# Chapter 13. Impact of Barrier Precautions in Reducing the Transmission of Serious Nosocomial Infections

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## Background

Many nosocomial infections are easily transferable from patient-to-patient, either via the hands of health care workers,[1,2] or through the contamination of inanimate objects, including clothing and equipment.[3,4] For some infections, the threat to other patients is considered serious enough that many institutions employ special barrier precautions, such as the use of gloves, gowns and disposable equipment for all patient contact, in caring for patients colonized or infected with these pathogens. Vancomycin-resistant enterococci (VRE)[5] and *Clostridium difficile*[6] represent 2 typical examples of nosocomial pathogens that may trigger such precautions.

Although adherence to barrier precautions to prevent the spread of particularly concerning nosocomial pathogens has obvious face validity, the utility of specific interventions and the optimal forms they should take remain unclear. This uncertainty may in part reflect the impact of particular aspects of the epidemiology of the targeted nosocomial pathogens – ie, the benefit of a given strategy may vary in different settings and with different organisms. Consequently, this chapter contrasts with the review of handwashing (Chapter 13), a practice for which the benefit was regarded as sufficiently established to warrant focusing on strategies for improving compliance. While compliance with barrier precautions is also an important topic and likely plays a significant role in the efficacy of such interventions, this chapter analyzes the literature evaluating the benefit of the barrier precautions themselves.

## Practice Description

Barrier precautions include any activity designed to prevent the spread of nosocomial pathogens from patient to patient. This chapter reviews the following 3 practices:

- *Use of gowns and gloves for all contact with patients colonized or infected with VRE and/or C. difficile:* Health care workers typically don gloves and gowns when entering the room of an infected or colonized patient, and remove them upon exiting (followed immediately by handwashing) to reduce the likelihood of clothing or equipment contamination that could transmit pathogens to other patients;
- *Use of dedicated or disposable examining equipment for patients colonized or infected with VRE and/or C. difficile*: Hospital equipment (ie, blood pressure cuffs, thermometers) remains in a patient's room and is not carried from room to room; and
- *Patient and/or staff cohorting for patients colonized or infected with VRE and/or C. difficile*: Patients colonized or infected with similar pathogens are admitted to specific floors of the hospital where designated health care workers care only for patients colonized or infected with these pathogens.

## Prevalence and Severity of the Target Safety Problem

Nosocomial infections, including *C. difficile*-associated diarrhea and VRE, significantly increase the morbidity and mortality of hospitalized patients.[5,6] Both infections are also associated with increased hospital costs. Recent evidence also suggests there may be a relationship between *C. difficile* and VRE, with *C. difficile* infection identified as a risk factor for VRE infection.[7] The increased incidence of both VRE and *C. difficile* can be attributed to spread from patient to patient.[5,6] Failure to recognize these dissemination patterns may result in an inability to contain outbreaks when they occur in the hospital.

*C. difficile* has been identified as the major, if not only, important cause of infectious diarrhea that develops in patients after hospitalization, occurring in up to 30% of adult hospitalized patients who developed diarrhea.[5] One study found an acquisition rate of 13% for patients hospitalized 1-2 weeks, which increased to 50% for patients hospitalized >4 weeks.[8] In addition, the incidence of *C. difficile* infection has increased in recent years, with one study reporting a 5-fold increase in clinical infection between 1993 and 1996.[9] *C. difficile* infection increases lengths of stay, often to as long as 18-30 days[10,11] and, when fulminant, can lead to exploratory and therapeutic surgical procedures.[12] Mortality attributable to *C. difficile*, while reported, occurs in fewer than 5% of patients.[13] The costs associated with *C. difficile* diarrhea, while not well described, may be as high as $10,000 per patient.[14]

VRE, first described in 1988, currently accounts for greater than 25% of all nosocomial enterococci.[6] Early national data suggested that infections with VRE were associated with mortality rates of over 36%, more than double that of patients with vancomycin-susceptible (VSE) infections.[15] While later studies called some of these results into question,[16,17] the most recent studies have again suggested that vancomycin-resistance carries an independent effect on mortality.[18] VRE infections are also associated with significantly higher hospital costs than those due to VSE.[18]

Although *C. difficile* and VRE are among the most common nosocomial pathogens that have significant effects on morbidity, mortality, and cost, there are a number of other nosocomial pathogens which could also be studied. These include pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA), extended-spectrum beta-lactamase (ESBL) producing *Enterobacteriaceae*, *Acinetobacter* species, and *Pseudomonas aeruginosa*. While these are all important nosocomial pathogens, *C. difficile* and VRE were chosen as examples because they are extremely common, and they represent both antibiotic-susceptible (*C. difficile*) and antibiotic-resistant (VRE) pathogens. Additionally, (unlike MRSA and *P. aeruginosa*) the epidemiology of both pathogens is complex, representing both person-to-person spread and association with prior antibiotic use, allowing for a more comprehensive discussion of the relative merits of both antimicrobial use interventions and barrier precaution interventions (see Chapter 15 for more discussion regarding other antimicrobial intervention practices) and their general application to other pathogens.

## Opportunities for Impact

As noted above, both VRE and *C. difficile* affect a large proportion of hospitalized patients. Improvements in barrier precaution interventions against these pathogens would have a tremendous impact. There are few data regarding the percentage of hospitals that employ any one of a number of barrier precautions (eg, gowns, gloves, disposable thermometers).[19] In addition, while standard practice is to apply barrier precautions for patients with nosocomial pathogens with demonstrated horizontal spread, compliance with precautions is frequently

poor,[20] often below 50%.[21] Purported reasons for this lack of compliance include lack of resources and busy staff workload.[20] Regardless, these results suggest that the opportunity for improvement in these practices is great.

**Study Designs**

A structured search of the PubMed database (including MEDLINE) and review of the bibliographies of relevant articles identified 19 studies that have examined the implementation of barrier precaution practices designed to impact the incidence of VRE and/or *C. difficile* infection (Table 13.1, 13.2, 13.3). All studies found on literature search were included in this review except for those reporting very small outbreaks (defined as fewer than 10 cases of *C. difficile* or VRE). Sixteen of the reviewed studies were before-after observational cohort studies (Level 3), in which baseline data regarding incidence of VRE or *C. difficile* were obtained during an observational period and compared to a second period after implementation of an intervention. Crude comparability data on the before and after groups (eg, total admissions, patient census) were provided in 2 reports[22,23] while only one study statistically compared the before and after groups to assess comparability.[24] Three reports[25-27] detailed unblinded comparative studies (Level 2) in which patients on different wards were assigned different interventions. Each of these studies assessed the comparability of the study groups on the basis of underlying demographic variables.

**Study Outcomes**

All of the studies reviewed reported changes in the incidence or prevalence of either VRE or *C. difficile* as a result of barrier precaution interventions (Level 1). For studies investigating *C. difficile*, all outcomes were reported in terms of clinical infections. For studies investigating VRE, outcomes were reported as VRE colonization and/or infection rates.

**Evidence for Effectiveness of the Practice**

As both VRE and *C. difficile* have clearly been shown to be transferable from patient-to-patient, interventions designed to improve barrier precautions yield significant reductions in the incidence of infection with these two pathogens. All studies that examined the effect of enhanced barrier precautions on *C. difficile* infection demonstrated benefit, suggesting that barrier precaution interventions are effective in controlling its emergence. Most studies employed a multifaceted approach including several different barrier precaution components. For example, one study combined use of vinyl gloves and ongoing educational interventions,[26] another included cohorting, culture screening, and daily room disinfection,[28] while another combined reinforcement of enteric precautions, replacement of electronic thermometers, and institution of closed paper towel dispensers.[29] Given the varied components of barrier precaution interventions instituted in different studies, it is difficult to determine the specific effect of any individual component.

The evidence of effectiveness of barrier precautions for VRE is somewhat less clear-cut. All but 4[27,30-32] of the studies examining the effect of barrier precautions on VRE demonstrated a benefit, but study design differences and particular epidemiologic trends may account for the inconsistent findings.

One of the 4 studies that noted no significant effect compared glove use to glove and gown use.[27] The second [30] noted that the emergence of VRE at the study institution was due to multiple genetically-unrelated strains, suggesting that person-to-person spread was less important at that site. It is thus not surprising that barrier precautions would have less of an

effect. In the third study,[32] routine rectal swab surveillance and contact precautions were instituted in response to a clinical outbreak of VRE and surveillance was continued for only 6 months. Since surveillance was not conducted prior to institution of precautions, it is impossible to say what the colonization prevalence had been prior to the intervention. Furthermore, as the authors point out, it may be that the outbreak would have been much worse had the precautions not been put in place. Finally, no determination of genetic relatedness (and hence spread) was made in this study. In the fourth study,[31] while there was a reduction in the isolation of VRE, there was not complete eradication. According to the authors, the most likely reason for this less-than-optimal response was poor compliance with contact precaution guidelines.

Thus, it appears that enhanced barrier precautions are generally effective in reducing the incidence of VRE but that various aspects of both the epidemiology of the VRE outbreak and the implementation of guidelines may temper the effectiveness of interventions. Similar to the studies investigating response of *C. difficile* to barrier precautions, most studies of VRE employed several components of barrier precautions as part of a multifaceted approach (Table 13.1). It is thus difficult to determine the specific effect of any individual component.

**Potential for Harm**

None of the reviewed studies reported any assessment of possible harm as a result of the barrier precaution interventions. In fact, the implementation of barrier precautions is unlikely to result in harm to the patient. One potential concern is that time necessary to comply with the interventions (eg, gowning, gloving), might make health care workers less likely to complete tasks necessary to provide acceptable patient care. Indeed, it has recently been noted that health care workers were half as likely to enter the rooms of patients on contact isolation.[33] Furthermore, while contact precautions appeared to have little effect on patient examination by resident physicians, attending physicians were 50% less likely to examine a patient on contact precautions compared to a patient not on precautions.[34] Future studies should address these concerns by documenting the time required to adhere to barrier precautions, and determining the potential impact of precautions on patient care.

Another potentially harmful consequence of barrier precaution interventions is the psychological effect that contact precautions may have on the isolated patient. While research has examined the effects of sensory deprivation and social isolation, a recent review of the literature noted little progress in the investigation of the psychological effects of contact isolation.[35]

**Costs and Implementation**

It seems apparent that the more complicated an intervention, the less likely health care workers will adhere to it. While 2 studies noted compliance with barrier precautions at close to 90%,[21,24] others noted levels closer to 70%.[31] One study actually noted compliance levels to be significantly higher in those health care workers who used both gowns and gloves compared to those using only gowns.[27] This somewhat counterintuitive finding suggests that other factors may be at play in influencing compliance. Of the reviewed studies that reported compliance levels, all did so relatively shortly after the initial implementation of interventions. Future studies should assess compliance with guidelines over a longer period.

Four studies reported the costs of specific interventions. Implementation of use of disposable thermometers was estimated at $14,055 per year at a 343-bed institution.[22] Another study of the impact of disposable thermometers estimated that the cost per prevented *C. difficile* infection would be approximately $611.[25] A study using a multifaceted approach estimated that

the annual expenses due directly to increased demand for gowns and gloves were approximately $11,000.[31] Finally, a multifaceted intervention at a 254-bed long-term care facility which included education, gowns and gloves for resident contact, no sharing of personal equipment, and daily double cleaning of resident rooms and wheelchairs, estimated the total cost of the intervention to be $12,061 Canadian (approximately $8000 US).[36]

The costs of implementing a program to enhance barrier precaution practices must be balanced against the potential cost savings due to decreased incidence of nosocomial infections. Both VRE and *C. difficile* infections have been associated with significantly increased length of hospital stay.[5,6] Preventing even a small number of these infections is likely to have a significant financial impact. While several of the reviewed studies documented costs associated with various interventions,[22,25,26,31,36] no study systematically compared these costs to the potential cost savings of infections prevented.

**Comment**

The majority of reviewed studies demonstrated a significant reduction in the incidence of VRE or *C. difficile* following barrier precaution interventions. The fact that not all studies found a benefit suggests that future studies should identify those scenarios (eg, outbreak, endemic colonization, etc.) in which attention to barrier precautions is most likely to be beneficial. In addition, it is possible that a combined intervention involving both enhanced barrier precautions as well as antibiotic formulary interventions might be needed in order to effect the greatest possible change in VRE and *C. difficile* infection rates. While these studies, much like those that examined the impact of antibiotic use practices, demonstrated short-term success, future studies should determine the efficacy of such interventions over the long term. Finally, the cost-effectiveness of such strategies should be investigated.

**Table 13.1. Studies of multifaceted approaches with and without "cohorting"***

| Study Setting | Compliance | Study Design, Outcomes | Change in *C. difficile* or VRE |
|---|---|---|---|
| 725-bed academic medical center in Philadelphia in 1987-88: before-after study of impact of multifaceted intervention (isolation precautions, clindamycin restriction) on *C. difficile*[37] | NA | Level 3, Level 1 | Cases of *C. difficile* decreased from 1.47 cases/100 hospital discharges in 1987 to 0.74 cases/100 hospital discharges by the second half of 1988 |
| 350-bed acute care hospital in Virginia in 1987-96: before-after study of impact of multifaceted intervention on *C. difficile* infections[23] | NA | Level 3, Level 1 | Mean annual new cases of *C. difficile* decreased from 155/year in the before period to 67/year in the after period ($p<0.05$). |
| 840-bed tertiary care center in Brussels in 1989-90: impact of a multifaceted infection control intervention, including cohorting, on incidence of *C. difficile*[28] | NA | Level 3, Level 1 | Incidence of *C. difficile* decreased from 1.5 cases/1000 admissions to 0.3 cases/1000 admission (protective efficacy 73%, 95% CI: 46-87%) |
| Bone marrow transplant unit of a large academic medical center in Texas in 1995: impact of multifaceted infection control intervention on *C. difficile* attack rate[29] | NA | Level 3, Level 1 | Attack rate for third week in May was 60%. Following intervention, rate dropped to 17% for remainder of May, 21% for June, and 7% for July ($p<0.05$) |
| Tertiary-care Veterans Affairs Medical Center in Brooklyn in 1991-95: impact of multifaceted infection control intervention on VRE rates[30] | NA | Level 3, Level 1 | Incidence of VRE cases per 1000 admissions was 0.6 in 1991, 3.3 in 1992. Following intervention, the rates were 8.0 in 1993 and 9.2 in 1994 |
| 22-bed oncology unit in a 650-bed tertiary care hospital in New York in 1993-95: impact of multifaceted infection control program, including cohorting, on VRE infection and colonization[24] | 91.7% of persons who entered room used gowns and gloves appropriately | Level 3, Level 1 | Incidence of VRE bloodstream infection (patients per 1000 patient-days) decreased from 2.1 to 0.45 ($p=0.04$). VRE colonization decreased from 20.7 to 10.3 ($p<0.001$). |
| 375-bed community hospital in Indianapolis in 1995-96: impact of cohorting on VRE prevalence[21] | Compliance with recom-mendations rose from 22% to 88% ($p<0.001$) | Level 3, Level 1 | VRE prevalence decreased from 8.1% to 4.7% ($p=0.14$). VRE among patients whose VRE status was unknown before cultures were obtained decreased from 5.9% to 0.8% ($p=0.002$). |

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|---|---|---|---|
| 254-bed long-term care facility in Toronto in 1996-97: impact of barrier precautions including cohorting on prevalence of VRE[36] | NA | Level 3, Level 1 | 4/85 (4.7%) patients initially screened were VRE colonized. No patients in subsequent screenings were positive. |

**Table 13.1. Studies of multifaceted approaches with and without "cohorting" (cont.)**

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|---|---|---|---|
| 23-bed oncology unit in a 1300-bed teaching hospital in South Africa in 1998: impact of barrier precautions including cohorting on VRE prevalence[39] | NA | Level 3, Level 1 | VRE colonization decreased from 19/34 (55%) patients to 1/14 (7%) following implementation of infection control interventions |
| 347-bed tertiary care medical center in Massachusetts in 1993: impact of a multifaceted infection control intervention including cohorting on VRE infection and colonization[31] | Overall hand-washing compliance was 71% | Level 3, Level 1 | In the year prior interventions, 116 patients were colonized or infected with VRE, compared with 126 in the year after implementation. |

* NA indicates not applicable; VRE, vancomycin-resistant enterococci.

**Table 13.2. Studies of barrier precaution interventions***

| Study Setting | Compliance | Study Design, Outcomes | Change in *C. difficile* or VRE |
|---|---|---|---|
| 370-bed academic medical center in Massachusetts in 1991-92: before-after study of impact of infection control interventions on *C. difficile* incidence[38] | NA | Level 3, Level 1 | Incidence of *C. difficile* increased from 0.49% to 2.25% from 1989 to 1993. Following interventions, incidence of *C. difficile* decreased to 1.32% |
| Veterans Administration Medical Center in Minnesota in 1986-87: impact of universal glove use on incidence of *C. difficile*[26] | Mean glove use/100 pts: 4539 on glove ward; 3603 on control ward (p=NS) | Level 2, Level 1 | Incidence of *C. difficile* on glove wards decreased from 7.7/1000 patients discharges to 1.5/1000 (p=0.015). No significant change in incidence on the control wards |
| 8-bed combined medical and surgical ICU in a 235-bed acute care hospital in New York City in 1990-91: impact of barrier precautions on VRE colonization[1] | NA | Level 3, Level 1 | 16 patients infected or colonized with VRE identified over 6 months period. No new VRE infection or colonization in the 2 months after intervention. |
| 250-bed university-affiliated hospital in Rhode Island in 1991-92: impact of sequential barrier precaution intervention on VRE[40] | NA | Level 3, Level 1 | 13 patients with VRE identified over 8 month period. In the 3 months after the first intervention (private room + gloves) 20 patients were found to have VRE. In the 6 months after the second intervention (gowns added), 4 patients were VRE positive. |
| 181 consecutive patients admitted to the medical ICU in a 900-bed urban teaching hospital in Chicago in 1994-95: comparison of impact of gown and glove vs. glove on incidence of VRE colonization[27] | Compliance in glove and gown group, 79%; glove group, 62% (p<0.001) | Level 2, Level 1 | 24 (25.8%) of the glove and gown group acquired VRE in the ICU compared to 21 (23.9%) of those patients in the gown only room (p=NS) |
| 550-bed tertiary teaching hospital in Minneapolis in 1993-94: impact of barrier precautions on VRE colonization[32] | NA | Level 3, Level 1 | Weekly rectal swab surveillance performed. Rates of VRE colonization remained at 7-9% throughout 6 month study period |

* ICU indicates intensive care unit; NA, not applicable; NS, not statistically significant; and VRE, vancomycin-resistant enterococci.

**Table 13.3. Studies of use of dedicated or disposable examining equipment***

| Study Setting | Compliance | Study Design, Outcomes | Change in *C. difficile* or VRE |
|---|---|---|---|
| 343-bed acute hospital and 538-bed skilled nursing facility in New York: before-after study of impact of replacing electronic thermometers with disposable thermometers on *C. difficile* infection rate[22] | 100% replacement of electronic thermo-meters | Level 3, Level 1 | Incidence of *C. difficile* decreased from 2.71 to 1.76 cases per 1000 patients in the acute hospital ($p<0.01$)<br>Incidence of *C. difficile* decreased from 0.41 to 0.11 cases per 1000 patient days in the skilled nursing facility ($p<0.01$) |
| 20 inpatient units in a 700-bed university hospital in Virginia: randomized crossover trial of impact of disposable thermometers for prevention of *C. difficile*[25] | 100% compliance with use of specific types of ther-mometers | Level 2, Level 1 | Incidence of *C. difficile* was 0.16 cases/1000 patient days in the intervention group compared to 0.37/1000 patient days in controls (RR 0.44, 95% CI: 0.21-0.93; p=0.026] |
| 343-bed acute care facility in New York in 1992: impact of change to tympanic thermometers on VRE incidence[22] | 100% switch to tympanic thermo-meters | Level 3, Level 1 | Tympanic thermometer use resulted in risk reduction for VRE of 60% (RR 0.41, 95% CI: 0.31-0.55) |

* CI indicates confidence interval; RR, relative risk; and VRE, vancomycin-resistant enterococci.

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