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Major article

Monitoring and improving the effectiveness of surface cleaning and disinfection

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Disinfection of noncritical environmental surfaces and equipment is an essential component of an infection prevention program. Noncritical environmental surfaces and noncritical medical equipment surfaces may become contaminated with infectious agents and may contribute to cross-transmission by acquisition of transient hand carriage by health care personnel. Disinfection should render surfaces and equipment free of pathogens in sufficient numbers to prevent human disease (ie, hygienically clean).

There is excellent evidence in the scientific literature that environmental contamination plays an important role in the transmission of several key health care–associated pathogens, including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), *Acinetobacter* sp, norovirus, and *Clostridium difficile*.[1-4] All of these pathogens have been demonstrated to persist in the environment for days (in some cases months), frequently contaminate the environmental surfaces in rooms of colonized or infected patients, transiently colonize the hands of health care personnel, be transmitted by health care personnel, and cause outbreaks in which environmental transmission was deemed to play a role. Importantly, a study by Stiefel et al demonstrated that contact with the environment was just as likely to contaminate the hands of health care providers as was direct contact with the patient.[5] Further, admission to a room in which the previous patient had been colonized or infected with MRSA, VRE, *Acinetobacter* or *C difficile* has been shown to be a risk factor for the newly admitted patient to develop colonization or infection.[6-8] The purpose of this article, which is adapted from other publications,[4,9,10] is to discuss the available options for monitoring environmental cleaning-disinfection and discuss methods for improving environmental cleaning-disinfection.

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IMPORTANCE OF PRODUCT AND PRACTICE

The disinfectants used in health care facilities are 1-step products, meaning they clean and disinfectant in 1-step rather than requiring 2 independent steps (ie, cleaning, followed by disinfection).[10] In general, no precleaning is necessary unless a spill or gross contamination is present, in which case cleaning precedes the use of a disinfectant. Disinfectants are intended for use on hard, nonporous surfaces; however, some products are Environmental Protection Agency (EPA)–registered for application to soft surfaces, such as hospital privacy curtains.[11] Hospitals should avoid the use of noncleanable surfaces, such as fabric chairs, in clinical areas and use a cleanable covering fabric (eg, vinyl). Cleaning is an important component of the cleaning-disinfection process because dust, dirt, and organic matter interfere with the effectiveness of the disinfectant by altering the antimicrobial activity of the disinfectant or protecting the pathogen from exposure to the disinfectant. In this article, we use the term cleaning-disinfection to reference this 1-step process for cleaning and disinfecting a noncritical item.[10] Cleaning refers to the removal of surface debris (eg, dust, organic material), whereas disinfection refers to the use of a disinfectant or germicide designed to kill microorganisms. Cleaning-disinfection or environmental cleaning, which refers broadly to an organized process for cleaning, disinfecting, and monitoring,[12,13] is a horizontal control measure. Horizontal controls are broad-based approaches to infection prevention because they attempt reduction to all infections caused by all pathogens and include hand hygiene, environmental control, and minimizing unnecessary use of invasive devices.[14] Often cleaning is enhanced by detergents and surfactants. Surfactants enhance the cleaning efficacy of the

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Table 1
Properties of an ideal disinfectant

Ideal properties
1. Broad spectrum: it should have a wide antimicrobial spectrum, including kill claims for the pathogens that are the common causes of HAIs and outbreaks.
2. Fast acting: it should have a rapid kill and short kill-contact time listed on the label.
3. Remains wet: it should keep surfaces wet long enough to meet listed kill-contact times with a single application or meet wet-times recommended by evidence-based guidelines.
4. Not affected by environmental factors: it should be active in the presence of organic matter (eg, blood, sputum, feces) and compatible with cotton, microfiber, soaps, detergents, and other chemicals encountered in use.
5. Nontoxic: it should not be irritating to the user, visitors, and patients. It should not induce allergic symptoms (especially asthma and dermatitis). The toxicity ratings for disinfectants are danger, warning, caution, and none. Everything being equal, choose products with the lowest toxicity rating.
6. Surface compatibility: it should be proven compatible with common health care surfaces and equipment.
7. Persistence: it should have sustained antimicrobial activity or residual antimicrobial effect on the treated surface.
8. Easy to use: it should be available in multiple forms, such as wipes (large and small), sprays, pull-tops, and refills. Directions for use should be simple and contain information about personal protective equipment as required.
9. Acceptable odor: it should have an odor deemed acceptable by users and patients or no odor.
10. Economical: costs should not be prohibitively high, but when considering costs of disinfectant should also consider product capabilities, cost per compliant use, and so forth.
11. Solubility: it should be soluble in water.
12. Stability: it should be stable in concentrate and use dilution.
13. Cleaner: it should have good cleaning properties.
14. Nonflammable: it should have flash point >150°F.

NOTE. Modified with permission from Molinari et al[17] and Rutala and Weber.[10]
Abbreviation: *HAI*, health care–associated infection.

disinfectant and ensure complete and even coverage of the surface, preventing beading that occurs with some liquids.[10,15] It is important to achieve even and thorough coverage of a surface to result in even and complete disinfection. Multiple studies have shown 10%-50% of the surfaces in patient rooms colonized or infected with *C difficile*, MRSA, and VRE are contaminated with these pathogens, and a lack of thoroughness of cleaning contaminated surfaces in patient rooms (mean 32% of objects cleaned) has been linked to an overall 120% increased risk of infection to the next occupant in that room.[1,6,16]

Although the process of selecting an optimal health care product or disinfectant used for low-level disinfection of noncritical items is commonplace in health care facilities, there are a very limited number of articles in the peer-reviewed literature on this topic.[10] The disinfectant or the product, is 1 of the 2 components essential for effective disinfection. Table 1 identifies the characteristics of the ideal disinfectant. Studies support the use of disinfection rather than the use of a nongermicidal detergent on environmental surfaces in health care.[18,19] One recent study showed that daily use of a disinfectant applied to environmental surfaces with a 80% compliance is superior to a nongermicidal detergent because it results in significantly reduced rates of health care–associated infections (HAIs) caused by *C difficile*, MRSA, and VRE.[20] Nongermicidal detergents are not recommended for multiple reasons,[19] including detergent wipes transfer significant amounts of epidemiologically important pathogens (eg, MRSA, *C difficile*) over surfaces[21] and disinfectants are more effective than detergents in reducing microbial contamination.[22] Similarly, results have demonstrated efficient transfer of *C difficile* spores from contaminated-to-clean surfaces by nonsporicidal wipes and overused sporicidal wipes.[23] To date, the perfect product for health care surface disinfection has not been introduced; however, there is a wide array of excellent disinfectants that offer a range of characteristics (Table 2).

To keep patients as safe as possible, health care facilities must consider what pathogens are the most common causes of HAIs, the most common causes of outbreaks and ward closures, and the unique pathogens of their facility. The product selected should be effective against the microorganisms that are the most common causes of HAIs and outbreaks (Table 3), according to nationally reported data. Because vegetative bacteria (eg, *S aureus*, *Enterococcus*, *Escherichia coli*, coagulase-negative *Staphylococcus*, *Pseudomonas aeruginosa*, *Klebsiella* spp, *Enterobacter* spp) are the pathogens that cause most HAIs (79.1%),[26,28] health care disinfectants should be effective against these pathogens.[10]

The other component, the practice, is thorough application such that the disinfectant contacts all hand-contact or touchable surfaces. It also involves proper training of hospital staff (especially environmental services and nursing) and adherence to the manufacturer's label instructions (except in the cases where an institution may prepare a formal risk assessment to follow alternate contact times such as ≥1 minute for vegetative bacteria). Other factors that affect practice and performance include sufficient contact time, concentration, surface type, ease of use, organic soil and hard water, porosity of the surface, compatibility of the disinfectant with the wipe used, and sufficient cleaning time. The combination of product and practice results in effective surface disinfection, including the reduction of patient risk via microbial removal and inactivation and improved patient outcomes.[10]

DISINFECTION USING LOW-LEVEL DISINFECTANTS

It has long been recommended in the United States that environmental surfaces in patient rooms be cleaned and disinfected on a regular basis (eg, daily, 3 times per week), when surfaces are visibly soiled, and after patient discharge (terminal cleaning).[29] There are now data that demonstrate daily disinfection of high-touch surfaces (compared with cleaning when soiled) was associated with a significant reduction in the frequency of pathogens on investigators' hands after contact with the surfaces and the mean number of bacteria acquired.[30] Disinfection is generally performed using an EPA-registered hospital disinfectant, such as a quaternary ammonium compound, chlorine, or phenol (Table 2). Newer products effective against health care–associated pathogens include improved hydrogen peroxide (HP) and peracetic acid–HP.[11,31-33]

MONITORING AND IMPROVING THE THOROUGHNESS OF CLEANING-DISINFECTION

The cleaning-disinfection of noncritical surfaces in hospitals is essential for reducing microbial contamination and reducing HAIs.[12,13,18] A recent Agency for Healthcare Research and Quality review offers an overview of the monitoring modalities,[12,13] which include visual inspection, microbiologic methods, fluorescent