The benefits of surface disinfection

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The effective use of disinfectants constitutes an important factor in preventing hospital-associated infections (HAIs). In 1968, E.H. Spaulding[1] proposed 3 categories of germicidal action to prevent a risk of infection associated with the use of equipment or surfaces: noncritical, semicritical, and critical. Environmental surfaces are considered noncritical items because they come in contact with intact skin, and intact skin is an important barrier to disease acquisition. Use of noncritical items or contact with noncritical surfaces carries a low risk of transmitting a pathogen to patients. Thus, the routine use of disinfectants to disinfect hospital floors and other surfaces (eg, bedside tables or bed rails) is controversial (Table 1).[2-7]

While noncritical surfaces have not been implicated directly in disease transmission, these surfaces potentially may contribute to cross-transmission by allowing acquisition of transient hand carriage by health care personnel due to contact with a contaminated surface or by patient contact with contaminated surfaces or medical equipment. Medical equipment surfaces may become contaminated with infectious agents and may serve as the vehicle in outbreaks for person-to-person transmission. The purpose of this commentary is to review briefly the epidemiologic, clinical, and experimental data and why evidence-based guidelines[8-12] recommend the use of hospital disinfectants on noncritical patient care surfaces (eg, bed rails), equipment surfaces (eg, blood-pressure cuffs and hemodialysis machines), and housekeeping surfaces (eg, floors) in patient care areas.

First, surfaces may contribute to transmission of epidemiologically important microbes such as methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), *Clostridium difficile*, and viruses (ie, norovirus, rotavirus, and rhinovirus). Several investigators have demonstrated that inanimate surfaces near infected patients commonly become contaminated with MRSA and VRE [12-15] and that the contamination can persist for hours to weeks on dry surfaces.[12,14] The fact that personnel may contaminate their gloves (or their hands in the absence of glove use)[13] by touching such surfaces suggests that contaminated environmental surfaces may serve as a reservoir or source of MRSA and VRE in hospitals. While the precise role of the environment in the transmission of diseases has not been fully delineated, environmental surface contamination may contribute to endemic or epidemic spread as the surfaces may act as a reservoir or source from which personnel contaminate their hands.[15,16] An aggressive environmental decontamination program has been credited with eradicating VRE from a burn unit [17] and *Acinetobacter* from a neurosurgical intensive care unit.[18] Similarly, environmental contamination associated with *C difficile* outbreaks is well-described.[19-22] Importantly, in a prospective study,[21] transmission to personnel or patient contacts of the strain cultured from the corresponding index case was correlated strongly with the intensity of environmental contamination. Since bacterial spores are relatively resistant to quaternary ammonium compounds (QACs) and phenolics, several investigators have studied the efficacy of environmental decontamination with chlorine. For example, Mayfield and coworkers[19] showed a marked reduction in *C difficile*–associated diarrhea rates in the bone-marrow transplant unit (from 8.6 to 3.3 cases per 1000 patient-days) during the period of bleach disinfection (1:10 dilution) of environmental surfaces compared to cleaning with a QAC.

Viruses can be acquired from environmental surfaces either directly from surface-to-finger-to-mouth or directly from surface-to-mouth.[23-25] Chemical disinfection of contaminated environmental surfaces has been shown to interrupt transfer of rhinovirus from these surfaces to hands.[26] In experimental studies, the use of disinfectants has been shown to be an efficient method of inhibiting the transmission of rotavirus to human subjects.[27]

Second, the impact of surface disinfection should not be dismissed because large well-designed trials assessing the impact of disinfectants versus detergents for environmental surfaces have not been published. The trials cited by Daschner and Dettenkofer

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Table 1. Epidemiologic evidence associated with the use of surface disinfectants or detergents on noncritical surfaces

Justification for use of disinfectants for noncritical surfaces
Surfaces may contribute to transmission of epidemiologically important microbes (eg, VRE, MRSA, *Clostridium difficile*, and viruses).
Disinfectants are required in the United States for surfaces contaminated by blood and other potentially infective material.
Detergents become contaminated and result in seeding the patients' environment with bacteria.
Disinfectants are more effective than detergents in reducing the microbial load on floors.
Disinfection of noncritical equipment and surfaces is recommended for patients on isolation precautions by the Centers for Disease Control and Prevention.
The advantage of using a single product for decontamination of noncritical surfaces (including floors and equipment) simplifies both training and practice.
Justification for using a detergent on floors
Noncritical surfaces contribute minimally to endemic health care–associated infections
No difference in health care–associated infection rates has been demonstrated when floors are cleaned with detergent versus disinfectant
Less environmental impact (aquatic or terrestrial) issues with disposal
No occupational health exposure issues
Lower costs
Use of antiseptics/disinfectants theoretically could select for antibiotic resistant bacteria
Produces more aesthetically pleasing floors

et al[6,7,28-30] have been small, of short duration, and suffer from low statistical power because the outcome, hospital-acquired infection, is one of low frequency. The low rate of infection makes it difficult to demonstrate statistically the efficacy of an intervention. Further, the requirement for demonstrating a reduction in overall infection rates is a stringent one that is not met by the majority of infection control interventions. It is estimated that the frequency of health care–associated infections in the United States occurs in approximately 5% of the 35 million hospitalized patients. Thus, even a small decrease (0.1%) would result in a public health benefit (1750 HAIs).[31]

Third, disinfectants are needed for surfaces contaminated by blood and other potentially infective materials. In the United States, to comply with the Occupational Safety and Health Administration rule on bloodborne pathogens, a blood spill must be cleaned using a disinfectant. The compliance directive states that the blood should be disinfected using an Environmental Protection Agency–registered hospital disinfectant, a disinfectant with a hepatitis B virus (HBV)/human immunodeficiency virus (HIV) claim, or a solution of 5.25% sodium hypochlorite (household bleach) diluted between 1:10 and 1:100 with water.[32] A study demonstrated that, in the presence of blood spills, a 1:10 final dilution of bleach should be used to inactivate bloodborne viruses.[33] Even at this concentration complete inactivation cannot be assured. This regulation is reasonable because HBV dried on a surface remains infective for at least 1 week.[34]

Fourth, detergent solutions become contaminated during use and can seed the patients' environment with bacteria. Investigators have shown that mop water becomes increasingly contaminated during floor cleaning, and mop water becomes contaminated if soap and water rather than a disinfectant is used (contamination of detergent water after cleaning a ward 34,000 CFU/mL versus 20 CFU/mL for disinfectants).[35] Spreading microorganisms on housekeeping surfaces and noncritical patient care surfaces via mopheads and cleaning cloths may aid in the spread of health care–associated pathogens. Dharan and associates[28] found that the use of detergents alone on both floors and patient room furniture led to an increase in the bacterial contamination in the patients' environmental surfaces after cleaning (average increase = 103.6 CFU/24cm^2). In addition, Engelhart et al[36] recently described a *P aeruginosa* outbreak in a hematology-oncology unit associated with contamination of the surface equipment when nongermicidal cleaning solutions, instead of disinfectants, were used for decontamination of the patients' environment.

Fifth, disinfectants are more effective than detergents in reducing microbial load on floors. Hospital floors become contaminated with microorganisms by settling of airborne bacteria, by contact with shoes, wheels, and other objects, and occasionally by spills. The removal of microbes is a component in the control of health care–associated infections. In an investigation on the cleaning of hospital floors, the use of soap and water (80% reduction) was less effective in reducing the numbers of bacteria than a phenolic disinfectant solution (99% reduction).[37]

Sixth, disinfection of noncritical equipment and surfaces is recommended for patients on isolation precautions. The Centers for Disease Control and Prevention (CDC) recommends in their Isolation Guideline[38] that noncritical equipment contaminated with blood, body fluids, secretions, or excretions be cleaned and disinfected after use. The same guideline recommends that, in addition to cleaning, disinfection of the bedside equipment and environmental surfaces (eg, bed rails, bedside tables, carts, commodes, door-knobs, and faucet handles) is indicated for certain pathogens, especially enterococci, which can survive in the inanimate environment for prolonged periods of time.[38]

Seventh, the current APIC guideline on disinfection recommends the use of disinfectants on noncritical patient equipment and housekeeping surfaces.[10] The CDC Environmental Infection Control guideline recommends to process noncritical patient-care

equipment with an Environmental Protection Agency–registered hospital disinfectant or disinfectant/detergent in accordance with germicide label instructions (Category II). It also recommends using a hospital disinfectant for general housekeeping purposes in patient-care areas where uncertainty exists as to the nature of the soil on the surfaces (eg, blood or body fluid contamination vs routine dust or dirt); or uncertainty exists regarding the presence of multidrug–resistant organisms on such surfaces (Category II).[8] This recommendation is based on 2 facts. First, the presence of visible blood contamination is a poor indicator for the presence of hepatitis B virus.[39] Second, many hospitalized patients are unknowingly colonized or infected with multidrug–resistant organisms,[12,40,41] and such patients will serve as a source for environmental contamination within their rooms. Thus, hospitals would need to treat all housekeeping surfaces with a disinfectant if they wished to comply with this recommendation.

Eighth, as noncritical patient care and equipment surfaces are generally disinfected, the use of a disinfectant throughout the hospital (both noncritical patient care and equipment surfaces and housekeeping surfaces) simplifies training environmental service personnel and facilitates appropriate practice.

In regard to the papers by Daschner and Schuster[6] and Dettenkofer and associates,[7] the authors raise several issues that warrant discussion.

First, "the use of disinfectants for routine surface disinfection is not recommended by any national center for nosocomial infection control in Europe" is not correct. In fact, the Robert Koch Institute in Germany, which has been tasked to produce guidelines by a federal infection protection law, published a guideline that recommends the use of surface disinfectants for patient equipment surfaces and noncritical housekeeping surfaces in patient care areas.[11] This guideline is an evidenced-based guideline and Dr Dettenkofer, Dr Daschner's coauthor, is a member of the working group.[11] A document published by the French Authorities also recommends using disinfectants for surface disinfection in patient care areas (P Hartemann, MD, written communication, April 2004; *www.minefi.gouv.fr/daj/guide/gpem/5719/5719.htm*). In addition, it should be mentioned that Daschner and Dettenkofer have recommended the use of disinfectants for surface disinfection (including floors) for MRSA colonized or infected patients. In fact, they recommended that the MRSA patient room be disinfected 3 times per day on intensive care units and once per day on normal wards.[42] Given the high prevalence of MRSA among hospitalized patients in most countries of the world[43] and that routine MRSA (and VRE) screening is rarely conducted, we should employ disinfectants for all hospitalized patients as unsuspected colonization is a routine occurrence.[12,40,41]

Second, in regard to an "increased resistance by pathogens to frequently used biocides and perhaps even to antibiotics,"[6] there is no evidence that using antiseptics/disinfectants selects for antibiotic-resistant organisms in nature or that mutants survive in nature.[44,45] Some researchers have suggested that the use of disinfectants or antiseptics (eg, triclosan) could facilitate the development of antibiotic-resistant microorganisms.[46,47] While there is evidence in laboratory studies of low-level resistance to the bisphenyl, triclosan, the concentrations of triclosan studied were low (generally < 1 μg/mL) and dissimilar from the higher levels used in antimicrobial products (2000-20,000 μg/mL).[48] Thus, researchers can create laboratory-derived mutants that demonstrate reduced susceptibility to antiseptics or disinfectants. In some experiments, such bacteria have demonstrated reduced susceptibility to certain antibiotics. However, there is no evidence that antiseptic/disinfectant or antibiotic resistance has occurred in nature or that these mutants survive in nature.[44,45] Multiple studies have demonstrated that the antibiotic-resistant bacteria are as susceptible to germicides as antibiotic-susceptible strains.[49,50]

Third, in regard to skin irritation and allergies in health care workers exposed to glutaraldehyde (a high-level disinfectant), formaldehyde, and glyoxal, these products are not recommended for use on noncritical surfaces or equipment in the United States.[10] In fact, a CDC guideline states "do not use high-level disinfectants for disinfection of either noncritical instruments and devices or any environmental surfaces."[8] Surface disinfection in the United States is accomplished by QACs (although benzalkonium chloride is not used), phenolics. and sodium hypochlorite.[8-10] One of the authors (D.J.W.) is the Medical Director of the Occupational Health Service at UNC Health Care System. In that capacity he personally sees all employees (5500 employees with 12,500 to 18,000 visits per year) with significant medical complaints, including allergies to medical products. He has not seen an employee with an allergic reaction to low-level disinfectants in the 11 years he has provided this service. One of the 2 references offered by Daschner and Schuster[6] that cites skin irritation and asthma using a low-level disinfectant employed in the United States, is asthma in a 39-year-old woman after inhalation for 5 minutes of a mixture of sodium hypochlorite and hydrochloric acid.[51] The release of chlorine from accidental mixing with acidic products is a rare domestic event. The other reference,[52] documented rare case reports of asthma precipitated by exposure to benzalkonium chloride.

However, in a case-control study where cases and controls were drawn from dermatology clinics, there was no increased sensitization to benzalkonium chloride noted in health care workers (2.0% health care workers vs 1.6% controls, $P > .05$).[53] The reference used by Daschner to support the statement that "benzalkonium is one of the leading allergens affecting health care personnel"[54] discussed disinfectant use as a risk factor for allergies in pig farmers. Certainly, environmental pollutants in pig farms and health care facilities is quantitatively and qualitatively different. Perhaps the study that Daschner and Schuster intended to reference was Schnuch and coworkers,[53] but this study neither demonstrated an increase risk of sensitization to benzalkonium chloride among nurses or physicians nor related a finding of a positive patch test to clinical symptoms.

To appraise these studies we used the ranking criteria reported by Dettenkofer et al[7] for assessing the efficacy of surface disinfection. Using these criteria we assessed the 4 references cited by Daschner and Schuster[6] regarding hazards posed to hospital personnel by disinfectants. Three of the 4 studies were rated as Level IV (case series without controls),[51-53] and one was rated as not relevant because the study population was not health care personnel.[54] Thus, all studies used for assessing hazards to health care workers from disinfectants meet only the lowest level of study design.[6] Well-designed immunologic evaluations of randomly selected health care workers and appropriate controls have not been performed, and hence the prevalence and incidence of clinically-relevant asthma or atopic dermatitis as a result of occupational exposure to surface disinfectants is unknown.

It has also been proposed that allergy to disinfectants is one of the leading causes of occupational diseases to nurses and housekeeping personnel in German hospitals.[2] Since this statement was unreferenced, we conducted a literature review (Medline) from 1966 to April 2004, which provided no evidence that suggests the use of low-level disinfectants (eg, phenolics and QACs) results in allergic symptoms in health care workers.[4]

Fourth, if biocides cause harm to the environment this would be a serious issue. However, the references cited by Daschner and Schuster[6] and Dettenkofer and associates[7] do not provide evidence that QACs have low biodegradability or QACs discharged by hospitals have toxic effects against microorganisms in sewage treatment plants (STPs).[55-57] In fact, one reference states "for QACs, contradictory results were reported for elimination, biodegradability and toxic effects against microorganisms in STPs as well as in biodegradability testing."[55] Regardless of the merits of this argument, adverse effects on human health have not been proposed or demonstrated. Thus, the US Environmental Protection Agency does not regulate the discharge of hospital disinfectants via waste water.

Lastly, we agree that well-designed studies should be undertaken to assess the efficacy of routine disinfection of noncritical surfaces in hospitals. However, we remind our infection control colleagues that CDC recommendations are based on well-designed published epidemiologic, clinical, or experimental data. The conclusion that the use of disinfectants by hospital personnel frequently leads to adverse health events or that discharge of disinfectants into waste water negatively impacts human health should not be made without supportive epidemiologic, clinical, or experimental data. Similarly, rigorous studies should be undertaken to assess any perceived adverse environmental and health consequences of using disinfectants in the hospital. Systematic reviews assessing the impact of hospital disinfectant practices should use the same study methodology for assessing both harms and benefits. To date this has not been done.

In summary, we believe for the benefits listed above, it is reasonable to use hospital disinfectants on noncritical patient care surfaces (eg, bedside tables and bed rails), patient equipment surfaces (eg, blood pressure cuffs, stethoscopes, hemodialysis machines and radiograph machines) and housekeeping surfaces in patient care areas.

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