Management of Multidrug-Resistant Organisms In Healthcare Settings, 2006

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I. Introduction

Multidrug-resistant organisms (MDROs), including methicillin-resistant *Staphylococcus aureus (*MRSA), vancomycin-resistant enterococci (VRE) and certain gram-negative bacilli (GNB) have important infection control implications that either have not been addressed or received only limited consideration in previous isolation guidelines. Increasing experience with these organisms is improving understanding of the routes of transmission and effective preventive measures. Although transmission of MDROs is most frequently documented in acute care facilities, all healthcare settings are affected by the emergence and transmission of antimicrobial-resistant microbes. The severity and extent of disease caused by these pathogens varies by the population(s) affected and by the institution(s) in which they are found. Institutions, in turn, vary widely in physical and functional characteristics, ranging from long-term care facilities (LTCF) to specialty units (e.g., intensive care units [ICU], burn units, neonatal ICUs [NICUs]) in tertiary care facilities. Because of this, the approaches to prevention and control of these pathogens need to be tailored to the specific needs of each population and individual institution. The prevention and control of MDROs is a national priority - one that requires that all healthcare facilities and agencies assume responsibility (1, 2). The following discussion and recommendations are provided to guide the implementation of strategies and practices to prevent the transmission of MRSA, VRE, and other MDROs. The administration of healthcare organizations and institutions should ensure that appropriate strategies are fully implemented, regularly evaluated for effectiveness, and adjusted such that there is a consistent decrease in the incidence of targeted MDROs.

Successful prevention and control of MDROs requires administrative and scientific leadership and a financial and human resource commitment (3-5). Resources must be made available for infection prevention and control, including expert consultation, laboratory support, adherence monitoring, and data analysis. Infection prevention and control professionals have found that healthcare personnel (HCP) are more receptive and adherent to the recommended control measures when organizational leaders participate in efforts to reduce MDRO transmission (3).

II. Background

MDRO definition. *For* epidemiologic purposes, MDROs are defined as microorganisms, predominantly bacteria, that are resistant to one or more classes of antimicrobial agents (1). Although the names of certain MDROs describe resistance to only one agent (e.g., MRSA, VRE), these pathogens are frequently resistant to most available antimicrobial agents.

These highly resistant organisms deserve special attention in healthcare facilities (2). In addition to MRSA and VRE, certain GNB, including those producing extended spectrum beta-lactamases (ESBLs) and others that are resistant to multiple classes of antimicrobial agents, are of particular concern[1]. In addition to *Escherichia coli* and *Klebsiella pneumoniae*, these include strains of *Acinetobacter baumannii* resistant to all antimicrobial agents, or all except imipenem, (6-12), and organisms such as *Stenotrophomonas maltophilia (*12-14), *Burkholderia cepacia (15, 16)*, and *Ralstonia pickettii (17)* that are intrinsically resistant to the broadest-spectrum antimicrobial agents. In some residential settings (e.g., LTCFs), it is important to control multidrug-resistant *S. pneumoniae (*MDRSP) that are resistant to penicillin and other broad-spectrum agents such as macrolides and fluroquinolones (18, 19). Strains of *S. aureus* that have intermediate susceptibility or are resistant to vancomycin (i.e., vancomycin-intermediate *S. aureus* [VISA], vancomycin-resistant *S. aureus* [VRSA]) (20-30) have affected specific populations, such as hemodialysis patients.

Clinical importance of MDROs. In most instances, MDRO infections have clinical manifestations that are similar to infections caused by susceptible pathogens. However, options for treating patients with these infections are often extremely limited. For example, until recently, only vancomycin provided effective therapy for potentially life-threatening MRSA infections and during the 1990's there were virtually no antimicrobial agents to treat infections caused by VRE. Although antimicrobials are now available for treatment of MRSA and VRE infections, resistance to each new agent has already emerged

[1] Multidrug-resistant strains of *M. tuberculosis* are not addressed in this document because of the markedly different patterns of transmission and spread of the pathogen and the very different control interventions that are needed for prevention of *M. tuberculosis* infection. Current recommendations for prevention and control of tuberculosis can be found at: Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* in Health-Care Settings, 2005 (https://www.cdc.gov/mmwr/pdf/rr/rr5417.pdf)

in clinical isolates (31-37). Similarly, therapeutic options are limited for ESBL-producing isolates of gram-negative bacilli, strains of *A. baumannii* resistant to all antimicrobial agents except imipenem (8-11, 38) and intrinsically resistant *Stenotrophomonas* sp. (12-14, 39). These limitations may influence antibiotic usage patterns in ways that suppress normal flora and create a favorable environment for development of colonization when exposed to potential MDR pathogens (i.e., selective advantage) (40).

Increased lengths of stay, costs, and mortality also have been associated with MDROs (41-46). Two studies documented increased mortality, hospital lengths of stay, and hospital charges associated with multidrug-resistant gram-negative bacilli (MDR-GNBs), including an NICU outbreak of ESBL-producing *Klebsiella pneumoniae (*47) and the emergence of third- generation cephalosporin resistance in *Enterobacter* spp. in hospitalized adults (48).

Vancomycin resistance has been reported to be an independent predictor of death from enterococcal bacteremia (44, 49-53). Furthermore, VRE was associated with increased mortality, length of hospital stay, admission to the ICU, surgical procedures, and costs when VRE patients were compared with a matched hospital population (54).

However, MRSA may behave differently from other MDROs. When patients with MRSA have been compared to patients with methicillin-susceptible *S. aureus (*MSSA), MRSA-colonized patients more frequently develop symptomatic infections (55, 56). Furthermore, higher case fatality rates have been observed for certain MRSA infections, including bacteremia (57-62), poststernotomy mediastinitis (63), and surgical site infections (64). These outcomes may be a result of delays in the administration of vancomycin, the relative decrease in the bactericidal activity of vancomycin (65), or persistent bacteremia associated with intrinsic characteristics of certain MRSA strains (66). Mortality may be increased further by *S. aureus* with reduced vancomycin susceptibility (VISA) (26, 67). Also some studies have reported an association between MRSA infections and increased length of stay, and healthcare costs (46, 61, 62), while others have not (64). Finally, some hospitals have observed an increase in the overall occurrence of staphylococcal infections following the introduction of MRSA into a hospital or special-care unit (68, 69).

III. Epidemiology of MDROs

Trends. Prevalence of MDROs varies temporally, geographically, and by healthcare setting (70, 71). For example, VRE emerged in the eastern United States in the early 1990s, but did not appear in the western United States until several years later, and MDRSP varies in prevalence by state (72). The type and level of care also influence the prevalence of MDROs. ICUs, especially those at tertiary care facilities, may have a higher prevalence of MDRO infections than do non-ICU settings (73, 74). Antimicrobial resistance rates are also strongly correlated with hospital size, tertiary-level care, and facility type (e.g., LTCF) (75, 76). The frequency of clinical infection caused by these pathogens is low in LTCFs (77, 78). Nonetheless, MDRO infections in LTCFs can cause serious disease and mortality, and colonized or infected LTCF residents may serve as reservoirs and vehicles for MDRO introduction into acute care facilities (78-88). Another example of population differences in prevalence of target MDROs is in the pediatric population. Point prevalence surveys conducted by the Pediatric Prevention Network (PPN) in eight U.S. PICUs and 7 U.S. NICUs in 2000 found ≤4% of patients were colonized with MRSA or VRE compared with 10-24% were colonized with ceftazidime- or aminoglycoside-resistant gram-negative bacilli; < 3% were colonized with ESBL-producing gram negative bacilli. Despite some evidence that MDRO burden is greatest in adult hospital patients, MDRO require similar control efforts in pediatric populations as well (89).

During the last several decades, the prevalence of MDROs in U.S. hospitals and medical centers has increased steadily (90, 91). MRSA was first isolated in the United States in 1968. By the early 1990s, MRSA accounted for 20%-25% of *Staphylococcus aureus* isolates from hospitalized patients (92). In 1999, MRSA accounted for >50% of *S. aureus* isolates from patients in ICUs in the National Nosocomial Infection Surveillance (NNIS) system; in 2003, 59.5% of *S. aureus* isolates in NNIS ICUs were MRSA (93). A similar rise in prevalence has occurred with VRE (94). From 1990 to 1997, the prevalence of VRE in enterococcal isolates from hospitalized patients increased from <1% to approximately 15% (95). VRE accounted for almost 25% of enterococcus isolates in NNIS ICUs in 1999 (94), and 28.5% in 2003 (93).

GNB resistant to ESBLs, fluoroquinolones, carbapenems, and aminoglycosides also have increased in prevalence. For example, in 1997, the SENTRY Antimicrobial Surveillance Program found that among *K. pneumoniae* strains isolated in the United States, resistance rates to ceftazidime and other third-generation cephalosporins were 6.6%, 9.7%, 5.4%, and 3.6% for bloodstream, pneumonia, wound, and urinary tract infections, respectively (95). In 2003, 20.6% of all *K. pneumoniae* isolates from NNIS ICUs were resistant to these drugs (93). Similarly, between 1999 and 2003, *Pseudomonas aeruginosa* resistance to fluoroquinolone antibiotics increased from 23% to 29.5% in NNIS ICUs (74). Also, a 3-month survey of 15 Brooklyn hospitals in 1999 found that 53% of *A. baumannii* strains exhibited resistance to carbapenems and 24% of *P. aeruginosa* strains were resistant to imipenem (10). During 1994-2000, a national review of ICU patients in 43 states found that the overall susceptibility to ciprofloxacin decreased from 86% to 76% and was temporally associated with increased use of fluoroquinolones in the United States (96).

Lastly, an analysis of temporal trends of antimicrobial resistance in non-ICU patients in 23 U.S. hospitals during 1996-1997 and 1998-1999 (97) found significant increases in the prevalence of resistant isolates including MRSA, ciprofloxacin-resistant *P. aeruginosa*, and ciprofloxacin- or ofloxacin-resistant *E. coli.* Several factors may have contributed to these increases including: selective pressure exerted by exposure to antimicrobial agents, particularly fluoroquinolones, outside of the ICU and/or in the community (7, 96, 98); increasing rates of community-associated MRSA colonization and infection (99, 100); inadequate adherence to infection control practices; or a combination of these factors.

Important concepts in transmission. Once MDROs are introduced into a healthcare setting, transmission and persistence of the resistant strain is determined by the availability of vulnerable patients, selective pressure exerted by antimicrobial use, increased potential for transmission from larger numbers of colonized or infected patients ("colonization pressure") (101, 102); and the impact of implementation and adherence to prevention efforts. Patients vulnerable to colonization and infection include those with severe disease, especially those with compromised host defenses from underlying medical conditions; recent surgery; or indwelling medical devices (e.g.,

urinary catheters or endotracheal tubes (103, 104)). Hospitalized patients, especially ICU patients, tend to have more risk factors than non-hospitalized patients do, and have the highest infection rates. For example, the risk that an ICU patient will acquire VRE increases significantly once the proportion of ICU patients colonized with VRE exceeds 50% (101) or the number days of exposure to a VRE-patient exceeds 15 days (105). A similar effect of colonization pressure has been demonstrated for MRSA in a medical ICU (102). Increasing numbers of infections with MDROs also have been reported in non-ICU areas of hospitals (97).

There is ample epidemiologic evidence to suggest that MDROs are carried from one person to another via the hands of HCP (106-109). Hands are easily contaminated during the process of care-giving or from contact with environmental surfaces in close proximity to the patient (110-113). The latter is especially important when patients have diarrhea and the reservoir of the MDRO is the gastrointestinal tract (114-117). Without adherence to published recommendations for hand hygiene and glove use (111) HCP are more likely to transmit MDROs to patients. Thus, strategies to increase and monitor adherence are important components of MDRO control programs (106, 118).

Opportunities for transmission of MDROs beyond the acute care hospital results from patients receiving care at multiple healthcare facilities and moving between acute-care, ambulatory and/or chronic care, and LTC environments. System-wide surveillance at LDS Hospital in Salt Lake City, Utah, monitored patients identified as being infected or colonized with MRSA or VRE, and found that those patients subsequently received inpatient or outpatient care at as many as 62 different healthcare facilities in that system during a 5-year span (119).

Role of colonized HCP in MDRO transmission. Rarely, HCP may introduce an MDRO into a patient care unit (120-123). Occasionally, HCP can become persistently colonized with an MDRO, but these HCP have a limited role in transmission, unless other factors are present. Additional factors that can facilitate transmission, include chronic sinusitis (120), upper respiratory infection (123), and dermatitis (124).

Implications of community-associated MRSA (CA-MRSA). The emergence of new epidemic strains of MRSA in the community, among patients without established MRSA risk factors, may present new challenges to MRSA control in healthcare settings (125-128).

Historically, genetic analyses of MRSA isolated from patients in hospitals worldwide revealed that a relatively small number of MRSA strains have unique qualities that facilitate their transmission from patient to patient within healthcare facilities over wide geographic areas, explaining the dramatic increases in HAIs caused by MRSA in the 1980s and early 1990s (129). To date, most MRSA strains isolated from patients with CA-MRSA infections have been microbiologically distinct from those endemic in healthcare settings, suggesting that some of these strains may have arisen *de novo* in the community via acquisition of methicillin resistance genes by established methicillin-susceptible *S. aureus (*MSSA) strains (130-132). Two pulsed-field types, termed USA300 and USA400 according to a typing scheme established at CDC, have accounted for the majority of CA-MRSA infections characterized in the United States, whereas pulsed-field types USA100 and USA200 are the predominant genotypes endemic in healthcare settings (133).

USA300 and USA400 genotypes almost always carry type IV of the staphylococcal chromosomal cassette (SCC) *mec*, the mobile genetic element that carries the *mec*A methicillin-resistance gene (133, 134). This genetic cassette is smaller than types I through III, the types typically found in healthcare associated MRSA strains, and is hypothesized to be more easily transferable between *S. aureus* strains.

CA-MRSA infection presents most commonly as relatively minor skin and soft tissue infections, but severe invasive disease, including necrotizing pneumonia, necrotizing fasciitis, severe osteomyelitis, and a sepsis syndrome with increased mortality have also been described in children and adults (134-136).

Transmission within hospitals of MRSA strains first described in the community (e.g. USA300 and USA400) are being reported with increasing frequency (137-140). Changing resistance patterns of MRSA in ICUs in the NNIS system from 1992 to 2003 provide

additional evidence that the new epidemic MRSA strains are becoming established healthcare-associated as well as community pathogens (90). Infections with these strains have most commonly presented as skin disease in community settings. However, intrinsic virulence characteristics of the organisms can result in clinical manifestations similar to or potentially more severe than traditional healthcare-associated MRSA infections among hospitalized patients. The prevalence of MRSA colonization and infection in the surrounding community may therefore affect the selection of strategies for MRSA control in healthcare settings.

IV. MDRO Prevention and Control

Prevention of infections. Preventing infections will reduce the burden of MDROs in healthcare settings. Prevention of antimicrobial resistance depends on appropriate clinical practices that should be incorporated into all routine patient care. These include optimal management of vascular and urinary catheters, prevention of lower respiratory tract infection in intubated patients, accurate diagnosis of infectious etiologies, and judicious antimicrobial selection and utilization. Guidance for these preventive practices include the Campaign to Reduce Antimicrobial Resistance in Healthcare Settings ([This link is no longer active: www.cdc.gov/drugresistance/healthcare.]), a multifaceted, evidence-based approach with four parallel strategies: infection prevention; accurate and prompt diagnosis and treatment; prudent use of antimicrobials; and prevention of transmission. Campaign materials are available for acute care hospitals, surgical settings, dialysis units, LTCFs and pediatric acute care units.

To reduce rates of central-venous-line associated bloodstream infections (CVL-BSIs) and ventilator-associated pneumonia (VAP), a group of bundled evidence-based clinical practices have been implemented in many U.S. healthcare facilities (118, 141-144). One report demonstrated a sustained effect on the reduction in CVL-BSI rates with this approach (145). Although the specific effect on MDRO infection and colonization rates have not been reported, it is logical that decreasing these and other healthcare-associated infections will in turn reduce antimicrobial use and decrease opportunities for emergence and transmission of MDROs.

Overview of the MDRO control literature. Successful control of MDROs has been documented in the United States and abroad using a variety of combined interventions. These include improvements in hand hygiene, use of Contact Precautions until patients are culture-negative for a target MDRO, active surveillance cultures (ASC), education, enhanced environmental cleaning, and improvements in communication about patients with MDROs within and between healthcare facilities.

Representative studies include:

1. Reduced rates of MRSA transmission in The Netherlands, Belgium, Denmark, and other Scandinavian countries after the implementation of aggressive and sustained infection control interventions (i.e., ASC; preemptive use of Contact Precautions upon admission until proven culture negative; and, in some instances, closure of units to new admissions). MRSA generally accounts for a very small proportion of *S. aureus* clinical isolates in these countries (146-150).
2. Reduced rates of VRE transmission in healthcare facilities in the three-state Siouxland region (Iowa, Nebraska, and South Dakota) following formation of a coalition and development of an effective region-wide infection control intervention that included ASC and isolation of infected patients. The overall prevalence rate of VRE in the 30 participating facilities decreased from 2.2% in 1997 to 0.5% in 1999 (151).
3. Eradication of endemic MRSA infections from two NICUs. The first NICU included implementation of ASC, Contact Precautions, use of triple dye on the umbilical cord, and systems changes to improve surveillance and adherence to recommended practices and to reduce overcrowding (152). The second NICU used ASC and Contact Precautions; surgical masks were included in the barriers used for Contact Precautions (153).
4. Control of an outbreak and eventual eradication of VRE from a burn unit over a 13-month period with implementation of aggressive culturing, environmental cleaning, and barrier isolation (154).
5. Control of an outbreak of VRE in a NICU over a 3-year period with implementation of ASC, other infection control measures such as use of a waterless hand disinfectant, and mandatory in-service education (155).

6. Eradication of MDR-strains of *A. baumannii* from a burn unit over a 16-month period with implementation of strategies to improve adherence to hand hygiene, isolation, environmental cleaning, and temporary unit closure (38).
7. In addition, more than 100 reports published during 1982-2005 support the efficacy of combinations of various control interventions to reduce the burden of MRSA, VRE, and MDR-GNBs (Tables 1 and 2). Case-rate reduction or pathogen eradication was reported in a majority of studies.
8. VRE was eradicated in seven special-care units (154, 156-160), two hospitals (161, 162), and one LTCF (163).
9. MRSA was eradicated from nine special-care units (89, 152, 153, 164-169), two hospitals (170), one LTCF (167), and one Finnish district (171). Furthermore, four MRSA reports described continuing success in sustaining low endemic MDRO rates for over 5 years (68, 166, 172, 173).
10. An MDR-GNB was eradicated from 13 special-care units (8, 9, 38, 174-180) and two hospitals (11, 181).

These success stories testify to the importance of having dedicated and knowledgeable teams of healthcare professionals who are willing to persist for years, if necessary, to control MDROs. Eradication and control of MDROs, such as those reported, frequently required periodic reassessment and the addition of new and more stringent interventions over time (tiered strategy). For example, interventions were added in a stepwise fashion during a 3-year effort that eventually eradicated MRSA from an NICU (152). A series of interventions was adopted throughout the course of a year to eradicate VRE from a burn unit (154). Similarly, eradication of carbapenem-resistant strains of *A. baumannii* from a hospital required multiple and progressively more intense interventions over several years (11).

Nearly all studies reporting successful MDRO control employed a median of 7 to 8 different interventions concurrently or sequentially (Table 1). These figures may underestimate the actual number of control measures used, because authors of these reports may have considered their earliest efforts routine (e.g., added emphasis on handwashing), and did not include them as interventions, and some ”single measures” are, in fact, a complex

combination of several interventions. The use of multiple concurrent control measures in these reports underscores the need for a comprehensive approach for controlling MDROs.

Several factors affect the ability to generalize the results of the various studies reviewed, including differences in definition, study design, endpoints and variables measured, and period of follow-up. Two-thirds of the reports cited in Tables 1 and 2 involved perceived outbreaks, and one-third described efforts to reduce endemic transmission. Few reports described preemptive efforts or prospective studies to control MDROs before they had reached high levels within a unit or facility.

With these and other factors, it has not been possible to determine the effectiveness of individual interventions, or a specific combination of interventions, that would be appropriate for all healthcare facilities to implement in order to control their target MDROs. Randomized controlled trials are necessary to acquire this level of evidence. An NIH-sponsored, randomized controlled trial on the prevention of MRSA and VRE transmission in adult ICUs is ongoing and may provide further insight into optimal control measures ([Current version of this document may differ from original.] Strategies to Reduce Transmission of Antimicrobial Resistant Bacteria in Intensive Care Units (STAR*ICU) Trial (https://clinicaltrials.gov/ct/show/NCT00100386?order=1)). This trial compares the use of education (to improve adherence to hand hygiene) and Standard Precautions to the use of ASC and Contact Precautions.

Control interventions. The various types of interventions used to control or eradicate MDROs may be grouped into seven categories. These include administrative support, judicious use of antimicrobials, surveillance (routine and enhanced), Standard and Contact Precautions, environmental measures, education and decolonization. These interventions provide the basis for the recommendations for control of MDROs in healthcare settings that follow this review and as summarized in Table 3. In the studies reviewed, these interventions were applied in various combinations and degrees of intensity, with differences in outcome.

1. ***Administrative support.*** In several reports, administrative support and involvement were important for the successful control of the target MDRO (3, 152, 182-185), and authorities in infection control have strongly recommended such support (2, 106, 107, 186). There are several examples of MDRO control interventions that require administrative commitment of fiscal and human resources. One is the use of ASC (8, 38, 68, 107, 114, 151, 152, 167, 168, 183, 184, 187-192). Other interventions that require administrative support include:
    1. implementing system changes to ensure prompt and effective communications e.g., computer alerts to identify patients previously known to be colonized/infected with MDROs (184, 189, 193, 194);
    2. providing the necessary number and appropriate placement of hand washing sinks and alcohol-containing hand rub dispensers in the facility (106, 195);
    3. maintaining staffing levels appropriate to the intensity of care required (152, 196-202); and
    4. enforcing adherence to recommended infection control practices (e.g., hand hygiene, Standard and Contact Precautions) for MDRO control. Other measures that have been associated with a positive impact on prevention efforts, that require administrative support, are direct observation with feedback to HCP on adherence to recommended precautions and keeping HCP informed about changes in transmission rates (3, 152, 182, 203-205). A “How-to guide” for implementing change in ICUs, including analysis of structure, process, and outcomes when designing interventions, can assist in identification of needed administrative interventions (195).

    Lastly, participation in existing, or the creation of new, city-wide, state-wide, regional or national coalitions, to combat emerging or growing MDRO problems is an effective strategy that requires administrative support (146, 151, 167, 188, 206, 207).

2. ***Education.*** Facility-wide, unit-targeted, and informal, educational interventions were included in several successful studies (3, 189, 193, 208-211). The focus of the interventions was to encourage a behavior change through improved understanding of the problem MDRO that the facility was trying to control. Whether the desired change involved hand hygiene, antimicrobial prescribing patterns, or other outcomes, enhancing understanding and creating a culture that supported and promoted the desired behavior, were viewed as essential to the success of the intervention. Educational campaigns to enhance adherence to hand hygiene

practices in conjunction with other control measures have been associated temporally with decreases in MDRO transmission in various healthcare settings (3, 106, 163).

3. ***Judicious use of antimicrobial agents.*** While a comprehensive review of antimicrobial stewardship is beyond the scope of this guideline, recommendations for control of MDROs must include attention to judicious antimicrobial use. A temporal association between formulary changes and decreased occurrence of a target MDRO was found in several studies, especially in those that focused on MDR-GNBs (98, 177, 209, 212-218). Occurrence of C. difficile-associated disease has also been associated with changes in antimicrobial use (219). Although some MRSA and VRE control efforts have attempted to limit antimicrobial use, the relative importance of this measure for controlling these MDROs remains unclear (193, 220). Limiting antimicrobial use alone may fail to control resistance due to a combination of factors; including
    1. the relative effect of antimicrobials on providing initial selective pressure, compared to perpetuating resistance once it has emerged;
    2. inadequate limits on usage; or
    3. insufficient time to observe the impact of this intervention. With the intent of addressing #2 and #3 above in the study design, one study demonstrated a decrease in the prevalence of VRE associated with a formulary switch from ticarcillin-clavulanate to piperacillin-tazobactam (221).

The CDC Campaign to Prevent Antimicrobial Resistance that was launched in 2002 provides evidence-based principles for judicious use of antimicrobials and tools for implementation (222) [This link is no longer active: www.cdc.gov/drugresistance/healthcare.]. This effort targets all healthcare settings and focuses on effective antimicrobial treatment of infections, use of narrow spectrum agents, treatment of infections and not contaminants, avoiding excessive duration of therapy, and restricting use of broad-spectrum or more potent antimicrobials to treatment of serious infections when the pathogen is not known or when other effective agents are unavailable. Achieving these objectives would likely diminish the selective pressure that favors proliferation of MDROs. Strategies for influencing antimicrobial prescribing patterns within

healthcare facilities include education; formulary restriction; prior-approval programs, including pre-approved indications; automatic stop orders; academic interventions to counteract pharmaceutical influences on prescribing patterns; antimicrobial cycling (223-226); computer-assisted management programs (227-229); and active efforts to remove redundant antimicrobial combinations (230). A systematic review of controlled studies identified several successful practices. These include social marketing (i.e. consumer education), practice guidelines, authorization systems, formulary restriction, mandatory consultation, and peer review and feedback. It further suggested that online systems that provide clinical information, structured order entry, and decision support are promising strategies (231). These changes are best accomplished through an organizational, multidisciplinary, antimicrobial management program (232).

4. ***MDRO surveillance.*** Surveillance is a critically important component of any MDRO control program, allowing detection of newly emerging pathogens, monitoring epidemiologic trends, and measuring the effectiveness of interventions. Multiple MDRO surveillance strategies have been employed, ranging from surveillance of clinical microbiology laboratory results obtained as part of routine clinical care, to use of ASC to detect asymptomatic colonization.

Surveillance for MDROs isolated from routine clinical cultures.

Antibiograms. The simplest form of MDRO surveillance is monitoring of clinical microbiology isolates resulting from tests ordered as part of routine clinical care. This method is particularly useful to detect emergence of new MDROs not previously detected, either within an individual healthcare facility or community-wide. In addition, this information can be used to prepare facility- or unit-specific summary antimicrobial susceptibility reports that describe pathogen-specific prevalence of resistance among clinical isolates. Such reports may be useful to monitor for changes in known resistance patterns that might signal emergence or transmission of MDROs, and also to provide clinicians with information to guide antimicrobial prescribing practices (233 - 235).

MDRO Incidence Based on Clinical Culture Results. Some investigators have used clinical microbiology results to calculate measures of incidence of MDRO

isolates in specific populations or patient care locations (e.g. new MDRO isolates/1,000 patient days, new MDRO isolates per month) (205, 236, 237). Such measures may be useful for monitoring MDRO trends and assessing the impact of prevention programs, although they have limitations. Because they are based solely on positive culture results without accompanying clinical information, they do not distinguish colonization from infection, and may not fully demonstrate the burden of MDRO-associated disease. Furthermore, these measures do not precisely measure acquisition of MDRO colonization in a given population or location. Isolating an MDRO from a clinical culture obtained from a patient several days after admission to a given unit or facility does not establish that the patient acquired colonization in that unit. On the other hand, patients who acquire MDRO colonization may remain undetected by clinical cultures (107). Despite these limitations, incidence measures based on clinical culture results may be highly correlated with actual MDRO transmission rates derived from information using ASC, as demonstrated in a recent multicenter study (237). These results suggest that incidence measures based on clinical cultures alone might be useful surrogates for monitoring changes in MDRO transmission rates.

MDRO Infection Rates. Clinical cultures can also be used to identify targeted MDRO infections in certain patient populations or units (238, 239). This strategy requires investigation of clinical circumstances surrounding a positive culture to distinguish colonization from infection, but it can be particularly helpful in defining the clinical impact of MDROs within a facility.

Molecular typing of MDRO isolates. Many investigators have used molecular typing of selected isolates to confirm clonal transmission to enhance understanding of MDRO transmission and the effect of interventions within their facility (38, 68, 89, 92, 138, 152, 190, 193, 236, 240).

Surveillance for MDROs by detecting asymptomatic colonization

Another form of MDRO surveillance is the use of active surveillance cultures (ASC) to identify patients who are colonized with a targeted MDRO (38, 107, 241). This

approach is based upon the observation that, for some MDROs, detection of colonization may be delayed or missed completely if culture results obtained in the course of routine clinical care are the primary means of identifying colonized patients (8, 38, 107, 114, 151, 153, 167, 168, 183, 184, 187, 189, 191-193, 242-244). Several authors report having used ASC when new pathogens emerge in order to define the epidemiology of the particular agent (22, 23, 107, 190). In addition, the authors of several reports have concluded that ASC, in combination with use of Contact Precautions for colonized patients, contributed directly to the decline or eradication of the target MDRO (38, 68, 107, 151, 153, 184, 217, 242). However, not all studies have reached the same conclusion. Poor control of MRSA despite use of ASC has been described (245). A recent study failed to identify cross-transmission of MRSA or MSSA in a MICU during a 10 week period when ASC were obtained, despite the fact that culture results were not reported to the staff (246). The investigators suggest that the degree of cohorting and adherence to Standard Precautions might have been the important determinants of transmission prevention, rather than the use of ASC and Contact Precautions for MRSA-colonized patients. The authors of a systematic review of the literature on the use of isolation measures to control healthcare-associated MRSA concluded that there is evidence that concerted efforts that include ASC and isolation can reduce MRSA even in endemic settings. However, the authors also noted that methodological weaknesses and inadequate reporting in published research make it difficult to rule out plausible alternative explanations for reductions in MRSA acquisition associated with these interventions, and therefore concluded that the precise contribution of active surveillance and isolation alone is difficult to assess (247).

Mathematical modeling studies have been used to estimate the impact of ASC use in control of MDROs. One such study evaluating interventions to decrease VRE transmission indicated that use of ASC (versus no cultures) could potentially decrease transmission 39% and that with pre-emptive isolation plus ASC, transmission could be decreased 65% (248). Another mathematical model examining the use of ASC and isolation for control of MRSA predicted that isolating colonized or infected patients on

the basis of clinical culture results is unlikely to be successful at controlling MRSA, whereas use of active surveillance and isolation can lead to successful control, even in settings where MRSA is highly endemic. (249) There is less literature on the use of ASC in controlling MDR-GNBs. Active surveillance cultures have been used as part of efforts to successful control of MDR-GNBs in outbreak settings. The experience with ASC as part of successful control efforts in endemic settings is mixed. One study reported successful reduction of extended- spectrum beta-lactamase –producing Enterobacteriaceae over a six year period using a multifaceted control program that included use of ASC (245). Other reports suggest that use of ASC is not necessary to control endemic MDR-GNBs. (250, 251).

More research is needed to determine the circumstances under which ASC are most beneficial (252), but their use should be considered in some settings, especially if other control measures have been ineffective. When use of ASC is incorporated into MDRO prevention programs, the following should be considered:

- The decision to use ASC as part of an infection prevention and control program requires additional support for successful implementation, including:
  1. personnel to obtain the appropriate cultures,
  2. microbiology laboratory personnel to process the cultures,
  3. mechanism for communicating results to caregivers,
  4. concurrent decisions about use of additional isolation measures triggered by a positive culture (e.g. Contact Precautions) and
  5. mechanism for assuring adherence to the additional isolation measures.
- The populations targeted for ASC are not well defined and vary among published reports. Some investigators have chosen to target specific patient populations considered at high risk for MDRO colonization based on factors such as location (e.g. ICU with high MDRO rates), antibiotic exposure history, presence of underlying diseases, prolonged duration of stay, exposure to other MDRO- colonized patients, patients transferred from other facilities known to have a high prevalence of MDRO carriage, or having a history of recent hospital or nursing home stays (107, 151, 253). A more commonly employed strategy involves obtaining surveillance cultures

from all patients admitted to units experiencing high rates of colonization/infection with the MDROs of interest, unless they are already known to be MDRO carriers (153, 184, 242, 254). In an effort to better define target populations for active surveillance, investigators have attempted to create prediction rules to identify subpopulations of patients at high risk for colonization on hospital admission (255, 256). Decisions about which populations should be targeted for active surveillance should be made in the context of local determinations of the incidence and prevalence of MDRO colonization within the intervention facility as well as other facilities with whom patients are frequently exchanged (257).

- Optimal timing and interval of ASC are not well defined. In many reports, cultures were obtained at the time of admission to the hospital or intervention unit or at the time of transfer to or from designated units (e.g., ICU) (107). In addition, some hospitals have chosen to obtain cultures on a periodic basis [e.g., weekly] (8, 153, 159) to detect silent transmission. Others have based follow-up cultures on the presence of certain risk factors for MDRO colonization, such as antibiotic exposure, exposure to other MDRO colonized patients, or prolonged duration of stay in a high risk unit (253).
- Methods for obtaining ASC must be carefully considered, and may vary depending upon the MDRO of interest.
    - MRSA: Studies suggest that cultures of the nares identify most patients with MRSA and perirectal and wound cultures can identify additional carriers (152, 258-261).
    - VRE: Stool, rectal, or perirectal swabs are generally considered a sensitive method for detection of VRE. While one study suggested that rectal swabs may identify only 60% of individuals harboring VRE, and may be affected by VRE stool density (262), this observation has not been reported elsewhere in the literature.
    - MDR-GNBs: Several methods for detection of MDR-GNBs have been employed, including use of peri-rectal or rectal swabs alone or in combination with oro-pharyngeal, endotracheal, inguinal, or wound cultures. The absence of standardized screening media for many gram-negative

bacilli can make the process of isolating a specific MDR-GNB a relatively labor-intensive process (38, 190, 241, 250).

- Rapid detection methods: Using conventional culture methods for active surveillance can result in a delay of 2-3 days before results are available. If the infection control precautions (e.g., Contact Precautions) are withheld until the results are available, the desired infection control measures could be delayed. If empiric precautions are used pending negative surveillance culture results, precautions may be unnecessarily implemented for many, if not most, patients. For this reason, investigators have sought methods for decreasing the time necessary to obtain a result from ASC. Commercially available media containing chromogenic enzyme substrates (CHROMagar MRSA) (263, 264) has been shown to have high sensitivity and specificity for identification of MRSA and facilitate detection of MRSA colonies in screening cultures as early as 16 hours after inoculation. In addition, real- time PCR-based tests for rapid detection of MRSA directly from culture swabs (< 1-2 hours) are now commercially available (265-267), as well as PCR-based tests for detection of *vanA* and *vanB* genes from rectal swabs (268). The impact of rapid testing on the effectiveness of active surveillance as a prevention strategy, however, has not been fully determined. Rapid identification of MRSA in one study was associated with a significant reduction in MRSA infections acquired in the medical ICU, but not the surgical ICU (265). A mathematical model characterizing MRSA transmission dynamics predicted that, in comparison to conventional culture methods, the use of rapid detection tests may decrease isolation needs in settings of low-endemicity and result in more rapid reduction in prevalence in highly-endemic settings (249).

- Some MDRO control reports described surveillance cultures of healthcare personnel during outbreaks, but colonized or infected healthcare personnel are rarely the source of ongoing transmission, and this strategy should be reserved for settings in which specific healthcare personnel have been epidemiologically implicated in the transmission of MDROs (38, 92, 152-154, 188).

5. ***Infection Control Precautions.*** Since 1996 CDC has recommended the use of Standard and Contact Precautions for MDROs "judged by an infection control program…to be of special clinical and epidemiologic significance." This recommendation was based on general consensus and was not necessarily evidence-based. No studies have directly compared the efficacy of Standard Precautions alone versus Standard Precautions and Contact Precautions, with or without ASC, for control of MDROs. Some reports mention the use of one or both sets of precautions as part of successful MDRO control efforts; however, the precautions were not the primary focus of the study intervention (164, 190, 205, 269- 271). The NIH-sponsored study mentioned earlier (Section: *Overview of the MDRO control literature*) may provide some answers (Strategies to Reduce Transmission of Antimicrobial Resistant Bacteria in Intensive Care Units (STAR*ICU) Trial (https://clinicaltrials.gov/ct/show/NCT00100386?order=1) [Current version of this document may differ from original.].

Standard precautions have an essential role in preventing MDRO transmission, even in facilities that use Contact Precautions for patients with an identified MDRO. Colonization with MDROs is frequently undetected; even surveillance cultures may fail to identify colonized persons due to lack of sensitivity, laboratory deficiencies, or intermittent colonization due to antimicrobial therapy (262). Therefore, Standard Precautions must be used in order to prevent transmission from potentially colonized patients. Hand hygiene is an important component of Standard Precautions. The authors of the *Guideline for Hand Hygiene in Healthcare Settings (106)* cited nine studies that demonstrated a temporal relationship between improved adherence to recommended hand hygiene practices and control of MDROs. It is noteworthy that in one report the frequency of hand hygiene did not improve with use of Contact Precautions but did improve when gloves were used (per Standard Precautions) for contact with MDRO patients (272).

MDRO control efforts frequently involved changes in isolation practices, especially during outbreaks. In the majority of reports, Contact Precautions were implemented for all patients found to be colonized or infected with the target

MDRO (See Table 2). Some facilities also preemptively used Contact Precautions, in conjunction with ASC, for all new admissions or for all patients admitted to a specific unit, until a negative screening culture for the target MDRO was reported (30, 184, 273).

Contact precautions are intended to prevent transmission of infectious agents, including epidemiologically important microorganisms, which are transmitted by direct or indirect contact with the patient or the patient's environment. A single-patient room is preferred for patients who require Contact Precautions. When a single-patient room is not available, consultation with infection control is necessary to assess the various risks associated with other patient placement options (e.g., cohorting, keeping the patient with an existing roommate). HCP caring for patients on Contact Precautions should wear a gown and gloves for all interactions that may involve contact with the patient or potentially contaminated areas in the patient's environment. Donning gown and gloves upon room entry and discarding before exiting the patient room is done to contain pathogens, especially those that have been implicated in transmission through environmental contamination (e.g., VRE, *C. difficile,* noroviruses and other intestinal tract agents; RSV) (109, 111, 274-277).

Cohorting and other MDRO control strategies. In several reports, cohorting of patients (152, 153, 167, 183, 184, 188, 189, 217, 242), cohorting of staff (184, 217, 242, 278), use of designated beds or units (183, 184), and even unit closure (38, 146, 159, 161, 279, 280) were necessary to control transmission. Some authors indicated that implementation of the latter two strategies were the turning points in their control efforts; however, these measures usually followed many other actions to prevent transmission. In one, two-center study, moving MRSA-positive patients into single rooms or cohorting these patients in designated bays failed to reduce transmission in ICUs. However, in this study adherence to recommendations for hand hygiene between patient contacts was only 21% (281). Other published studies, including one commissioned by the American Institute of Architects and the Facility Guidelines Institute ([This link is no longer active: www.aia.org/aah_gd_hospcons.]), have documented a beneficial relationship between private rooms and reduction in risk of

acquiring MDROs (282). Additional studies are needed to define the specific contribution of using single-patient rooms and/or cohorting on preventing transmission of MDROs.

Duration of Contact Precautions. The necessary duration of Contact Precautions for patients treated for infection with an MDRO, but who may continue to be colonized with the organism at one or more body sites, remains an unresolved issue. Patients may remain colonized with MDROs for prolonged periods; shedding of these organisms may be intermittent, and surveillance cultures may fail to detect their presence (84, 250, 283). The 1995 HICPAC guideline for preventing the transmission of VRE suggested three negative stool/perianal cultures obtained at weekly intervals as a criterion for discontinuation of Contact Precautions (274). One study found these criteria generally reliable (284). However, this and other studies have noted a recurrence of VRE positive cultures in persons who subsequently receive antimicrobial therapy and persistent or intermittent carriage of VRE for more than 1 year has been reported (284-286). Similarly, colonization with MRSA can be prolonged (287, 288). Studies demonstrating initial clearance of MRSA following decolonization therapy have reported a high frequency of subsequent carriage (289, 290). There is a paucity of information in the literature on when to discontinue Contact Precautions for patients colonized with a MDR-GNB, possibly because infection and colonization with these MDROs are often associated with outbreaks.

Despite the uncertainty about when to discontinue Contact Precautions, the studies offer some guidance. In the context of an outbreak, prudence would dictate that Contact Precautions be used indefinitely for all previously infected and known colonized patients. Likewise, if ASC are used to detect and isolate patients colonized with MRSA or VRE, and there is no decolonization of these patients, it is logical to assume that Contact Precautions would be used for the duration of stay in the setting where they were first implemented. In general, it seems reasonable to discontinue Contact Precautions when three or more surveillance cultures for the target MDRO are repeatedly negative over the course of a week or two in a patient who has not received antimicrobial therapy for several weeks, especially in the

absence of a draining wound, profuse respiratory secretions, or evidence implicating the specific patient in ongoing transmission of the MDRO within the facility.

Barriers used for contact with patients infected or colonized with MDROs. Three studies evaluated the use of gloves with or without gowns for all patient contacts to prevent VRE acquisition in ICU settings (30, 105, 273). Two of the studies showed that use of both gloves and gowns reduced VRE transmission (30, 105) while the third showed no difference in transmission based on the barriers used (273). One study in a LTCF compared the use of gloves only, with gloves plus contact isolation, for patients with four MDROs, including VRE and MRSA, and found no difference (86). However, patients on contact isolation were more likely to acquire MDR-*K. pneumoniae* strains that were prevalent in the facility; reasons for this were not specifically known. In addition to differences in outcome, differing methodologies make comparisons difficult. Specifically, HCP adherence to the recommended protocol, the influence of added precautions on the number of HCP-patient interactions, and colonization pressure were not consistently assessed.

Impact of Contact Precautions on patient care and well-being. There are limited data regarding the impact of Contact Precautions on patients. Two studies found that HCP, including attending physicians, were half as likely to enter the rooms of (291), or examine (292), patients on Contact Precautions. Other investigators have reported similar observations on surgical wards (293). Two studies reported that patients in private rooms and on barrier precautions for an MDRO had increased anxiety and depression scores (294, 295). Another study found that patients placed on Contact Precautions for MRSA had significantly more preventable adverse events, expressed greater dissatisfaction with their treatment, and had less documented care than control patients who were not in isolation (296). Therefore, when patients are placed on Contact Precautions, efforts must be made by the healthcare team to counteract these potential adverse effects.

6. ***Environmental measures.*** The potential role of environmental reservoirs, such as surfaces and medical equipment, in the transmission of VRE and other MDROs has been the subject of several reports (109-111, 297, 298). While environmental cultures are not routinely recommended (299), environmental cultures were used in several studies to document contamination, and led to interventions that included the use of dedicated noncritical medical equipment (217, 300), assignment of dedicated cleaning personnel to the affected patient care unit (154), and increased cleaning and disinfection of frequently-touched surfaces (e.g., bedrails, charts, bedside commodes, doorknobs). A common reason given for finding environmental contamination with an MDRO was the lack of adherence to facility procedures for cleaning and disinfection. In an educational and observational intervention, which targeted a defined group of housekeeping personnel, there was a persistent decrease in the acquisition of VRE in a medical ICU (301). Therefore, monitoring for adherence to recommended environmental cleaning practices is an important determinant for success in controlling transmission of MDROs and other pathogens in the environment (274, 302).

   In the MDRO reports reviewed, enhanced environmental cleaning was frequently undertaken when there was evidence of environmental contamination and ongoing transmission. Rarely, control of the target MDRO required vacating a patient care unit for complete environmental cleaning and assessment (175, 279).

7. ***Decolonization.*** Decolonization entails treatment of persons colonized with a specific MDRO, usually MRSA, to eradicate carriage of that organism. Although some investigators have attempted to decolonize patients harboring VRE (220), few have achieved success. However, decolonization of persons carrying MRSA in their nares has proved possible with several regimens that include topical mupirocin alone or in combination with orally administered antibiotics (e.g., rifampin in combination with trimethoprim- sulfamethoxazole or ciprofloxacin) plus the use of an antimicrobial soap for bathing (303). In one report, a 3-day regimen of baths with povidone-iodine and nasal therapy with mupirocin resulted in eradication of nasal MRSA colonization (304). These

and other methods of MRSA decolonization have been thoroughly reviewed. (303, 305-307).

Decolonization regimens are not sufficiently effective to warrant routine use. Therefore, most healthcare facilities have limited the use of decolonization to MRSA outbreaks, or other high prevalence situations, especially those affecting special-care units. Several factors limit the utility of this control measure on a widespread basis:

1. identification of candidates for decolonization requires surveillance cultures;
2. candidates receiving decolonization treatment must receive follow-up cultures to ensure eradication; and
3. recolonization with the same strain, initial colonization with a mupirocin-resistant strain, and emergence of resistance to mupirocin during treatment can occur (289, 303, 308-310).

HCP implicated in transmission of MRSA are candidates for decolonization and should be treated and culture negative before returning to direct patient care. In contrast, HCP who are colonized with MRSA, but are asymptomatic, and have not been linked epidemiologically to transmission, do not require decolonization.

IV. Discussion

This review demonstrates the depth of published science on the prevention and control of MDROs. Using a combination of interventions, MDROs in endemic, outbreak, and non-endemic settings have been brought under control. However, despite the volume of literature, an appropriate set of evidence-based control measures that can be universally applied in all healthcare settings has not been definitively established. This is due in part to differences in study methodology and outcome measures, including an absence of randomized, controlled trials comparing one MDRO control measure or strategy with another. Additionally, the data are largely descriptive and quasi-experimental in design (311). Few reports described preemptive efforts or prospective studies to control MDROs before they had reached high levels within a unit or facility. Furthermore, small hospitals and LTCFs are infrequently represented in the literature.

A number of questions remain and are discussed below.

Impact on other MDROS from interventions targeted to one MDRO. Only one report described control efforts directed at more than one MDRO, i.e., MDR-GNB and MRSA (312). Several reports have shown either decreases or increases in other pathogens with efforts to control one MDRO. For example, two reports on VRE control efforts demonstrated an increase in MRSA following the prioritization of VRE patients to private rooms and cohort beds (161). Similarly an outbreak of *Serratia marcescens* was temporally associated with a concurrent, but unrelated, outbreak of MRSA in an NICU (313). In contrast, Wright and colleagues reported a decrease in MRSA and VRE acquisition in an ICU during and after their successful effort to eradicate an MDR-strain of *A. baumannii* from the unit (210).

Colonization with multiple MDROs appears to be common (314, 315). One study found that nearly 50% of residents in a skilled-care unit in a LTCF were colonized with a target MDRO and that 26% were co-colonized with >1 MDRO; a detailed analysis showed that risk factors for colonization varied by pathogen (316). One review of the literature (317) reported that patient risk factors associated with colonization with MRSA, VRE, MDR-GNB, *C. difficile* and *Candida sp* were the same. This review concluded that control programs that focus on only one organism or one antimicrobial drug are unlikely to succeed because vulnerable patients will continue to serve as a magnet for other MDROs.

Costs. Several authors have provided evidence for the cost-effectiveness of approaches that use ASC (153, 191, 253, 318, 319). However, the supportive evidence often relied on assumptions, projections, and estimated attributable costs of MDRO infections. Similar limitations apply to a study suggesting that gown use yields a cost benefit in controlling transmission of VRE in ICUs (320). To date, no studies have directly compared the benefits and costs associated with different MDRO control strategies.

Feasibility. The subject of feasibility, as it applies to the extrapolation of results to other healthcare settings, has not been addressed. For example, smaller hospitals and LTCFs may lack the on-site laboratory services needed to obtain ASC in a timely manner. This factor could limit the applicability of an aggressive program based on obtaining ASC

and preemptive placement of patients on Contact Precautions in these settings. However, with the growing problem of antimicrobial resistance, and the recognized role of all healthcare settings for control of this problem, it is imperative that appropriate human and fiscal resources be invested to increase the feasibility of recommended control strategies in every setting.

Factors that influence selection of MDRO control measures.

Although some common principles apply, the preceding literature review indicates that no single approach to the control of MDROs is appropriate for all healthcare facilities. Many factors influence the choice of interventions to be applied within an institution, including:

- ***Type and significance of problem MDROs within the institution*.** Many facilities have an MRSA problem while others have ESBL-producing *K. pneumoniae*. Some facilities have no VRE colonization or disease; others have high rates of VRE colonization without disease; and still others have ongoing VRE outbreaks. The magnitude of the problem also varies**.** Healthcare facilities may have very low numbers of cases, e.g., with a newly introduced strain, or may have prolonged, extensive outbreaks or colonization in the population. Between these extremes, facilities may have low or high levels of endemic colonization and variable levels of infection.

- ***Population and healthcare-settings.*** The presence of high-risk patients (e.g., transplant, hematopoietic stem-cell transplant) and special-care units (e.g. adult, pediatric, and neonatal ICUs; burn; hemodialysis) will influence surveillance needs and could limit the areas of a facility targeted for MDRO control interventions. Although it appears that MDRO transmission seldom occurs in ambulatory and outpatient settings, some patient populations (e.g., hemodialysis, cystic fibrosis) and patients receiving chemotherapeutic agents are at risk for colonization and infection with MDROs. Furthermore, the emergence of VRSA within the outpatient setting (22, 23, 25) demonstrates that even these settings need to make MDRO prevention a priority.

Differences of opinion on the optimal strategy to control MDROs. Published guidance on the control of MDROs reflects areas of ongoing debate on optimal control strategies. A key issue is the use of ASC in control efforts and preemptive use of Contact Precautions pending negative surveillance culture results (107, 321, 322). The various guidelines currently available exhibit a spectrum of approaches, which their authors deem to be evidence-based. One guideline for control of MRSA and VRE, the Society for Healthcare Epidemiology of America (SHEA) guideline from 2003 (107), emphasizes routine use of ASC and Contact Precautions. That position paper does not address control of MDR-GNBs. The salient features of SHEA recommendations for MRSA and VRE control and the recommendations in this guideline for control of MDROs, including MRSA and VRE, have been compared (323); recommended interventions are similar. Other guidelines for VRE and MRSA, e.g., those proffered by the Michigan Society for Infection Control ([This link is no longer active www.msiconline.org/resource_sections/aro_guidelines.]), emphasize consistent practice of Standard Precautions and tailoring the use of ASC and Contact Precautions to local conditions, the specific MDROs that are prevalent and being transmitted, and the presence of risk factors for transmission. A variety of approaches have reduced MDRO rates (3, 164, 165, 209, 214, 240, 269, 324). Therefore, selection of interventions for controlling MDRO transmission should be based on assessments of the local problem, the prevalence of various MDRO and feasibility. Individual facilities should seek appropriate guidance and adopt effective measures that fit their circumstances and needs. Most studies have been in acute care settings; for non-acute care settings (e.g., LCTF, small rural hospitals), the optimal approach is not well defined.

Two-tiered approach for control of MDROs. Reports describing successful control of MDRO transmission in healthcare facilities have included seven categories of interventions (Table 3). As a rule, these reports indicate that facilities confronted with an MDRO problem selected a combination of control measures, implemented them, and reassessed their impact. In some cases, new measures were added serially to further enhance control efforts. This evidence indicates that the control of MDROs is a dynamic process that requires a systematic approach tailored to the problem and healthcare setting. The nature of this evidence gave rise to the two-tiered approach to MDRO control

recommended in this guideline. This approach provides the flexibility needed to prevent and control MDRO transmission in every kind of facility addressed by this guideline. Detailed recommendations for MDRO control in all healthcare settings follow and are summarized in Table 3 (Tier 1). Table 3, which applies to all healthcare settings, contains two tiers of activities. In the first tier are the baseline level of MDRO control activities designed to ensure recognition of MDROs as a problem, involvement of healthcare administrators, and provision of safeguards for managing unidentified carriers of MDROs.

With the emergence of an MDRO problem that cannot be controlled with the basic set of infection control measures, additional control measures should be selected from the second tier of interventions presented in Table 3 (Tier 2). Decisions to intensify MDRO control activity arise from surveillance observations and assessments of the risk to patients in various settings.

Circumstances that may trigger these decisions include:

- Identification of an MDRO from even one patient in a facility or special unit with a highly vulnerable patient population (e.g., an ICU, NICU, burn unit) that had previously not encountered that MDRO.
- Failure to decrease the prevalence or incidence of a specific MDRO (e.g., incidence of resistant clinical isolates) despite infection control efforts to stop its transmission. (Statistical process control charts or other validated methods that account for normal variation can be used to track rates of targeted MDROs) (205, 325, 326).

The combination of new or increased frequency of MDRO isolates and patients at risk necessitates escalation of efforts to achieve or re-establish control, i.e., to reduce rates of transmission to the lowest possible level. Intensification of MDRO control activities should begin with an assessment of the problem and evaluation of the effectiveness of measures in current use. Once the problem is defined, appropriate additional control measures should be selected from the second tier of Table 3. A knowledgeable infection prevention and control professional or healthcare epidemiologist should make this determination. This approach requires support from the governing body and medical staff of the facility. Once interventions are implemented, ongoing surveillance should be used to determine whether

selected control measures are effective and if additional measures or consultation are indicated. The result of this process should be to decrease MDRO rates to minimum levels.

Healthcare facilities must not accept ongoing MDRO outbreaks or high endemic rates as the status quo. With selection of infection control measures appropriate to their situation, all facilities *can achieve* the desired goal and reduce the MDRO burden substantially.

V. Prevention of Transmission of Multidrug Resistant Organisms

The CDC/HICPAC system for categorizing recommendations is as follows:

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 epidemiologic studies or a theoretical rationale.

No recommendation Unresolved issue. Practices for which insufficient evidence or no consensus regarding efficacy exists.

V.A. General recommendations for all healthcare settings independent of the prevalence of multidrug resistant organism (MDRO) infections or the population served. (See Table 3, Tier 1.)

V.A.1. Administrative measures

V.A.1.a. Make MDRO prevention and control an organizational patient safety priority. (3, 146, 151, 154, 182, 185, 194, 205, 208, 210, 242, 327, 328) *Category IB*

V.A.1.b. Provide administrative support, and both fiscal and human resources, to prevent and control MDRO transmission within the healthcare organization (3, 9, 146, 152, 182-184, 208, 328, 329) *Category IB*

V.A.1.c. In healthcare facilities without expertise for analyzing epidemiologic data, recognizing MDRO problems, or devising effective control strategies (e.g., small or rural hospitals, rehabilitation centers, long-term care facilities [LTCFs], freestanding ambulatory centers), identify experts who can provide consultation as needed. (151, 188) *Category II*

V.A.1.d. Implement systems to communicate information about reportable MDROs [e.g., VRSA, VISA, MRSA, Penicillin resistant S. pneumoniae (PRSP)] to administrative personnel and as required by state and local health authorities ([This link is no longer active: www.cdc.gov/epo/dphsi/nndsshis.htm. Information may be available on National Notifiable Diseases Surveillance System (NNDSS) (https://wwwn.cdc.gov/nndss/) accessed May 4, 2016]).Refer to websites for updated requirements of local and state health departments. *Category II/IC*

V.A.1.e. Implement a multidisciplinary process to monitor and improve healthcare personnel (HCP) adherence to recommended practices for Standard and Contact Precautions (3, 105, 182, 184, 189, 242, 273, 312, 330). *Category IB*

V.A.1.f. Implement systems to designate patients known to be colonized or infected with a targeted MDRO and to notify receiving healthcare facilities and personnel prior to transfer of such patients within or between facilities. (87, 151) *Category IB*

V.A.1.g. Support participation of the facility or healthcare system in local, regional, and national coalitions to combat emerging or growing MDRO problems. (41, 146, 151, 167, 188, 206, 207, 211, 331). *Category IB*

V.A.1.h. Provide updated feedback at least annually to healthcare providers and administrators on facility and patient-care-unit trends in MDRO infections. Include information on changes in prevalence or incidence of infection, results of assessments for system failures, and action plans to improve adherence to and effectiveness of recommended infection control practices to prevent MDRO transmission. (152, 154, 159, 184, 204, 205, 242, 312, 332) *Category IB*

V.A.2. Education and training of healthcare personnel

V.A.2.a. Provide education and training on risks and prevention of MDRO transmission during orientation and periodic educational updates for healthcare personnel; include information on organizational experience

with MDROs and prevention strategies. (38, 152, 154, 173, 176, 189, 190, 203, 204, 217, 242, 330, 333, 334) *Category IB*

⚠ Edit [February 2017]: An § indicates text that was edited for clarity. The edit does not constitute change to the intent of the recommendations.

V.A.3. Judicious use of antimicrobial agents § (i.e., systems to promote optimal treatment of infections and appropriate antimicrobial use).

V.A.3.a. **In hospitals and LTCFs**, ensure that a multidisciplinary process is in place to review antimicrobial utilization, local susceptibility patterns (antibiograms), and antimicrobial agents included in the formulary to foster appropriate antimicrobial use. (209, 212, 214, 215, 217, 242, 254, 334-339) *Category IB*

V.A.3.b. Implement systems (e.g., computerized physician order entry, comment in microbiology susceptibility report, notification from a clinical pharmacist or unit director) to prompt clinicians to use the appropriate antimicrobial agent and regimen for the given clinical situation. (156, 157, 161, 166, 174, 175, 212, 214, 218, 254, 334, 335, 337, 340-346) *Category IB*

V.A.3.b.i. Provide clinicians with antimicrobial susceptibility reports and analysis of current trends, updated at least annually, to guide antimicrobial prescribing practices. (342, 347) *Category IB*

V.A.3.b.ii. In settings that administer antimicrobial agents but have limited electronic communication system infrastructures to implement physician prompts (e.g., LTCFs, home care and infusion companies), implement a process for appropriate review of prescribed antimicrobials. Prepare and distribute reports to prescribers that summarize findings and provide suggestions for improving antimicrobial use. (342, 348, 349) *Category II*

V.A.4. Surveillance

V.A.4.a. In microbiology laboratories, use standardized laboratory methods and follow published guidance for determining antimicrobial susceptibility of targeted (e.g., MRSA, VRE, MDR-ESBLs) and emerging (e.g., VRSA,

MDR-*Acinetobacter baumannii*) MDROs. (8, 154, 177, 190, 193, 209, 254, 347, 350-353) *Category IB*

V.A.4.b. In all healthcare organizations, establish systems to ensure that clinical microbiology laboratories (in-house and out-sourced) promptly notify infection control staff or a medical director/ designee when a novel resistance pattern for that facility is detected. (9, 22, 154, 162, 169) *Category IB*

V.A.4.c. **In hospitals and LTCFs**, develop and implement laboratory protocols for storing isolates of selected MDROs for molecular typing when needed to confirm transmission or delineate the epidemiology of the MDRO within the healthcare setting. (7, 8, 38, 140, 153, 154, 187, 190, 208, 217, 354, 355) *Category IB*

V.A.4.d. Prepare facility-specific antimicrobial susceptibility reports as recommended by the Clinical and Laboratory Standards Institute (CLSI) ([This link is no longer active: www.phppo.cdc.gov/dls/master/default.aspx.]); monitor these reports for evidence of changing resistance patterns that may indicate the emergence or transmission of MDROs. (347, 351, 356, 357) *Category IB*/IC

V.A.4.d.i. In **hospitals and LTCFs with special-care units** (e.g., ventilator-dependent, ICU, or oncology units), develop and monitor unit-specific antimicrobial susceptibility reports. (358-361) *Category IB*

V.A.4.d.ii. Establish a frequency for preparing summary reports based on volume of clinical isolates, with updates at least annually. (347, 362) *Category II/IC*

V.A.4.d.iii. In healthcare organizations that outsource microbiology laboratory services (e.g., ambulatory care, home care, LTCFs, smaller acute care hospitals), specify by contract that the laboratory provide either facility-specific susceptibility data or local or regional aggregate susceptibility data in order to identify prevalent MDROs and trends in the geographic area served. (363) *Category II*

V.A.4.e. Monitor trends in the incidence of target MDROs in the facility over time using appropriate statistical methods to determine whether MDRO rates are decreasing and whether additional interventions are needed. (152, 154, 183, 193, 205, 209, 217, 242, 300, 325, 326, 364, 365) *Category IA*

V.A.4.e.i. Specify isolate origin (i.e., location and clinical service) in MDRO monitoring protocols in hospitals and other large multi-unit facilities with high-risk patients. (8, 38, 152-154, 217, 358, 361) *Category IB*

V.A.4.e.ii. Establish a baseline (e.g., incidence) for targeted MDRO isolates by reviewing results of clinical cultures; if more timely or localized information is needed, perform baseline point prevalence studies of colonization in high-risk units. When possible, distinguish colonization from infection in analysis of these data. (152, 153, 183, 184, 189, 190, 193, 205, 242, 365) *Category IB*

V.A.5. Infection control precautions to prevent transmission of MDROs

⚠ **Edit [February 2017]:** An * indicates recommendations that were renumbered for clarity. The renumbering does not constitute change to the intent of the recommendations.

V.A.5.a. Follow Standard Precautions during all patient encounters in all settings in which healthcare is delivered. (119, 164, 255, 315, 316) *Category IB*

V.A.5.b. Use masks according to Standard Precautions when performing splash-generating procedures (e.g., wound irrigation, 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). Masks are not otherwise recommended for prevention of MDRO transmission from patients to healthcare personnel during routine care (e.g., upon room entry). (8, 22, 151, 152, 154, 189, 190, 193, 208, 240, 366) *Category IB*

V.A.5.c. Use of Contact Precautions

V.A.5.c.i. **In acute-care hospitals**, implement Contact Precautions routinely for all patients infected with target MDROs and for patients that have been previously identified as being colonized with target MDROs (e.g., patients transferred from other units or facilities who are known to be colonized). (11, 38, 68, 114, 151, 183, 188, 204, 217, 242, 304) *Category IB*

V.A.5.c.ii. **In LTCFs**,

1. * Consider the individual patient's clinical situation and prevalence or incidence of MDRO in the facility when deciding whether to implement or modify Contact Precautions in addition to Standard Precautions for a patient infected or colonized with a target MDRO. *Category II*
2. * For relatively healthy residents (e.g., mainly independent) follow Standard Precautions, making sure that gloves and gowns are used for contact with uncontrolled secretions, pressure ulcers, draining wounds, stool incontinence, and ostomy tubes/bags. (78-80, 85, 151, 367, 368) *Category II*
3. * For ill residents (e.g., those totally dependent upon healthcare personnel for healthcare and activities of daily living, ventilator-dependent) and for those residents whose infected secretions or drainage cannot be contained, use Contact Precautions in addition to Standard Precautions. (316, 369, 370) *Category II*
4. * For MDRO colonized or infected patients without draining wounds, diarrhea, or uncontrolled secretions, establish ranges of permitted ambulation, socialization, and use of common areas based on their risk to other patients and on the ability of the colonized or infected patients to observe proper hand hygiene and other recommended precautions to contain secretions and excretions. (151, 163, 371) *Category II*

V.A.5.d. **In ambulatory settings**, use Standard Precautions for patients known to be infected or colonized with target MDROs, making sure that gloves and

gowns are used for contact with uncontrolled secretions, pressure ulcers, draining wounds, stool incontinence, and ostomy tubes and bags. *Category II*

V.A.5.e. **In home care settings**

1. * Follow Standard Precautions making sure to use gowns and gloves for contact with uncontrolled secretions, pressure ulcers, draining wounds, stool incontinence, and ostomy tubes and bags. *Category II*
2. * Limit the amount of reusable patient-care equipment that is brought into the home of patients infected or colonized with MDROs. When possible, leave patient-care equipment in the home until the patient is discharged from home care services. *Category II*
3. * If noncritical patient-care equipment (e.g., stethoscopes) cannot remain in the home, clean and disinfect items before removing them from the home, using a low to intermediate level disinfectant, or place reusable items in a plastic bag for transport to another site for subsequent cleaning and disinfection. *Category II*

V.A.5.f. * **In ambulatory or home care settings**, no recommendation is made for routine use of gloves, gowns, or both to prevent MDRO transmission in ambulatory or home care settings. *Unresolved issue*

V.A.5.g. * **In hemodialysis units,** follow the "Recommendations to Prevent Transmission of Infections in Chronic Hemodialysis Patients"(372) ([This link is no longer active: www.cms.hhs.gov/home/regsguidance.asp]).*Category IC*

V.A.5.h. * **Discontinuation of Contact Precautions**. No recommendation can be made regarding when to discontinue Contact Precautions. *Unresolved issue* (See Background for discussion of options.)

V.A.5.i. * **Patient placement in hospitals and LTCFs**

V.A.5.i.1. * When single-patient rooms are available, assign priority for these rooms to patients with known or suspected MDRO colonization or infection. Give highest priority to those patients who have conditions that may facilitate transmission,

e.g., uncontained secretions or excretions. (8, 38, 110, 151, 188, 208, 240, 304) *Category IB*

V.A.5.i.2. * When single-patient rooms are not available, cohort patients with the same MDRO in the same room or patient-care area. (8, 38, 92, 151-153, 162, 183, 184, 188, 217, 242, 304) *Category IB*

V.A.5.i.3. * When cohorting patients with the same MDRO is not possible, place MDRO patients in rooms with patients who are at low risk for acquisition of MDROs and associated adverse outcomes from infection and are likely to have short lengths of stay. *Category II*

V.A.6. Environmental measures

V.A.6.a. Clean and disinfect surfaces and equipment that may be contaminated with pathogens, including those that are in close proximity to the patient (e.g., bed rails, over bed tables) and frequently-touched surfaces in the patient care environment (e.g., door knobs, surfaces in and surrounding toilets in patients' rooms) on a more frequent schedule compared to that for minimal touch surfaces (e.g., horizontal surfaces in waiting rooms). (111, 297, 373) *Category IB*

V.A.6.b. Dedicate noncritical medical items to use on individual patients known to be infected or colonized with MDROs. (38, 217, 323, 374, 375) *Category IB*

V.A.6.c. Prioritize room cleaning of patients on Contact Precautions. Focus on cleaning and disinfecting frequently touched surfaces (e.g., bedrails, bedside commodes, bathroom fixtures in the patient's room, doorknobs) and equipment in the immediate vicinity of the patient. (109, 110, 114-117, 297, 301, 373, 376, 377) *Category IB*

V.B. Intensified interventions to prevent MDRO transmission (See Table 3, Tier 2.)

The interventions presented below have been utilized in various combinations to reduce transmission of MDROs in healthcare facilities. Neither the effectiveness of individual components nor that of specific combinations of control measures has been assessed in controlled trials. Nevertheless, various combinations of control elements selected under

the guidance of knowledgeable content experts have repeatedly reduced MDRO transmission rates in a variety of healthcare settings.

V.B.1. Indications and approach

V.B.1.a. Indications for intensified MDRO control efforts (VII.B.1.a.i and VII.B.1.a.ii) should result in selection and implementation of one or more of the interventions described in VII.B.2 to VII.B.8 below. Individualize the selection of control measures according to local considerations (8, 11, 38, 68, 114, 152-154, 183-185, 189, 190, 193, 194, 209, 217, 242, 312, 364, 365). *Category IB*

V.B.1.a.i. When incidence or prevalence of MDROs are not decreasing despite implementation of and correct adherence to the routine control measures described above, intensify MDRO control efforts by adopting one or more of the interventions described below. (92, 152, 183, 184, 193, 365) *Category IB*

V.B.1.a.ii. When the *first* case or outbreak of an epidemiologically important MDRO (e.g., VRE, MRSA, VISA, VRSA, MDR-GNB) is identified within a healthcare facility or unit. (22, 23, 25, 68, 170, 172, 184, 240, 242, 378) *Category IB*

V.B.1.b. Continue to monitor the incidence of target MDRO infection and colonization after additional interventions are implemented. If rates do not decrease, implement more interventions as needed to reduce MDRO transmission. (11, 38, 68, 92, 152, 175, 184, 365) *Category IB*

V.B.2. Administrative measures

V.B.2.a. Identify persons with experience in infection control and the epidemiology of MDRO, either in house or through outside consultation, for assessment of the local MDRO problem and for the design, implementation, and evaluation of appropriate control measures (3, 68, 146, 151-154, 167, 184, 190, 193, 242, 328, 377). *Category IB*

V.B.2.b. Provide necessary leadership, funding, and day-to-day oversight to implement interventions selected. Involve the governing body and leadership of the healthcare facility or system that have organizational responsibility for this and other infection control efforts. (8, 38, 152, 154, 184, 189, 190, 208) *Category IB*

V.B.2.c. Evaluate healthcare system factors for their role in creating or perpetuating transmission of MDROs, including: staffing levels, education and training, availability of consumable and durable resources, communication processes, policies and procedures, and adherence to recommended infection control measures (e.g., hand hygiene and Standard or Contact Precautions). Develop, implement, and monitor action plans to correct system failures. (3, 8, 38, 152, 154, 172, 173, 175, 188, 196, 198, 199, 208, 217, 280, 323, 379, 380) *Category IB*

V.B.2.d. During the process, update healthcare providers and administrators on the progress and effectiveness of the intensified interventions. Include information on changes in prevalence, rates of infection and colonization; results of assessments and corrective actions for system failures; degrees of adherence to recommended practices; and action plans to improve adherence to recommended infection control practices to prevent MDRO transmission. (152, 154, 159, 184, 204, 205, 312, 332, 381) *Category IB*

V.B.3. Educational interventions

Intensify the frequency of MDRO educational programs for healthcare personnel, especially those who work in areas in which MDRO rates are not decreasing. Provide individual or unit-specific feedback when available. (3, 38, 152, 154, 159, 170, 182, 183, 189, 190, 193, 194, 204, 205, 209, 215, 218, 312) *Category IB*

V.B.4. Judicious use of antimicrobial agents

Review the role of antimicrobial use in perpetuating the MDRO problem targeted for intensified intervention. Control and improve antimicrobial use as indicated. Antimicrobial agents that may be targeted include vancomycin, third-generation cephalosporins, and anti-anaerobic agents for VRE (217); third-generation cephalosporins for ESBLs (212, 214, 215); and quinolones and carbapenems (80, 156, 166, 174, 175, 209, 218, 242, 254, 329, 334, 335, 337, 341). *Category IB*

V.B.5. Surveillance

V.B.5.a. Calculate and analyze prevalence and incidence rates of targeted MDRO infection and colonization in populations at risk; when possible, distinguish colonization from infection (152, 153, 183, 184, 189, 190, 193, 205, 215, 242, 365). *Category IB*

V.B.5.a.i. Include only one isolate per patient, not multiple isolates from the same patient, when calculating rates (347, 382). *Category II*

V.B.5.a.ii. Increase the frequency of compiling and monitoring antimicrobial susceptibility summary reports for a targeted MDRO as indicated by an increase in incidence of infection or colonization with that MDRO. *Category II*

V.B.5.b. Develop and implement protocols to obtain active surveillance cultures (ASC) for targeted MDROs from patients in populations at risk (e.g., patients in intensive care, burn, bone marrow/stem cell transplant, and oncology units; patients transferred from facilities known to have high MDRO prevalence rates; roommates of colonized or infected persons; and patients known to have been previously infected or colonized with an MDRO). (8, 38, 68, 114, 151-154, 167, 168, 183, 184, 187-190, 192, 193, 217, 242) *Category IB*

V.B.5.b.i. Obtain ASC from areas of skin breakdown and draining wounds. In addition, include the following sites according to target MDROs:

V.B.5.b.i.1. For MRSA: Sampling the anterior nares is usually sufficient; throat, endotracheal tube aspirate, percutaneous gastrostomy sites, and perirectal or perineal cultures may be added to increase the yield. Swabs from several sites may be placed in the same selective broth tube prior to transport. (117, 383, 384) *Category IB*

V.B.5.b.i.2. For VRE: Stool, rectal, or perirectal samples should be collected. (154, 193, 217, 242) *Category IB*

V.B.5.b.i.3. For MDR-GNB: Endotracheal tube aspirates or sputum should be cultured if a respiratory tract reservoir is suspected, (e.g., Acinetobacter spp., Burkholderia spp.). (385, 386) *Category IB*.

V.B.5.b.ii. Obtain surveillance cultures for the target MDRO from patients at the time of admission to high-risk areas, e.g.,

ICUs, and at periodic intervals as needed to assess MDRO transmission. (8, 151, 154, 159, 184, 208, 215, 242, 387) *Category IB*

V.B.5.c. Conduct culture surveys to assess the efficacy of the enhanced MDRO control interventions.

V.B.5.c.i. Conduct serial (e.g., weekly, until transmission has ceased and then decreasing frequency) unit-specific point prevalence culture surveys of the target MDRO to determine if transmission has decreased or ceased. (107, 167, 175, 184, 188, 218, 339) *Category IB*

V.B.5.c.ii. Repeat point-prevalence culture surveys at routine intervals or at time of patient discharge or transfer until transmission has ceased. (8, 152-154, 168, 178, 190, 215, 218, 242, 388) *Category IB*

V.B.5.c.iii. If indicated by assessment of the MDRO problem, collect cultures to assess the colonization status of roommates and other patients with substantial exposure to patients with known MDRO infection or colonization. (25, 68, 167, 193) *Category IB*

V.B.5.d. Obtain cultures of healthcare personnel for target MDRO when there is epidemiologic evidence implicating the healthcare staff member as a source of ongoing transmission. (153, 365) *Category IB*

V.B.6. Enhanced infection control precautions

⚠ **Edit [February 2017]:** An * indicates recommendations that were renumbered for clarity. The renumbering does not constitute change to the intent of the recommendations.

V.B.6.a. * Use of Contact Precautions

V.B.6.a.i. Implement Contact Precautions routinely for all patients colonized or infected with a target MDRO. (8, 11, 38, 68, 114, 151, 154, 183, 188, 189, 217, 242, 304) *Category IA*

V.B.6.a.ii. Because environmental surfaces and medical equipment, especially those in close proximity to the patient, may be contaminated, don gowns and gloves before or upon entry to

the patient's room or cubicle. (38, 68, 154, 187, 189, 242) *Category IB*

V.B.6.a.iii. **In LTCFs**, modify Contact Precautions to allow MDRO colonized/infected patients whose site of colonization or infection can be appropriately contained and who can observe good hand hygiene practices to enter common areas and participate in group activities. (78, 86, 151, 367) *Category IB*

V.B.6.b. When ASC are obtained as part of an intensified MDRO control program, implement Contact Precautions until the surveillance culture is reported negative for the target MDRO. (8, 30, 153, 389, 390) *Category IB*

V.B.6.c. No recommendation is made regarding universal use of gloves, gowns, or both in high-risk units in acute-care hospitals. (153, 273, 312, 320, 391) *Unresolved issue*

V.B.7. Implement policies for patient admission and placement as needed to prevent transmission of a problem MDRO. (183, 184, 189, 193, 242, 339, 392) *Category IB*

V.B.7.a.i. Place MDRO patients in single-patient rooms. (6, 151, 158, 160, 166, 170, 187, 208, 240, 282, 393-395) *Category IB*

V.B.7.a.ii. Cohort patients with the same MDRO in designated areas (e.g., rooms, bays, patient care areas. (8, 151, 152, 159, 161, 176, 181, 183, 184, 188, 208, 217, 242, 280, 339, 344) *Category IB*

V.B.7.a.iii. When transmission continues despite adherence to Standard and Contact Precautions and cohorting patients, assign dedicated nursing and ancillary service staff to the care of MDRO patients only. Some facilities may consider this option when intensified measures are first implemented. (184, 217, 242, 278) *Category IB*

V.B.7.a.iv. Stop new admissions to the unit of facility if transmission continues despite the implementation of the enhanced control measures described above. (Refer to state or local regulations that may apply upon closure of hospital units or services.) (9, 38, 146, 159, 161, 168, 175, 205, 279, 280, 332, 339, 396) *Category IB*

V.B.8. Enhanced environmental measures

V.B.8.a. Implement patient-dedicated or single-use disposable noncritical equipment (e.g., blood pressure cuff, stethoscope) and instruments and devices. (38, 104, 151, 156, 159, 163, 181, 217, 323, 329, 367, 389, 390, 394) *Category IB*

V.B.8.b. Intensify and reinforce training of environmental staff who work in areas targeted for intensified MDRO control and monitor adherence to environmental cleaning policies. Some facilities may choose to assign dedicated staff to targeted patient care areas to enhance consistency of proper environmental cleaning and disinfection services. (38, 154, 159, 165, 172, 173, 175, 178-181, 193, 205, 208, 217, 279, 301, 327, 339, 397) *Category IB*

V.B.8.c. Monitor (i.e., supervise and inspect) 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 HCP (e.g., bedrails, carts, bedside commodes, doorknobs, faucet handles). (8, 38, 109, 111, 154, 169, 180, 208, 217, 301, 333, 398) *Category IB*

V.B.8.d. Obtain environmental cultures (e.g., surfaces, shared medical equipment) when there is epidemiologic evidence that an environmental source is associated with ongoing transmission of the targeted MDRO. (399-402) *Category IB*

V.B.8.e. Vacate units for environmental assessment and intensive cleaning when previous efforts to eliminate environmental reservoirs have failed. (175, 205, 279, 339, 403) *Category II*

V.B.9. Decolonization

V.B.9.a. Consult with physicians with expertise in infectious diseases and/or healthcare epidemiology on a case-by-case basis regarding the appropriate use of decolonization therapy for patients or staff during limited periods of time, as a component of an intensified MRSA control program. (152, 168, 170, 172, 183, 194, 304) *Category II*

V.B.9.b. When decolonization for MRSA is used, perform susceptibility testing for the decolonizing agent against the target organism in the individual being treated or the MDRO strain that is epidemiologically implicated in

transmission. Monitor susceptibility to detect emergence of resistance to the decolonizing agent. Consult with a microbiologist for appropriate testing for mupirocin resistance, since standards have not been established. (289, 290, 304, 308) *Category IB*

V.B.9.b.i. Because mupirocin-resistant strains may emerge and because it is unusual to eradicate MRSA when multiple body sites are colonized, do not use topical mupirocin routinely for MRSA decolonization of patients as a component of MRSA control programs in any healthcare setting. (289, 404) *Category IB*

V.B.9.b.ii. Limit decolonization of HCP found to be colonized with MRSA to persons who have been epidemiologically linked as a likely source of ongoing transmission to patients. Consider reassignment of HCP if decolonization is not successful and ongoing transmission to patients persists. (120, 122, 168) *Category IB*

V.B.9.c. No recommendation can be made for decolonizing patients with VRE or MDR-GNB. Regimens and efficacy of decolonization protocols for VRE and MDR-GNB have not been established. (284, 286, 288, 307, 387, 405) *Unresolved issue*

Glossary - Multidrug-Resistant Organisms

Ambulatory care settings. Facilities that provide health care to patients who do not remain overnight (e.g., hospital-based outpatient clinics, nonhospital-based clinics and physician offices, urgent care centers, surgicenters, free-standing dialysis centers, public health clinics, imaging centers, ambulatory behavioral health and substance abuse clinics, physical therapy and rehabilitation centers, and dental practices.

Cohorting. In the context of this guideline, this term applies to 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 (cohorting patients). During outbreaks, healthcare personnel may be assigned to a cohort of patients to further limit opportunities for transmission (cohorting staff).

Contact Precautions. Contact Precautions are a set of practices used to prevent transmission of infectious agents that are spread by direct or indirect contact with the patient or the patient's environment. Contact Precautions also apply where the presence of excessive wound drainage, fecal incontinence, or other discharges from the body suggest an increased transmission risk. A single patient room is preferred for patients who require Contact Precautions. When a single patient room is not available, consultation with infection control is helpful to assess the various risks associated with other patient placement options (e.g., cohorting, keeping the patient with an existing roommate). In multi-patient rooms, ≥3 feet spatial separation of between beds is advised to reduce the opportunities for inadvertent sharing of items between the infected/colonized patient and other patients. Healthcare personnel caring for patients on Contact Precautions wear a gown and gloves for all interactions that may involve contact with the patient or potentially contaminated areas in the patient's environment. Donning of gown and gloves upon room entry, removal before exiting the patient room and performance of hand hygiene immediately upon exiting are done to contain pathogens.

Epidemiologically important pathogens. Infectious agents that have one or more of the following characteristics:

1. A propensity for transmission within healthcare facilities based on published reports and the occurrence of temporal or geographic clusters of ≥2 patients, (e.g., VRE, MRSA and MSSA, *Clostridium difficile*, norovirus, RSV, influenza, rotavirus, Enterobacter spp; Serratia spp., group A streptococcus). However, for group A streptococcus, most experts consider a single case of healthcare-associated disease a trigger for investigation and enhanced control measures because of the devastating outcomes associated with HAI group A streptococcus infections. For susceptible bacteria that are known to be associated with asymptomatic colonization, isolation from normally sterile body fluids in patients with significant clinical disease would be the trigger to consider the organism as epidemiologically important.
2. Antimicrobial resistance implications:
    - Resistance to first-line therapies (e.g., MRSA, VRE, VISA, VRSA, ESBL-producing organisms).
    - Unusual or usual agents with unusual patterns of resistance within a facility, (e.g., the first isolate of *Burkholderia cepacia* complex or Ralstonia spp. in non-CF patients or a quinolone-resistant strain of Pseudomonas in a facility.
    - Difficult to treat because of innate or acquired resistance to multiple classes of antimicrobial agents (e.g., Stenotrophomonas maltophilia, Acinetobacter spp.).
3. Associated with serious clinical disease, increased morbidity and mortality (e.g., MRSA and MSSA, group A streptococcus); or
4. A newly discovered or reemerging pathogen. The strategies described for MDROs may be applied for control of epidemiologically important organisms other than MDROs.

Hand hygiene. A general term that applies to any one of the following:

1. handwashing with plain (nonantimicrobial) soap and water);
2. antiseptic hand wash (soap containing antiseptic agents and water);
3. antiseptic hand rub (waterless antiseptic product, most often alcohol-based, rubbed on

all surfaces of hands); or

4. surgical hand antisepsis (antiseptic hand wash or antiseptic hand rub performed preoperatively by surgical personnel to eliminate transient hand flora and reduce resident hand flora).

Healthcare-associated infection (HAI). An infection that develops in a patient who is cared for in any setting where healthcare is delivered (e.g., acute care hospital, chronic care facility, ambulatory clinic, dialysis center, surgicenter, home) and is related to receiving health care (i.e., was not incubating or present at the time healthcare was provided). In ambulatory and home settings, HAI would apply to any infection that is associated with a medical or surgical intervention performed in those settings.

Healthcare epidemiologist. A person whose primary training is medical (M.D., D.O.) and/or masters or doctorate-level epidemiology who has received advanced training in healthcare epidemiology. Typically these professionals direct or provide consultation to an infection prevention and control program in a hospital, long term care facility (LTCF), or healthcare delivery system (also see infection prevention and control professional).

Healthcare personnel (HCP). All paid and unpaid persons who work in a healthcare setting, also known as healthcare workers (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 services that support the delivery of healthcare such as dietary, housekeeping, engineering, maintenance personnel).

Home care. A wide-range of medical, nursing, rehabilitation, hospice, and social services delivered to patients in their place of residence (e.g., private residence, senior living center, assisted living facility). Home health-care services include care provided by home health aides and skilled nurses, respiratory therapists, dieticians, physicians, chaplains, and volunteers; provision of durable medical equipment; home infusion therapy; and physical, speech, and occupational therapy.

Infection prevention and control professional (ICP). A person whose primary training is in either nursing, medical technology, microbiology, or epidemiology and who has acquired

specialized training in infection control. Responsibilities may include collection, analysis, and feedback of infection data and trends to healthcare providers; consultation on infection risk assessment, prevention and control strategies; performance of education and training activities; implementation of evidence-based infection control practices or those mandated by regulatory and licensing agencies; application of epidemiologic principles to improve patient outcomes; participation in planning renovation and construction projects (e.g., to ensure appropriate containment of construction dust); evaluation of new products or procedures on patient outcomes; oversight of employee health services related to infection prevention; implementation of preparedness plans; communication within the healthcare setting, with local and state health departments, and with the community at large concerning infection control issues; and participation in research.

Infection prevention and control program. A multidisciplinary program that includes a group of activities to ensure that recommended practices for the prevention of healthcare-associated infections are implemented and followed by healthcare personnel, making the healthcare setting safe from infection for patients and healthcare personnel. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) requires the following five components of an infection prevention and control program for accreditation:

1. *surveillance:* monitoring patients and healthcare personnel for acquisition of infection and/or colonization;
2. *investigation:* identification and analysis of infection problems or undesirable trends;
3. *prevention:* implementation of measures to prevent transmission of infectious agents and to reduce risks for device- and procedure-related infections;
4. *control:* evaluation and management of outbreaks; and
5. *reporting:* provision of information to external agencies as required by state and federal law and regulation ([This link is no longer active: www.jcaho.org.]). The infection prevention and control program staff has the ultimate authority to determine infection control policies for a healthcare organization with the approval of the organization's governing body.

Long-term care facilities (LTCFs). An array of residential and outpatient facilities designed to meet the bio-psychosocial needs of persons with sustained self-care deficits. These include skilled nursing facilities, chronic disease hospitals, nursing homes, foster and group homes,

institutions for the developmentally disabled, residential care facilities, assisted living facilities, retirement homes, adult day health care facilities, rehabilitation centers, and long-term psychiatric hospitals.

Mask. A term that applies collectively to items used to cover the nose and mouth and includes both procedure masks and surgical masks ([This link is no longer active: www.fda.gov/cdrh/ode/guidance/094.html#4.]).

Multidrug-resistant organisms (MDROs). In general, bacteria (excluding M. tuberculosis) that are resistant to one or more classes of antimicrobial agents and usually are resistant to all but one or two commercially available antimicrobial agents (e.g., MRSA, VRE, extended spectrum beta-lactamase [ESBL]-producing or intrinsically resistant gram-negative bacilli).

Nosocomial infection. Derived from two Greek words "nosos" (disease) and "komeion" (to take care of). Refers to any infection that develops during or as a result of an admission to an acute care facility (hospital) and was not incubating at the time of admission.

Standard Precautions. A group 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 agents, (e.g. wear gloves for handling, contain heavily soiled equipment, properly clean and disinfect or sterilize reusable equipment before use on another patient).

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Table 1. Categorization of Reports about Control of MDROs in Healthcare Settings, 1982-2005

MDRO	MDR-GNB	MRSA	VRE
No. of Studies Reviewed/category	30	35	39

Types of Healthcare Facilities from which Study or Report Arose

Facility Type	MDR-GNB	MRSA	VRE
No. (%) from academic facilities [α]	30 (100)	28 (80)	33 (85)
No. (%) from other hospitals	0	4 (11)	3 (8)
No. (%) from LTCFs	0	1 (3)	2 (5)
No. (%) from multiple facilities in a region	0	2 (6)	1 (2)

α Variably described as university hospitals, medical school affiliated hospitals, VA teaching hospitals, and, to a much lesser extent, community teaching hospitals

Unit of Study for MDRO Control Efforts

Unit of Study	MDR-GNB	MRSA	VRE
Special unit [β]	20	13	19
Hospital	10	19	17
LTCF	0	1	2
Region	0	2	1

β Includes intensive care units, burn units, dialysis units, hematology/oncology units, neonatal units, neonatal intensive care units, and, in a few instances, individual wards of a hospital

Nature of Study or Report on MDRO Control [χ]

Nature of Study	MDR-GNB	MRSA	VRE
Outbreak	22	19	28
Non-outbreak	8	16	11

χ Based on authors' description – if they called their experience an outbreak or not; authors vary in use of term so there is probable overlap between two categories

Total Period of Observation after Interventions Introduced

Time Period	MDR-GNB	MRSA	VRE
Less than 1 year	17	14	25
1-2 years	6	6	6
2-5 years	5	11	8
Greater than 5 years	2	4	

Numbers of Control Measures Employed in Outbreaks/Studies

Outbreak Control Measures	MDR-GNB	MRSA	VRE
Range	2-12	0-11	1-12
Median	7	7	8
Mode	8	7	9

Table 2. Number of Studies Using Control Measures for MDROs Employed in Studies Performed in Healthcare Settings, 1982-2005

Focus of MDRO Study	MDR-GNB (n=30) No. (%)	MRSA (n=35) No. (%)	VRE (n=39) No. (%)
Education of staff, patients or visitors	19 (63)	11 (31)	20 (53)
Emphasis on handwashing	16 (53)	21 (60)	9 (23)
Use of antiseptics for handwashing	8 (30)	12 (36)	16 (41)
Contact Precautions or glove use [α]	20 (67)	27 (77)	34 (87)
Private Rooms	4 (15)	10 (28)	10 (27)
Segregation of cases	4 (15)	3 (9)	5 (14)
Cohorting of Patients	11 (37)	12 (34)	14 (36)
Cohorting of Staff	2 (7)	6 (17)	9 (23)
Change in Antimicrobial Use	12 (41)	1 (3)	17 (44)
Surveillance cultures of patients	19 (63)	34 (97)	36 (92)
Surveillance cultures of staff	9 (31)	8 (23)	7 (19)
Environmental cultures	15 (50)	14 (42)	15 (38)
Extra cleaning & disinfection	11 (37)	7 (21)	20 (51)
Dedicated Equipment	5 (17)	0	12 (32)
Decolonization	3 (10)	25 (71)	4 (11)
Ward closure to new admission or to all patients	6 (21)	4 (12)	5 (14)
Other miscellaneous measures	6 (22) [β]	9 (27) [χ]	17 (44) [δ]

α Contact Precautions mentioned specifically, use of gloves with gowns or aprons mentioned, barrier precautions, strict isolation, all included under this heading

β includes signage, record flagging, unannounced inspections, selective decontamination, and peer compliance monitoring (1 to 4 studies employing any of these measures)

χ includes requirements for masks, signage, record tracking, alerts, early discharge, and preventive isolation of new admissions pending results of screening cultures (1 to 4 studies employing any of these measures)

δ includes computer flags, signage, requirement for mask, one-to-one nursing, changing type of thermometer used, and change in rounding sequence (1 to 7 studies employing any of these measures)

References for Tables 1 and 2

MDR-GNBs: (6, 8, 9, 11, 16, 38, 174, 175, 180, 209, 210, 213-215, 218, 334, 388, 406, 407)

MRSA: (68, 89, 152, 153, 165-173, 183, 188, 194, 204, 205, 208, 240, 269, 279, 280, 289, 304, 312, 327, 365, 392, 397, 408-412)

Table 3. Tier 1. General Recommendations for Routine Prevention and Control of MDROs in Healthcare Settings

Administrative Measures/Adherence Monitoring	MDRO Education	Judicious Antimicrobial Use	Surveillance	Infection Control Precautions to Prevent Transmission	Environmental Measures	Decolonization
Make MDRO prevention/control an organizational priority. Provide administrative support and both fiscal and human resources to prevent and control MDRO transmission. *(IB)* Identify experts who can provide consultation and expertise for analyzing epidemiologic data, recognizing MDRO problems, or devising effective control strategies, as needed. *(II)* **Implement systems to communicate information about reportable MDROs to administrative personnel and state/local health departments. (II)** Implement a multi-disciplinary process to monitor and improve HCP adherence to recommended practices for Standard and Contact Precautions.*(IB)* Implement systems to designate patients known to be colonized or infected with a targeted MDRO and to notify receiving healthcare facilities or personnel prior to transfer of such patients within or between facilities. *(IB)* Support participation in local, regional and/or national coalitions to combat emerging or growing MDRO problems.*(IB)* Provide updated feedback at least annually to healthcare providers and administrators on facility and patient- care unit MDRO infections. Include information on changes in prevalence and incidence, problem assessment and performance improvement plans. (*IB)*	Provide education and training on risks and prevention of MDRO transmission during orientation and periodic educational updates for HCP; include information on organizational experience with MDROs and prevention strategies. *(IB)*	**In hospitals and LTCFs**, ensure that a multi-disciplinary process is in place to review local susceptibility patterns (antibiograms], and antimicrobial agents included in the formulary, to foster appropriate antimicrobial use. *(IB)* Implement systems (e.g., CPOE, susceptibility report comment, pharmacy or unit director notification) to prompt clinicians to use the appropriate agent and regimen for the given clinical situation. *(IB)* Provide clinicians with antimicrobial susceptibility reports and analysis of current trends, updated at least annually, to guide antimicrobial prescribing practices. *(IB)* In settings with limited electronic communication system infrastructures to implement physician prompts, etc., at a minimum implement a process to review antibiotic use. Prepare and distribute reports to providers. *(II)*	Use standardized laboratory methods and follow published guidelines for determining antimicrobial susceptibilities of targeted and emerging MDROs. Establish systems to ensure that clinical micro labs (in-house and outsourced) promptly notify infection control or a medical director/designee when a novel resistance pattern for that facility is detected. *(IB)* In hospitals and LTCFs: • develop and implement laboratory protocols for storing isolates of selected MDROs for molecular typing when needed to confirm transmission or delineate epidemiology of MDRO in facility. (IB) • establish laboratory-based systems to detect and communicate evidence of MDROs in clinical isolates (IB) • prepare facility-specific atimicrobial susceptibility reports as recommended by CLSI; monitor reports for evidence of changing resistance that may indicate emergence or transmission of MDROs (IA/IC) • develop and monitor special-care unit-specific antimicrobial susceptibility reports (e.g., ventilator- dependent units, ICUs, oncology units). (IB) • monitor trends in incidence of target MDROs in the facility over time to determine if MDRO rates are decreasing or if additional interventions are needed. (IA)	Follow Standard Precautions in all healthcare settings. *(IB)* Use of Contact Precautions (CP): • In ***acute care settings:*** Implement CP for all patients known to be colonized/infected with target MDROs.*(IB)* • In ***LTCFs:*** *Consider the individual patient's clinical situation and facility resources in deciding whether to implement CP (II)* • In ***ambulatory and home care settings,*** *follow Standard Precautions (II)* • In ***hemodialysis units*****:** Follow dialysis specific guidelines *(IC)* No recommendation can be made regarding when to discontinue CP. (*Unresolved issue)* Masks are not recommended for routine use to prevent transmission of MDROs from patients to HCWs. Use masks according to Standard Precautions when performing splash-generating procedures, caring for patients with open tracheostomies with potential for projectile secretions, and when there is evidence for transmission from heavily colonized sources (e.g., burn wounds). Patient placement in ***hospitals and LTCFs*****:** • When single-patient rooms are available, assign priority for these rooms to patients with known or suspected MDRO colonization or infection. Give highest priority to those patients who have conditions that may facilitate transmission, e.g., uncontained secretions or excretions. When single-patient rooms are not available, cohort patients with the same MDRO in the same room or patient-care area. *(IB)* • When cohorting patients with the same MDRO is not possible, place MDRO patients in rooms with patients who are at low risk for acquisition of MDROs and associated adverse outcomes from infection and are likely to have short lengths of stay. (*II)*	Follow recommended cleaning, disinfection and sterilization guidelines for maintaining patient care areas and equipment. Dedicate non-critical medical items to use on individual patients known to be infected or colonized with an MDRO. Prioritize room cleaning of patients on Contact Precautions. Focus on cleaning and disinfecting frequently touched surfaces (e.g., bed rails, bedside commodes, bathroom fixtures in patient room, doorknobs) and equipment in immediate vicinity of patient.	Not recommended routinely

Institute one or more of the interventions described below when

1. incidence or prevalence of MDROs are not decreasing despite the use of routine control measures; or
2. the *first* case or outbreak of an epidemiologically important MDRO (e.g., VRE, MRSA, VISA, VRSA, MDR-GNB) is identified within a healthcare facility or unit (*IB)* Continue to monitor the incidence of target MDRO infection and colonization; if rates do not decrease, implement additional interventions as needed to reduce MDRO transmission.

Table 3. Tier 2. Recommendations for Intensified MDRO Control Efforts

Administrative Measures/Adherence Monitoring	MDRO Education	Judicious Antimicrobial Use	Surveillance	Infection Control Precautions to Prevent Transmission	Environmental Measures	Decolonization
Obtain expert consultation from persons with experience in infection control and the epidemiology of MDROs, either in-house or through outside consultation, for assessment of the local MDRO problem and guidance in the design, implementation and evaluation of appropriat4e control measures. *(IB)* Provide necessary leadership, funding and day-to-day oversight to implement interventions selected. *(IB)* Evaluate healthcare system factors for role in creating or perpetuating MDRO transmission, including staffing levels, education and training, availability of consumable and durable resources; communication processes, and adherence to infection control measures.*(IB)* Update healthcare providers and administrators on the progress and effectiveness of the intensified interventions. *(IB)*	Intensify the frequency of educational programs for healthcare personnel, especially for those who work in areas where MDRO rates are not decreasing. Provide individual or unit-specific feedback when available. *(IB)*	Review the role of antimicrobial use in perpetuating the MDRO problem targeted for intensified intervention. Control and improve antimicrobial use as indicated. Antimicrobial agents that may be targeted include vancomycin, third generation cephalosporins, anti- anaerobic agents for VRE; third generation cephalosporins for ESBLs; and quinolones and carbapenems. *(IB)*	Calculate and analyze incidence rates of target MDROs (single isolates/patient; location-, service-specific) *(IB)* Increase frequency of compiling, monitoring antimicrobial susceptibility summary reports *(II)* Implement laboratory protocols for storing isolates of selected MDROs for molecular typing; perform typing if needed *(IB)* Develop and implement protocols to obtain active surveillance cultures from patients in populations at risk. *(IB)* (See recommendations for appropriate body sites and culturing methods.) Conduct culture surveys to assess efficacy of intensified MDRO control interventions. Conduct serial (e.g., weekly) unit- specific point prevalence culture surveys of the target MDRO to determine if transmission has decreased or ceased.*(IB)* Repeat point-prevalence culture-surveys at routine intervals and at time of patient discharge or transfer until transmission has ceased. *(IB)* If indicated by assessment of the MDRO problem, collect cultures to assess the colonization status of roommates and other patients with substantial exposure to patients with known MDRO infection or colonization. *(IB)* Obtain cultures from HCP for target MDROs when there is epidemiologic evidence implicating the staff member as a source of ongoing transmission. *(IB)*	Use of Contact Precautions: Implement Contact Precautions (CP) routinely for all patients colonized or infected with a target MDRO. *(IA)* Don gowns and gloves *before or upon entry* to the patient's room or cubicle. *(IB)* In LTCFs, modify CP to allow MDRO-colonized/infected patients whose site of colonization or infection can be appropriately contained and who can observe good hand hygiene practices to enter common areas and participate in group activities When active surveillance cultures are obtained as part of an intensified MDRO control program, implement CP until the surveillance culture is reported negative for the target MDRO *(IB)* No recommendation is made for universal use of gloves and/or gowns. (*Unresolved issue)* Implement policies for patient admission and placement as needed to prevent transmission of the problem MDRO. *(IB)* When single-patient rooms are available, assign priority for these rooms to patients with known or suspected MDRO colonization or infection. Give highest priority to those patients who have conditions that may facilitate transmission, e.g., uncontained secretions or excretions. When single-patient rooms are not available, cohort patients with the same MDRO in the same room or patient-care area. *(IB)* When cohorting patients with the same MDRO is not possible, place MDRO patients in rooms with patients who are at low risk for acquisition of MDROs and associated adverse outcomes from infection and are likely to have short lengths of stay. (*II)* Stop new admissions to the unit or facility if transmission continues despite the implementation of the intensified control measures. *(IB)*	Implement patient.-dedicated use of non-critical equipment *(IB)* Intensify and reinforce training of environmental staff who work in areas targeted for intensified MDRO control. Some facilities may choose to assign dedicated staff to targeted patient care areas to enhance consistency of proper environmental cleaning and disinfection services *(IB)* 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 HCWs (e.g., bedrails, carts, bedside commodes, doorknobs, faucet handles) *(IB)*. Obtain environmental cultures (e.g., surfaces, shared equipment) only when epidemiologically implicated in transmission *(IB)* Vacate units for environmental assessment and intensive cleaning when previous efforts to control environmental transmission have failed *(II)*	Consult with experts on a case-by-case basis regarding the appropriate use of decolonization therapy for patients or staff during limited period of time as a component of an intensified MRSA control program *(II)* When decolonization for MRSA is used, perform susceptibility testing for the decolonizing agent against the target organism or the MDRO strain epidemiologically implicated in transmission. Monitor susceptibility to detect emergence of resistance to the decolonizing agent. Consult with microbiologists for appropriate testing for mupirocin resistance, since standards have not been established. Do not use topical mupirocin routinely for MRSA decolonization of patients as a component of MRSA control programs in any healthcare setting. *(IB)* Limit decolonization to HCP found to be colonized with MRSA who have been epidemiologically implicated in ongoing transmission of MRSA to patients. *(IB)* No recommendation can be made for decolonization of patients who carry VRE or MDR- GNB.