

Recommendations for Prevention and Control of Methicillin- Resistant *Staphylococcus aureus* (MRSA) in Acute Care Facilities

Minnesota Department of Health



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November, 2011

Reviewed and updated (references only) February 2010
Reviewed and updated (references only) November 2008
Originally published January 15, 2008

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11/2011

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Executive Summary

An estimated 1.7 million healthcare-associated infections occur each year in the United States resulting in over 98,000 deaths.¹ A recent study conducted by the Centers for Disease Control and Prevention estimated that there were 94,000 invasive MRSA infections in the United States in 2005, 86% of which were healthcare-associated.² Furthermore, the proportion of all *S. aureus* isolates that are resistant to methicillin has been increasing each year and MRSA now accounts for over 60% of all *S. aureus* isolated from intensive care unit patients.³

This report serves as the Minnesota Department of Health (MDH) Recommendations for Methicillin-Resistant *Staphylococcus aureus* (MRSA) Control in Acute Care Facilities (hereafter referred to as The Recommendations) as required under Minnesota Statutes, section 144.585. The purpose of this document is to provide a standard set of recommendations for the prevention and control of MRSA in acute care facilities in Minnesota. It is expected that facilities will implement The Recommendations by January 1, 2009.

This document was created to enhance rather than duplicate existing published recommendations and guidelines for MRSA control in acute care settings. Extensive literature reviews, expertise from the MDH MRSA Recommendations Task Force (MDH-MRTF) and discussions with national content experts served as the basis for the Recommendations. MDH will review The Recommendations annually and modify them as needed to reflect new scientific developments concerning effective MRSA prevention and control.

Public comments were solicited on a draft version of The Recommendations. The MDH MRSA Recommendations Task Force (MDH-MRTF) reviewed and evaluated the public comments and made revisions to the draft version in creating the final Recommendations.

Minnesota Statutes, section 144.585 states: “In developing the MRSA recommendations, the Department of Health shall consider the following infection prevention and control practices: 1) identification of MRSA-colonized patients in all intensive care units (ICU) or other at-risk patients identified by the hospital; 2) isolation of identified MRSA-colonized or MRSA-infected patients in an appropriate manner; 3) adherence to hand hygiene requirements; and 4) monitor trends in the incidence of MRSA in the hospital over time and modify interventions if MRSA infection rates do not decrease.”

Infection prevention and control practices two through four in the statute are included in The Recommendations as standard MRSA infection prevention and control practices for acute care facilities. The statute also calls on MDH to consider active surveillance testing in a subset of patients (practice 1 in the statute). The MDH-MRTF carefully considered this practice and concluded that requiring identification of MRSA-colonized patients through active surveillance testing in a pre-defined subset of patients for all admissions, at all times, in all acute care facilities in Minnesota is not the ideal approach to decrease healthcare-associated MRSA and other healthcare-associated infections. The main factor behind this decision is that acute care facilities, the populations they serve (including populations with varying degrees of risk for MRSA) and the services they provide, vary across the state. Rather than requiring active surveillance testing in a pre-defined subset of patients, The Recommendations require acute care facilities to conduct an annual MRSA risk assessment using active surveillance testing to identify patients at high risk for MRSA colonization or units with high rates of MRSA transmission. This process will allow acute care facilities to identify, target and monitor interventions to their individually identified high-risk populations and/or units creating the potential for greater reduction in transmission of MRSA. Under The Recommendations, acute care facilities must

also consider the standard use of active surveillance testing in targeted populations or units as a part of an enhanced infection prevention and control program when routine infection prevention and control practices do not result in decreased MRSA infection rates.

The Recommendations are comprised of four sections: Infrastructure and culture to support MRSA infection prevention and control, Baseline infection prevention and control recommendations, Tier One Recommendations, and Tier Two Recommendations. The baseline infection prevention and control recommendations will prevent the transmission of MRSA and be useful in decreasing transmission of other healthcare-associated infections including *Clostridium difficile*, extended-spectrum beta-lactamase producing Gram-negative bacteria, and vancomycin-resistant enterococci. Transmission of MRSA within acute healthcare facilities is of great concern, although it is estimated that MRSA is responsible for less than 15% of all healthcare-associated infections.^{4,5}

General infection prevention and control measures include administrative support, process measures, and infection prevention and control measures. Administrative support for infection prevention and control activities (e.g. adequate funding and staffing) is critical to the success of programs aimed at reducing healthcare-associated infections. Process measures involve implementing a group of interventions that, when used together, have been shown to achieve better healthcare-associated infection prevention outcomes than if implemented alone such as interventions for preventing ventilator-associated pneumonia, central-line associated bloodstream infections, and surgical site infections.^{6,7} Infection prevention and control measures include hand hygiene, Standard Precautions and Transmission-Based Precautions.

In addition to general infection prevention and control measures, The Recommendations adopt a two-tiered approach for preventing and controlling MRSA transmission in acute care

facilities. Tier One Recommendations for MRSA control in acute care settings include core MRSA infection prevention tools such as strict adherence to Contact Precautions, adherence to recommended hand hygiene practices, and thorough environmental cleaning. In facilities not performing facility-wide active surveillance testing, Tier One Recommendations require acute care facilities to conduct an annual MRSA risk assessment using active surveillance testing to determine populations or units at risk for MRSA colonization and/or to determine MRSA transmission rates. This annual assessment will assist facilities in determining when Tier Two Recommendations are indicated.

Tier Two Recommendations are indicated when hospital-acquired MRSA infection rates are not decreasing despite implementation of and adherence to the general infection prevention and control measures and Tier One Recommendations. Tier Two Recommendations call for monitoring healthcare worker compliance with infection prevention and control measures in identified high-risk units or populations, intensified environmental measures, and active surveillance testing for all admissions to identified high-risk units or of high-risk populations.

Prevention and control of MRSA necessitates that healthcare facilities implement an antimicrobial stewardship program to augment their infection prevention and control program. Antibiotic misuse, including overuse of broad-spectrum antibiotics, is the biggest driver of antimicrobial resistance and contributes appreciably to the development of resistant organisms including MRSA. Effective antimicrobial stewardship programs are necessary to optimize therapeutic outcomes while minimizing unintended consequences of antimicrobial use.⁸

Facility-wide commitment to antimicrobial stewardship and infection prevention and control practice measures are essential to prevent healthcare-associated infections. An

institutional philosophy that supports these elements is critical to achieving success in decreasing transmission of MRSA and other healthcare-associated infections.

Relationship to Currently Published Recommendations

This document was created to enhance rather than duplicate existing published recommendations and guidelines for MRSA control in acute care settings (e.g. guidelines developed by the Healthcare Infection Control Practices Advisory Committee [HICPAC], Institute for Healthcare Improvement [IHI], Association for Professionals in Infection Control and Epidemiology [APIC] and Society of Healthcare Epidemiology of America [SHEA]).⁹⁻¹⁵ Additional guidance can be found in guidelines developed by experts in specialty care areas (e.g. Association of Perioperative Registered Nurses [AORN] and the American College of Cardiology).¹⁶⁻¹⁹ Acute care facilities should work with their various departments and units, including specialty care areas (e.g. operating rooms, peri-operative areas, anesthesia, and cardiac catheter laboratories) to determine how best to implement this document.

Background

Staphylococcus aureus

Staphylococcus aureus bacteria are Gram-positive cocci that are both coagulase and catalase positive and have long been recognized as important pathogens in human disease. *S. aureus* can cause a wide range of infections from non-invasive skin and soft tissue infections to invasive infections of the bone, joint, and blood; but it can also colonize the human body without causing disease. Up to 30% of the population at any point in time is colonized with *S. aureus*, most often in the anterior nares.²⁰ Until the development of penicillin for use as an antibiotic in the 1940s, up to 50% of serious *S. aureus* infections resulted in death. Unfortunately, shortly after the introduction of penicillin, *S. aureus* strains resistant to penicillin were isolated.²¹

A similar pattern was seen with *S. aureus* resistant to methicillin. Methicillin was first introduced in 1960 and *S. aureus* isolates that demonstrated resistance to methicillin were isolated in 1961.²² MRSA was first identified as a hospital-acquired pathogen in United States hospitals in 1968.²³ Since then, MRSA infections have increased such that in 2004 more than 60% of *S. aureus* isolates from intensive care unit patients were resistant to methicillin.³ Additionally, a recent nationwide point-prevalence study looking at MRSA colonization and infection in hospitalized patients found that 46.3 out of every 1,000 hospitalized patients (30.7 out of every 1,000 hospitalized patients in Minnesota) were colonized or infected with MRSA.²⁴

MRSA infections have been shown to result in longer lengths of hospital stays, increased costs, and increased mortality compared to methicillin-susceptible *Staphylococcus aureus* (MSSA) infections.²⁵⁻³² Additionally, it has been shown that patients colonized with MRSA are more likely to develop MRSA infections when compared to patients colonized with MSSA who

develop MSSA infections.^{27,33,34} Furthermore, a study conducted in a surgical intensive care unit found that MRSA may be transmitted between patients and healthcare workers more easily than MSSA.³⁵

MRSA infections were initially seen in patients with frequent exposures to healthcare settings, including patients with a history of recent surgery, hospitalization, dialysis, or residence in a long-term care facility.³⁶ MRSA infections in patients with healthcare exposures are termed healthcare-associated (HA) MRSA. In the 1980s, MRSA infections were seen in patients who lacked healthcare risk factors.³⁷⁻³⁹ MRSA infections in patients lacking traditional healthcare risk factors are termed community-associated (CA) MRSA infections.

Isolates from patients with traditional HA-MRSA infections tend to be different than isolates from CA-MRSA patients. HA-MRSA isolates are resistant to more classes of non-beta-lactam antibiotics and possess different toxin profiles than CA-MRSA isolates.⁴⁰ CA-MRSA isolates are more likely to possess Panton-Valentine leukocidin (PVL) and certain other staphylococcal enterotoxins than HA-MRSA isolates.^{40,41} The presence of these toxins in CA-MRSA strains has been associated with increased virulence of the organism.⁴²⁻⁴⁴ This is of concern, as recent reports have described CA-MRSA strains causing infections in acute care facilities.⁴⁵⁻⁴⁹

Increases in methicillin-resistance among community-associated staphylococcal isolates have been reported.⁵⁰⁻⁵² In some regions more than half of all community-associated staphylococcal infections reported are methicillin-resistant.⁵³ Minnesota has conducted prospective surveillance on CA-MRSA infections in 12 sentinel hospital laboratories located throughout the state since 2000. The number of CA-MRSA infections reported from the 12 sentinel sites has increased dramatically over the 7 years of study, from 131 cases (12% of total

MRSA infections) reported in 2000 to over 1,400 cases (42% of total MRSA infections) reported in 2006.^{38,51,54}

A recently published study describing the burden of invasive MRSA in the United States in 2005 calculated an average invasive MRSA infection rate of 31.8 per 100,000 people nationally and a rate of 19.2 per 100,000 people in Minnesota.² Using the national incidence rate, approximately 90,000 invasive MRSA infections and 18,000 deaths occurred in 2005.² When the calculated incidence rate of invasive MRSA infections in Minnesota (19.2 per 100,000) is applied to the population of Minnesota, 1,000 invasive MRSA infections occurred in Minnesota in 2005.² Using hospital discharge data for the Midwestern United States, it was estimated that MRSA was coded in the discharge diagnosis at a rate of 7.23 per 1,000 patient discharges and the rate of MRSA-associated hospitalizations doubled from 1999 to 2005.⁵⁵

Since 2005, when population-based estimates of invasive MRSA infections first became available,² the incidence of invasive health care-associated MRSA infections has decreased with an estimated 9.4% annual decrease in hospital-onset (nosocomial) and an estimated 5.7% annual decrease among patients who had onset of their infection outside the hospital but who had recent exposure to health care delivery.⁵⁶ Although the reasons for the observed decrease in incidence of invasive health care-associated MRSA infections are not known, the researchers discussed possible contributing factors, including MRSA infection prevention, hand hygiene, and central line-associated bloodstream infection prevention initiatives.^{56,57}

MRSA prevention and control continues to be an important issue in United States healthcare facilities and ongoing vigilance to MRSA infection prevention and control strategies and support of infection prevention personnel is necessary.

Infection Prevention and Control

The Centers for Disease Control and Prevention (CDC) has developed guidelines for infection prevention and control precautions for use by healthcare personnel. The infection prevention and control precautions are divided into two main categories: Standard Precautions and Transmission-Based Precautions. Standard Precautions assume that all blood, body fluids, secretions, excretions, non-intact skin, and mucous membranes contain transmissible infectious agents. Standard Precautions apply to all patients in healthcare facilities, regardless of suspected or confirmed infection status. Standard Precautions include: hand hygiene; use of gloves, gown, mask, eye protection or face shield depending on anticipated exposure to blood or body fluids; and safe injection practices. Standard Precautions require the use of gloves if contact with patient blood or body fluids/secretions is anticipated; gown use if it is anticipated that healthcare worker clothing will become contaminated with potentially infectious material; mask, goggles and/or face shields or combinations of each for use during splash-generating procedures, when caring for patients with open tracheostomies and the potential for projectile secretions exists, and in circumstances where there is evidence of transmission from heavily colonized sources.^{10,58}

In addition to Standard Precautions, Transmission-Based Precautions are used when the route(s) of transmission is (are) not completely interrupted using Standard Precautions alone. There are three categories of Transmission-Based Precautions: Contact Precautions, Droplet Precautions and Airborne Precautions. Contact Precautions are recommended for patients with MRSA infection or colonization. For diseases that have more than one route of transmission, multiple types of Transmission-Based Precautions are required.^{10,58}

Contact Precautions are intended to prevent transmission of infectious agents transmitted by direct or indirect contact with the patient or the patient's environment. Examples of infectious

agents/conditions that require the use of Contact Precautions include MRSA, certain other antimicrobial-resistant organisms, and *Clostridium difficile*-associated diarrhea. Patients on Contact Precautions should be placed in a single-patient room and healthcare providers caring for these patients should wear a gown and gloves for all interactions that may involve contact with the patient or potentially contaminated areas/items in the patient's environment.^{10,58}

Several published documents address infection prevention and control practices for antimicrobial-resistant organisms including MRSA. These documents include: 1) Management of Multidrug-Resistant Organisms (MDROs) in Healthcare Settings, 2006, Healthcare Infection Control Practices Advisory Committee (HICPAC); 2) Getting Started Kit: Reduce Methicillin-Resistant *Staphylococcus aureus* (MRSA) How-to Guide, Institute for Healthcare Improvement (IHI); 3) Guide to Elimination of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Transmission in Hospital Settings, Association for Professionals in Infection Control and Epidemiology (APIC); 4) Society for Healthcare Epidemiology of America (SHEA) Guideline for Preventing Nosocomial Transmission of Multidrug-Resistant Strains of *Staphylococcus aureus* and *Enterococcus*; and 5) Strategies to prevent transmission of methicillin-resistant *Staphylococcus aureus* in acute care hospitals (SHEA/IDSA).^{10-13,59}

Infection prevention and control staff should be aware of and utilize the published recommendations for the control of MRSA and other MDROs (HICPAC, APIC, SHEA, IHI) and stay current with published literature describing new information regarding best practices for controlling MRSA.^{6,10-13,58}

Administrative Support

Administrative support is vital to the success of MRSA control and other infection prevention activities. Control of MRSA requires the participation and support of the acute care

facility administration. Additionally, a commitment of financial and human resource assets must be made available for infection prevention and control staff and activities.⁶⁰⁻⁶² It has been shown that administrative and organizational leadership support for infection prevention and control programs has been associated with improvements in healthcare provider acceptance and adherence to recommended infection prevention and control practices.⁶⁰

Review of Specific Infection Prevention and Control Interventions

Patient Placement of the MRSA-Colonized or -Infected Patient

Patients colonized or infected with MRSA are to be placed in a private (single-patient) room and on Contact Precautions when admitted to acute care facilities.¹⁰

Although placing MRSA-colonized or -infected patients on Contact Precautions has been shown to decrease transmission, this practice can have negative effects on patients and their care.⁶³⁻⁶⁶ Patients in isolation have been found to have higher anxiety and depression scores than non-isolated patients.^{67,68} Several studies have documented that healthcare providers are less likely to examine patients on Contact Precautions and spend less time in direct contact with patients during exams.^{63,64} When compared to non-isolated patients, isolated patients are less likely to have their vital signs recorded, have fewer physician progress notes, are more likely to complain about their care and are more likely to experience an adverse event.⁶⁹ Facilities must be aware of the potential care disparities and compensate through staff education and awareness campaigns and efforts to prioritize and improve hand hygiene.⁶⁵

Cohorting MRSA-Colonized or -Infected Patients

Cohorting is the practice of grouping patients infected or colonized with the same infectious agent together or confining them to one patient care area to prevent contact with susceptible patients. If single-patient rooms are not available, MRSA-colonized or -infected patients may be cohorted with other patients under some circumstances. This can include placing MRSA patients in rooms with other MRSA patients or with patients with no history of MRSA and who are at low risk for acquisition of MRSA and associated adverse outcomes from infection and who are likely to have short lengths of stay.^{10,58}

There are few data on the efficacy of patient cohorting as a stand-alone infection prevention and control strategy. Most studies describe patient cohorting as one part of a combination of infection prevention and control strategies for MRSA transmission prevention.⁷⁰⁻
⁷⁴ Host factors in the MRSA-infected or -colonized patient that influence the risk of MRSA transmission must be considered when evaluating cohorting candidates. These patient factors include draining wounds or other uncontained body fluids, presence of invasive devices, ability to perform basic hygiene, and ability to understand and cooperate with instructions.⁷⁵ In general, patients with fewer risk factors for MRSA transmission are better candidates for cohorting.

To reduce the risk of cross-contamination while cohorting patients, it is necessary to maintain the integrity of each isolation space.¹¹ Each patient's bed area must be considered a separate isolation space. Healthcare workers must perform hand hygiene and change personal protective equipment between providing care to patients cohorted in one room. Where feasible, equipment (e.g. blood pressure cuff, stethoscope, tourniquet, computer) should be dedicated to the use of one patient. When the use of separate equipment is not possible, equipment must be thoroughly disinfected between patients.^{10,11}

Personal Protective Equipment

The hands of healthcare workers can become contaminated with infectious organisms (e.g. MRSA) without the worker having direct contact with the colonized or infected patient as a result of environmental contamination of frequently touched surfaces in the patient room (bedrails, countertops, etc.).⁷⁶⁻⁷⁹ For this reason, HICPAC requires gloves to be worn to enter a room where a patient is on Contact Precautions regardless of anticipated contact with the patient or the patient's environment.⁵⁸ Glove use has also been shown to increase healthcare worker hand hygiene compliance.⁸⁰

For patients colonized or infected with MRSA, healthcare workers are required to don a gown prior to patient room entry.¹⁰ Studies have suggested that universal gowning upon room entry may help to increase healthcare worker compliance with infection prevention and control practices overall. A study that evaluated rates of patient colonization with another MDRO, vancomycin-resistant enterococci (VRE), found no difference in VRE colonization with universal use of gowns and gloves; however, compliance with infection prevention and control recommendations increased 17% when universal gowning was required for room entry.⁸¹ A second study also demonstrated an increase in compliance with precautions, although there was no decrease in MDROs in the hospital during the study period.⁸² Several studies noted a decrease in VRE colonization rates when universal gown and glove use were required compared to glove and gown use only when contact with the patient or patient's environment was anticipated.⁸³⁻⁸⁶

As a part of Standard Precautions, masks are required when performing splash-generating procedures, when caring for patients with open tracheostomies and the potential for projectile secretions exists, and in circumstances where there is evidence of transmission from heavily colonized sources (e.g. draining wounds).^{10,59} One study suggested that mask use for activities that involved intensive patient contact or manipulation of colonized or infected sites during MRSA outbreaks may result in decreased transient healthcare worker nasal, hand, and throat colonization with MRSA.⁸⁷ Some hospitals have chosen to implement this infection prevention and control measure.

Hand Hygiene

Transient contamination of healthcare worker hands can occur in the process of caring for patients with MRSA or after contact with the environment of patients with MRSA.^{76,88,89} MRSA was found on uniforms and gowns of 65% of healthcare workers performing care activities for

patients with MRSA and 42% of healthcare workers having contact only with the environment in an MRSA patient's room had MRSA on their gloves.⁹⁰ Another study found that 13% of healthcare worker hands were contaminated with the same organisms present on the outside of their gloves.⁹¹ Additionally, a study demonstrated VRE present on the hands of 29% of healthcare workers who also had VRE present on the outside of their gloves.⁹² Multiple studies have shown that improvements in healthcare worker's hand hygiene compliance have been associated with decreases in MRSA transmission.⁹³⁻⁹⁶

Reported rates of hand hygiene compliance among healthcare workers are low, ranging from 5% to 81% with an average of 40%.⁹⁷⁻⁹⁹ Barriers to appropriate hand hygiene include facility design issues (lack of easy access to soap and sinks or alcohol-based hand sanitizer), staffing issues (nursing shortages, time constraints, lack of role models for hand hygiene), lack of education (belief that glove use substitutes for hand hygiene, belief that there is a low risk of acquisition of infectious organisms from patient, lack of knowledge on hand hygiene guidelines and protocols), and skin irritation (harsh soaps causing skin breakdown).¹⁰⁰

Strategies to increase healthcare worker hand hygiene compliance include hand hygiene education efforts, providing healthcare workers with feedback on hand hygiene performance, administrative support, and introduction of an alcohol-based hand sanitizer.^{60,93,98,101-106}

Sustained increases in hand hygiene compliance have been reported when multifaceted interventions, such as those that include education and feedback activities, are implemented.^{93,98}

Monitoring hand hygiene practices among healthcare workers is essential to assess baseline compliance rates and provide information on changes in adherence to hand hygiene recommendations after implementation of interventions. Monitoring of hand hygiene compliance can be done by direct observation (healthcare worker observation or patient assessment) and

indirect observation (monitoring consumption of products or electronic monitoring of hand cleaning stations).^{93,99,101,103,107,108} While direct observation is the most reliable method of assessing hand hygiene compliance, it is also the most labor-intensive.¹⁰⁷ Some combination of direct and indirect measurements may be used to monitor hand hygiene compliance rates. Examples of hand hygiene compliance monitoring tools can be found at www.handhygiene.org or from the Institute for Healthcare Improvement website at www.ihl.org.

Guidelines for hand hygiene in healthcare settings are available including: 1) “Guideline for Hand Hygiene in Health-Care Settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force” and 2) “WHO Guidelines on Hand Hygiene in Healthcare.”^{99,107} Facilities should follow these guidelines’ recommendations for hand hygiene.

Visitors of Patients on MRSA Contact Precautions

Visitors to patients on Contact Precautions should be instructed about basic infection prevention and control practices, including hand hygiene, to reduce the risk of disease transmission.^{10,58} Although several studies have included visitor use of gloves and gowns for room entry to patients on Contact Precautions, the studies did not specifically analyze the impact of this practice on disease transmission.^{85,109,110} The routine use of personal protective equipment (e.g. gowns, gloves) for visitor room entry is not necessary; however, visitors assisting in the direct care of patients should follow Standard Precautions for the use of personal protective equipment.

Environmental Cleaning

MRSA can persist on surfaces for extended periods of time ranging from 1 to 56 days.^{111,112} Personnel and patients can acquire MRSA by coming into contact with a

contaminated environment or objects in the environment.^{76,90,113-116} Thorough, regular cleaning and disinfection of patient rooms and equipment is a vital component of preventing MRSA transmission in the healthcare setting, regardless of the patient's known MRSA status.^{90,114} Up to 25% of patients without known MRSA infection or colonization were found to have objects in their environment (over-bed table, door handles, etc.) contaminated with MRSA.^{117,118} Administration, infection prevention and control, environmental services and nursing leadership must collaborate to ensure thorough cleaning, education and training of staff, and adequate staffing levels.¹¹ Education must be tailored to the education level and language preferences of all staff, including, environmental services staff. Checklists may be helpful to ensure that appropriate cleaning procedures are being followed; sample checklists are available from CDC (see Appendix A), APIC, and IHI.^{11,12}

Screening Patients for MRSA

Several populations have been identified as being at increased risk for ongoing MRSA colonization. The most commonly identified risk groups include elderly patients, long-term care facility residents, patients with chronic skin lesions, patients with a history of recent hospitalization, dialysis patients, patients transferred or released from correctional facilities, or patients with a recent history of antibiotic use.^{36,119-134}

The groups with the highest MRSA colonization rates may vary among institutions, depending on the populations served by the facility. Conducting a point prevalence survey (e.g. collecting nasal swabs on every person admitted to a unit or facility over a period of time, from one to several days) may help to identify groups at risk for MRSA in individual facilities. This approach also helps facilities appropriately target resources to areas that have the most potential to benefit from decreased MRSA transmission.^{10,135}

Surgical patients colonized with MRSA may be at an increased risk for MRSA surgical site infections (SSI). Some researchers have noted increased rates of MRSA SSI among cardiothoracic and orthopedic surgical patients colonized with MRSA.^{136,137} Results of implemented pre-surgical screening and treatment for MRSA have been varied, with some studies demonstrating decreased MRSA SSI rates with pre-surgical treatment of MRSA-colonized patients^{137,138} while others found no difference in MRSA SSI rates in treated versus non-treated patients.¹³⁶ SSI prevention measures, including good preoperative practices such as appropriate timing for antimicrobial administration and skin preparation practices, may have greater impacts on reducing MRSA SSI. Screening and treatment may be considered if MRSA SSI rates are not decreasing despite adherence to SSI prevention measures (SSI prevention measures available from: www.ihl.org).

Patients in intensive care units may be at increased risk for MRSA infection compared to non-intensive care unit patients because many are receiving antibiotics and have at least one indwelling invasive or medical device (e.g. on a ventilator, presence of a central line). Intensive care unit patients colonized with MRSA are almost four times more likely to develop MRSA bacteremia compared to patients colonized with MSSA that develop MSSA bacteremia.¹³⁹ In critically ill patients, MRSA bacteremia has been found to result in a higher attributable mortality rate than MSSA.³⁰ Additionally, one study demonstrated that MRSA spread more easily to patients than did MSSA in a surgical ICU and the ease of spread was attributed to antimicrobial selective pressures or intrinsic factors within MRSA.³⁵

Recent reports describing outbreaks of MRSA among infants in newborn nurseries suggest that pregnant woman may be another high-risk group due to increasing CA-MRSA rates.

Additionally, studies of vaginal/rectal MRSA colonization among pregnant women have found colonization rates of up to 10 percent.¹⁴⁰⁻¹⁴²

Screening patients to identify those colonized with MRSA can be an important tool in MRSA infection prevention and control. Colonized persons are generally asymptomatic and can remain colonized with MRSA for extended periods of time, ranging from months to years.^{88,143,144} Because clinical cultures are generally used only in symptomatic patients, the majority of patients colonized with MRSA go undetected and can act as a reservoir in the MRSA transmission cycle.^{119,123,145-148}

MRSA colonization has been reported from the anterior nares, hands and other skin sites (intact and non-intact), throat, urine, perineum, and stool.¹⁴⁹⁻¹⁵³ However, the anterior nares is the most common site of MRSA colonization and is the preferred anatomical site for MRSA screening if only one site is used.^{149,153}

Active Surveillance Testing

Active surveillance testing (AST) is surveillance conducted for the purpose of identifying patients (typically by collecting a swab from the anterior nares) with MRSA. The rationale for conducting AST is to identify colonized patients so that additional precautions can be applied (e.g. Contact Precautions).

There have been no published randomized, controlled trials to study the efficacy of AST alone in decreasing the rate of MRSA infection, colonization, or transmission within acute care facilities. In part, this is due to the difficulty of distinguishing the impact of AST on MRSA transmission rates from the impact attributable to other infection prevention and control practices (e.g. hand hygiene, Contact Precautions, and environmental cleaning) that are components of routine patient care.

Current literature indicates that AST, performed among identified high-risk patient populations or high-risk patient care units, in conjunction with routine infection prevention and control practices, can result in decreased MRSA infection rates.^{147,154-167} High-risk units vary between facilities and may include general intensive care units, burn units, post-surgical units (e.g. orthopedic or cardiac), or other units to which patients with increased MRSA risk factors (e.g. invasive lines, receiving antimicrobial therapy, compromised skin integrity) are cared for.^{147,148,155,157} When used properly, the practice of conducting AST with isolation of patients found to be carrying MRSA has demonstrated cost savings to the healthcare facility in most instances.^{147,156,157,159,160,168-170}

A retrospective interrupted time series study of four major infection prevention and control interventions (maximally sterile central vascular catheter placement, introduction of alcohol-based hand sanitizer, hand hygiene campaign, and intensive care unit AST for MRSA) found that only the use of intensive care unit AST was associated with decreases in the incidence of MRSA bacteremia.¹⁵⁵ Active surveillance testing from intensive care unit patients decreased the incidence density of bacteremia by 75% in the intensive care unit AST was conducted. Of significance, the researchers also noted a 67% decrease in the incidence of MRSA bacteremia hospital-wide when AST was conducted in intensive care unit patients.¹⁵⁵

Conversely, other studies in acute care patients using AST have not shown decreased MRSA transmission rates.^{167,171-175} This suggests that other infection prevention and control strategies such as increased hand hygiene adherence, adherence to Contact Precautions, cohorting of nursing staff and decreasing patient bioload may control transmission just as effectively as the use of AST.^{171,172,176}

In summary, AST, particularly in conjunction with other infection prevention and control practices (e.g. hand hygiene, Contact Precautions, environmental cleaning), has been found to decrease MRSA transmission rates among high-risk units or populations. However, at this time, the optimal use of AST is not clear and consensus about how to use AST has not been achieved among published guidelines or organizations.¹⁷⁷ When considering the use of AST for MRSA prevention and control, it is important to consider local MRSA epidemiology, infection prevention practices, and vulnerability of the patient population; AST alone is not effective.¹⁷⁸

Discontinuing Contact Precautions

Healthcare facilities struggle with the decision about when to remove patients that have had a positive MRSA test from Contact Precautions. The HICPAC guidelines categorize discontinuation of Contact Precautions as an unresolved issue, although the background discussion does describe taking a “reasonable” approach. More recent studies acknowledge the problem, noting that increased use of AST will increase the use of Contact Precautions dramatically. As a result, the question of when to discontinue precautions is quickly becoming more pressing.

One factor that impacts when to remove a patient from Contact Precautions is the duration of MRSA colonization. The duration of MRSA colonization in a patient can vary, and studies have demonstrated MRSA colonization ranging from 3 months to greater than 2 years.^{88,143,144,179} Persistence of carriage was influenced by both modifiable and non-modifiable risk factors.^{10,143,144,180,181} Risk factors associated with persistent carriage included breaks in the skin, indwelling devices, receipt of immunosuppressive therapy, and receipt of hemodialysis.^{143,144,180,181} One study also showed a trend toward an association between admission to the hospital from a chronic care institution and persistent MRSA carriage.¹⁴⁴

Although not explicitly done for the purpose of developing a protocol to discontinue Contact Precautions, the studies of MRSA carriage provide background for developing a protocol for discontinuation of Contact Precautions.

Screening Healthcare Workers for MRSA

Although healthcare workers can become colonized with MRSA, colonized healthcare workers are rarely the cause of MRSA outbreaks in acute care settings, and transmission of MRSA from colonized healthcare workers to patients is thought to be rare.^{182,183} Instances associated with increased risk of MRSA transmission from colonized healthcare workers to patients have been noted when healthcare workers have chronic skin conditions, chronic otitis media, or when nasally colonized healthcare workers develop viral respiratory infections which result in increased shedding of MRSA.¹⁸⁴⁻¹⁸⁸ Unless there is epidemiological evidence linking healthcare workers to ongoing MRSA transmission, screening healthcare workers for MRSA is not recommended. Healthcare worker screening may result in identifying transient MRSA carriage not associated with transmission,^{151,189} disruption of staff routine and stigmatization of colonized healthcare workers.^{10,190} Factors to consider in managing an outbreak include strain type of the MRSA isolate (matching outbreak pattern), location of MRSA colonization (nares, hands, groin), and whether ongoing transmission to patients persists.¹⁹¹

Healthcare workers implicated in transmission should be screened for MRSA colonization and colonized healthcare workers implicated in transmission are candidates for decolonization.¹⁰ The purpose of treating MRSA-colonized healthcare workers implicated in transmission is to interrupt MRSA transmission, not to permanently decolonize the healthcare worker. Facilities should evaluate MRSA-colonized healthcare workers associated with

transmission to determine if they need to be furloughed from patient contact while undergoing decolonization.

Management of MRSA Colonization

There are no standard recommendations for management of persons colonized with MRSA. Most published studies report on patients or healthcare workers with nasal colonization and very little information is available on successful decolonization strategies for colonization at non-nasal sites.¹⁹²⁻¹⁹⁵ The most common nasal decolonization regimes use mupirocin ointment alone or in combination with antimicrobial body washes and/or systemic antimicrobials.

Several different decolonization regimens have been described in the literature with initial success rates of over 90%;^{192,194,196,197} however, long-term decolonization success has not been adequately researched. One paper reported that 61% of patients remained decolonized at 90 days post treatment¹⁹⁴ while a second study reported that 54% of patients remained decolonized after 8 months.¹⁹² In another study where 85% of the patients had MRSA in more than one body site, only 6% of patients were successfully decolonized despite using a decolonization protocol that included body wash with an antimicrobial soap, mupirocin for patients nasally colonized with MRSA and systemic antimicrobials when clinically indicated.¹⁹⁸

Systemic antimicrobials may be more useful when dealing with non-nasal sites of colonization although there is a lack of published data on this subject. Use of systemic antimicrobials should be weighed against the risks of patient side effects and of adding to overall antimicrobial pressure that can contribute to antimicrobial resistance.

Care is needed when using a decolonization protocol that uses mupirocin, as prolonged use of mupirocin has been associated with emergence of mupirocin resistance.¹⁹⁹⁻²⁰¹ A study of Canadian MRSA isolates over a 10-year period found a five-fold increase in mupirocin

resistance.²⁰² Consultation with an infectious disease physician is recommended prior to initiating a widespread decolonization protocol for patients.

Antibiotic Stewardship

There is a strong correlation between antimicrobial use and antimicrobial resistance.²⁰³ Antimicrobial selection pressure, as a result of antimicrobial misuse, contributes to the emergence of resistant organisms.²⁰⁴ Studies have shown that antibiotic use is associated with an increased risk of colonization and/or infection with resistant organisms.^{205,206} Specifically, studies have reported an association between antibiotic use and the development of MRSA colonization and/or infection.^{124,125,128,176,207-211}

As much as 50% of all antimicrobial use is inappropriate.²¹² Misuse encompasses the use of broad spectrum agents when narrow-spectrum agents would be effective, antimicrobial prescribing for infections with a viral etiology, and prescribing clinically unnecessary doses and extended duration of treatment.^{213,214} Misuse of antimicrobial agents jeopardizes the utility of these drugs and threatens the successful treatment of all infections.

More than 70% of the bacteria that cause hospital-acquired infections are resistant to at least one of the drugs most commonly used to treat them.⁴ Furthermore, infections caused by multidrug-resistant bacteria are increasing. These infections, formerly seen primarily in hospital intensive care units, now occur in other inpatient settings as well as in ambulatory care. Persons infected with drug-resistant organisms are more likely to have a longer hospital stay and require treatment with more expensive and more toxic antibiotics than persons infected with non-resistant organisms.^{215,216} As a result, antimicrobial-resistant infections place increasing financial burden on the healthcare system, with treatment costs for patients infected with resistant organisms estimated to be \$4 to 7 billion annually in the United States.²⁰⁴

Antimicrobial stewardship is critical to the management of antimicrobial resistance, including MRSA. Judicious antimicrobial use programs, combined with a comprehensive infection prevention and control program, have been shown to curb the emergence and transmission of antimicrobial resistant bacteria.^{217,218}

Antimicrobial stewardship entails the optimal selection, dosage, and duration of antimicrobial treatment that results in the best clinical outcome for the treatment or prevention of infection.²¹² Antimicrobial stewardship in acute care facilities incorporates practices such as automatic stop orders, antibiotic cycling, authorization systems, formulary restriction, mandatory consultation and peer review and feedback.¹⁰ Effective antimicrobial stewardship programs are multifaceted and focus on all levels of the healthcare delivery system including direct care providers, healthcare administration, ancillary staff, patients and payers.^{8,219}

Education and Training of Healthcare Workers

An important aspect of effective infection prevention and control strategies is ensuring that all parties (e.g. healthcare workers, patients, visitors, environmental service staff, etc.) are educated about the facility's recommended infection prevention and control practices. Infection prevention and control programs that include healthcare worker education, accountability, and feedback have been shown to have higher rates of healthcare worker adherence to infection prevention recommendations and lower rates of MRSA or VRE transmission.²²⁰⁻²²² Healthcare providers are more receptive and adherent to the recommended control measures when organization leaders participate and are seen as supportive of infection prevention and control programs.⁶⁰ Resources must be allocated for infection prevention education for patient care and patient care support staff.

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Category Ranking Descriptions

The following system was used for categorizing recommendations (For MDH Recommendations based on CDC/HICPAC recommendations, the CDC/HICPAC categories were used.):

Category IA - Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies

Category IB - Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale.

Category IC - Required for implementation, as mandated by federal and/or state regulation or standard

Category II - Suggested for implementation and supported by suggestive clinical or epidemiological studies or a theoretical rationale

MDH-MRTF Consensus Statement - MDH-MRTF recommendation. This category was used for infection prevention practices that the MDH-MRTF thought were essential to MRSA infection prevention and control but were practices not addressed by CDC/HICPAC. These infection prevention practices were not listed in current HICPAC documents or were listed in HICPAC documents but given no category ranking or a Category II ranking. The MDH-MRTF came to a group consensus when addressing issues not covered by the aforementioned existing recommendations and guidelines for MRSA control by conducting extensive literature review and holding in-depth discussions on current standards of practice.

A. INFRASTRUCTURE AND CULTURE TO SUPPORT MRSA INFECTION PREVENTION AND CONTROL

1. Administrative support for infection prevention and control (MDH-MRTF Consensus Statement)
 - a. Administration should provide support, both financial and human resources (e.g. empower front-line multi-disciplinary teams, provide necessary supplies, resources, and personnel [i.e., infection preventionist, microbiologist, environmental services]) to prevent and control MRSA transmission within the facility including: IB^{10,11,58,60,61,72,73,93,116,223,224}
 - i. Adherence to infection prevention and control practices as a measure of accountability (i.e. Administration and managers held accountable for infection prevention and control lapses in areas under their supervision).
 - ii. Staff training on infection prevention and control policies
 - iii. Adherence to facility infection prevention and control policies by all staff (employed and credentialed).
 - iv. Collaboration between infection prevention and control, medical and nursing staff, ancillary services, and environmental services to ensure effective implementation of infection prevention and control programs/policies.
 - v. Patient and family/visitor education regarding infection prevention and control programs.
 - vi. Inclusion of infection prevention and control practices into the job description of every hospital employee and contract staff.
 - vii. Adequate funding for infection prevention and control activities/interventions, including staffing and information technology to support automation where possible.
 - viii. Ensure funding for annual MRSA risk assessments.
 - ix. Promote a culture that supports adherence to infection prevention protocols.
 - b. Administration should support programs that promote antimicrobial stewardship and ensure that systems are in place to promote optimal clinical management of infections. IB¹⁰
 - c. Administration should provide funding for contracts with experts to provide consultation if the facility does not have expertise in development/implementation of infection prevention and control strategies, antimicrobial stewardship, and/or epidemiologic data analysis.
2. Antimicrobial stewardship (MDH-MRTF Consensus Statement)^{4,8,10}
 - a. Acute care facilities should develop a multidisciplinary antimicrobial stewardship team that includes, at a minimum, a physician and a clinical pharmacist with infectious disease training or interest. Additional members may include clinical microbiologists, information technology specialists, infection preventionists, and hospital epidemiologists.
 - b. Facilities should have a mechanism to review antimicrobial utilization and ensure judicious antimicrobial use. This may include:

- i. Antimicrobial use audits and feedback to prescribers
 - ii. Development of antimicrobial formularies and preauthorization requirements for antimicrobial use
 - iii. Provider education regarding antimicrobial stewardship
 - iv. Development of guidelines and clinical treatment pathways that incorporate local microbiology and antimicrobial resistance patterns
 - v. Antimicrobial order forms
 - vi. Implementing a process for streamlining, deescalating, or dose optimization of therapy based on antibiotic susceptibility testing results
 - vii. Implement an expectation for parenteral to oral conversions when clinically appropriate
 - c. Facilities that lack expertise in antimicrobial stewardship should consider establishing cooperative relationships or consultations with facilities that have such expertise.
- 3. Infection prevention and control policies and procedures
 - a. Base policies/procedures on published guidelines (HICPAC, APIC, SHEA, IHI) and update as appropriate in accordance with available scientific data. (MDH-MRTF Consensus Statement)^{6,10,11,13,58,59}
- 4. Education
 - a. Provide infection prevention and control, including MRSA, education at new employee orientation. IB¹⁰
 - b. Provide information on the facility's experience with MDROs and prevention strategies.

B. BASELINE INFECTION PREVENTION AND CONTROL RECOMMENDATIONS

- 1. Infection prevention and control practices^{10,13,58,92,225,226}
 - a. Standard Precautions should be used in the care of all patients, regardless of MRSA status. IB
 - i. Use of gown, gloves, face shield, mask and/or eye protection (goggles) should be determined by patient interaction and the extent of anticipated blood, body fluid, or pathogen exposure
 - b. Implement Transmission-based Precautions (Contact Precautions, Droplet Precautions, and Airborne Precautions) as indicated. IB
 - c. Healthcare workers should follow hand hygiene recommendations. IA (See section B.2)
 - d. Facilities that lack expertise in developing and implementing infection prevention and control strategies should consider establishing cooperative relationships with facilities that have such expertise. (II, MDH-MRTF Consensus Statement)
- 2. Hand hygiene IA^{10,11,13,58,107,108}
 - a. Implement a comprehensive hand hygiene program for all healthcare workers based on published guidelines. IA^{10,11,58,59,107}
 - b. Hand hygiene must be performed:
 - i. Before and after direct contact with patients IB

- ii. After removing gloves IB
 - iii. Before handling an invasive device for patient care IB
 - iv. After contact with body fluids or excretions, mucous membranes, non-intact skin, or wound dressings IA
 - v. When moving from a contaminated body site to a clean body site during patient care IA
 - vi. After contact with inanimate objects in the immediate vicinity of the patient IB
- c. Monitor healthcare worker compliance with hand hygiene and provide performance feedback. Tools, including knowledge assessment questionnaires, checklists, and monitoring forms, have been developed and are available from IHI, WHO and various other sources. IA^{108,227-229}
 - d. If hand hygiene compliance is low, develop an action plan designed to improve healthcare worker adherence to recommended hand hygiene practices. IB Factors to consider when developing an action plan include: number and location of sinks and alcohol-based hand sanitizer dispensers, clear hand hygiene policies, availability of educational materials, and institutional culture that holds healthcare workers accountable for performing hand hygiene.^{99,107}
3. Environmental measures
- a. Administration, infection prevention, environmental services and nursing leadership should work together to ensure thorough education and training of environmental services staff. (MDH-MRTF Consensus Statement)
 - b. Administration should ensure adequate staffing for environmental services staff based on industry standards. (MDH-MRTF Consensus Statement)¹¹
 - c. Environmental services staff are considered healthcare workers and should don personal protective equipment for room entry as described in C.2.c. (MDH-MRTF Consensus Statement)
 - d. Use EPA-registered and facility-approved disinfectants; follow manufacturers' instructions for recommended dilutions and contact time. (MDH-MRTF Consensus Statement)

C. TIER ONE RECOMMENDATIONS FOR MRSA PREVENTION AND CONTROL

1. MRSA risk assessment

Acute care facilities should develop a plan to conduct an MRSA risk assessment at least yearly. (MDH-MRSA Consensus Statement)

- a. Facilities that screen all patients for MRSA should monitor MRSA infection and colonization rates as described in C.5 (for more information on AST, see Background, *Active Surveillance Testing*).
- b. Facilities that do not screen all patients for MRSA must conduct a yearly MRSA risk assessment to identify MRSA risk groups or assess MRSA transmission rates.^{10,59,70,72,74,119,230} Examples of risk assessments include:
 - i. A point prevalence study (screen all hospital admissions or admission to targeted to high risk populations/units) to determine risk groups/units.

- ii. A transmission study (screen patients at admission and discharge for a period of time hospital-wide or (on high risk populations/units) to evaluate MRSA transmission rates.
 - c. Potential groups to target for MRSA screening include:
 - i. Patients admitted to intensive care units (e.g. medical, surgical, or neonatal)^{146,147,155,156,169,231}
 - ii. Patients admitted to high risk wards/units (e.g. burn, bone marrow/stem cell transplant, and oncology units)¹⁵⁸
 - iii. Long-term care facility residents^{119,123,124,207,232-234}
 - iv. Patients transferred from other acute care facilities^{207,235}
 - v. Hemodialysis patients²³⁵
 - vi. Patients readmitted to the hospital less than 30 days from previous discharge^{119,120,125,207,232,233}
 - vii. Assisted living facility residents
 - viii. Pregnant women^{142,236}
 - ix. Surgical patients^{16,17,137,138,237-239}
 - d. Potential anatomical sites for MRSA screening IB:¹⁰
 - i. Anterior nares (usually sufficient to sample only anterior nares but other sites can be added)^{121,149,153}
 - ii. Areas of skin breakdown and draining wounds^{120,124,149}
 - iii. Throat¹⁵²
 - iv. Invasive devices²⁰⁷
 - v. Peri-rectal or perineal cultures^{150,153}
 - vi. For pregnant women: nasal and/or vaginal/rectal colonization prior to delivery^{142,236}
- 2. Infection prevention and control practices for patients with MRSA^{10,13,92,225,226}
 - a. Patients with any of the following must be placed on Contact Precautions in addition to Standard Precautions:
 - i. MRSA infection, any anatomical site IA¹⁰
 - ii. MRSA colonization, any anatomical site IA¹⁰
 - iii. History of MRSA colonization or infection (see section C.10). (MDH-MRTF Consensus Statement)
 - b. Consider placing patients presenting with suspect MRSA skin infection on Contact Precautions. (MDH-MRTF Consensus Statement)
 - c. Personal protective equipment requirements for healthcare workers caring for MRSA patients:
 - i. Gloves
 - 1. Required for all healthcare workers entering the patient room/area. IB^{10,58,76,80}
 - ii. Gowns
 - 1. Required for all healthcare workers entering the room/area regardless of anticipated patient contact. IB^{10,58,81,83-86}
 - iii. Surgical Masks
 - 1. Masks should be used when required by Standard Precautions. Standard Precautions require mask use when performing splash-

generating procedures (e.g. wound irrigations, oral suctioning, intubation); when caring for patients with open tracheostomies and the potential for projectile secretions; and in circumstances where there is evidence of transmission from heavily colonized sources (e.g. burn wounds). IB^{10,58,59,74,87,116}

- d. Monitoring of healthcare worker Contact Precautions compliance: (MDH-MRTF Consensus Statement)
 - i. Consider periodic monitoring to assess healthcare worker compliance with Contact Precautions.^{59,240}
 - ii. Report summarized Contact Precautions compliance rates back to healthcare workers.⁵⁹
- e. Contact Precautions room^{10,58,226}
 - i. Private (single-patient) rooms should be used for all MRSA-positive patients, whether infected or colonized, whenever possible. If a private room is not available, cohorting MRSA patients can be considered. See section C.6 for cohorting recommendations. IB^{10,58,90,116}
 - ii. Signage should be posted at the entrance to patient rooms that states the patient is on Contact Precautions and provides details regarding procedure for room entry. (MDH-MRTF Consensus Statement)⁵⁸
 - 1. Special consideration may be given for posting signs on behavioral health units or other non-acute inpatient units. If Contact Precaution signs are not posted in these units, another means of communicating patient Contact Precaution status must be determined. (MDH-MRTF Consensus Statement)
 - iii. Implement patient-dedicated or single-use disposable non-critical equipment, instruments and devices when possible. IB¹⁰
 - 1. In facilities utilizing electronic medical records: Consider having dedicated electronic medical record computers for each patient on Contact Precautions to prevent possible spread of MRSA via keyboards, mouse, etc. When having a dedicated electronic medical record computer is not feasible, the facility should develop and implement a policy for computer use in an effort to minimize the potential for transmission. The policy should include whether gloves should be worn during computer use and list procedures and frequency for cleaning computer equipment. (MDH-MRTF Consensus Statement)
 - iv. Patients should be restricted to their room, except when in need of diagnostic or therapeutic services, or when leaving is deemed beneficial for patient. (MDH-MRTF Consensus Statement)
 - 1. Establish ranges of permitted ambulation, socialization, and use of common areas based on the risk of transmission to other patients and on the ability of the patient to comply with infection prevention and control measures. (II, MDH-MRTF Consensus Statement)¹⁰
 - v. Procedure for patient coming out of room for psycho-social activities (MDH-MRTF Consensus Statement) (See section C.7 for patient transport)

for diagnostic services and section C.2.e.v for therapeutic activities. See section C.9 for caregiver requirements for patients who have caregiver assistance.):

1. At a minimum, patient's clothing/gown must not be visibly soiled and patient must have performed hand hygiene prior to exiting the room.
 - a. Any patient with draining wounds or skin lesions should be dressed in a clean gown before leaving the room.
 2. Body substances must be contained (wounds covered, incontinent patients diapered, coughing patient secretions contained).
- vi. Procedure for patients coming out of room for therapeutic activities (e.g. physical therapy [PT] or occupational therapy [OT]) (MDH-MRTF Consensus Statement)
1. Patient must don clean gown and perform hand hygiene prior to exiting the room.
 2. Body substances must be contained (wounds covered, incontinent patients diapered, coughing patient secretions contained).
 3. Healthcare worker must don gown and gloves prior to room entry and must remove personal protective equipment and perform hand hygiene prior to leaving patient room.
 4. Acute care facilities should develop protocols for PT and OT providing care to patients outside of the patient room. Factors to consider when developing a policy include:
 - a. Personal protective equipment should not routinely be used by PT or OT staff outside of the patient room but can be considered for use if anticipating contact with blood or body fluid that cannot be contained or patient's inability to change into a clean gown.
 - b. Environmental cleaning of PT/OT equipment after patient use.
 - c. Description of any limitations to patient interactions with other patients during PT/OT sessions.

Note: Although placing MRSA-colonized or -infected patients on Contact Precautions has been shown to decrease transmission, this practice can have negative effects on patients and their care (see Background, *Placement of the MRSA-colonized or MRSA-infected Patient*)⁶³⁻⁷⁰.

3. Identification of patients with history of or current MRSA infection or colonization¹⁰
 - a. Implement a reliable method of identifying and tracking new and previously positive MRSA patients (e.g., computer based "flagging" system or visual cue placed on patient's paper chart). IB
 - b. Patients may have MRSA flags removed when they meet the criteria outlined in section C.10. (MDH-MRFT Consensus Statement)

4. Environmental measures

- a. Clean and disinfect surfaces and equipment that may be contaminated with MRSA (items in close proximity to the patient and frequently touched surfaces in the patient room) on a more frequent schedule compared to that for minimal touch surfaces. IB^{10,76,90,118,241} At a minimum, patient rooms and frequently touched surfaces should be cleaned at least once per day.
- b. Consider designating cleaning responsibilities for all items in a patient care room to determine what items are being cleaned by environmental versus nursing staff to ensure no items/surfaces are missed. (MDH-MRTF Consensus Statement)
- c. Infection prevention should provide guidance to determine how patient care supplies located inside the patient rooms are managed for patients on Contact Precautions. (MDH-MRTF Consensus Statement)
- d. Monitor cleaning performance to ensure consistent cleaning and disinfection of surfaces in close proximity to the patient and those likely to be touched by the patient and healthcare workers. IB¹⁰
 - i. Cleaning checklists for environmental services staff may help to ensure consistent cleaning practices. Examples of cleaning compliance checklists are available from CDC (see Appendix A), APIC, and IHI.¹¹
- e. At a minimum, patient privacy curtains should be cleaned when visibly soiled. II, (MDH-MRTF Consensus Statement)²⁴²
- f. Clean and disinfect equipment used for patients on Contact Precautions before their use on other patients, including vital sign machines and computers. IB¹⁰
- g. Clean and disinfect Contact Precautions rooms after patient discharge per standard terminal room cleaning/disinfection procedures. IB¹⁰

5. MRSA surveillance methodology²⁴³⁻²⁴⁵ IA

- a. Conduct facility-wide surveillance for patients with MRSA to identify trends, outbreaks, and increased incidence of MRSA. IA
- b. Follow standard methods and definitions (e.g. National Healthcare Safety Network [NHSN]) to conduct surveillance for healthcare facility-onset (nosocomial) MRSA infection, at a minimum. When possible, distinguish colonization from infection. IA^{10,59,70,149,230,244-248}

Conducting surveillance for MRSA colonization and MRSA infection allows for monitoring the overall MRSA burden in the facility.

Note: A MRSA infection that meets surveillance criteria for a HAI²⁴⁴ in a patient known to be colonized with MRSA should be counted as healthcare facility-onset.
- c. Healthcare facility-onset MRSA incidence rates and results from annual MRSA risk assessments should be used to determine facility MRSA infection prevention and control strategies. References for calculating rates have been published. IB^{10,59,72,73,249}
- d. Facilities that lack expertise in conducting surveillance, analyzing epidemiologic data, and/or detecting outbreaks, should consider establishing cooperative relationships with facilities that have such expertise. (II, MDH-MRTF Consensus Statement)¹⁰

6. Placement of patients with MRSA (MDH-MRTF Consensus Statement)^{10,58}
- a. Place MRSA patients in a private (single-patient) room. **IB**
If a private room is not available MRSA patients may be cohorted.^{70,72,73,86}
 - b. Prior to cohorting, consider the following risk factors for each patient:
 - i. Open, draining wounds that require complex wound care
 - ii. Uncontained body fluids (including active coughing or upper respiratory secretions)
 - iii. Indwelling vascular access device (excluding peripheral lines) or on a ventilator
 - iv. Ability to perform basic hygiene or needing assistance with basic hygiene
 - v. Ability to cooperate with infection prevention and control measures
 - vi. In the process of meeting criteria for removal from Contact Precautions as described in C.10
 - vii. On Contact Precautions for “presumed” or “rule out” MRSA prior to lab confirmation
 - viii. History of infection or colonization with other antimicrobial resistant organisms (e.g. vancomycin-resistant enterococci)
 - c. If no MRSA patient meets the cohorting criteria described above and a private room is not available, consult with Infection Prevention or refer to facility infection prevention and control policies prior to cohorting patients. MRSA-colonized or -infected patients may be placed in the same room as a patient without MRSA. However, patients with history of colonization or infection with other antimicrobial resistant organisms are not eligible for cohorting with MRSA patients.
 - i. Infection Prevention may consider the following MRSA patient risk factors when determining an appropriate roommate:
 1. Active infection with MRSA
 2. Uncontained drainage requiring frequent dressing changes or uncontained body fluids
 3. Unwillingness or inability to cooperate with infection prevention and control measures
 - ii. Infection Prevention may consider the following risk factors in the non-MRSA patient:
 1. Non-intact skin, open wounds, stasis ulcers, or decubitus ulcers
 2. Invasive devices (e.g. indwelling urinary catheters, tracheostomy or tracheal tubes, chest tubes, gastrostomy tubes, vascular access devices [excluding peripheral lines])
 3. Immune system status (e.g. chemotherapy, history of transplant, chronic or high dose corticosteroid therapy or has other immune-compromising conditions)
 4. Ability to cooperate with infection prevention and control measures
 - iii. Infection Prevention should develop protocols to reduce the risk of MRSA transmission when a non-MRSA colonized or infected patient is roomed with an MRSA patient including consideration of:
 1. Maintaining separate supplies for the MRSA patient

2. Assigning different nursing staff to each patient
 3. Assigning the bathroom to one patient and a commode to the other. If bathroom is shared, determine frequency of cleaning and disinfecting.
 - d. Patients with no or unknown MRSA infection or colonization history that are preemptively placed on Contact Precautions while awaiting MRSA screening results should not be roomed with known or suspect MRSA colonized or infected patients.
 - e. Newborns of mothers with MRSA colonization or infection should be placed on Contact Precautions and roomed with the mother. If not possible to room infant with mother, place infant on Contact Precautions in the nursery. MRSA-colonized or -infected infants in the nursery should be at least three feet from other infants.²⁵⁰
7. Transporting and receiving patients with MRSA (MDH-MRTF Consensus Statement)^{58,75,226}
- a. Personal protective equipment is not routinely needed during patient transports. PPE should be used when contact with blood or body fluid is anticipated and when transporting a patient in his/her existing bed. (II, MDH-MRTF Consensus Statement)
 - b. Transporting patients with MRSA: Acute care facilities must have protocols for transporting MRSA patients.
 - i. Notify the receiving department of patient's Contact Precautions status prior to arrival at the department (This could be accomplished via a flag in the patient's chart, noting the Contact Precautions status on patient transport passport ("ticket to ride" or via other means).¹¹
 - ii. Contain body substances before transport (cover wounds, contain body fluids of incontinent patients, contain secretions of coughing patients) II
 - iii. Instruct or assist patient to perform hand hygiene prior to leaving room.
 - iv. Ensure the patient's gown/robe is not visibly soiled. A clean sheet should be placed on patient when transported in a bed.
 - v. Patient transport personnel follow instructions on Contact Precaution sign when entering patient room.
 - vi. Use a clean wheelchair/gurney for patient transport. Disinfect wheelchair/gurney if wheelchair/gurney handgrips or handles are contaminated during the process of patient loading. Disinfect other contaminated equipment that will be transported with patient.
 - a. Educate transport personnel regarding importance of minimizing environmental contamination with MRSA.
 - vii. Remove PPE and perform hand hygiene after patient has been transferred to wheelchair/gurney. Transporters may carry clean gloves in their pockets to use if patient contact is required during transport.

- viii. Upon arrival at destination, transporter performs hand hygiene and puts on clean PPE if s/he will be assisting with moving patient.
 - ix. Perform hand hygiene after delivering patient OR after removing PPE worn to assist patient at destination.
 - x. Clean and disinfectant wheelchair/gurney before it is used to transport another patient.
 - xi. Transport personnel should remove visibly soiled PPE when leaving room.
 - xii. Consider requiring a healthcare worker with no contact with the patient (no PPE needed) to accompany transport where gown and gloves will be worn. The clean healthcare worker is responsible for opening doors and pressing elevator buttons to limit environmental contamination.
 - c. Receiving patients with MRSA: Acute care facilities must have protocols for receiving MRSA patients.
 - i. Patient history of MRSA and Contact Precautions status must be communicated to receiving staff.
 - ii. Receiving area must follow Contact Precautions for patient interactions in all areas of the facility (including pre-op, operating rooms, post-operative areas, CT/radiology, and dialysis areas).
 - iii. Contact Precaution patients should be brought back to room/testing area as soon as possible to limit time in waiting rooms.
 - iv. Receiving staff should wear gloves and gown for contact with patient.
 - v. Surfaces that the patient or healthcare worker had contact with during the procedure should be disinfected after MRSA patient has left.
 - vi. Receiving staff should perform hand hygiene after glove/gown removed and after cleaning room/equipment.
 - d. Transferring patients between facilities
 - i. Implement a system to notify inter-facility transfer personnel and receiving healthcare facilities and personnel of patient colonization or infection status. See Appendix A for CDC Inter-facility Infection Control Transfer Form. IB¹⁰
8. Microbiology procedures for MRSA (MDH-MRTF Consensus Statement)^{10,75,178,251,252}
- a. Methods for detecting MRSA colonization
 - i. Culture methods
 - a. When screening for MRSA, a full culture work-up is not necessary. Perform oxacillin (or equivalent) sensitivity testing to determine presence or absence of MRSA.
 - b. Conventional culture methods involve isolation of *S. aureus* on blood agar or mannitol salt agar with follow-up confirmatory testing and susceptibility testing. A negative result is usually available in 48 hours, but it may take as long as 3-4 days to finalize the MRSA result.

- c. Rapid media detection (e.g. CHROMagar, MRSAselect, or mannitol salt agar with oxacillin) allows positive results in as early as 24 hours with final results in 24 to 48 hours.
 - ii. Molecular testing/PCR: Rapid tests probing for genetic sequences unique to MRSA are available (e.g. GeneOhm™, and GeneXpert®) and can reduce the time from screening to result, allowing for more rapid patient placement into Contact Precautions. However, they are more expensive than conventional and rapid media culture methods.
 - iii. Antimicrobial sensitivity testing should be periodically performed on a subset of colonization isolates to monitor resistance trends.
 - b. Clinical cultures
 - iv. Cultures being processed for a clinical work-up should have antibiotic sensitivity testing, as per laboratory protocol.
 - c. Notification of newly positive cultures/tests
 - v. A procedure should be in place for the microbiology laboratory to notify the appropriate facility staff when a test is positive for MRSA. IB¹⁰
 - d. Microbiology labs should attempt to save MRSA isolates for a period of time (one to three months, or another length of time as determined by infection prevention and control) in the event that additional isolate testing is needed. IB^{10,116}
 - e. Microbiology labs should prepare facility-specific antimicrobial susceptibility reports (antibiograms) as recommended by the Clinical and Laboratory Standards Institute. IB/IC¹⁰
 - f. In healthcare facilities that outsource microbiology laboratory services, specify by contract that the laboratory provide facility-specific susceptibility data or local or regional aggregate susceptibility data in order to identify MRSA susceptibility trends. II¹⁰
- 9. Visitors of patients on Contact Precautions (MDH-MRTF Consensus Statement)^{58,75,226}
 - a. Visitors should be informed of infection prevention and control practices and the importance of following the practices. MRSA informational pamphlets for patients and family members are available in Appendix C and at www.health.state.mn.us.
 - b. Facilities should assess patients and patient population of their facility and implement more comprehensive infection prevention and control practices as deemed necessary. (For example, a hospital burn unit may choose to implement more stringent infection prevention and control practices for visitors than a rehabilitation unit located in the same facility.)
 - c. Visitors should be instructed to perform hand hygiene before entering and after leaving the patient's room (regardless of patient contact).
 - d. Establish ranges of care/contact based on visitor's ability to comply with infection prevention and control procedures (visitor must understand the need for and agree to adhere to hand hygiene and personal protective equipment requirements).
 - e. Visitors should wear personal protective equipment while providing direct physical care to a patient with MRSA:
 - i. Visitors should be instructed on how to properly put on and remove personal protective equipment (gloves/gowns/mask).

- ii. Gloves:
 - a. Required for visitors providing direct care to the patient.^{10,76,80}
- iii. Gowns:
 - a. Required for visitors providing direct care to the patient.¹⁰
- iv. Masks:
 - a. Masks should be used when required by Standard Precautions. Standard Precautions require mask use when performing splash-generating procedures (e.g. wound irrigations, oral suctioning, intubation); when caring for patients with open tracheostomies and the potential for projectile secretions; and in circumstances where there is evidence of transmission from heavily colonized sources (e.g. burn wounds). IB¹⁰
- f. Visitors planning to see multiple patients should don personal protective equipment as described for health care providers in section C.2.c to prevent MRSA transmission to other patients in the facility.

10. Discontinuing Contact Precautions/removing patient flags for MRSA (MDH-MRTF Consensus Statement)

- a. Patients with the following risk factors are not eligible for discontinuing Contact Precautions during their hospital stay:
 - i. Reside in a long-term care facility or long-term acute care facility^{123,124,144,232}
 - ii. Receive hemodialysis¹⁴³
 - iii. On antimicrobials active against MRSA^{10,125,253}
 - iv. Admitted for a suspect staphylococcal infection
 - v. Have areas of chronic open wounds or skin breakdown (e.g. decubitus ulcers)^{10,124,143,144,181}
 - vi. Have long-term invasive devices (e.g. gastrostomy tube, endotracheal tube)¹⁸¹
 - vii. Recurrent infection or colonization with MRSA (patients previously cleared and presenting with new infection or colonization)
 - viii. Have other MRSA risk factors as identified by the admitting facility
- b. Contact Precautions may be discontinued when the following criteria have been met:
 - i. There is documentation of a minimum of two consecutive negative nares cultures/tests and a minimum of two consecutive negative cultures/tests from previously positive sites(s) (where applicable, note C.10.a).^{10,181}
 - ii. Consecutive cultures/tests should be at least 7 days apart.^{10,59}
 - iii. Cultures/tests should be obtained no sooner than one week after completion of decolonization and/or clinical treatment.¹⁰
 - iv. Cultures/tests do not need to be obtained during the same hospitalization; cultures obtained during multiple hospitalizations or from outpatient visits may count towards the two negative cultures/tests needed provided the patient does not fall into the categories outline in C.10.a at time of specimen collection.¹⁰

- c. For infants on Contact Precautions due to mother's MRSA status, that are not rooming in with the mother, Contact Precautions may be discontinued when the mother is cleared of MRSA, per these Recommendations (C.10.b). (MDH-MRTF Consensus Statement)
11. Recommendations for decolonization and management of patients colonized with MRSA (MDH-MRTF Consensus Statement)^{13,137,138,195,197,239}
- a. Routine decolonization of MRSA-colonized patients is not recommended. IB¹⁰
Decolonization may be indicated:
 - i. When patients with MRSA positive nares are associated with ongoing transmission in an outbreak situation.
 - ii. In nasally colonized MRSA patients having a surgical procedure that has been identified by the facility as high risk for MRSA surgical site infection.
 - b. Goal of decolonization
 - i. The goal of a decolonization regimen in patients associated with outbreaks is to interrupt the transmission of MRSA, not to permanently decolonize the patient.
 - ii. The goal of a decolonization regimen in high-risk preoperative patients is to prevent an MRSA surgical site infection. As such, the decolonization protocol should be started several days prior to surgery.
 - c. Decolonization protocols are intended for patients colonized with MRSA in the nares (patients with MRSA colonization at sites other than nares should not be routinely decolonized). Although several researchers have described various decolonization protocols, there are no standard regimens for MRSA decolonization.^{254,255}
 - d. Infectious Disease medical consultation should be sought prior to starting any decolonization therapy, when possible.¹⁰ When decolonization has been deemed appropriate, the following regimens have been suggested:¹⁹⁷
 - i. Nasal decolonization with mupirocin applied to the nares twice a day for 5-10 days
 - ii. Nasal decolonization with mupirocin for 5-10 days and topical body decolonization regimens with a skin antiseptic solution (e.g. chlorhexidine baths/showers/wipes every day for 5-10 days (as tolerated). If topical body decolonization solutions are used, contact with eyes and mucus membranes should be avoided and patients should test the product on a small area of skin as the products can cause allergic reactions and skin irritation.
 - e. Oral antimicrobial therapy is not routinely recommended for decolonization. The use of systemic antimicrobials may be considered on a case-by-case basis. When possible, obtain Infectious Disease medical consultation prior to beginning a systemic antimicrobial decolonization regimen.
 - f. Culturing/testing patients for MRSA following completion of a decolonization protocol is not routinely recommended in the absence of an active infection (see section C.10 about when to discontinue Contact Precautions).

12. Management of healthcare workers with MRSA (MDH-MRTF Consensus Statement)^{10,151,239}

- a. Healthcare workers with MRSA infection or colonization not associated with MRSA transmission to patients should have their care managed through their healthcare provider.
 - i. Facilities should develop a policy to determine if healthcare workers infected or colonized with MRSA need to be furloughed from direct patient contact.¹⁸⁴⁻¹⁸⁸ Factors to consider in developing such a policy include:
 - a. Location of MRSA infection/colonization
 - b. Ability of draining MRSA skin infections to be contained and covered
 - c. Healthcare worker compliance with infection prevention and control precautions
- b. Routinely screening healthcare workers for MRSA colonization is not recommended, as this practice is generally not effective in controlling transmission of MRSA IB^{10,70}
 - ii. Attempts to identify healthcare workers colonized with MRSA should be considered in the presence of noted outbreaks and/or clusters of MRSA (as defined by pulsed-field gel electrophoresis or other biotyping method) where healthcare workers have been epidemiologically linked in disease transmission and where traditional outbreak control measures have not been successful in interrupting transmission.
 - iii. Some facilities require mask use in an attempt to reduce healthcare workers risk of nasal colonization during outbreak situations.⁸⁷
- c. If healthcare worker screening for MRSA colonization/infection is indicated (e.g. during an outbreak investigation), the following (anatomical sites may be considered):
 - i. Bilateral anterior nares IB^{10,121,149,153}
 - ii. Open skin lesions and draining wounds IB^{10,120,124,149}
 - a. If multiple skin lesions/draining wounds present, sample maximum of four lesions/wounds prioritizing by level of severity.
 - iii. Hands^{239,256,257}
- d. Nasal decolonization of MRSA colonized healthcare workers
 - i. Decolonization objectives
 - a. When a healthcare worker is found to be colonized or infected with an MRSA strain linked to the investigation, decolonization can be considered as a tool to interrupt MRSA transmission during outbreaks where traditional control measures have not been successful in ending the outbreak. The goal of healthcare worker decolonization is to interrupt transmission, not to permanently eradicate colonization.
 - ii. If nasal decolonization is indicated, see section C.11 for more information.
 - iii. Facilities should develop a policy to determine if MRSA-colonized or -infected healthcare workers associated with MRSA transmission need to

be furloughed from direct patient contact^{258,259}. Factors that can be considered when evaluating colonized healthcare workers include:

- a. Strain type of MRSA isolate (matching outbreak pattern)
- b. Location of MRSA colonization (nares, hands, groin)
- c. Ongoing transmission to patients

13. Specialty-care areas within acute care facilities (MDH-MRTF Consensus Statement)

- a. Infection Prevention and Control should work with the various specialty-care areas within their facility (e.g. operating rooms, peri-operative areas, dialysis units, behavior health units, cardiac catheter laboratories, radiology) to ensure that MRSA infection prevention and control recommendations are implemented.¹⁶⁻¹⁹
- b. Hospital-based ambulatory settings^{58,260}
 - i. Hospital-based ambulatory settings should have protocols in place for MRSA control including consideration of the following:
 - a. At a minimum, Standard Precautions should be implemented in outpatient service areas.
 - b. Gloves and gowns should be used for contact with uncontrolled secretions, pressure ulcers, draining wounds, stool incontinence, and ostomy tubes and bags. II¹⁰
 - c. Patients with MRSA may wait in common waiting areas for outpatient services.
 - d. Cleaning and disinfect exam rooms and patient equipment between patient use, per environmental services protocol using an EPA-registered disinfectant.
 - e. When feasible, infection prevention and administrative personnel from hospitals and clinics should work together to develop protocols to screen patients for MRSA colonization/infection, implement decolonization protocols when indicated, and discontinue precautions when results are negative (see section C.10). A protocol should be developed to communicate results and progress.

14. MRSA surgical site infection prevention (MDH-MRTF Consensus Statement)^{13,16,17,137,138,237-239}

- a. Facilities should monitor their post-operative MRSA infection rates.
- b. Facilities should consider pre-surgical screening of patients undergoing major surgical procedures that are at increased risk of developing MRSA infections. Identification of high-risk patients can be done based on post-operative MRSA infection rates, surgical site infection prevention compliance rates, or other risk factors as determined by the facility.
- c. Consider decolonization of patients nasally colonized with MRSA scheduled to have a surgical procedure that has been identified by the facility as high risk for MRSA surgical site infection.
- d. Follow published guidelines for selecting preoperative surgical antimicrobial prophylaxis agents for patients colonized with MRSA or at high risk for MRSA colonization.^{17,219}

D. TIER TWO RECOMMENDATIONS FOR MRSA PREVENTION AND CONTROL

1. Indications for Tier Two Recommendations (MDH-MRTF Consensus Statement)
 - a. Facilities should consider implementing Tier Two Recommendations when the incidence or prevalence of healthcare facility-onset (nosocomial) MRSA infections is not decreasing despite implementation of and correct adherence to routine infection prevention and control measures outlined in Tier One.
 - i. References for determining rates have been published. IB^{10,59,72,73,249}
 - b. Facilities should evaluate potential causes (i.e. unidentified patient colonization, inadequate environmental cleaning/disinfection, non-compliance with infection prevention and control policies) when MRSA rates are not decreasing and select Tier Two infection prevention and control practices that are appropriate for the facility.
 - c. Facilities with few/sporadic cases of healthcare facility-onset (nosocomial) MRSA infections should use judgment to determine if implementation of Tier Two Recommendations is warranted.
 - d. Facilities may consider implementing Tier Two Recommendations if they determine that healthcare workers are non-compliant with Tier One infection prevention and control measures.
2. Rationale for Tier Two Recommendations (MDH-MRTF Consensus Statement)
 - a. The interventions described in section D have been utilized in various combinations to reduce transmission of MRSA in healthcare facilities. Neither the effectiveness of individual components nor that of specific combinations of these control measures has been assessed in controlled trials. Nevertheless, various combinations of these control elements selected under the guidance of content experts have repeatedly reduced MRSA infection and transmission rates in various healthcare settings.^{10,11,58,59,146,147,155-160,168-171}
 - b. The intervention or combination of interventions used should be determined by infection prevention staff based on current infection prevention and control practices already in place and factors contributing to ongoing MRSA transmission.
 - c. Tier One Recommendations should continue to be implemented when Tier Two Recommendations are utilized.
3. Infection prevention and control practices to reduce MRSA transmission
 - a. Continue Tier One Recommendations. No changes for Tier Two.
4. Monitoring healthcare worker compliance with infection prevention and control practices (MDH-MRTF Consensus Statement)
 - a. Monitor healthcare worker compliance with Contact Precautions, especially use of personal protective equipment and hand hygiene. Provide individual or unit-specific feedback on adherence.

5. Environmental measures (MDH-MRTF Consensus Statement)
 - a. Intensify and reinforce training of environmental staff that work in areas targeted for enhanced MRSA control and monitor adherence to cleaning protocols.
 - b. Consider dedicating staff to targeted patient areas to ensure consistency of proper environmental cleaning and disinfection. IB^{10,95,116,230,261,262}
 - c. Clean and disinfect surfaces and equipment that may be contaminated with MRSA (items in close proximity to the patient and frequently touched surfaces in the patient room) on a more frequent schedule compared to that for minimal touch surfaces. IB^{10,76,90,118,241} At a minimum, patient rooms and frequently touched surfaces should be cleaned at least once per day.
 - d. Consider obtaining environmental cultures when there is epidemiologic evidence that an environmental source is associated with ongoing MRSA transmission. Consult facility microbiology laboratory supervisors and MDH for assistance in developing an environmental screening protocol as needed. IB^{10,263}
 - e. Designate cleaning responsibilities for all items in a patient care room to determine what items are being cleaned by environmental versus nursing staff to ensure items/surfaces are not missed.
 - f. Consider changing patient privacy curtains after a patient on Contact Precautions is discharged.
 - g. Clean and disinfect equipment used for patients on Contact Precautions before their use on other patients, including vital sign machines and computers. IB¹⁰
 - h. Clean and disinfect Contact Precaution rooms after patient discharge per standard terminal room cleaning procedures. IB¹⁰
 - i. Vacate the units or sections of the unit for environmental assessment and intensive cleaning when previous efforts to eliminate environmental reservoirs have failed and environmental contamination is implicated in continued microbial transmission. II^{10,159,230}

6. Active surveillance testing (AST) (MDH-MRT Consensus Statement)
 - a. Consider screening patients identified as high risk for MRSA colonization or infection by your facility MRSA risk assessment. The rationale for AST is to identify colonized patients so that additional precautions can be applied (e.g. Contact Precautions). Examples of patients that may be candidates for AST include:
 - i. Patients found to be at risk for MRSA colonization through facility's MRSA risk assessment;
 - ii. Patients found to be at risk for MRSA colonization through facility's MRSA risk assessment;
 - iii. Patients admitted to units where rates of MRSA transmission are not decreasing;
 - iv. Patients admitted to high-risk units such as intensive care units, burn units, bone marrow/stem cell transplant and oncology units.
 - b. Cultures/screening swabs may be collected on admission, or on admission and at predetermined time periods after admission to monitor possible MRSA transmission.

- c. Preemptive placement in Contact Precautions – facilities that screen patients for MRSA on admission may consider implementing Contact Precautions and placing patients in private rooms (or cohorting) until results of screening tests are known. This may be implemented for every patient with screening tests obtained or a portion of those patients based on facility-defined risk factors and availability of patient rooms.
 - d. Screening cultures/tests (anatomical sites)^{10,13,75}
 - i. Minimal requirement: bilateral anterior nares, utilizing one (1) culturette for both nares IB^{10,121,149,153}
 - ii. Additional recommended sites: any open skin lesions or draining wounds noted on admission (including surgical sites) IB^{10,120,124,149}
 - 1. If multiple skin lesions/draining wounds present, sample maximum of four lesions/wounds prioritizing by level of severity.
7. Education
- a. Increase frequency of MRSA education provided to healthcare workers. IB
 - b. Provide individual or unit-specific feedback on adherence to Contact Precautions, hand hygiene, and MRSA infection rates when possible. IB¹⁰
8. Administrative support (MDH-MRTF Consensus Statement)
- a. Administration should provide necessary leadership, funding, and oversight to implement interventions selected. IB
 - b. Evaluate healthcare system factors for their role in assisting or perpetuating transmission of MRSA, including staffing levels, education and training, availability of consumable and durable resources, communication processes, and policies and procedures. Develop, implement, and monitor action plans to correct system failures. IB^{10,11}
 - c. If MRSA infection rates do not decrease, assign dedicated nursing and ancillary service staff to the care of MRSA patients only. IB¹⁰
 - d. If MRSA transmission continues despite implementation of enhanced control measures, stop new admits to the unit. IB¹⁰
9. Placement of patients with MRSA
- a. Continue Recommendations for placement of patients with MRSA in C.6. No changes for Tier Two.
10. Transporting and receiving patients with MRSA
- a. Continue Recommendations for transporting and receiving patients with MRSA in C.7. No changes for Tier Two.
11. Visitors of patients on Contact Precautions (MDH-MRTF Consensus Statement)^{58,75,226}
- a. Visitors should wear personal protective equipment to enter patient room.
 - i. Visitors should be instructed on how to properly put on and remove personal protective equipment (gloves/gowns/mask)
 - ii. Gloves:
 - 1. Required for visitors entering patient room.

iii. Gowns:

1. Required for visitors entering patient room.

iv. Masks:

1. Masks should be used when required by Standard Precautions. Standard Precautions require mask use when performing splash-generating procedures (e.g. wound irrigations, oral suctioning, intubation); when caring for patients with open tracheostomies and the potential for projectile secretions; and in circumstances where there is evidence of transmission from heavily colonized sources (e.g. burn wounds). IB¹⁰

- e. Visitors should remove personal protective equipment and perform hand hygiene after leaving patient room.

12. Discontinuing Contact Precautions/removing patient flags for MRSA

- a. Continue Recommendations for discontinuing Contact Precautions/removing patient flags for MRSA in C.10. No changes for Tier Two.

13. Recommendations for decolonization and management of patients colonized with MRSA

- a. Consider use of daily chlorhexidine baths for all patients on units/areas with high-risk patient populations (e.g. ICU)²⁶⁴

14. Management of healthcare workers with MRSA

- a. Continue Recommendations for management of healthcare workers with MRSA in C.12. No changes for Tier Two.

MRSA Risk Assessment and Surveillance Definitions

The following definitions are for conducting MRSA surveillance in healthcare facilities.

Community-onset (CO) MRSA: MRSA collected ≤ 3 days after admission to the facility (i.e., days 1, 2, or 3 of admission). Facilities may choose to further define community-onset MRSA infection/colonization into healthcare-associated and community-associated:

Community-onset community-associated MRSA: Infection/colonization that was present or incubating on admission to the facility (e.g., specimen collected as an outpatient or an inpatient ≤ 3 days after admission to the facility) in a patient with no history of healthcare exposure as defined below.

Community-onset healthcare-associated MRSA: Infection/colonization that was present or incubating on admission to the facility (e.g., specimen collected as an outpatient or an inpatient ≤ 3 days after admission to the facility) in a patient with a history of healthcare exposure as defined below.

Healthcare facility-onset (HO) (nosocomial) MRSA colonization: Colonization detected > 3 days after admission to the facility (i.e., on or after day 4) and patient has no known prior history of MRSA and patient does not have a MRSA infection meeting NHSN definitions (MDH-MRTF Consensus Statement).

Healthcare facility-onset (HO) (nosocomial) MRSA infection:

- 1) Specimen collected > 3 days after admission to the facility (i.e., on or after day 4)²⁴⁵ *and*
- 2) Infection meeting criteria for healthcare-associated infection per NHSN²⁴⁴

Common Abbreviations

APIC	Association for Professionals in Infection Control and Epidemiology
AST	Active surveillance testing
CA-MRSA	Community-associated MRSA
HA-MRSA	Healthcare-associated MRSA
HICPAC	Healthcare Infection Control Practices Advisory Committee
IDSA	Infectious Disease Society of America
IHI	Institute for Healthcare Improvement
MDH	Minnesota Department of Health
MDH-MRTF	Minnesota Department of Health-MRSA Recommendations Task Force
MDRO	Multi-drug resistant organism
MRSA	Methicillin-resistant <i>Staphylococcus aureus</i>
MSSA	Methicillin-susceptible <i>Staphylococcus aureus</i>
NHSN	National Healthcare Safety Network
SHEA	Society of Healthcare Epidemiology of America
SSI	Surgical site infection
VRE	Vancomycin-resistant Enterococcus

Glossary

Active surveillance testing (AST): AST is surveillance conducted for the purpose of actively identifying patients colonized with MRSA to initiate infection prevention and control precautions. Cultures can be taken upon facility admission or on facility admission and at other pre-determined time points (e.g. every 7 days, at discharge from unit/hospital, etc.).

Clinical culture: A specimen from a body site (e.g. skin, bone, body fluid) that is collected in order to detect organisms in the lab using culture techniques.

Cohorting: The practice of grouping patients infected or colonized with the same infectious agent together to confine their care to one area and prevent contact with susceptible patients.

Colonization: The presence of microorganisms at a body site that are not causing adverse clinical manifestations of illness or infection.

Community-onset (CO) MRSA: MRSA collected ≤ 3 days after admission to the facility (i.e., days 1, 2, or 3 of admission). Facilities may choose to further define community-onset MRSA infection/colonization into healthcare-associated and community-associated:

Community-onset community-associated MRSA: Infection/colonization that was present or incubating on admission to the facility (e.g., specimen collected as an outpatient or an inpatient ≤ 3 days after admission to the facility) in a patient with no history of healthcare exposure as defined below.

Community-onset healthcare-associated MRSA: Infection/colonization that was present or incubating on admission to the facility (e.g., specimen collected as an outpatient or an inpatient ≤ 3 days after admission to the facility) in a patient with a history of healthcare exposure as defined below.

Contact Precautions: A set of infection prevention practices. Practices include Standard Precautions plus placing the patient in a private room (or cohorting if a private room is not available), wearing gloves and gown upon room entry, and designating patient supplies and equipment whenever possible.

Hand hygiene: Cleaning hands with antimicrobial hand soap and warm water for at least 15 seconds or the application of an alcohol-based hand sanitizer if hands are not visibly soiled

Healthcare worker: All paid and unpaid persons who work in a healthcare setting (e.g. any person who has professional or technical training in a healthcare-related field and provides patient care in a healthcare setting or any person who provides a service that supports the delivery of healthcare such as dietary, housekeeping, engineering, and maintenance personnel).

Healthcare-associated MRSA: See definition for community-onset MRSA

Healthcare exposure: hospitalization, surgery, dialysis or residence in a chronic or acute care facility in the year prior to specimen collection date or presence of a percutaneous indwelling medical device or catheter at the time of specimen collection (e.g. tracheostomy, gastrostomy, Foley or supra-pubic catheter, PICC line, etc. but excluding internal devices that do not have access to the exterior of the body [e.g. pacemakers, etc.]

Healthcare facility-onset (HO) (nosocomial) MRSA colonization (MDH-MRTF Consensus Statement): Colonization detected > 3 days after admission to the facility (i.e., on or after day 4) and patient has no known prior history of MRSA and patient does not have a MRSA infection meeting NHSN definitions.

Healthcare facility-onset (HO) (nosocomial) MRSA infection:

- 1) Specimen collected > 3 days after admission to the facility (i.e., on or after day 4)²⁴⁵ *and*
- 2) Infection meeting criteria for healthcare-associated infection per NHSN²⁴⁴

Infection: The pathological state resulting from the invasion of the body by pathogenic microorganisms that produce disease. Examples of healthcare-associated infections for surveillance purposes have been developed by the National Healthcare Safety Network (NHSN) and can be found at <http://www.cdc.gov/ncidod/dhqp/pdf/nnis/NosInfDefinitions.pdf>.

Standard Precautions: A set of infection prevention practices that apply to all patients, regardless of suspected or confirmed diagnosis or presumed infection status. Standard Precautions are a combination and expansion of Universal Precautions and body Substance Isolation. Standard Precautions are based on the principle that all blood, body fluids, secretions, excretions except sweat, nonintact skin, and mucous membranes may contain transmissible infectious agents. Standard Precautions includes hand hygiene, and depending on the anticipated exposure, use of gloves, gown, mask, eye protection, or face shield. Also, equipment or items in the patient environment likely to have been contaminated with infectious fluids must be handled in a manner to prevent transmission of infectious agent, (e.g. wear gloves for handling, contain heavily soiled equipment, properly clean and disinfect or sterilize reusable equipment before use on another patient.) Standard Precautions defines the need for personal protective equipment:

Gloves: Wear gloves (clean, nonsterile gloves are adequate) when touching blood, body fluids, secretions, excretions, and contaminated items. Put on clean gloves just before touching mucous membranes and nonintact skin. Change gloves between tasks and procedures on the same patient after contact with material that may contain a high concentration of microorganisms. Remove gloves promptly after use, before touching noncontaminated items and environmental surfaces, and before going to another patient, and wash hands immediately to avoid transfer of microorganisms to other patients or environments.

Gown: Wear a gown (a clean, nonsterile gown is adequate) to protect skin and to prevent soiling of clothing during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions. Select a gown that is appropriate for the activity and amount of fluid likely to be encountered. Remove a soiled

gown as promptly as possible and wash hands to avoid transfer of microorganisms to other patients or environments.

Mask: Wear a mask and eye protection or a face shield to protect mucous membranes of the eyes, nose, and mouth during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions.

Minnesota Statute 144.585

347.3 **Sec. 15. [144.585] METHICILLIN-RESISTANT STAPHYLOCOCCUS AUREUS**

347.4 **CONTROL PROGRAMS.**

- 347.5 In order to improve the prevention of hospital-associated infections due
347.6 to methicillin-resistant Staphylococcus aureus ("MRSA"), every hospital shall
347.7 establish an MRSA control program that meets Minnesota Department of Health
347.8 MRSA recommendations as published January 15, 2008. In developing the MRSA
347.9 recommendations, the Department of Health shall consider the following infection control
347.10 practices:
- 347.11 (1) identification of MRSA-colonized patients in all intensive care units, or other
347.12 at-risk patients identified by the hospital;
 - 347.13 (2) isolation of identified MRSA-colonized or MRSA-infected patients in an
347.14 appropriate manner;
 - 347.15 (3) adherence to hand hygiene requirements; and
 - 347.16 (4) monitor trends in the incidence of MRSA in the hospital over time and modify
347.17 interventions if MRSA infection rates do not decrease.
- 347.18 The Department of Health shall review the MRSA recommendations on an annual basis
347.19 and revise the recommendations as necessary, in accordance with available scientific data.

References

1. Klevens RM, Edwards J, Richards C, et al. Estimating health care-associated infections and deaths in U.S. Hospitals, 2002. *Public Health Reports* 2007;122:160-6.
2. Klevens RM, Morrison M, Nadle J, et al. Invasive methicillin-resistant *Staphylococcus aureus* infections in the United States. *JAMA* 2007;298:1763-71.
3. Klevens RM, Edwards JR, Tenover FC, McDonald LC, Horan T, Gaynes R. Changes in the epidemiology of methicillin-resistant *Staphylococcus aureus* in intensive care units in US hospitals, 1992-2003. *Clin Infect Dis* 2006;42:389-91.
4. NNIS. National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. *Am J Infect Control* 2004;32:470-85.
5. Hidron AI, Edwards JR, Patel J, et al. NHSN annual update: antimicrobial-resistant pathogens associated with healthcare-associated infections: annual summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2006-2007. *Infect Control Hosp Epidemiol* 2008;29:996-1011.
6. Institute for Healthcare Improvement. 2008. (Accessed at www.ihl.org.)
7. Office USGA. Health-care-associated infections in hospitals: Leadership needed from HHS to prioritize prevention practices and improve data on these infections. In: GAO, ed.; 2008.
8. Dellit T, Owens R, McGowan JE, Jr., et al. Infectious Diseases Society of America and the Society of Healthcare Epidemiology of America Guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clin Infect Dis* 2007;44:159-77.
9. Rutala WA, Weber DJ, (HICPAC) tHICPAC. Guideline for disinfection and sterilization in healthcare facilities, 2008. In. Chapel Hill, NC: CDC; 2008.
10. Siegel J, Rhinehart E, Jackson M, Chiarello C, Healthcare Infection Control Practices Advisory Committee. Management of Multi-drug Resistant Organisms in Healthcare Settings, 2006. In; 2006.
11. IHI Getting Started Kit: Reduce Methicillin-Resistant *Staphylococcus aureus* (MRSA) Infection How-to Guide. 2006. (Accessed December 2006, at <http://www.ihl.org/knowledge/Pages/Tools/HowtoGuideReduceMRSAInfection.aspx>.)
12. APIC Guide to the Elimination of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Transmission in Hospital Settings, 2nd Edition. 2010. (Accessed at http://www.apic.org/downloads/MRSA_elimination_guide_27030.pdf.)
13. Muto CA, Jernigan JA, Ostrowsky BE, et al. SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of *Staphylococcus aureus* and *Enterococcus*. *Infect Control Hosp Epidemiol* 2003;24:362-86.
14. Calfee DP, Salgado CD, Classen D, et al. Strategies to prevent transmission of methicillin-resistant *Staphylococcus aureus* in acute care hospitals. *Infect Control Hosp Epidemiol* 2008;29 Suppl 1:S62-80.
15. Yokoe DS, Mermel LA, Anderson DJ, et al. A compendium of strategies to prevent healthcare-associated infections in acute care hospitals. *Infect Control Hosp Epidemiol* 2008;29 Suppl 1:S12-21.
16. Association of Perioperative Registered Nurses. Recommended practices for prevention of transmissible infections in the perioperative practice setting. *AORN J* 2007;85:383-96.
17. Engelman R, Shahian D, Shemin R, et al. The society of thoracic surgeons practice guideline series: Antibiotic prophylaxis in cardiac surgery, Part II: Antibiotic choice. *Ann Thorac Surg* 2007;83:1569-76.
18. American Society of Anesthesiologists. Recommendations for infection control for the practice of anesthesiology (Second edition). 1999.
19. Chambers C, Eisenhauer M, McNicol L, et al. Infection control guidelines for the cardiac catheterization laboratory: Society guidelines revisited. *Catheter Cardiovasc Interv* 2006;67:78-86.
20. Kluytmans J, van Belkum A, Verbrugh H. Nasal carriage of *Staphylococcus aureus*: Epidemiology, underlying mechanisms, and associated risks. *Clin Microbiol Rev* 1997;10:505-20.
21. Rammelkamp C, Maxon T. Resistance of *Staphylococcus aureus* to the action of penicillin. *Proceedings of the Society for Experimental Biology and Medicine* 1942;51:386-9.
22. Jevons M. "Celbenin"-resistant Staphylococci. *British Medical Journal* 1961;1:124-5.
23. Barrett F, McGehee R, Finland M. Methicillin-resistant *Staphylococcus aureus* at Boston City Hospital. *N Engl J Med* 1968;279:441-8.
24. Jarvis WR, Schlosser J, Chinn RY, Tweeten S, Jackson M. National prevalence of methicillin-resistant *Staphylococcus aureus* in inpatients at US health care facilities, 2006. *Am J Infect Control* 2007;35:631-7.

25. Melzer M, Eykyn S, Gransden W, Chinn S. Is methicillin-resistant *Staphylococcus aureus* more virulent than methicillin-susceptible *S. aureus*? A comparative cohort study of British patients with nosocomial infection and bacteremia. *Clin Infect Dis* 2003;37:1453-60.
26. Cosgrove SE, Sakoulas G, Perencevich EN, Schwaber MJ, Karchmer AW, Carmeli Y. Comparison of mortality associated with methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* bacteremia: a meta-analysis. *Clin Infect Dis* 2003;36:53-9.
27. Davis KA, Stewart JJ, Crouch HK, Florez CE, Hospenthal DR. Methicillin-resistant *Staphylococcus aureus* (MRSA) nares colonization at hospital admission and its effect on subsequent MRSA infection. *Clin Infect Dis* 2004;39:776-82.
28. Selvey LA, Whitby M, Johnson B. Nosocomial methicillin-resistant *Staphylococcus aureus* bacteremia: Is it any worse than nosocomial methicillin-sensitive *Staphylococcus aureus* bacteremia? *Infect Control Hosp Epidemiol* 2000;21:645-8.
29. Romero-Vivas J, Rubio M, Fernandez C, Picazo JJ. Mortality associated with nosocomial bacteremia due to methicillin-resistant *Staphylococcus aureus*. *Clin Infect Dis* 1995;21:1417-23.
30. Blot SI, Vandewoude KH, Hoste EA, Colardyn FA. Outcome and attributable mortality in critically ill patients with bacteremia involving methicillin-susceptible and methicillin-resistant *Staphylococcus aureus*. *Arch Intern Med* 2002;162:2229-35.
31. Reed SD, Friedman JY, Engemann JJ, et al. Costs and outcomes among hemodialysis-dependent patients with methicillin-resistant or methicillin-susceptible *Staphylococcus aureus* bacteremia. *Infect Control Hosp Epidemiol* 2005;26:175-83.
32. Mekontso-Dessap A, Kirsch M, Brun-Buisson C, Louisance D. Poststernotomy mediastinitis due to *Staphylococcus aureus*: Comparison of methicillin-resistant and methicillin-susceptible cases. *Clin Infect Dis* 2001;32:877-83.
33. Huang SS, Platt R. Risk of methicillin-resistant *Staphylococcus aureus* infection after previous infection or colonization. *Clin Infect Dis* 2003;36:281-5.
34. Honda H, Krauss MJ, Coopersmith CM, et al. *Staphylococcus aureus* nasal colonization and subsequent infection in intensive care unit patients: does methicillin resistance matter? *Infect Control Hosp Epidemiol* 2010;31:584-91.
35. Vriens MR, Fluit AC, Troelstra A, Verhoef J, van der Werken C. Is methicillin-resistant *Staphylococcus aureus* more contagious than methicillin-susceptible *S. aureus* in a surgical intensive care unit? *Infect Control Hosp Epidemiol* 2002;23:491-4.
36. Brumfitt W, Hamilton-Miller J. Methicillin-resistant *Staphylococcus aureus*. *N Engl J Med* 1989;320:1188-96.
37. Saravolatz LD, Pohlod DJ, Arking LM. Community-acquired methicillin-resistant *Staphylococcus aureus* infections: A new source for nosocomial outbreaks. *Ann Intern Med* 1982;97:325-9.
38. Naimi TS, LeDell KH, Boxrud DJ, et al. Epidemiology and clonality of community-acquired methicillin-resistant *Staphylococcus aureus* in Minnesota, 1996-1998. *Clin Infect Dis* 2001;33:990-6.
39. CDC. Four Pediatric deaths from community-acquired methicillin-resistant *Staphylococcus aureus*--Minnesota and North Dakota, 1997-1999. *MMWR Morb Mortal Wkly Rep* 1999;48:707-10.
40. Naimi TS, LeDell KH, Como-Sabetti K, et al. Comparison of community- and health care-associated methicillin-resistant *Staphylococcus aureus* infection. *JAMA* 2003;290:2976-84.
41. McDougal LK, Steward CD, Killgore GE, Chaitram JM, McAllister SK, Tenover FC. Pulsed-field gel electrophoresis typing of oxacillin-resistant *Staphylococcus aureus* isolates from the United States: Establishing a national database. *J Clin Microbiol* 2003;41:5113-20.
42. Baba T, Takeuchi F, Kuroda M, et al. Genome and virulence determinants of high virulence community-acquired MRSA. *Lancet* 2002;359:1819-27.
43. Gillet Y, Issartel B, Vanhems P, et al. Association between *Staphylococcus aureus* strains carrying gene for Panton-Valentine leukocidin and highly lethal necrotising pneumonia in young immunocompetent patients. *Lancet* 2002;359:753-9.
44. Lina G, Piemont Y, Godail-Gamot F, et al. Involvement of Panton-Valentine leukocidin-producing *Staphylococcus aureus* in primary skin infections and pneumonia. *Clin Infect Dis* 1999;29:1128-32.
45. Davis SL, Rybak MJ, Amjad M, Kaatz GW, McKinnon PS. Characteristics of patients with healthcare-associated infection due to SCCmec type IV methicillin-resistant *Staphylococcus aureus*. *Infect Control Hosp Epidemiol* 2006;27:1025-31.
46. Gonzalez BE, Rueda AM, Shelburne SA, 3rd, Musher DM, Hamill RJ, Hulten KG. Community-associated strains of methicillin-resistant *Staphylococcus aureus* as the cause of healthcare-associated infection. *Infect Control Hosp Epidemiol* 2006;27:1051-6.

47. Klevens RM, Morrison MA, Fridkin SK, et al. Community-associated methicillin-resistant *Staphylococcus aureus* and healthcare risk factors. *Emerg Infect Dis* 2006;12:1991-3.
48. Maree CL, Daum RS, Boyle-Vavra S, Matayoshi K, Miller LG. Community-associated methicillin-resistant *Staphylococcus aureus* isolates causing healthcare-associated infections. *Emerging Infectious Diseases* 2007;13:236-42.
49. Cooper BS, Medley GF, Stone SP, et al. Methicillin-resistant *Staphylococcus aureus* in hospitals and the community: Stealth dynamics and control catastrophes. *Proc Natl Acad Sci U S A* 2004;101:10223-8.
50. Buckingham SC, McDougal LK, Cathey LD, et al. Emergence of community-associated methicillin-resistant *Staphylococcus aureus* at a Memphis, Tennessee Children's Hospital. *Pediatr Infect Dis J* 2004;23:619-24.
51. Buck JM, Como-Sabetti K, Harriman KH, et al. Community-associated methicillin-resistant *Staphylococcus aureus*, Minnesota, 2000-2003. *Emerg Infect Dis* 2005;11:1532-8.
52. Jungk J, Como-Sabetti K, Stinchfield P, Ackerman P, Harriman K. Epidemiology of methicillin-resistant *Staphylococcus aureus* at a pediatric healthcare system, 1991-2003. *Pediatr Infect Dis J* 2007;26:339-44.
53. Frazee BW, Lynn J, Charlebois ED, Lambert L, Lowery D, Perdreau-Remington F. High prevalence of methicillin-resistant *Staphylococcus aureus* in emergency department skin and soft tissue infections. *Ann Emerg Med* 2005;45:311-20.
54. Minnesota Department of Health. Annual summary of communicable diseases reported to the Minnesota Department of Health, 2006. MDH Disease Control Newsletter 2007.
55. Klein E, Smith DL, Laxminarayan R. Hospitalizations and deaths caused by methicillin-resistant *Staphylococcus aureus*, United States, 1999-2005. *Emerg Infect Dis* 2007;13:1840-6.
56. Kallen AJ, Mu Y, Bulens S, et al. Health care-associated invasive MRSA infections, 2005-2008. *JAMA* 2010;304:641-8.
57. Perencevich EN, Diekema DJ. Decline in invasive MRSA infection: where to go from here? *JAMA* 2010;304:687-9.
58. Siegel J, Rhinehart E, Jackson M, Chiarello L, Healthcare Infection Control Practices Advisory Committee. 2007 Guidelines for isolation precautions: Preventing transmission of infectious agents in healthcare settings
59. Association for Professionals in Infection Control and Epidemiology Inc. Guide to the elimination of methicillin-resistant *Staphylococcus aureus* (MRSA) transmission in hospital settings. March 2007.
60. Larson EL, Early E, Cloonan P, Sugrue S, Parides M. An organizational climate intervention associated with increased handwashing and decreased nosocomial infections. *Behav Med* 2000;26:14-22.
61. Goldmann DA, Weinstein RA, Wenzel RP, et al. Strategies to prevent and control the emergence and spread of antimicrobial-resistant microorganisms in hospitals. A challenge to hospital leadership. *JAMA* 1996;275:234-40.
62. Murphy D, Whiting J. Dispelling the myths: The true cost of healthcare-associated infections. In: *APIC*; 2007:1-16.
63. Kirkland KB, Weinstein JM. Adverse effects of contact isolation. *Lancet* 1999;354:1177-8.
64. Saint S, Higgins LA, Nallamothu BK, Chenoweth C. Do physicians examine patients in contact isolation less frequently? A brief report. *Am J Infect Control* 2003;31:354-6.
65. Kirkland KB. Taking off the gloves: toward a less dogmatic approach to the use of contact isolation. *Clin Infect Dis* 2009;48:766-71.
66. Morgan DJ, Diekema DJ, Sepkowitz K, Perencevich EN. Adverse outcomes associated with Contact Precautions: a review of the literature. *American journal of infection control* 2009;37:85-93.
67. Tarzi S, Kennedy P, Stone S, Evans M. Methicillin-resistant *Staphylococcus aureus*: psychological impact of hospitalization and isolation in an older adult population. *J Hosp Infect* 2001;49:250-4.
68. Evans HL, Shaffer MM, Hughes MG, et al. Contact isolation in surgical patients: A barrier to care? *Surgery* 2003;134:180-8.
69. Stelfox HT, Bates DW, Redelmeier DA. Safety of patients isolated for infection control. *JAMA* 2003;290:1899-905.
70. Jernigan JA, Titus MG, Groschel DH, Getchell-White S, Farr BM. Effectiveness of contact isolation during a hospital outbreak of methicillin-resistant *Staphylococcus aureus*. *Am J Epidemiol* 1996;143:496-504.
71. Kotilainen P, Routamaa M, Peltonen R, et al. Eradication of methicillin-resistant *Staphylococcus aureus* from a health center ward and associated nursing home. *Arch Intern Med* 2001;161:859-63.
72. Murray-Leisure KA, Geib S, Graceley D, et al. Control of epidemic methicillin-resistant *Staphylococcus aureus*. *Infect Control Hosp Epidemiol* 1990;11:343-50.
73. Jochimsen EM, Fish L, Manning K, et al. Control of vancomycin-resistant enterococci at a community hospital: Efficacy of patient and staff cohorting. *Infect Control Hosp Epidemiol* 1999;20:106-9.

74. Montecalvo MA, Jarvis WR, Uman J, et al. Infection-control measures reduce transmission of vancomycin-resistant enterococci in an endemic setting. *Ann Intern Med* 1999;131:269-72.
75. Arnold MS, Dempsey JM, Fishman M, McAuley PJ, Tibert C, Vallande NC. The best hospital practices for controlling methicillin-resistant *Staphylococcus aureus*: On the cutting edge. *Infect Control Hosp Epidemiol* 2002;23:69-76.
76. Bhalla A, Pultz NJ, Gries DM, et al. Acquisition of nosocomial pathogens on hands after contact with environmental surfaces near hospitalized patients. *Infect Control Hosp Epidemiol* 2004;25:164-7.
77. Ehrenkranz N, Alfonso B. Failure of bland soap handwash to prevent hand transfer of patient bacteria to urethral catheters. *Infect Cont Hosp Epidemiol* 1991;12:654-62.
78. Marples RR, Towers A. A laboratory model for the investigation of contact transfer of micro-organisms. *J Hyg (Lond)* 1979;82:237-48.
79. Mackintosh C, Hoffman P. An extended model for transfer of micro-organisms via the hands: Differences between organisms and the effect of alcohol disinfection. *J Hyg (Lond)* 1984;92:345-55.
80. Kim PW, Roghmann MC, Perencevich EN, Harris AD. Rates of hand disinfection associated with glove use, patient isolation, and changes between exposure to various body sites. *Am J Infect Control* 2003;31:97-103.
81. Slaughter S, Hayden MK, Nathan C, et al. A comparison of the effect of universal use of gloves and gowns with that of glove use alone on acquisition of vancomycin-resistant enterococci in a medical intensive care unit. *Ann Intern Med* 1996;125:448-56.
82. Bearman G, Marra A, Sessler C, et al. A controlled trial of universal gloving versus contact precautions for preventing the transmission of multidrug-resistant organisms. *Am J Infect Control* 2007;35:650-5.
83. Srinivasan A, Song X, Ross T, Merz W, Brower R, Perl TM. A prospective study to determine whether cover gowns in addition to gloves decrease nosocomial transmission of vancomycin-resistant enterococci in an intensive care unit. *Infect Control Hosp Epidemiol* 2002;23:424-8.
84. Puzniak LA, Gillespie KN, Leet T, Kollef M, Mundy LM. A cost-benefit analysis of gown use in controlling vancomycin-resistant *Enterococcus* transmission: Is it worth the price? *Infect Control Hosp Epidemiol* 2004;25:418-24.
85. Puzniak LA, Leet T, Mayfield J, Kollef M, Mundy LM. To gown or not to gown: The effect on acquisition of vancomycin-resistant enterococci. *Clin Infect Dis* 2002;35:18-25.
86. Boyce JM, Opal SM, Chow JW, et al. Outbreak of multidrug-resistant *Enterococcus faecium* with transferable vanB class vancomycin resistance. *J Clin Microbiol* 1994;32:1148-53.
87. Lacey S, Flaxman D, Scales J, Wilson A. The usefulness of masks in preventing transient carriage of epidemic methicillin-resistant *Staphylococcus aureus* by healthcare workers. *J Hosp Infect* 2001;48:308-11.
88. Sanford MD, Widmer AF, Bale MJ, Jones RN, Wenzel RP. Efficient detection and long-term persistence of the carriage of methicillin-resistant *Staphylococcus aureus*. *Clin Infect Dis* 1994;19:1123-8.
89. Coello R, Jimenez J, Garcia M, et al. Prospective study of infection, colonization and carriage of methicillin-resistant *Staphylococcus aureus* in an outbreak affecting 990 patients. *Eur J Microbiol Infect Dis* 1994;13:74-81.
90. Boyce JM, Potter-Bynoe G, Chenevert C, King T. Environmental contamination due to methicillin-resistant *Staphylococcus aureus*: Possible infection control implications. *Infect Control Hosp Epidemiol* 1997;18:622-7.
91. Tenorio AR, Badri SM, Sahgal NB, et al. Effectiveness of gloves in the prevention of hand carriage of vancomycin-resistant enterococcus species by health care workers after patient care. *Clin Infect Dis* 2001;32:826-9.
92. Olsen RJ, Lynch P, Coyle MB, Cummings J, Bokete T, Stamm WE. Examination gloves as barriers to hand contamination in clinical practice. *Jama* 1993;270:350-3.
93. Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Infection Control Programme. Lancet* 2000;356:1307-12.
94. Webster J, Faoagali JL, Cartwright D. Elimination of methicillin-resistant *Staphylococcus aureus* from a neonatal intensive care unit after hand washing with triclosan. *J Paediatr Child Health* 1994;30:59-64.
95. Zafar AB, Butler RC, Reese DJ, Gaydos LA, Mennonna PA. Use of 0.3% triclosan (Bacti-Stat) to eradicate an outbreak of methicillin-resistant *Staphylococcus aureus* in a neonatal nursery. *Am J Infect Control* 1995;23:200-8.
96. MacDonald A, Dinah F, MacKenzie D, Wilson A. Performance feedback of hand hygiene, using alcohol gel as the skin decontaminant, reduces the number of inpatients newly affected by MRSA and antibiotic costs. *J Hosp Infect* 2004;56:56-63.
97. Berg D, Hershov R, Ramirez C, Weinstein R. Control of nosocomial infections in an intensive care unit in Guatemala City. *Clin Infect Dis* 1995;21:588-93.

98. Dubbert PM, Dolce J, Richter W, Miller M, Chapman SW. Increasing ICU staff handwashing: Effects of education and group feedback. *Infect Control Hosp Epidemiol* 1990;11:191-3.
99. World Health Organization. WHO Guidelines on Hand Hygiene in Health Care, 2009.
100. Pittet D. Improving compliance with hand hygiene in hospitals. *Infect Cont Hosp Epidemiol* 2000;21:381-6.
101. Hugonnet S, Perneger TV, Pittet D. Alcohol-based handrub improves compliance with hand hygiene in intensive care units. *Arch Intern Med* 2002;162:1037-43.
102. Maury E, Alzieu M, Baudel J, et al. Availability of an alcohol solution can improve hand disinfection compliance in an intensive care unit. *Am J Respir Crit Car Med* 2000;162:324-7.
103. Bischoff W, Reynolds T, Hall G, Wenzel RP, Edmond M. Handwashing compliance by health care workers: The impact of introducing an accessible, alcohol-based hand antiseptic. *Arch Intern Med* 2000;160:1017-21.
104. Muto CA, Siström M, Farr BM. Hand hygiene rates unaffected by installation of dispensers of a rapidly acting hand antiseptic. *Am J Infect Control* 2000;28:273-6.
105. Harbarth S, Pittet D, Grady L, et al. Interventional study to evaluate the impact of an alcohol-based hand gel in improving hand hygiene compliance. *Pediatr Infect Dis J* 2002;21:489-95.
106. Harrington G, Watson K, Bailey M, et al. Reduction in hospitalwide incidence of infection or colonization with methicillin-resistant *Staphylococcus aureus* with use of antimicrobial hand-hygiene gel and statistical process control charts. *Infect Cont Hosp Epidemiol* 2007;28:837-44.
107. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Infect Cont Hosp Epidemiol* 2002;23 [suppl]:S3-40.
108. IHI How-to Guide: Improving Hand Hygiene. A Guide for Improving Practices among Health Care Workers., 2009. (Accessed January 2008, at <http://www.ihl.org/IHI/topics/criticalcare/intensivecare/tools/>.)
109. Hanna H, Umphrey J, Tarrand J, Mendoza M, Raad I. Management of an outbreak of vancomycin-resistant enterococci in the medical intensive care unit of a cancer center. *Infect Cont Hosp Epidemiol* 2001;22:217-9.
110. Simor A, Lee M, Vearncombe M, et al. An outbreak due to multiresistant *Acinetobacter baumannii* in a burn unit: Risk factors for acquisition and management. *Infect Cont Hosp Epidemiol* 2002;23:261-7.
111. Neely A, Maley M. Survival of enterococci and staphylococci on hospital fabrics and plastics. *J Clin Microbiol* 2000;38:724-6.
112. Huang R, Mehta S, Weed D, Price C. Methicillin-resistant *Staphylococcus aureus* survival on hospital fomites. *Infect Cont Hosp Epidemiol* 2006;27:1267-9.
113. Martinez J, Ruthazer R, Hansjosten K, Barefoot L, Snyderman D. Role of environmental contamination as a risk factor for acquisition of vancomycin-resistant enterococci in patients treated in a medical intensive care unit. *Arch Intern Med* 2003;163:1905-12.
114. Hardy K, Oppenheim B, Gossain S, Gao F, Hawkey P. A study of the relationship between environmental contamination with methicillin-resistant *Staphylococcus aureus* (MRSA) and patients' acquisition of MRSA. *Infect Cont Hosp Epidemiol* 2006;27:127-32.
115. Hota B. Contamination, disinfection, and cross-colonization: Are hospital surfaces reservoirs for nosocomial infection? *Clin Infect Dis* 2004;39:1182-9.
116. Rampling A, Wiseman S, Davis L, et al. Evidence that hospital hygiene is important in the control of methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 2001;49:109-16.
117. Wilson A, Hayman S, Whitehouse T, et al. Importance of the environment for patient acquisition of methicillin-resistant *Staphylococcus aureus* in the intensive care unit: A baseline study. *Crit Care Med* 2007;35:1-5.
118. Oie S, Suenaga S, Sawa A, Kamiya A. Association between isolation sites of methicillin-resistant *Staphylococcus aureus* (MRSA) in patients with MRSA-positive body sites and MRSA contamination in their surrounding environmental surfaces. *Jpn J Infect Dis* 2007;60:367-9.
119. Harbarth S, Sax H, Fankhauser-Rodriguez C, Schrenzel J, Agostinho A, Pittet D. Evaluating the probability of previously unknown carriage of MRSA at hospital admission. *Am J Med* 2006;119:275.e15-e23.
120. Lucet JC, Chevret S, Durand-Zaleski I, Chastang C, Regnier B. Prevalence and risk factors for carriage of methicillin-resistant *Staphylococcus aureus* at admission to the intensive care unit. *Arch Intern Med* 2003;163:181-8.
121. Kenner J, O'Connor T, Piantanida N, et al. Rates of carriage of methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* in an outpatient population. *Infect Control Hosp Epidemiol* 2003;24:439-44.
122. Kuehnert MJ, Kruszon-Moran D, Hill HA, et al. Prevalence of *Staphylococcus aureus* nasal colonization in the United States, 2001-2002. *J Infect Dis* 2006;193:172-9.

123. Lucet JC, Grenet K, Armand-Lefevre L, et al. High prevalence of carriage of methicillin-resistant *Staphylococcus aureus* at hospital admission in elderly patients: implications for infection control strategies. *Infect Control Hosp Epidemiol* 2005;26:121-6.
124. Troillet N, Carmeli Y, Samore MH, et al. Carriage of methicillin-resistant *Staphylococcus aureus* at hospital admission. *Infect Control Hosp Epidemiol* 1998;19:181-5.
125. Furuno JP, McGregor JC, Harris AD, et al. Identifying groups at high risk for carriage of antibiotic-resistant bacteria. *Arch Intern Med* 2006;166:580-5.
126. Alfaro C, Mascher-Denen M, Fergie J, Purcell K. Prevalence of methicillin-resistant *Staphylococcus aureus* nasal carriage in patients admitted to Driscoll Children's Hospital. *Pediatr Infect Dis J* 2006;25:459-61.
127. Charlebois ED, Bangsberg DR, Moss NJ, et al. Population-based community prevalence of methicillin-resistant *Staphylococcus aureus* in the urban poor of San Francisco. *Clin Infect Dis* 2002;34:425-33.
128. Hidron AI, Kourbatova EV, Halvosa JS, et al. Risk factors for colonization with methicillin-resistant *Staphylococcus aureus* (MRSA) in patients admitted to an urban hospital: Emergence of community-associated MRSA nasal carriage. *Clin Infect Dis* 2005;41:159-66.
129. Baillargeon J, Kelley M, Leach C, Baillargeon G, Pollack B. Methicillin-resistant *Staphylococcus aureus* infection in the Texas prison system. *Clin Infect Dis* 2004;38:e92-5.
130. CDC. Methicillin-resistant *Staphylococcus aureus* skin or soft tissue infections in a state prison--Mississippi, 2000. *MMWR Morb Mortal Wkly Rep* 2001;50:919-22.
131. Pan ES, Diep BA, Carleton HA, et al. Increasing prevalence of methicillin-resistant *Staphylococcus aureus* infection in California jails. *Clin Infect Dis* 2003;37:1384-8.
132. Wootton SH, Arnold K, Hill HA, et al. Intervention to reduce the incidence of methicillin-resistant *Staphylococcus aureus* skin infections in a correctional facility in Georgia. *Infect Control Hosp Epidemiol* 2004;25:402-7.
133. CDC. Invasive methicillin-resistant *Staphylococcus aureus* infections among dialysis patients--United States, 2005. *MMWR* 2007;56:197-9.
134. Haley CC, Mittal D, LaViolette A, Jannapureddy S, Parvez N, Haley R. Methicillin-resistant *Staphylococcus aureus* infection or colonization present at hospital admission: Multivariable risk factor screening to increase efficiency of surveillance culturing. *J Clin Microbiol* 2007;45:3031-8.
135. Hartley D, Furuno J, Wright M, Smith D, Perencevich EN. The role of institutional epidemiologic weight in guiding infection surveillance and control in community and hospital populations. *Infect Cont Hosp Epidemiol* 2006;27:170-4.
136. Kalmeijer MD, Coertjens H, van Nieuwland-Bollen PM, et al. Surgical site infections in orthopedic surgery: The effect of mupirocin nasal ointment in a double-blind, randomized, placebo-controlled study. *Clin Infect Dis* 2002;35:353-8.
137. Kluytmans JA, Mouton JW, VandenBergh MF, et al. Reduction of surgical-site infections in cardiothoracic surgery by elimination of nasal carriage of *Staphylococcus aureus*. *Infect Control Hosp Epidemiol* 1996;17:780-5.
138. VandenBergh MF, Kluytmans JA, van Hout BA, et al. Cost-effectiveness of perioperative mupirocin nasal ointment in cardiothoracic surgery. *Infect Control Hosp Epidemiol* 1996;17:786-92.
139. Pujol M, Pena C, Pallares R, et al. Nosocomial *Staphylococcus aureus* bacteremia among nasal carriers of methicillin-resistant and methicillin-susceptible strains. *Am J Med* 1996;100:509-16.
140. Bratu S, Eramo A, Kopec R, et al. Community-associated methicillin-resistant *Staphylococcus aureus* in hospital nursery and maternity units. *Emerg Infect Dis* 2005;11:808-13.
141. Eckhardt C, Halvosa JS, Ray S, Blumberg HM. Transmission of methicillin-resistant *Staphylococcus aureus* in the neonatal intensive care unit from a patient with community-acquired disease. *Infect Cont Hosp Epidemiol* 2003;24:460-1.
142. Creech C, Litzner B, Talbot TR, Schaffner W. Frequency of vaginal colonization with community-associated methicillin-resistant *Staphylococcus aureus* in pregnant woman. In: *Infectious Disease Society of America*; 2006; Toronto, Ontario, Canada; 2006.
143. Marschall J, Muhlemann K. Duration of methicillin-resistant *Staphylococcus aureus* carriage, according to risk factors for acquisition. *Infect Control Hosp Epidemiol* 2006;27:1206-12.
144. Scanvic A, Denic L, Gaillon S, Giry P, Andremont A, Lucet JC. Duration of colonization by methicillin-resistant *Staphylococcus aureus* after hospital discharge and risk factors for prolonged carriage. *Clin Infect Dis* 2001;32:1393-8.
145. Salgado CD, Farr BM. What proportion of hospital patients colonized with methicillin-resistant *Staphylococcus aureus* are identified by clinical microbiological cultures? *Infect Control Hosp Epidemiol* 2006;27:116-21.

146. Girou E, Pujade G, Legrand P, Cizeau F, Brun-Buisson C. Selective screening of carriers for control of methicillin-resistant *Staphylococcus aureus* (MRSA) in high-risk hospital areas with a high level of endemic MRSA. *Clin Infect Dis* 1998;27:543-50.
147. Clancy M, Graepler A, Wilson M, Douglas I, Johnson J, Price CS. Active screening in high-risk units is an effective and cost-avoidant method to reduce the rate of methicillin-resistant *Staphylococcus aureus* infection in the hospital. *Infect Control Hosp Epidemiol* 2006;27:1009-17.
148. Huang SS, Rifas-Shiman S, Warren DK, et al. Improving methicillin-resistant *Staphylococcus aureus* surveillance and reporting in intensive care units. *J Infect Dis* 2007;195:330-8.
149. Kunori T, Cookson B, Roberts JA, Stone S, Kibbler C. Cost-effectiveness of different MRSA screening methods. *J Hosp Infect* 2002;51:189-200.
150. Boyce JM, Havill NL, Maria B. Frequency and possible infection control implications of gastrointestinal colonization with methicillin-resistant *Staphylococcus aureus*. *J Clin Microbiol* 2005;43:5992-5.
151. Cookson B, Peters B, Webster M, Phillips I, Rahman M, Noble W. Staff carriage of epidemic methicillin-resistant *Staphylococcus aureus*. *J Clin Microbiol* 1989;27:1471-6.
152. Ringberg H, Petersson C, Hugo W, Johansson PJ. The throat: An important site of MRSA colonization. *Scand J Infect Dis* 2006;38:888-93.
153. Eveillard M, de Lasseuse A, Barnaud G, Ricard J, Joly-Guillou ML. Evaluation of a strategy of screening multiple anatomical sites for methicillin-resistant *Staphylococcus aureus* at admission to a teaching hospital. *Infect Cont Hosp Epidemiol* 2006;27:181-4.
154. Robicsek A, Beaumont JL, Paule SM, et al. Universal surveillance for methicillin-resistant *Staphylococcus aureus* in 3 affiliated hospitals. *Ann Intern Med* 2008;148:409-18.
155. Huang SS, Yokoe D, Hinrichsen V, et al. Impact of routine intensive care unit surveillance cultures and resultant barrier precautions on hospital-wide methicillin-resistant *Staphylococcus aureus* bacteremia. *Clin Infect Dis* 2006;43:971-8.
156. Karchmer TB, Durbin LJ, Simonton BM, Farr BM. Cost-effectiveness of active surveillance cultures and contact/droplet precautions for control of methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 2002;51:126-32.
157. Papia G, Louie M, Tralla A, Johnson C, Collins V, Simor AE. Screening high-risk patients for methicillin-resistant *Staphylococcus aureus* on admission to the hospital: Is it cost effective? *Infect Control Hosp Epidemiol* 1999;20:473-7.
158. Singh N, Squier C, Wannstedt C, Keyes L, Wagener MM, Cacciarelli TV. Impact of an aggressive infection control strategy on endemic *Staphylococcus aureus* infection in liver transplant recipients. *Infect Control Hosp Epidemiol* 2006;27:122-6.
159. Vriens M, Blok H, Fluit A, Troelstra A, Van Der Werken C, Verhoef J. Costs associated with a strict policy to eradicate methicillin-resistant *Staphylococcus aureus* in a Dutch University Medical Center: A 10-year survey. *Eur J Clin Microbiol Infect Dis* 2002;21:782-6.
160. West T, Guerry C, Hiott M, Morrow N, Ward K, Salgado CD. Effect of targeted surveillance for control of methicillin-resistant *Staphylococcus aureus* in a community hospital system. *Infect Cont Hosp Epidemiol* 2006;27:233-8.
161. Muder RR, Cunningham C, McCray E, et al. Implementation of an industrial systems-engineering approach to reduce the incidence of methicillin-resistant *Staphylococcus aureus* infection. *Infect Control Hosp Epidemiol* 2008;29:702-8, 7 p following 8.
162. Wenzel RP, Bearman G, Edmond MB. Screening for MRSA: a flawed hospital infection control intervention. *Infect Control Hosp Epidemiol* 2008;29:1012-8.
163. Rodriguez-Bano J, Garcia L, Ramirez E, et al. Long-term control of endemic hospital-wide methicillin-resistant *Staphylococcus aureus* (MRSA): the impact of targeted active surveillance for MRSA in patients and healthcare workers. *Infect Control Hosp Epidemiol* 2010;31:786-95.
164. Peterson LR, Diekema DJ. To screen or not to screen for methicillin-resistant *Staphylococcus aureus*. *Journal of Clinical Microbiology* 2010;48:683-9.
165. Ellingson K, Muder RR, Jain R, et al. Sustained reduction in the clinical incidence of methicillin-resistant *Staphylococcus aureus* colonization or infection associated with a multifaceted infection control intervention. *Infect Control Hosp Epidemiol* 2011;32:1-8.
166. Jain R, Kralovic SM, Evans ME, et al. Veterans Affairs initiative to prevent methicillin-resistant *Staphylococcus aureus* infections. *N Engl J Med* 2011;364:1419-30.
167. Jeyaratnam D, Whitty CJ, Phillips K, et al. Impact of rapid screening tests on acquisition of methicillin resistant *Staphylococcus aureus*: cluster randomised crossover trial. *BMJ* 2008;336:927-30.

168. BJORHOLT I, HAGLIND E. Cost-savings achieved by eradication of epidemic methicillin-resistant *Staphylococcus aureus* (EMRSA)-16 from a large teaching hospital. *Eur J Clin Microbiol Infect Dis* 2004;23:688-95.
169. CHAIX C, DURAND-ZALESKI I, ALBERTI C, BRUN-BUISSON C. Control of endemic methicillin-resistant *Staphylococcus aureus*: A cost-benefit analysis in an intensive care unit. *JAMA* 1999;282:1745-51.
170. HERR C, HECKRODT T, HOFMANN F, SCHNETTLER R, EIKMANN T. Additional costs for preventing the spread of methicillin-resistant *Staphylococcus aureus* and a strategy for reducing these costs on a surgical ward. *Infect Cont Hosp Epidemiol* 2003;24:673-8.
171. NIJSSSEN S, BONTEN MJ, WEINSTEIN RA. Are active microbiological surveillance and subsequent isolation needed to prevent the spread of methicillin-resistant *Staphylococcus aureus*? *Clin Infect Dis* 2005;40:405-9.
172. VERNON M, HAYDEN MK, TRICK W, HAYES R, BLOM DW, WEINSTEIN R. Chlorhexidine gluconate to cleanse patients in a medical intensive care unit: The effectiveness of source control to reduce the bioburden of vancomycin-resistant enterococci. *Arch Intern Med* 2006;166:274-6.
173. HUSKINS WC. Results of the strategies to reduce transmission of antimicrobial resistant bacteria in adult intensive care units (STAR*ICU) Trial. 17th Annual Scientific Meeting of the Society of Healthcare Epidemiology of America; Baltimore, MD, April 2007.
174. HARBARTH S, FANKHAUSER C, SCHRENZEL J, et al. Universal screening for methicillin-resistant *Staphylococcus aureus* at hospital admission and nosocomial infection in surgical patients. *JAMA* 2008;299:1149-57.
175. HUSKINS WC, HUCKABEE CM, O'GRADY NP, et al. Intervention to reduce transmission of resistant bacteria in intensive care. *N Engl J Med* 2011;364:1407-18.
176. MAHAMAT A, MACKENZIE FM, BROOKER K, MONNET DL, DAURES JP, GOULD IM. Impact of infection control interventions and antibiotic use on hospital MRSA: a multivariate interrupted time-series analysis. *Int J Antimicrob Agents* 2007;30:169-76.
177. MCGINIGLE KL, GOURLAY ML, BUCHANAN IB. The use of active surveillance cultures in adult intensive care units to reduce methicillin-resistant *Staphylococcus aureus*-related morbidity, mortality, and costs: a systematic review. *Clin Infect Dis* 2008;46:1717-25.
178. HARBARTH S, HAWKEY PM, TENOVER F, STEFANI S, PANTOSTI A, STRUELENS MJ. Update on screening and clinical diagnosis of methicillin-resistant *Staphylococcus aureus* (MRSA). *International Journal of Antimicrobial Agents* 2011;37:110-7.
179. MATTNER F, BIERTZ F, ZIESING S, GASTMEIER P, CHABERNY IF. Long-term persistence of MRSA in re-admitted patients. *Infection* 2010;38:363-71.
180. DIEKEMA DJ, EDMOND M. Look before you leap: Active surveillance for multidrug-resistant organisms. *Clin Infect Dis* 2007;44:1101-7.
181. BEAUJEAN D, WEERSINK A, BLOK H, VERHOEF J. Determining the risk factors for methicillin-resistant *Staphylococcus aureus* carriage after discharge from hospital. *J Hosp Infect* 1999;42:213-8.
182. VONBERG R, STAMM-BALDERJAHN S, HANSEN S, et al. How often do asymptomatic healthcare workers cause methicillin-resistant *Staphylococcus aureus* outbreaks? A systematic evaluation. *Infect Cont Hosp Epidemiol* 2006;27:1123-7.
183. LESSING M, JORDENS J, BOWLER I. When should healthcare workers be screened for methicillin-resistant *Staphylococcus aureus*? *J Hosp Infect* 1996;34:205-10.
184. SHERETZ RJ, REAGAN DR, HAMPTON KD, et al. A cloud adult: The *Staphylococcus aureus*-virus interaction revisited. *Ann Intern Med* 1996;124:539-47.
185. FAIBIS F, LAPORTE C, FIACRE A, et al. An outbreak of methicillin-resistant *Staphylococcus aureus* surgical-site infections initiated by a healthcare worker with chronic sinusitis. *Infect Control Hosp Epidemiol* 2005;26:213-5.
186. BOYCE JM, OPAL SM, POTTER-BYNOE G, MEDEIROS AA. Spread of methicillin-resistant *Staphylococcus aureus* in a hospital after exposure to a health care worker with chronic sinusitis. *Clin Infect Dis* 1993;17:496-504.
187. BERTIN M, J V, SCHMITT S, et al. Outbreak of methicillin-resistant *Staphylococcus aureus* colonization and infection in a neonatal intensive care unit epidemiologically linked to a healthcare worker with chronic otitis. *Infect Cont Hosp Epidemiol* 2006;27:581-5.
188. BERTHELOT P, GRATARD F, FASCIA P, et al. Implication of a healthcare worker with chronic skin disease in the transmission of an epidemic strain of methicillin-resistant *Staphylococcus aureus* in a pediatric intensive care unit. *Clin Infect Dis* 2003;24:299-300.
189. SCARNATO F, MALLARET M, CROIZE J, et al. Incidence and prevalence of methicillin-resistant *Staphylococcus aureus* nasal carriage among healthcare workers in geriatric departments: Relevance to preventive measures. *Infect Cont Hosp Epidemiol* 2003;24:456-8.
190. SHEPPARD M. Control of methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 1996;32:73-8.

191. British Columbia Centre for Disease Control. British Columbia guidelines for control of antibiotic resistant organisms (AROs) [Methicillin-resistant *Staphylococcus aureus* (MRSA) and Vancomycin-Resistant Enterococci (VRE)]. 2001.
192. Simor AE, Phillips E, McGeer A, et al. Randomized controlled trial of chlorhexidine gluconate for washing, intranasal mupirocin, and rifampin and doxycycline versus no treatment for the eradication of methicillin-resistant *Staphylococcus aureus* colonization. *Clin Infect Dis* 2007;44:178-85.
193. Dupeyron C, Campillo B, Richardet JP, Soussy CJ. Long-term efficacy of mupirocin in the prevention of infections with methicillin-resistant *Staphylococcus aureus* in a gastroenterology unit. *J Hosp Infect* 2006;63:385-92.
194. Mody L, Kauffman CA, McNeil SA, Galecki AT, Bradley SF. Mupirocin-based decolonization of *Staphylococcus aureus* carriers in residents of 2 long-term care facilities: A randomized, double-blind, placebo-controlled trial. *Clin Infect Dis* 2003;37:1467-74.
195. Sandri AM, Dalarosa MG, Ruschel de Alcantara L, da Silva Elias L, Zavascki AP. Reduction in incidence of nosocomial methicillin-resistant *Staphylococcus aureus* (MRSA) infection in an intensive care unit: Role of treatment with mupirocin ointment and chlorhexidine baths for nasal carriers of MRSA. *Infect Control Hosp Epidemiol* 2006;27:185-7.
196. Darouiche R, Wright C, Hamill R, Koza M, Lewis D, Markowski J. Eradication of colonization by methicillin-resistant *Staphylococcus aureus* by using oral minocycline-rifampin and topical mupirocin. *Antimicrob Agents Chemother* 1991;35:1612-5.
197. Liu C, Bayer A, Cosgrove SE, et al. Clinical Practice Guidelines by the Infectious Diseases Society of America for the Treatment of Methicillin-Resistant *Staphylococcus aureus* Infections in Adults and Children. *Clin Infect Dis* 2011;52:e18-55.
198. Hansen D, Patzke P, Werfel U, Benner D, Brauksiepe A, Popp W. Success of MRSA eradication in hospital routine: Depends on compliance. *Infection* 2007;35:260-4.
199. Marshall C, Wesselingh S, McDonald M, Spelman D. Control of endemic MRSA: What is the evidence? *J Hosp Infect* 2004;56:253-68.
200. Boyce JM. MRSA patients: Proven methods to treat colonization and infection. *J Hosp Infect* 2001;48 Suppl A:S9-14.
201. Laupland KB, Conly JM. Treatment of *Staphylococcus aureus* colonization and prophylaxis for infection with topical intranasal mupirocin: An evidence-based review. *Clin Infect Dis* 2003;37:933-8.
202. Simor A, Stuart T, Louie L, et al. Mupirocin-resistant, methicillin-resistant *Staphylococcus aureus* (MRSA) in Canadian hospitals. *Antimicrob Agents Chemother* 2007;51:3880-6.
203. Levy S, Fitzgerald G, Macone A. Changes in the intestinal flora of farm personnel after introduction of tetracycline-supplemented feed on a farm. *N Engl J Med* 1976;295:583-8.
204. Tenover FC. Reasons for the emergence of antibiotic resistance. *Am J Med Sci* 1996;311:9-16.
205. Bonten M, Slaughter S, Ambergen A, et al. The role of "colonization pressure" in the spread of vancomycin-resistant enterococci: An important control variable. *Arch Intern Med* 1998;158:1127-32.
206. McCaig LF, Hughes JM. Trends in antimicrobial drug prescribing among office-based physicians in the United States. *JAMA* 1995;273:214-9.
207. Safdar N, Maki DG. The commonality of risk factors for nosocomial colonization and infection with antimicrobial-resistant *Staphylococcus aureus*, enterococcus, gram-negative bacilli, *Clostridium difficile*, and *Candida*. *Ann Intern Med* 2002;136:834-44.
208. Ellis MW, Hospenthal DR, Dooley DP, Gray PJ, Murray CK. Natural history of community-acquired methicillin-resistant *Staphylococcus aureus* colonization and infection in soldiers. *Clin Infect Dis* 2004;39:971-9.
209. Harbarth S, Liassine N, Dharan S, Herrault P, Auckenthaler R, Pittet D. Risk factors for persistent carriage of methicillin-resistant *Staphylococcus aureus*. *Clin Infect Dis* 2000;31:1380-5.
210. Leman R, Alvarado-Ramy F, Pocock S, et al. Nasal carriage of methicillin-resistant *Staphylococcus aureus* in an American Indian population. *Infect Control Hosp Epidemiol* 2004;25:121-5.
211. Moran GJ, Krishnadasan A, Gorwitz RJ, et al. Methicillin-resistant *S. aureus* infections among patients in the emergency department. *N Engl J Med* 2006;355:666-74.
212. Gerding D. The search for good antimicrobial stewardship. *Joint Commission J Qual Improv* 2001;27:403-4.
213. Arnold S, Allen U, Al-Zahrani M, Tan D, Wang E. Antibiotic prescribing by pediatricians for respiratory tract infection in children. *Clin Infect Dis* 1999;29:312-7.
214. Emmer C, Besser R. Combating antimicrobial resistance: Intervention programs to promote appropriate antibiotic use. *Infect Med* 2002;19:160-73.

215. McGowan JE, Jr. Economic impact of antimicrobial resistance. *Emerg Infect Dis* 2001;7:286-92.
216. Cosgrove SE, Carmeli Y. The impact of antimicrobial resistance on health and economic outcomes. *Clin Infect Dis* 2003;36:1433-7.
217. Fraser G, Stogsdill P, Dickens J, Wennberg D, Smith R, Prato B. Antibiotic optimization: an evaluation of patient safety and economic outcomes. *Arch Intern Med* 1997;157:1689-94.
218. Bantar C, Sartori B, Vesco E, et al. A hospitalwide intervention program to optimize the quality of antibiotic use: impact on prescribing practice, antibiotic consumption, cost savings, and bacterial resistance. *Clin Infect Dis* 2003;37:180-6.
219. Perz J, Craig AS, Coffey C, et al. Changes in antibiotic prescribing for children after a community-wide campaign. *JAMA* 2002;287:3103-9.
220. Cromer AL, Hutsell SO, Latham SC, et al. Impact of implementing a method of feedback and accountability related to contact precautions compliance. *Am J Infect Control* 2004;32:451-5.
221. Zoutman DE, Ford BD. The relationship between hospital infection surveillance and control activities and antibiotic-resistant pathogen rates. *Am J Infect Control* 2005;33:1-5.
222. Lemmen SW, Zolldann D, Gastmeier P, Luticken R. Implementing and evaluating a rotating surveillance system and infection control guidelines in 4 intensive care units. *Am J Infect Control* 2001;29:89-93.
223. Cooper BS, Stone SP, Kibbler CC, et al. Isolation measures in the hospital management of methicillin resistant *Staphylococcus aureus* (MRSA): systematic review of the literature. *BMJ* 2004;329:533.
224. O'Boyle C, Jackson M, Henly S. Staffing requirements for infection control programs in US health care facilities: Delphi project. *Am J Infect Control* 2002;30:321-33.
225. Grant J, Ramman-Haddad L, Libman M. The role of gowns in preventing nosocomial transmission of methicillin-resistant *Staphylococcus aureus* (MRSA): Gown use in MRSA control. *Infect Cont Hosp Epidemiol* 2006;27:191-4.
226. Association for Professionals in Infection Control and Epidemiology Inc. APIC Text of Infection Control and Epidemiology. Washington, D.C.; 2005.
227. <http://www.npsa.nhs.uk/cleanyourhands>. Accessed January 2008.
228. <http://www.cdc.gov/cleanhands/>. Accessed January 2008.
229. VHA Hand Hygiene Information and Tools 2008. (Accessed at <http://www.patientsafety.gov/SafetyTopics/HandHygiene/index.html>.)
230. Curran ET, Benneyan JC, Hood J. Controlling methicillin-resistant *Staphylococcus aureus*: a feedback approach using annotated statistical process control charts. *Infect Control Hosp Epidemiol* 2002;23:13-8.
231. Merrer J, Santoli F, Appere de Vecchi C, Tran B, De Jonghe B, Outin H. "Colonization pressure" and risk of acquisition of methicillin-resistant *Staphylococcus aureus* in a medical intensive care unit. *Infect Control Hosp Epidemiol* 2000;21:718-23.
232. Warren DK, Nitin A, Hill C, Fraser VJ, Kollef MH. Occurrence of co-colonization or co-infection with vancomycin-resistant enterococci and methicillin-resistant *Staphylococcus aureus* in a medical intensive care unit. *Infect Control Hosp Epidemiol* 2004;25:99-104.
233. Jernigan JA, Pullen A, Partin C, Jarvis WR. Prevalence of and risk factors for colonization with methicillin-resistant *Staphylococcus aureus* in an outpatient clinic population. *Infect Cont Hosp Epidemiol* 2003;24:445-50.
234. Talon DR, Bertrand X. Methicillin-resistant *Staphylococcus aureus* in geriatric patients: Usefulness of screening in a chronic-care setting. *Infect Control Hosp Epidemiol* 2001;22:505-9.
235. Price MF, McBride ME, Wolf JE, Jr. Prevalence of methicillin-resistant *Staphylococcus aureus* in a dermatology outpatient population. *South Med J* 1998;91:369-71.
236. Fortunov R, Allen C, Hulten K, et al. Maternal nasal colonization of term and near term previously healthy neonates with community-acquired *Staphylococcus aureus* infections. In: Infectious Disease Society of America; 2006; Toronto, Ontario, Canada; 2006.
237. Engemann JJ, Carmeli Y, Cosgrove SE, et al. Adverse clinical and economic outcomes attributable to methicillin resistance among patients with *Staphylococcus aureus* surgical site infection. *Clin Infect Dis* 2003;36:592-8.
238. Singh N, Paterson DL, Chang FY, et al. Methicillin-resistant *Staphylococcus aureus*: the other emerging resistant gram-positive coccus among liver transplant recipients. *Clin Infect Dis* 2000;30:322-7.
239. Weber S, Herwaldt L, McNutt L, et al. An outbreak of *Staphylococcus aureus* in a pediatric cardiothoracic surgery unit. *Infect Cont Hosp Epidemiol* 2002;23:77-81.
240. Berhe M, Edmond M, Bearman G. Measurement and feedback of infection control process measures in the intensive care unit: Impact on compliance. *Am J Infect Control* 2006;34:537-9.

241. Duckro AN, Blom DW, Lyle EA, Weinstein RA, Hayden MK. Transfer of vancomycin-resistant enterococci via health care worker hands. *Arch Intern Med* 2005;165:302-7.
242. Sehulster L, Chinn RY. Guidelines for environmental infection control in health-care facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). *MMWR Recomm Rep* 2003;52:1-42.
243. Cohen AL, Calfee D, Fridkin SK, et al. Recommendations for metrics for multidrug-resistant organisms in healthcare settings: SHEA/HICPAC Position paper. *Infect Control Hosp Epidemiol* 2008;29:901-13.
244. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *American journal of infection control* 2008;36:309-32.
245. CDC. National Healthcare Safety Network. Multidrug-Resistant Organism & *Clostridium difficile* Infection (MDRO/CDI) Module. 2011:1-28.
246. Calfee DP, Durbin LJ, Germanson TP, Toney DM, Smith EB, Farr BM. Spread of methicillin-resistant *Staphylococcus aureus* (MRSA) among household contacts of individuals with nosocomially acquired MRSA. *Infect Control Hosp Epidemiol* 2003;24:422-6.
247. Simor AE, Ofner-Agostini M, Bryce E, et al. The evolution of methicillin-resistant *Staphylococcus aureus* in Canadian hospitals: 5 years of national surveillance. *CMAJ* 2001;165:21-6.
248. Gustafson TL. Practical risk-adjusted quality control charts for infection control. *Am J Infect Control* 2000;28:406-14.
249. Boyce JM, Jackson MM, Pugliese G, et al. Methicillin-resistant *Staphylococcus aureus* (MRSA): a briefing for acute care hospitals and nursing facilities. The AHA Technical Panel on Infections Within Hospitals. *Infect Control Hosp Epidemiol* 1994;15:105-15.
250. Committee on Infectious Diseases American Academy of Pediatrics. Red Book, 27th Edition; 2006.
251. Clinical and Laboratory Standards Institute. Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically; Approved standard. In. 7 ed; 2006:M7-A6.
252. Clinical and Laboratory Standards Institute/NCCLS. Performance standards for antimicrobial susceptibility testing: 17th informational supplement. In: CLSI/NCCLS document M100-S17, 2007.
253. Diekema DJ, Pfaller MA, Schmitz FJ, et al. Survey of infections due to *Staphylococcus* species: frequency of occurrence and antimicrobial susceptibility of isolates collected in the United States, Canada, Latin America, Europe, and the Western Pacific region for the SENTRY Antimicrobial Surveillance Program, 1997-1999. *Clin Infect Dis* 2001;32 Suppl 2:S114-32.
254. Gorwitz RJ, Jernigan D, Powers J, Jernigan J, Participants in the CDC-Convended Experts' Meeting on Management of MRSA in the Community. Strategies for clinical management of MRSA in the community: Summary of an experts' meeting convened by the Centers for Disease Control and Prevention; 2006.
255. Friedel D, Climo M. Nasal colonization with methicillin-resistant *Staphylococcus aureus*: Clinical implications and treatment. *Curr Infect Dis Rep* 2007;9:201-7.
256. Reagan DR, Doebbeling BN, Pfaller MA, et al. Elimination of coincident *Staphylococcus aureus* nasal and hand carriage with intranasal application of mupirocin calcium ointment. *Ann Intern Med* 1991;114:101-6.
257. Tammelin A, Klotz F, Hambraeus A, Stahle E, Ransjo U. Nasal and hand carriage of *Staphylococcus aureus* in staff at a department for thoracic and cardiovascular surgery: Endogenous or exogenous source? *Infect Cont Hosp Epidemiol* 2003;24:686-9.
258. Boylard E, Tablan OC, Williams W, et al. Guideline for infection control in healthcare personnel. 1998.
259. Mangram A, Horan T, Pearson M, Silver L, Jarvis WR, HICPAC. Guideline for prevention of surgical site infection, 1999. *Infect Cont Hosp Epidemiol* 1999;20:247-78.
260. Friedman C, Barnette M, Buck AS, et al. Requirements for infrastructure and essential activities of infection control and epidemiology in out-of-hospital settings: A Consensus Panel report. *Am J Infect Control* 1999;27:418-30.
261. Cohen SH, Morita MM, Bradford M. A seven-year experience with methicillin-resistant *Staphylococcus aureus*. *Am J Med* 1991;91:233S-7S.
262. Hitomi S, Kubota M, Mori N, et al. Control of a methicillin-resistant *Staphylococcus aureus* outbreak in a neonatal intensive care unit by unselective use of nasal mupirocin ointment. *J Hosp Infect* 2000;46:123-9.
263. Weese J. Environmental surveillance for MRSA. In: Ji Y, ed. *Methods in Molecular Biology: MRSA Protocols*. Totowa: Humana Press; 2007.
264. Climo MW, Sepkowitz KA, Zuccotti G, et al. The effect of daily bathing with chlorhexidine on the acquisition of methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, and healthcare-associated

bloodstream infections: results of a quasi-experimental multicenter trial. Critical care medicine 2009;37:1858-65.

Appendices

Appendix A – List of Resources

Instructions for Nasal Swab Culture Collection

- Available in the “Guide to the Elimination of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Transmission in Hospital Settings 2nd Edition, 2010” from the Association for Professionals in Infection Control and Epidemiology (pg. 33) at www.apic.org

Cultural Transformation: Making the Business Case for Infection Control Activities

- Available in the “Guide to the Elimination of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Transmission in Hospital Settings 2nd Edition, 2010” from the Association for Professionals in Infection Control and Epidemiology (pages 47-50) at www.apic.org
- Dunagan WC, Murphy DM, Hollenbeak CS, Miller SB. Making the business case for infection control: pitfalls and opportunities. *Am J Infect Control*. 2002;30:86-92
- Scheckler WE, Brimhall D, Buck AS, Farr BM, Friedman C, Baribaldi RA, et.al. Requirements for infrastructure and essential activities of infection control and epidemiology in hospitals: A consensus panel report. *Infect Control Hosp Epidemiol* 1998;19:114-124

Hand Hygiene

- “How-to Guide: Improving Hand Hygiene. A Guide for Improving Practices Among Health Care Workers”. Available from www.ihl.org
<http://www.ihl.org/IHI/Topics/CriticalCare/IntensiveCare/Tools/HowtoGuideImprovingHandHygiene.htm>
- Boyce JM, Pittet D. Guideline for Hand Hygiene in health-care settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Available at:
<http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5116a1.htm>.
- World Alliance for Safer Health Care. WHO Guidelines on Hand Hygiene in Health Care. Available from
http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf
- The Joint Commission. Measuring Hand Hygiene Adherence: Overcoming the Challenges. 2009. Available at:
http://www.jointcommission.org/patientsafely/infectioncontrol/hh_monograph.htm

Environmental Services Cleaning Checklists

- Available in Appendix A and B of “Getting Started Kit: Reduce methicillin-resistant *Staphylococcus aureus* (MRSA) infection. How-to Guide” by the Institute for Healthcare Improvement. Available at
<http://www.ihl.org/IHI/Programs/Campaign/MRSAInfection.htm>
- Evaluating Environmental Cleaning checklists, available from CDC at
http://www.cdc.gov/HAI/prevent/prevention_tools.html

Surveillance Methodology/Data Analysis

- Available in the “Guide to the Elimination of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Transmission in Hospital Settings 2nd Edition, 2010” from the Association for Professionals in Infection Control and Epidemiology (pages 21-34) at www.apic.org
- Association for Professionals in Infection Control and Epidemiology (APIC). Text of Infection Control and Epidemiology. 2nd Edition. Washington, D.C.: Association for Professionals in Infection Control and Epidemiology, Inc; 2005. (Chapters 3, 5, 6, 7, 8)
- Gustafson TL. Practical risk-adjusted quality control charts for infection control. *Am J Infect Control*. 2000;28:406-14.
- Curran ET, Benneyan JC, Hood J. Controlling methicillin-resistant *Staphylococcus aureus*: A feedback approach using annotated statistical process control charts. *Infect Control Hosp Epidemiol* 2002;23:13-18
- CDC National Healthcare Safety Network (NHSN) Available at <http://www.cdc.gov/nhsn/>

MRSA Fact Sheets for Patients and Families

- “Learning about MRSA: A Guide for Patients” available from MDH at <http://www.health.state.mn.us/divs/idepc/diseases/mrsa/index.html> (Appendix C)
- “FAQs (frequently asked questions) about MRSA” Available from CDC/SHEA/APIC/IDSA/Joint Commission/American Hospital Association at http://www.cdc.gov/mrsa/pdf/SHEA-mrsa_tagged.pdf

CDC MRSA Prevention Tools

- Inter-facility Infection Control Transfer Form. Available from CDC at <http://www.cdc.gov/HAI/toolkits/InterfacilityTransferCommunicationForm11-2010.pdf>
- MRSA Prevention Toolkit. Available from CDC at http://www.cdc.gov/HAI/prevent/prevention_tools.html

Appendix B - Script for nursing staff when collecting surveillance cultures:

“As a part of XXXXXX hospital’s commitment to reduce antibiotic-resistant bacteria and keep patients safe, a specimen will be collected from your nose to determine if you are carrying bacteria called MRSA (methicillin-resistant *Staphylococcus aureus*). If your test comes back positive, nurses, doctors, and other healthcare staff will wear gowns and gloves when they come into your room. If your test comes back positive, you will receive more information about MRSA.”

Methicillin-Resistant *Staphylococcus aureus* (MRSA)

What is *Staphylococcus aureus*?

Staphylococcus aureus, often called “staph”, are bacteria commonly carried on the skin or in the noses of healthy people. Staph bacteria are one of the most common causes of skin infections in the U.S. Most of the infections are minor (such as pimples or boils) and most can be treated without antibiotics.

Staph bacteria can also cause serious infections (such as blood stream infections or pneumonia). In the past, most serious staph infections were treated with a certain type of antibiotic (medicine) related to penicillin. Over the past 50 years, treatment of these infections have become more difficult because staph bacteria have become resistant to some types of antibiotics, this means the antibiotics do not kill the bacteria. Some of the staph bacteria that are resistant to antibiotics are called methicillin-resistant *Staphylococcus aureus* (MRSA).

Where is MRSA found?

MRSA can be found on the skin and in the noses of some people without causing illness. When MRSA is on the body but not causing an infection it is called colonization. Infection occurs when the MRSA bacteria enter the body and cause disease.

What type of infections are caused by MRSA?

MRSA most often causes skin infections, such as pimples or boils. MRSA can also cause infections of the bone, blood, or urinary tract.

Who usually gets an MRSA infection?

MRSA most often occurs among people in hospitals and health care facilities (such as nursing homes or dialysis centers) who have weakened immune systems.

People who have not been in a hospital or healthcare care facility can also get MRSA. This is known as community-associated MRSA.

How is MRSA spread?

MRSA is spread by skin-to-skin contact or by contact with items that have become contaminated with MRSA, such as bandages, bed sheets, towels and washcloths.

What are the symptoms of MRSA?

The type of symptoms you have will depend on where the MRSA will depend on the site of infection. If MRSA is in a wound, the area around the wound may be red, warm, swollen, and have pus-like drainage.

How do you test for MRSA infections?

A test of your skin or area of the body that might be infected will show if there is an MRSA infection. Sometimes this may be done using a swab to test for MRSA in your nose or on your skin. If you have had an MRSA infection in the past, you may be tested from time to time to see if you still have MRSA.

How do you treat MRSA infections?

Many MRSA skin infections will heal on their own, without the need for additional treatment. Some MRSA infections will need to be treated with medicine (antibiotics)

How can you prevent the spread of MRSA at home?

- Clean your hands well and often with soap and warm water or use an alcohol-based hand rub, especially after changing bandages or touching the infected area.
- Use gloves when touching any wounds or touching body fluids
- Keep your wounds or sores covered
- Avoid sharing personal items (such as towels, washcloths, razors, or clothing)
- Clean frequently used household surfaces (sinks, bathtubs/showers, tables, countertops, light switches, doorknobs) with a household cleaner

Can an MRSA infection come back?

It is possible for an MRSA infection to come back. To prevent this from happening, follow your healthcare provider's directions while you have the infection, and follow the prevention steps listed above.

Appendix D – Letter to patient regarding MRSA positive surveillance culture result (if discharged before result is known)

Date

Dear Patient Name

When you were admitted to XXX Hospital on XXX, you had a specimen collected from your nose to determine if you were carrying bacteria called MRSA (methicillin-resistant *Staphylococcus aureus*). The results of that test showed that MRSA was found in your nose. We are sending you this letter to provide you with some information about MRSA.

Staphylococcus aureus (staph) bacteria are often found in the nose or on the skin. People who have MRSA in their nose with no symptoms of infection are “carriers of” or “colonized with” MRSA. Most of the time, staph bacteria found in the nose or on the skin do not cause problems.

MRSA can cause infection if it gets inside the body. Most of the time, MRSA causes skin infections. MRSA skin infections can look like:

- large, red, painful bumps under the skin (boils or abscesses)
- a cut that is swollen and filled with pus
- a blister that is full of pus (impetigo)
- a sore that looks or feels like a spider bite.

It is also possible for MRSA to cause infections in other areas of the body such as the blood, lungs, joints, open wounds or urine. Symptoms of MRSA infection in other areas of the body can include fever, pain, chills, shortness of breath, and pain or difficulty urinating. It is important to recognize symptoms of MRSA infection. If you ever have symptoms of MRSA infection, you should notify your healthcare provider as soon as possible. Early treatment can prevent MRSA infections from getting worse.

Anyone can get MRSA. MRSA can be spread by touching someone or something that has the MRSA bacteria on it. In your home, simple measures such as washing your hands and not sharing personal items help prevent the spread of MRSA. In the hospital, extra precautions to prevent the spread of MRSA are taken. If you are admitted to XXX Hospital, your caregivers will wear gloves and a gown when caring for you. Extra precautions are needed in hospitals because healthcare workers touch many patients throughout the day, and they do not want to spread MRSA from person to person.

The enclosed fact sheet has more information on MRSA, including how to prevent the spread of MRSA. We hope this information helps you understand that:

1. MRSA in the nose usually does not cause problems
2. MRSA can cause infections and it is important to recognize symptoms of MRSA infection
3. Keeping hands clean by washing with soap and water or using an alcohol based hand rub product is very important in preventing the spread of MRSA.
4. Hospitals take extra steps to prevent the spread of MRSA.

If you have questions about MRSA you can call XXXX.

Sincerely
XXXXXX