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Major Article

Tracking and controlling soft surface contamination in health care settings

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Background: Study objectives were to track the transfer of microbes on soft surfaces in health care environments and determine the efficiency of an Environmental Protection Agency (EPA)–registered soft surface sanitizer in the health care environment.

Methods: Soft surfaces at 3 health care facilities were sampled for heterotrophic plate count (HPC) bacteria, *Staphylococcus* spp, *Streptococcus pyogenes*, and *Escherichia coli* followed by a tracer study with a virus surrogate seeded onto volunteer hands and commonly touched surfaces. The occurrence of microbial contaminants was determined along with microbial reductions using the soft surface sanitizer. Soft surfaces were swabbed pre- and postintervention.

Results: Tracer viruses spread to 20%-64% and 13%-41% of surfaces in long-term health care facilities and physicians' offices, respectively. Only 1 pathogen, methicillin-resistant *Staphylococcus aureus*, was recovered. The waiting room chairs had the highest concentration of HPC bacteria before disinfection (145.4 ± 443.3 colony forming units [cfu]/cm^2), and the privacy curtains had the lowest (39.5 ± 84.2 cfu/cm^2). Reductions of up to 98.5% were achieved with the sanitizer in health care settings and up to 99.99% under controlled laboratory conditions.

Conclusions: Soft surfaces are involved in the spread of microbes throughout health care facilities. Routine application of an EPA-registered sanitizer for soft surfaces can help to reduce the microbial load and minimize exposure risks.

Preventing nosocomial disease transmission in health care facilities is challenging because of a high volume of ill and immunocompromised occupants and a highly transitory community. Hospital-acquired infections (HAIs) affect >1.7 million people in the United States each year.[1] Of these, approximately 100,000 people die from the infection or related complications.[1] Fomites play an important role in the transmission of HAIs, and patients occupying rooms that previously housed a patient with vancomycin-resistant enterococci, methicillin-resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile*, or *Acinetobacter* spp have a 73% increase in their risk of acquiring the same pathogen.[2] Studies show that items in close proximity to the patient, such as bedside tables and bed rails, were contaminated with nosocomial pathogens at higher rates than other surfaces, such as the floor, and therefore have a greater contribution to the infection process.[3-5]

Fomite disinfection and cleaning disrupts the ecologic niches of pathogens and have been shown to decrease the number of secondary infections.[6] In addition, surface disinfection can decrease the economic burden of HAIs. In 2007, the estimated cost of HAIs ranged from $28.4-$33.8 billion, and the use of infection control interventions saved $5.7-$31.5 billion.[7] The disinfection of hard nonporous surfaces has often been prioritized in the infection control protocols and preventative measures of health care facilities. In an online survey of 45 health care professional end users, only 1 in 5 said they clean soft surfaces as frequently as hard surfaces.[8] Soft surfaces' (porous surfaces such as curtains, chairs, mattresses, and mouse pads) contribution to nosocomial disease and contaminant transport has often been overlooked, despite epidemiologic evidence for a link between soft surface textiles and disease outbreaks.[9] Although studies have demonstrated that soft surfaces are frequently contaminated with nosocomial pathogens that are able to persist for an extended period of time, no direct correlations have been made regarding HAIs.[10,11]

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Sanitization and disinfection of soft porous surfaces have been difficult to achieve because porous surfaces provide protection for microorganisms from disinfectants and other environmental conditions, in addition to encouraging the growth of biofilms.[12] Survival on these surfaces can influence transmission rates and increase the risk of acquiring a secondary infection.

The purpose of this study is to determine the prevalence of common bacterial pathogens and the efficacy of a soft surface sanitizer in the health care environment, targeting surfaces expected to have high concentrations of microbes, such as waiting room and nurses' chairs. An MS2 phage surrogate tracer study was conducted in conjunction with this study, investigating the pattern of transfer of pathogens in long-term health care facilities and physicians' offices in Pima County, Arizona.

METHODS

Recovery efficiency: laboratory controlled study

Chair surfaces were simulated using 2- × 2-in plywood tiles wrapped in a layer of batting and upholstery fabric. Simulated surfaces were inoculated with 100 μL of *S aureus* bacterial suspension (10^8 colony forming units [cfu]/mL) in the form of ten 10-μL drops per surface. Two additional replicate surfaces were included for a total of 3 surfaces per experiment. The inoculated chair surfaces were allowed to air dry at room temperature for 5 minutes. Surfaces were then swabbed using sterile swabs containing letheen as a neutralizing agent, and were assayed according to the protocol in Table 1.

Sanitizer efficacy: seeded study

Simulated chair surfaces were inoculated with *S aureus* bacterial suspension following the aforementioned protocol. After drying, an ethanol-based sanitizing spray (Citrace; Clorox Healthcare, Oakland, CA) was then applied to each surface. The sanitizer was applied at a distance of 6-8 in from the surface sprayed until the surface was completely wet but not saturated and allowed to air dry for 30 seconds, as per manufacturer's instructions. Samples were then collected using letheen swabs. Simulated chair surfaces that did not receive any application of sanitizer were used as a control. Samples were assayed as per protocols in Table 1, and reductions were calculated.

Background: pathogen and indicator testing

Background samples were collected from 2 different types of health care settings, intermediate- and long-term care facilities (n = 3) and occupational doctors' offices (n = 3) in Pima County, Arizona. Each location was visited twice with a minimum of 1 week in between visits. Three types of soft surface sites were targeted at these locations, including waiting room chairs, patient room chairs, and privacy curtains. Samples were collected by swabbing 25.8 cm^2 of the surface with letheen swabs and then assaying for heterotrophic plate count (HPC) bacteria, *Staphylococcus* spp, *Streptococcus pyogenes*, and *Escherichia coli* according to the following protocols.

Sanitization

After the background sampling, an additional health care center, a local urgent care clinic, was recruited. Surfaces were divided into two 25.8-cm^2 areas. One area was swabbed prior to sanitizer application as per the background protocol. The sanitizing agent was applied to the surface using the same protocol as in the laboratory experiments. The remaining 25.8-cm^2 area was swabbed after sanitization. Samples were transported to the laboratory on ice for processing. HPC assays were completed as previously described, and bacterial counts were compared in the pre- and postsanitization samples. Samples with microbial counts below the limit of detection (1.6 cfu/cm^2) were assigned a lower limit value of 1.6 in all calculations.

Tracer study

A controlled tracer study was conducted in conjunction with the testing of the soft surface disinfectant spray. MS2 phage was used to represent enteric viruses because of their similar size, shape, and survival rates. A single blind seeding was conducted in which 100 μL of MS2 were seeded on 1 volunteer's hands and a commonly touched hard surface (doorknob in breakroom).

Site locations in this study included 3 long-term care facilities and 3 physicians' offices in Pima County, Arizona (Table 2). At all sites, an approximate sample area of 100 cm^2 was swabbed 4 hours postseeding using a spongestick (3M, Maplewood, MN). Swab samples were then processed for the presence of the seeded MS2 phage surrogate using the top agar overlay technique. Samples were incubated at 37°C for 24 hours. After incubation plaques were counted, and concentrations were calculated. The limit of detection was 0.5 plaque forming units/100 cm^2.

RESULTS

The soft surface sanitizer showed a 99.99% reduction of seeded microbes in laboratory-controlled studies. In health care environments, a 95%-98.5% reduction of HPC bacteria was achieved, with the highest $\log_{10}$ reduction of 1.8 seen for waiting room chairs (n = 30), which had an average HPC background concentration of

Table 1
Microbial methods for assays

Organism	Base media	Incubation time and temperature	Additional tests
Heterotrophic plate count bacteria	R2A agar	5 d at 24°C	N/A
Staphylococcus spp	Mannitol salt agar	2 d at 37°C	Hemolysis Gram stain Catalase Tube and slide coagulase Polymyxin-B and β-lactam Resistance
Streptococcus pyogenes	Blood agar with nalidixic acid and colistin	2 d at 37°C	Gram stain Catalase
Escherichia coli	mFC agar	1 d at 44°C	N/A
MS2 bacteriophage	Trypic soy agar Top agar	1 d at 37°C	N/A

N/A, not applicable.