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Treatment and Prevention of Hospital Infections (D Vilar-Compte, Section Editor)

# Barrier Precautions in the Era of Multidrug Pathogens

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## Abstract

*Purpose of review* There is a continuing debate regarding contact precaution (CP) usage for endemic multidrug-resistant organisms (MDROs). In this review, we examine current recommendations for CP and highlight differences in CP use between endemic and non-endemic MDROs.

*Recent findings* The discontinuation of CP had no effect on the incidence of methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant *Enterococci*. The evidence regarding CP for extended-spectrum beta-lactamase producing Enterobacteriaceae is inconclusive, highlighting the need for more research to determine best infection control strategies. Carbapenem-resistant Enterobacteriaceae maintains a sporadic pattern in the USA, supporting current recommendations to use CP for colonized and infected patients. MDR *Acinetobacter baumannii* (MDR-AB) is extremely virulent and responsible for outbreaks in healthcare settings, emphasizing the need for CP use with MDR-AB infected patients. *Candida auris* (*C. auris*) is often misdiagnosed; it is resistant to UV light and quaternary ammonium low-level disinfection. Because little is known about the transmission of *C. auris*, significant caution and CP use are necessitated. There is little research on vancomycin-resistant *S. aureus* (VRSA) control strategies due to its rarity; thus, CP is strongly recommended.

*Summary* Contact precautions are frequently part of a bundled infection control approach that involves meticulous hand hygiene, patient decolonization, chlorhexidine gluconate bathing, and reducing the use of invasive devices. Healthcare facilities should continue to utilize CP for non-endemic MDROs and the presence of endemic MDROs; however, CP may not add benefit to the current infection prevention bundle approach.

## Introduction

Multidrug-resistant organisms (MDROs) are an emerging threat to patient safety in modern healthcare [1]. The incidence of multidrug-resistant organisms is increasing and outpacing the development of new antibiotic therapies. In the 1970s, contact precautions were employed for the prevention of MDROs in healthcare setting. Most hospitals continue to employ policies that uphold this tenet of infection prevention. We explore the use of contact precautions for MDROs, with a focus on endemic versus emerging pathogens of epidemiologic significance.

# Endemic multidrug-resistant organisms

Endemic pathogens are consistently present in a geographic area [2, 3]. What is endemic in one geographic area may be an outbreak in a different area, making the geographic aspect of the pathogen important. Though endemic pathogens often have the ability to cause patient harm, due to their common nature, their presence in the environment is expected. In the presence of endemic MDROs, there is increased clinical experience and a greater understanding of these pathogens compared to their non-endemic counterparts [4]. Infection prevention and control (IPC) teams must fastidiously attempt to control all non-endemic MDROs in their environments in order to prevent emerging MDROs from becoming endemic in their healthcare settings.

# Contact precautions: a closer look

To ensure optimal infection prevention, the Center for Disease Control and Prevention (CDC) recommends gowning and gloving (and eye protection when indicated), appropriate patient room assignments, transporting patients infrequently and safely, use of dedicated patient equipment, and ensuring proper room cleaning after a patient has been discharged from that room [5]. In this review, we refer to these strategies, coupled with correctly donning and doffing of Personal Protective Equipment (PPE) and the environmental control strategies highlighted below, as "high-quality CP" [6]. Breaches in CP may not adequately protect Healthcare Workers (HCWs) or patients from MDRO exposure.

To correctly don and doff PPE, HCW must follow specific, sequential steps. The first step of donning is performing hand hygiene. Healthcare workers may forget this step when they know they are going to don PPE. Other frequent errors when donning and doffing include improperly securing gown ties, applying/removing gown and gloves in wrong sequential order, and doffing after leaving the patient's room. Hospitals can incorporate one-step doffing to help alleviate some of these breaches. One-step doffing describes the process when the HCW removes the gown and gloves simultaneously, and disposes of the gown and gloves together, before exiting the patient's room. Studies show that one-step doffing is an easier procedure for HCW and results in fewer breaches [7]. Because many studies prove that errors occur most often in the doffing process, our definition of high-quality CP includes one-step doffing [8••, 9].

Environmental control, as part of high-quality CP, refers to the measures taken inside the patient room to decrease the risk of MDRO transmission. Up to 73% of patient rooms are colonized with MDROs; thus, IPC programs should encourage dedicated equipment such as stethoscopes, vital sign monitoring devices, and disposable patient care supplies for all patients on CP for MDROs [9]. Healthcare workers should be cognizant of their interaction with the patient environment and perform hand hygiene between dirty activities (such as wound care) and clean activities (such as central line care), even if they do not leave the patient's room in between such activities. In addition to using dedicated equipment, HCW and environmental service workers (EVS) must maintain meticulous attention to environmental cleaning during the use of CP. Environmental cleaning is a horizontal infection prevention measure that leads to a decrease in bioburden within the healthcare area and therefore limits the transmission of MDROs [10, 11]. Environmental service workers can enhance cleaning by adding certain disinfectants such as peracetic acid or hydrogen peroxide and/or the utilization of ultraviolet light treatment [6, 12] (Table 1).

## Endemic MRSA and VRE

Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *Enterococci* (VRE) are two of the most common MDROs found in USA acute care hospitals, long-term care hospitals, and rehabilitation institutions. MRSA emerged in the late 1960s with VRE following 20 years later in the mid-1980s. Both are endemic in most hospitals in the USA [13]. The CDC's 2019 report, *Antibiotic Resistance Threats in the United States*, estimates the number of infections in 2017 caused by MRSA and VRE to be 323,700 and 54,500 [14], with mortality estimates of 10,600 and 5400, respectively, though rates of hospital-acquired VRE have

**Table 1. Multidrug-resistant organisms and contact precautions**

| Organism: | Comment: |
|---|---|
| Endemic MRSA | The CDC recommends application of CP; however, recent publications have demonstrated that high compliance with horizontal infection prevention practices (hand hygiene, bare below the elbows, CHG skin decolonization, central line checklists) can prevent transmission |
| Endemic VRE | The CDC recommends application of CP; however, recent publications have demonstrated that high compliance with horizontal infection prevention practices (hand hygiene, bare below the elbows, CHG skin decolonization, central line checklists) can prevent transmission |
| ESBL | High-quality CP |
| CRE | High-quality CP; consider 1:1 staffing if possible for CRE-positive patients with an uncontrolled draining wound/site, an artificial airway with uncontained respiratory secretions, invasive medical devices, and/or if the patient is on oncology units we recommend one to one nursing care |
| MDR *Acinetobacter baumannii* | High-quality CP |
| *C. auris* | High-quality CP; consider 1:1 staffing if possible |
| VRSA and VSSA | High-quality CP; consider 1:1 staffing if possible |

decreased in the past decade (emerging threats ref) while rates of MRSA have stabilized [15].

Both the CDC and a large volume of literature support for the use of CP for the prevention of MRSA and VRE in acute care settings [16, 17]. However, many studies on MRSA and VRE transmission reduction employ bundled strategies including CP, monitoring hand hygiene compliance, reducing invasive devices, and decolonizing high-risk patients. This bundled approach provides little assurance to the individual impact of one specific intervention, making it difficult to discern the validity contact precautions have on reduction of HAIs [18].

Carey et al. reported no increase in the incidence of MRSA and VRE when switching from CP to standard precautions [19••]. Within intensive care settings, researchers did not find an association between universal CP and decrease in acquisition of MRSA and VRE [20, 21•]. Furthermore, meta-analysis conducted regarding the outcomes of discontinuation of CP showed no change in the rates of MRSA and VRE or even reduction in rates when focuses shift away from CP to horizontal interventions [22, 23]. Our institution discontinued the routine use of CP for endemic pathogens in 2013 (except for patient-specific conditions like uncontrolled secretions or a draining wound not contained by a dressing), and we have not seen an increase in the rates of either MRSA or VRE [24]. We instead focus on robust compliance of horizontal IPC measures, such as hand hygiene, chlorhexidine gluconate (CHG) skin decolonization, and environmental cleaning between patients.

Despite a growing body of literature supporting the de-escalation of CP in endemic settings for the ongoing control of MRSA and VRE, the practice remains controversial and is currently not recommended by the CDC. Some find the endorsement of CP for some MDROs and not others to be potentially confusing for bedside clinical staff members [25]. Others point out that the CDC stands firm on its recommendation for CP for all MDROs, regardless of endemic or epidemic situation [26]. Healthcare institutions should routinely review their policies on the use of CP for the prevention of transmission of MDROs and specify both the organisms and the patient-specific conditions in which contact precautions are expected [27]. We suggest that healthcare settings weigh the risks and benefits of de-escalating CP for endemic MRSA and VRE with an emphasis on high-quality horizontal infection prevention interventions based on local rates, resources, and needs [10, 28, 29].

## ESBL: a growing public health concern

Extended-spectrum beta-lactamase producing Enterobacteriaceae (ESBLs) are a common cause of healthcare-associated infections and are resistant to antibiotics like penicillins and cephalosporins. First reported in the 1980s, the most common types are *Escherichia coli* and *Klebsiella pneumoniae*. ESBLs caused nearly 200,000 infections in hospitalized patients in 2017, resulting in approximately 9100 deaths [30]. ESBL rates are increasing worldwide, with approximately 14% of healthy individuals colonized, though researchers estimate that only 2% of the population in the Americas is colonized [31].

The literature regarding the healthcare-associated incidence of ESBL is inconclusive, as is the literature discussing the most effective ways to prevent

transmission within the healthcare setting. McDaniel et al. performed a systematic literature review and reported increasing ESBL incidence rates. However, the incidence of community-onset ESBL increased at a higher rate than hospital-onset ESBL rates, leading to questions about where ESBL transmission is most likely to occur [31, 32]. They determined that healthcare providers have an incomplete understanding of the burden of ESBL and call for more research to best define risk reduction strategies. Tschudin-Sutter et al. were similarly inconclusive regarding whether CP is an effective way to prevent the transmission of ESBL in the healthcare setting [33•]. They also acknowledge that the transmission of plasmids, not strains, may also play a role in ESBL transmission. The inconclusive information about where and how transmission occurs, and whether CPs are useful to prevent transmission [10, 32, 34, 35], force healthcare settings to determine what is best for protection within their institutions. Tschudin-Sutter et al. recommend that settings opting against CP for ESBL regularly perform ESBL surveillance and, when feasible, molecular typing of ESBL to ensure that hospital-onset ESBL is not actively occurring [33].

Despite the inconclusive evidence, in settings with close contact and prolonged stays, high-quality CP may decrease transmission of ESBL. The CDC recommends CP for all patients with ESBL. However, CPs are costly, increase patient isolation, and may only provide limited protection against ESBL transmission due to transmission often occurring in the community setting. Nonetheless, until we know more about IPC strategies to best prevent the spread of ESBL, we believe that the benefits of CP for ESBL prevention do outweigh the potential patient harm that may occur from putting a patient on CP.

## Carbapenem-resistant pathogens: an evolving, global public health concern

Carbapenem-resistant gram-negative bacteria are emerging MDROs causing great concern among IPC programs worldwide [36]. The World Health Organization has declared that the development of antibiotics for these pathogens is at a critical level (making it the highest priority) [37]. Two carbapenem-resistant gram-negative bacteria discussed in this review are Enterobacteriaceae (CRE) and *Acinetobacter baumannii* (CRAB).

## CRE

Carbapenem-resistant Enterobacteriaceae are resistant to carbapenems and additional classes of antibiotics. Resistance occurs through various mechanisms including the production of carbapenemase and chromosomal mutations [14]. Naas and Nordmann reported the first discovery of carbapenemase in 1994 [38]. There were approximately 13,100 CRE infections and 1100 CRE related dates in 2017. CRE infections are most common in healthcare facilities, especially in patients with invasive devices [14, 38].

Contact precautions are effective in the control of transmission of CRE colonization and infection in acute care, long-term care, and rehabilitation facilities [39, 40]. Healthcare workers should maintain high-quality CP when transitioning patients between various levels of care, such as from long-term care

to acute care facilities [20]. Discontinuation of CP for patients colonized or infected with CRE varies widely among institutions and many have no criteria for discontinuation whatsoever [41]. Some institutions have successfully de-escalated CP for CRE carriers after patients had three consecutive negative cultures, each taken at least 3 days apart [42]. The invasive nature of testing for CRE and average length of stay in acute care hospitals often does not lend itself to such a cumbersome nine-day testing process. Therefore, many institutions opt to maintain CP for the duration of inpatient hospitalization for CRE colonized and infected persons. Tracking of CRE prevalence in regional areas helps to show if the pathogen is transitioning from a sporadic pattern to an epidemic or endemic pattern [14]. The current sporadic pattern of CRE in the USA, combined with the highly resistant nature of the organism(s) associated with CRE, supports the recommendation for maintaining contact precautions in colonized and infected patients in the settings of both acute and long-term care [26, 43•].

## MDR *Acinetobacter baumannii*

MDR *Acinetobacter baumannii* (MDR-AB) infections predominantly occur in hospitalized patients or patients with recent healthcare setting exposure. These infections have been responsible for many outbreaks in healthcare settings. Researchers believe that *Acinetobacter* was first isolated in the 1910s. *Acinetobacter baumannii* is the most common cause of *Acinetobacter* infections in humans, infecting approximately 8500 people in 2017 and causing 700 deaths [14].

MDR-AB most often causes ventilator-associated pneumonias (VAPs) or central line associated bloodstream infections (CLABSIs) [44]. MDR-AB causes IPC teams particular concern because of both its resistance to antibiotics and its ability to survive for extended periods on environmental surfaces. *Acinetobacter baumannii* can even survive in very dry conditions, like on dust or other particulates [45]. Because of its virulence, HCW must utilize high-quality CP in all aspects of patient care for MDR-AB-infected patients.

Reviews by both Tomczyk et al. and Terrawattanapong et al. demonstrate the need for more research regarding prevention of both MDR-AB and CRE. Both of these multidrug-resistant gram-negative bacteria are virulent, difficult to treat with existing antibiotics, and have been responsible for numerous outbreaks in healthcare settings [45, 46•]. For the prevention of the spread of MDROs of epidemiologic significance, the literature recommends that healthcare facilities implement additional aspects of IPC. Both antibiotic stewardship programs and environmental disinfection strategies to control the source of infection are aspects of an IPC program that can effectively control these particularly virulent MDROs [37, 45, 46•]. More research regarding novel IPC strategies would assist in more effectively controlling these organisms to ensure that they do not become endemic within healthcare facilities.

## *Candida auris*: an emerging infectious disease threat

*Candida auris* (*C. auris*) is a rare and multidrug-resistant fungal pathogen that is increasingly concerning to the healthcare community [14]. More

than 30 countries report *C. auris* as a cause of bloodstream and wound infections [14]. *Candida auris* is commonly misdiagnosed due to its similarity to other *Candida* strains [14]. Many healthcare facilities have difficulty identifying *C. auris* to the necessary species level of specificity using their routine testing methodologies which leads to additional specimen collection and necessitates the sending of isolates to state laboratories for confirmatory testing [12]. This additional laboratory work leads to delays correct diagnosis and treatment of *C. auris*.

Several attributes of *C. auris* limit the effectiveness of standard infection prevention precautions. *C. auris* creates biofilms, can exist on surfaces within the patient environment, and is resistant to two common forms of disinfection and bioburden reduction utilized in the healthcare setting: quaternary ammonium low-level disinfection and ultraviolet light [12]. Rapid spread of the organism throughout the healthcare environment is also a worrisome possibility. *C. auris* is transmitted by person-to-person contact, most often by HCWs, and patients' or family members' hands. Patients suspected or confirmed to have *C. auris* infection should therefore be isolated and cared for using high-quality CP [47]. Prevention of the spread of this organism is essential in the healthcare setting, leading to the need for meticulous hand hygiene practices. Since there are many unknown factors regarding the spread and treatment of *C. auris*, heightened awareness, early isolation, and maintaining strict, high-quality contact precautions are needed [48•].

## VRSA

Strains of *Staphylococcus aureus* developed resistance to penicillin in the 1950s and resistance to methicillins (MRSA) in the 1970s. These newly evolved resistances led healthcare providers to increasingly prescribe vancomycin to treat these resistant pathogens [49]. Laboratorians found that *S. aureus* developed intermittent resistance to vancomycin following its use as the primary antibiotic for serious MRSA infections in the 1990s, and researchers first found vancomycin-resistant *S. aureus* (VRSA) in 2002 [50]. Though VRSA remains rare, it poses great risks to infected patients, and IPC programs must ensure that their healthcare settings use proper precautions to prevent its spread.

Of the MDROs discussed herein, VRSA is the least common. It is so uncommon that, in addition to high-quality CP and other IPC measures, the CDC recommends that health departments and healthcare facilities conduct contact investigations for all VRSA patients to determine which contacts to test for VRSA-exposure [49]. HCW must comply with strict, high-quality CP when caring for any patient with VRSA. The CDC also recommends that healthcare facilities dedicate certain staff to caring for VRSA patients in order to minimize potential exposure and transmission [49]. Because there have been so few cases of VRSA-positive patients, there is little research on the topic of specific IPC strategies to prevent transmission. Thus, we recommend that healthcare facilities use the knowledge we have regarding other MDRO transmission to guide VRSA prevention strategies.

## Conclusion

We highlight the important nuance between the uses of CP for endemic vs. non-endemic MRDOs. Multidrug-resistant organisms are a significant and increasingly concerning matter of public health and safety. Many MDROs are uncommon and non-endemic. In non-endemic conditions or increasing rates, healthcare associated MDRO infections, the application of both CP, and an aggressive horizontal infection prevention strategy. For endemic MDROs, the incremental benefit of CP atop a robust horizontal infection program may be minimal [22, 23]. Potential negative consequences of CP include less HCW-patient time with isolated patients, delayed patient admissions and discharges, increased feelings of anxiety and depression, and decreased patient satisfaction [22, 51, 52]. Contact precautions also increase a patient's risk of adverse outcomes like hospital-acquired pressure ulcers and falls and are a financial burden to healthcare settings by increasing lengths of stay and costs of caring for the patient [13, 52, 53]. Most recently, Martin et al. found that when CPs for MRSA and VRE were discontinued at their institution, there was a 72% reduction in non-infectious adverse events [54••].

For non-endemic MDRO and for endemic pathogens in patients who have specific conditions (like uncontrolled secretions or draining wound not contained by a dressing) or who are hospitalized on units with particular risk factors (like burn units or bone marrow transplant units), the use of contact precautions may provide greater benefits than harms. Infection prevention and control teams should relentlessly strive to prevent the emergence of an endemic MDRO foothold in healthcare settings. The goal is to apply CP judiciously, with maximal bundle compliance, on the most vulnerable of patient populations harboring non-endemic MDRO pathogens.

## Data Availability

N/A

## Funding

N/A

## Compliance with Ethical Standards

**Conflict of Interest**
Rachel Pryor declares that she has no conflict of interest. Carli Viola-Luqa declares that she has no conflict of interest. Olivia Hess declares that she has no conflict of interest. Gonzalo Bearman declares that he has no conflict of interest.

**Code Availability**
N/A

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Martin et al. found that when contact precautions were discontinued, the rate of adverse events declined. This reinforces our argument that the risks of contact precautions for endemic MDROs outweigh the benefit they may add.


## Publisher's Note