure 1) illustrates the results retrieved from each literature search. The primary outcome for the systematic review was the relationship between environmental decontamination and personal hygiene and the risk of methicillin resistant *Staphylococcus aureus* acquisition. The inclusion criteria (Table 2) for this study included full text articles with a randomized control trial or cohort study design. Personal hygiene interventions of interest were not limited to practices on or by patients or practices by healthcare professionals. Personal hygiene interventions were eligible for inclusion in the systematic review if used on or by patients directly or by healthcare professionals. Articles that studied MDRO or healthcare associated infection acquisition as the primary outcome were also included in this study if the individual incidence rate, prevalence, odds, or risk ratio for MRSA acquisition was reported in the results. Both hospital and community acquired MRSA outcomes were eligible for participation in this study. Articles without a specified infection were excluded as well as articles with

healthcare associated infections other than CA-MRSA and HA-MRSA. Only articles published in English were included. There were no restrictions placed on date of publication, sex, age, or country. Titles and abstracts were examined for relevance to the research question. After eliminating excluded articles, full text articles were examined for relevance to the research question and articles that did not meet the inclusion criteria were eliminated. A final quality assessment was conducted on the articles eligible for review to evaluate whether the purpose was clearly stated, if relevant background and literature was reviewed, participants were randomized, results reported in statistical significance, and included a conclusion appropriate as per results (Table 2). There was no funding source for this study. As a Georgia State University student, the author was given full access to the data needed to complete this study.

Figure 1: Flowchart of Selection of Studies

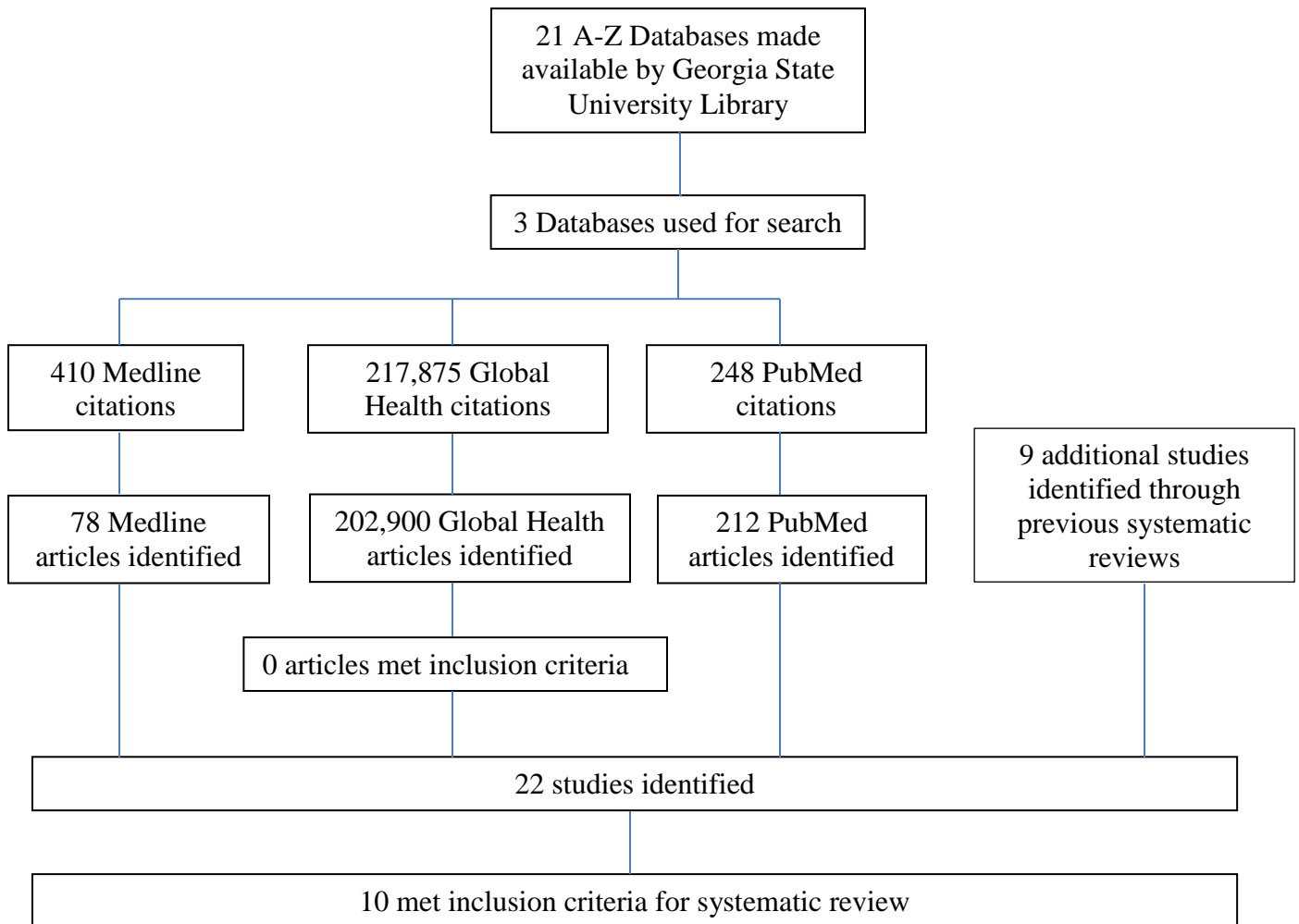


Table 1: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
➤ Full text articles in any country	➤ Systematic Reviews
➤ Personal hygiene and environmental decontamination intervention	➤ Case control studies
➤ Decreased MRSA acquisition (risk, odds, prevalence, incidence) included as a primary outcome of interest	➤ Studies without full text available after search
➤ Randomized control trials	➤ Studies including nonhuman subject participants.
➤ Cohort studies	➤ Letters to editor
	➤ Combined intervention results

Table 2: Quality Assessment of Reviewed Articles

Author	Purpose Clearly Stated	Relevant Background and Literature Reviewed	Randomization of Participants	Results reported in Statistical Significance	Conclusion Appropriate as Per Results	Study Design
Alfa (2015)	Yes	Yes	Yes	Yes	Yes	Comparative
Cromer (2008)	No	Yes	Yes	No	Yes	Non comparative
Datta (2011)	Yes	Yes	Yes	Yes	Yes	Comparative
David (2014)	Yes	Yes	Yes	Yes	Yes	Comparative
Johnson (2005)	Yes	Yes	Yes	Yes	Yes	Non comparative
Monistrol (2011)	Yes	Yes	Yes	Yes	Yes	Non comparative
Passaretti (2012)	Yes	Yes	Yes	Yes	Yes	Comparative
Pittet (2000)	Yes	Yes	Yes	Yes	Yes	Non comparative
Stone (2012)	Yes	Yes	Yes	Yes	Yes	Comparative
Viray (2014)	Yes	Yes	Yes	Yes	Yes	Comparative

RESULTS

There were 21 databases provided by Georgia State University's Library A-Z database. Pubmed, Medline, and Global Health were most relevant to the public health topic for the purpose of completing this systematic review. PubMed is maintained by the National Center for Biotechnology Information and contains biomedical literature from the database Medline, journals and online books discussing life sciences, behavioral sciences, chemical sciences, and bioengineering. The PubMed article search yielded 248 articles; after filtering the search to only provide articles that included full texts, 212 articles were presented. Each PubMed title and abstract was reviewed for relevancy, 10 full text articles were reviewed for inclusion criteria, and 7 articles were included in the systematic review.

The Medline database includes articles from medical journals related to medicine, preclinical sciences, the healthcare system, dentistry, veterinary medicine, and nursing. Using the keywords (mdro) AND (cleaning) OR (hygiene) AND (prevention) AND (mrsa), Medline yielded 410 appropriate articles and citations. The search was filtered to only include full text articles. Each article title was evaluated, followed by abstracts, if found relevant to the nature of the study. There were 10 full text articles reviewed for eligibility and 2 articles met the inclusion criteria for the study.

The Global Health database provides online books, patents, and index journal articles on a number of public health issues including non-communicable diseases, hygiene, and biomedical life science to name a few. The keyword search yielded 217,875 appropriate articles. To minimize the results, the search was filtered to only include articles that were academic journals (202,900) and reported in English (111,628).

The remaining articles were sorted to provide the most relevant articles, having the larger number of sought keywords, in descending order. All articles and abstracts screened in the Global Health database for relevancy to the systematic review were found to be irrelevant, given that many involved nonhuman subjects and most of which were irrelevant to MRSA prevention.

A systematic review was discovered during the Medline database search evaluating the impact of hand hygiene on hospital acquired infections in hospital wards. The systematic review included 13 articles, 2 were excluded due to irrelevant outcome variables measured. Of the 11 full text articles assessed for inclusion in the systematic review, 1 met inclusion criteria for this systematic review. Other databases were considered for review; however, they were not provided by the institution. For instance, keywords were searched in the American Journal of Infection Control database but were only available with membership and associated with a monetary payment.

The studies included in the systematic review varied in setting and no restraints were placed on the study time period in which the study was conducted. There were nine of ten studies included that were conducted between 1994 and 2012, one of ten did not specify a time in which the study was conducted but was published in 2014. The location of each study was distributed with 50% conducted in the United States, 10% in Canada, 10% in Australia, and 30% in Europe. There were 9 studies conducted in hospital settings ranging from 500 beds to 1250 beds in size with HA-MRSA as the outcome measure; one study was conducted in a correctional facility and CA-MRSA was the outcome measure. Of the ten articles that met the inclusion criteria, 3 (30%) studied environmental decontamination processes and 7 (70%) studied what would fall under the category of

personal hygiene, whether personal hygiene included a change in hand hygiene compliance or bathing techniques. Studies were categorized as comparative and non-comparative; there were 4 comparative cohort studies with control groups in this systematic review and 6 non-comparative randomized control trials. The quality assessment conducted for the 10 articles found 9 (90%) to have a clearly stated purpose, relevant background and literature, randomized study participants, an appropriate conclusion, and reported the results in statistical significance. One of ten articles (10%) did not have a clearly stated introductory purpose; however the purpose was understood given the results that were presented in the conclusion. The same study conducted by Cromer et al. did not report the result in statistical significance, failing to include a confidence interval and p-value. The author concluded a significant result by simply expressing significance in writing. Of the ten studies reviewed, 9 (90%) reported a significant decrease in the prevalence or incidence of MRSA acquisition after introduction of a personal hygiene or environmental decontamination intervention. The characteristics of each reviewed study and the results of each study are presented below in tables 3 and 4. Figure 2 also illustrates the baseline or pre intervention, and post intervention results in cases per 1,000 bed days of 7 of the 10 articles included in the systematic review.

Table 3: Characteristics of Studies Included in Systematic Review

Author	Title	Study Design	Setting & Sample	Intervention	Outcome Measure
Alfa (2015)	Use of daily disinfectant cleaner instead of a daily cleaner reduced hospital-acquired infection rates	Prospective cohort study	538 Bed acute care tertiary hospital in Canada	Daily hospital wide use of disinfectant cleaner	Reduction of MRSA rate
Cromer (2008)	Monitoring and Feedback of Hand Hygiene Compliance and the Impact on Facility Acquired Methicillin Resistant Staphylococcus aureus	Randomized controlled trial	A 588 bed not-for-profit teaching medical center in South Carolina	Hand hygiene compliance	Reduction in facility acquired MRSA
Datta (2011)	Environmental Cleaning Intervention and Risk of Acquiring Multidrug Resistant Organisms From Prior Room Occupants	Retrospective Cohort Study	Patients admitted to 10 intensive care units at a 750 bed academic medical center	1) Targeted feedback regarding adequacy of cleaning using a novel, nontoxic tracking marker whose marks are visible only under UV light, 2) changing the application of disinfectant from pouring from bottles onto cleaning cloths to bucket immersion of cleaning cloths, 3) education regarding the importance of repeated bucket immersion during cleaning.	Decreased risk of MRSA acquisition

David (2014)	A Randomized Controlled Trial of Chlorhexidine-Soaked Cloths to Reduce Methicillin-Resistant and Methicillin Susceptible <i>Staphylococcus aureus</i> Carriage Prevalence in an Urban Jail	Prospective Cohort study	4,196 detainees in 68 detention tanks in a county jail in Dallas, Texas	Skin cleaning with Chlorhexidine gluconate soaked disposable wash cloths	Decreased prevalence of MRSA
Johnson (2005)	Efficacy of an Alcohol/Chlorohexidine Hand Hygiene Program in a Hospital with High Rates of Nosocomial Methicillin Resistant <i>Staphylococcus aureus</i> (MRSA) Infection	Randomized controlled trial	840 Bed University of Melbourne teaching hospital	1)Alcohol/chlorohexidine hand hygiene solution 2) Alcohol impregnated wipes 3) Mupirocin and triclosan body washes 3) Culture change program	Health care worker hand hygiene compliance; Volume of ACHRS used; Prevalence of patient and healthcare worker colonization; environmental MRSA contamination ; rates of clinical MRSA infection; Rates of laboratory detection of ESBL-producing <i>Escherichia coli</i> and <i>Klebsiella</i> spp.
Monistrol (2011)	Impact of a Hand Hygiene Educational Programme on Hospital Acquired Infections in Medical Wards	Randomized Controlled trial	Hospital Universitari Mutua, a 500 bed tertiary care hospital, in Terrassa, Spain	Hand hygiene compliance, Alcohol rub consumption	Reduce HA-MRSA acquisition

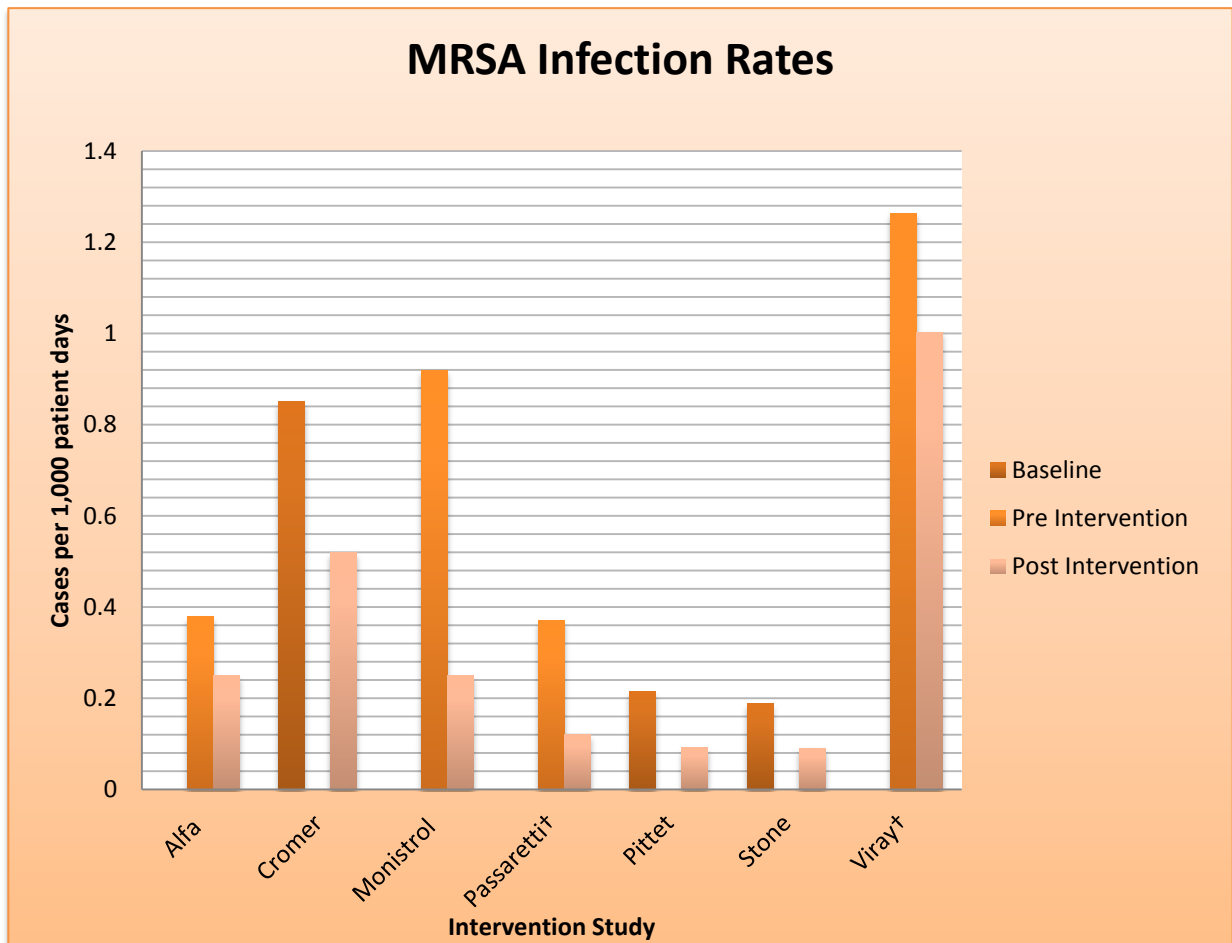
Passaretti (2012)	An Evaluation of Environmental Decontamination with Hydrogen Peroxide Vapor for Reducing the Risk of Patient Acquisition of Multidrug-Resistant Organisms	Prospective cohort study	6 high risk units at Johns Hopkins Hospital, a 994 bed tertiary referral center	Hydrogen peroxide vapor decontamination	Reduced risk of acquiring MDROs
Pittet et al (2000)	Effectiveness of a Hospital Wide Programme to Improve Compliance with Hand Hygiene	Randomized controlled trial	The University of Geneva Hospitals, an acute care teaching hospital in Geneva, Switzerland	Compliance with hand hygiene during routine patient care	Nosocomial infection rates, Attack rates of MRSA, and consumption of hand rub disinfectant
Stone (2012)	Evaluation of the National Cleanyourhands Campaign to Reduce <i>Staphylococcus aureus</i> bacteremia and <i>Clostridium difficile</i> Infection in Hospitals in England and Wales by Improved Hand Hygiene: Four Year, Prospective, Ecological, Interrupted Time Series Study	Randomized controlled trial	187 Acute Trusts in England and Wales	Installation of bedside alcohol hand rub, materials promoting hand hygiene and institutional engagement, regular hand hygiene audits	Reduced methicillin resistant <i>Staphylococcus aureus</i> , methicillin susceptible <i>Staphylococcus aureus</i> , and <i>Clostridium difficile</i> infection
Viray (2014)	Daily bathing with chlorhexidine-based soap and the prevention of <i>Staphylococcus aureus</i> transmission and infection	Randomized controlled trial	1,250-bed tertiary care teaching hospital	Institution of daily chlorhexidine bathing in an ICU	Decreased MRSA transmission

Article	Intervention	Measure	Statistical Result
Alfa (2015)	≥80% housekeeper compliance with hospital wide implementation of a disinfectant cleaner in a disposable wipe system	Incidence density/ Incidence rate ratio	Infection rate control, 3.8 cases/10,000 patient days intervention, 2.5 cases/10,000 patient days (P=.0071; Wald 95% confidence limits, 1.402-0.8884)
Cromer (2008)	Hand hygiene compliance	Incidence density/ Incidence rate ratio	38.8% reduction (51 infections avoided) Decrease from 0.85 per 1,000 patient days in 2005 to 0.52 per 1,000 patient days in 2006
Datta (2011)	Environmental cleaning intervention including 1) feedback regarding the adequacy of cleaning 2) repeated immersion of cleaning cloths into buckets filled with disinfectant, and 3) educational campaign	Cumulative incidence rate	Baseline Odds Ratio , 1.3 [1.0-1.8]; P=.04 Intervention Odds Ratio , 0.5 [0.3-0.8]; P=.006 Risk at Baseline, 3.9% Risk during Intervention, 2.9%, P=.03
David (2014)	Skin cleaning with Chlorohexidine soaked cloths for six months	Prevalence rate	Insignificant Baseline prevalence: control, 8.3% intervention, 8.4% Post intervention prevalence: control, % (95% CI), 10.0 (6.8-14.7) intervention, % (95% CI), 8.7 (5.1-14.4) Risk Reduction: 1.4% (95% CI, -4.8% to 7.1%; P=.655)
Johnson (2005)	Introduction of alcohol/chlorohexidine hand hygiene solution, improved cleaning of shared ward equipment, and comprehensive 'culture change' package to improve hand hygiene compliance.	Cumulative incidence rate	Percent Reduction 40% reduction in rate of total clinical MRSA isolates per 100 patient-discharges (95% CI, 23%-58%) P<0.001
Monistrol (2011)	Multimodal educational campaign on hand hygiene	Incidence density/ Incidence	0.92 per 1,000 hospital days in PRE period vs 0.25 per 1,000 hospital days in the POST period. P=0.02

	compliance encouraging the use of alcohol-based hand rub in internal medical wards.	rate ratio	
Passaretti (2012)	Hydrogen peroxide vapor room disinfection	Incidence density/ Incidence rate ratio	Crude IR Control: 3.7 per 1,000 patient days Intervention: 1.2 per 1,000 patient days Adjusted incidence rate ratio, [95% CI], 0.53, [.16-1.79]; P=.30
Pittet (2000)	Overall compliance with hand hygiene during routine patient care	Incidence rate ratio	Transmission rates decreased from 2.16 episodes per 10,000 patient days to 0.93 episodes per 10,000 patient days P<0.001
Stone (2012)	Installation of bedside alcohol hand rub, materials promoting hand hygiene and institutional engagement, regular hand hygiene audits	Incidence rate ratio	Rates of MRSA fell from 1.88 cases per 10,000 bed days to 0.91 cases per 10,000 bed days
Viray (2014)	Daily bathing with chlorhexidine based soap	Incidence rate ratio	20.68% decrease [pre-intervention 12.64 vs post intervention 10.03 cases/1000 patient-days-at-risk (95% CI: -5.19 to -0.04, P=0.046)

Table 4: Results of Reviewed Articles

Figure 2: MRSA Infection Rates



The bars show the incidence rates of the studies included in the systematic review at the baseline or pre-intervention, and the incidence rate results post intervention. The Datta, David, and Johnson studies were excluded from the table due to differences in axis variables. Refer to Table 4 for the results of the Datta, David, and Johnson studies.

† expressed in cases per 100 patient days

DISCUSSION

All articles included in this systematic review observed a decrease in MRSA acquisition when either environmental decontamination procedures or personal hygiene practices were improved or implemented, and in compliance with. The purpose of this study was to address the research question “Can personal hygiene and environmental decontamination practices independently reduce MRSA acquisition?” While some studies examined the effectiveness of these policies and procedures in addition to other interventions, the practice of environmental decontamination and improvement of personal hygiene independently had a significant effect on reducing MRSA acquisition.

Hand hygiene is the single most effective way to prevent the spread of germs from person to person and also prevents the spread of germs from contaminated surfaces. While this systematic review only focuses on the acquisition of MRSA, compliance with environmental decontamination procedures and the use of personal hygiene practices both have the ability to reduce the acquisition of a number of hospital acquired infections. The main reason for the focus on MRSA specifically is due to the observed lack of attention given to the bacterial infection in hospitals by healthcare professionals. There were 226 opportunities presented to perform hand hygiene during an unannounced hand hygiene audit by infection control nurses in a Taiwan hospital in 2003. Of the 226 opportunities, hospital staff was only seen washing their hands 16.6% of the time (Chen, Sheng, Wang, Chang, Lin, Tien, Hsu, Tsai, 2011).

Methicillin resistant *Staphylococcus aureus* is an infection that can be reduced significantly with compliance to programs that are already set in place by hospitals. Many hospitals already use many of the practices that were studied during this systematic

review but further studies have shown that compliance with these regulations are poor amongst healthcare workers. Most hospitals have a MRSA policy with instructions expressing how to efficiently care for patients with MRSA and cleaning procedures to reduce the likelihood of spreading the infection to other patients, similar to appendix 1.

Other organizations have recommended interventions to prevent hospital acquired infections, including MRSA. In healthcare environments that are considered high touch when dealing with patients, the Ontario Provincial Infectious Disease Advisory Committee and the US Center for Disease Control and Prevention (CDC) recommends disinfection followed by additional cleaning. The Ontario Provincial Infectious Disease Advisory Committee also recommends the use of either Ultraviolet-visible marker or adenosing triphosphate when cleaning high touch patient care environments. These methods will allow for monitoring cleaning compliance, drawing attention to areas that were not properly cleaned (Alfa et al, 2015). The World Health Organization (WHO) has recognized hospital acquired infections as a priority in the healthcare system and has made several recommendations to contribute to a decrease in MSRA infection rates. One public health intervention set in place was the ‘Clean care is safer care’ campaign launched in 2005 which focused on improving hand hygiene practices globally (Harbarth, 2006). In October of 2004, a year prior to the campaign launch, the World Health Organization launched the World Alliance for Patient Safety. Hospital acquired infections were selected as the first topic of the Global Patient Safety Challenge. Again, hand hygiene compliance was identified as the main component of the challenge. The simplicity, standardization, and low costs associated with hand hygiene made the practice the best introductory topic. The primary barrier for this program was poor compliance of

hand hygiene by healthcare providers, regardless of available resources. The hospital wide hand hygiene program consisted of lectures with posttests, performance feedback, use of hand hygiene compliance as a quality indicator, visual and verbal reminders by infection control nurses, and rewards of \$160.00 for an outstanding performance. In 2007, a fine of \$3.00 was to be paid by those who failed to comply, or did not modify their behavior after face to face communication (Chen et al, 2011).

MRSA most often spreads from patient to patient by the colonized hands of healthcare workers after handling contaminated materials or during contact with patients (Harbarth, 2006). Research shows that healthcare workers' gloves were contaminated 42% of the time after touching surfaces contaminated with the bacteria. Hospital environmental surfaces, healthcare worker gowns, and patient care items contaminated by patients infected or colonized with MRSA pose significant risks for MRSA acquisition. Boyce et al found that 73% of hospital rooms containing patients colonized with MRSA had some form of environmental contamination (Turabelidze et al, 2006). Strict compliance with policies and standard precautions could prevent most cases of cross transmission without the need for recognition of patients who are MRSA carriers (Harbarth, 2006). For instance, a study showed that MRSA colonized patients had a reduced risk of infection when placed in rooms that were previously occupied by MRSA positive patients after proper decontamination. Studies have shown that promotion of alcohol based hand rinses can be cost effective by reducing the episodes of cross infection ((Harbarth, 2006).

Contact isolation and active screening surveillance are the most mentioned methods of preventing hospital acquired MRSA. Many studies have evaluated the

effectiveness of these prevention methods, while few have made an effort to evaluate decontamination and hygiene practices in reducing acquisition. Of the articles included in this systematic review, 90% (9 of 10) reported a significant decrease in MRSA acquisition when the quality of cleaning procedures was enhanced and in compliance. .. Isolating MRSA positive patients leaves fewer rooms available for MRSA negative patients and masks the problem rather than make an effort to prevent the problem. Monitoring the compliance of cleaning processes will not only be beneficial to reducing the incidence of MRSA but will also improve hospital wide cleanliness.

Extended hospital stays and additional treatment due to hospital acquired infections can be costly and compliance with these programs could save hospitals thousands of dollars a year. Unfortunately, there are not many studies that evaluate the cost effectiveness of cleaning compliance in reducing MRSA acquisition. With the prevalence of MRSA isolates reducing as a result of cleaning compliance, it is expected that these practices be very cost effective and reduce the need for isolation practices, which can be costly. Pittet et al was the first to evaluate the economic impact of effective hand hygiene programs on decreasing hospital acquired infections. The cost of such a program is estimated to be less than \$57,000 per year for 2600 bed hospitals, or \$1.42 per admitted patient. Supplementary costs associated with the increased use of alcohol based hand rub averaged \$6.07 per 100 patient days, saving \$100 per each prevented infection (Chen et al, 2011).

Community associated MRSA is the leading cause of skin and soft tissue infections in US correctional facilities (David et al, 2014). Poor personal hygiene is the primary risk factor. Prisoners often take fewer showers and practice personal hygiene less

often than individuals that are not incarcerated. Another risk factor is the environment in which they live; jails are crowded and prisoners share many of the same common areas. The interplay of these risk factors including the use of antimicrobial drugs and interaction of environments contaminated by MRSA are more pronounced in these settings. In the Turabelidze study, 90% of the cases studied did not acquire MRSA until being incarcerated. This 90% received culture confirmed MRSA infection fewer than 90 of being incarcerated. Other settings with closely related risk factors include nursing homes, military recruits, and football teams. Nguyen et al found that sharing soap was associated with recurrent MRSA infections in a football team (Turabelidze et al, 2006). There is a need for implementation of hygiene and decontamination programs in all of these settings along with education on prevention. This systematic review reviewed clinical settings where HA-MRSA was prevalent as well as correctional facilities where CA-MRSA acquisition was assessed. The results for both study settings were similar. Improving hygiene practices and environmental conditions may prevent and interrupt future MRSA outbreaks in these at risk setting (Turabelidze et al, 2006).

This study had limitations including limited access to articles made available online. This study could have included more reviewed articles; however, many online databases required a payment for use of the articles. To avoid having to pay for peer reviewed articles, the literature search was limited to databases that were available for free as a Georgia State University student. Due to the systematic review search strategy and specific keyword search, there is a possibility that some personal hygiene and environmental decontamination interventions were excluded from this review. Keywords such as hygiene and hand hygiene could have possibly yielded different results, however,

it was expected that the keyword “hygiene” would also yield articles with the keyword “hand hygiene”. Some of the full text articles reviewed for inclusion did not provide sufficient results which excluded them from the systematic review.

CONCLUSION

Fortunately, improvements have been made over the past ten years by incorporating more clinical standards for alcohol based hand hygiene in US hospitals (Johnson et al, 2005); however compliance remains a greater concern. Further research needs to be conducted to evaluate the benefits and cost effectiveness of personal hygiene and environmental decontamination in reducing both CA-MRSA and HA-MRSA. Research may find that changes in cleaning procedures and compliance with hygiene and decontamination practices may be more cost effective than interventions that are discussed more often, patient contact isolation and active surveillance testing. Along with the implementation of these programs should be a monthly hospital wide check for compliance to ensure that the goals set for the program are met.

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APPENDIX

1. West London Mental Health MRSA policy

West London Mental Health. *Policy: ICP12*. 2015