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Environmental contamination makes an important contribution to hospital infection

John M. Boyce[a,b]

[a]*Infectious Diseases Section, Hospital of Saint Raphael, New Haven, USA*
[b]*Yale University School of Medicine, New Haven, CT, USA*

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Summary Meticillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) are capable of surviving for days to weeks on environmental surfaces in healthcare facilities. Environmental surfaces frequently touched by healthcare workers are commonly contaminated in the rooms of patients colonized or infected with MRSA or VRE. A number of studies have documented that healthcare workers may contaminate their hands or gloves by touching contaminated environmental surfaces, and that hands or gloves become contaminated with numbers of organisms that are likely to result in transmission to patients. Pathogens may also be transferred directly from contaminated surfaces to susceptible patients. There is an increasing body of evidence that cleaning or disinfection of the environment can reduce transmission of healthcare-associated pathogens. Because routine cleaning of equipment items and other high-touch surfaces does not always remove pathogens from contaminated surfaces, improved methods of disinfecting the hospital environment are needed. Preliminary studies suggest that hydrogen peroxide vapour technology deserves further evaluation as a method for decontamination of the environment in healthcare settings.

For several decades, there has been considerable controversy over whether or not contaminated environmental surfaces contribute to transmission of healthcare-associated pathogens. This article reviews the evidence that environmental surfaces contaminated with meticillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) contribute to the occurrence of healthcare-associated infections. In addition, it describes a new strategy that has been used to eliminate environmental contamination by *Clostridium difficile*, another pathogen for which contaminated environmental surfaces serve as a reservoir for transmission.

The potential for contaminated environmental surfaces to contribute to transmission of healthcare-associated pathogens depends on a number of factors, including the ability of pathogens to remain viable on a variety of dry environmental surfaces, the frequency with which they contaminate surfaces commonly touched by

* John M. Boyce, MD. Hospital of Saint Raphael, 1450 Chapel Street, New Haven, CT 06511, USA.

patients and healthcare workers, and whether or not levels of contamination are sufficiently high to result in transmission to patients.

Pathogens such as MRSA, VRE and *C. difficile* have the ability to remain viable on dry surfaces for days, weeks or even months. For example, strains of MRSA can remain viable for up to 14 days on Formica surfaces, and for up to six to nine weeks on cotton-blanket material.[1,2] Some epidemic strains of MRSA have been shown to survive longer and at higher concentrations than non-epidemic strains.[3] A unique experiment conducted by Colbeck[4] demonstrated that *S. aureus* can remain virulent and capable of causing infection for at least 10 days after exposure to dry surfaces.

The proportion of hospital surfaces contaminated with MRSA has varied considerably in published reports, ranging from 1% to 27% of surfaces in patient rooms on regular hospital wards, and from a few percent to 64% of surfaces in burn units with MRSA patients. The frequency of contamination has been shown to vary depending on the body sites at which patients are colonized or infected. In one study, 36% of surfaces cultured in the rooms of patients with MRSA in a wound or urine were contaminated, compared to 6% of surfaces in the rooms of patients with MRSA at other body sites.[5] In a recent study by Otter *et al.*,[6] ten standardized high-touch surfaces were cultured in the rooms of eight patients with heavy gastrointestinal colonization by MRSA and concomitant diarrhoea (cases) and in the rooms of six patients with MRSA at other body sites, but not in their stool (controls). The investigators found that 59% of surfaces were contaminated with MRSA in the rooms of case patients who had heavy gastrointestinal colonization with MRSA and concomitant diarrhoea. MRSA was recovered most frequently from bedside rails (100% of those cultured), followed by blood pressure cuffs (88%), television remote control devices (75%), bedside tables and toilet seats (63% each), toilet rails and dressers (50% each), door handles (38%) and intravenous pumps (25%). In contrast, significantly fewer (23%) surfaces were contaminated in the rooms of control patients who had MRSA at other body sites, but not in their stool. In the rooms of control patients, bedside rails were also the most frequently contaminated site (67%), followed by toilets and call buttons (33% each). The other seven standardized sites cultured in the rooms of control patients were contaminated less than 20% of the time. In another study, community-acquired strains of MRSA (CA-MRSA), which are becoming increasingly common worldwide, were found to contaminate 19% of surfaces in an outpatient clinic that cared for patients with human immunodeficiency syndrome.[7] Two healthcare workers (HCWs) who worked in the clinic developed infections caused by CA-MRSA strains. One of the infected HCWs who did not have direct contact with patients became infected with the same strain that was found on environmental surfaces. Although extensive cleaning effectively removed CA-MRSA from surfaces in the outpatient clinic described by Johnston *et al.*,[7] routine cleaning of contaminated environmental surfaces does not always eliminate MRSA from high-touch surfaces in hospitals.[8,9]

Environmental contamination may contribute to transmission of healthcare pathogens when healthcare workers contaminate their hands or gloves by touching contaminated surfaces, or when patients come into direct contact with contaminated surfaces. Transmission of MRSA from environmental surfaces to gloves or hands of HCWs has been documented by several investigators. In one study, 42% of 12 nurses who had no direct contact with patients contaminated their gloves by touching objects in the rooms of patients with MRSA in a wound or urine.[5] In another study, 31% of volunteers who touched bed rails and overbed tables in patient rooms contaminated their hands with *S. aureus* (35% of which were MRSA).[8] When volunteers touched bed rails and overbed tables in unoccupied rooms that had been terminally cleaned, 7% contaminated their hands with *S. aureus*.[8]

Transmission of MRSA from contaminated environmental sources to patients has occurred in a variety of settings. Schultsz *et al.*[10] presented convincing evidence that ultrasonic nebulizers were the source of an MRSA outbreak among patients. Other studies have provided suggestive evidence that contaminated ventilation grills were sources of MRSA outbreaks in hospitals.[11,12] In a study by Hardy *et al.*[13] the authors concluded that three patients acquired MRSA from the environment, but did not exclude HCWs as another potential source.

The role of contaminated environmental surfaces in transmission of healthcare-associated pathogens is also supported by the fact that cleaning and/or disinfection of the environment can reduce the incidence of healthcare-associated colonization or infection. Schultsz *et al.*[10] demonstrated that cleaning contaminated ultrasonic nebulizers implicated in transmission terminated an outbreak of MRSA. Cleaning contaminated ventilation grills was associated with control of several other MRSA outbreaks.[11,12] Rampling *et al.*[14] concluded