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Major Article

Cleaning and disinfection in home care: A comparison of 2 commercial products with potentially different consequences for respiratory health

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Background: Home care aides perform personal care and homemaking services in client homes, including cleaning and disinfection (C&D). Although C&D are performed to remove soil and dust, they are increasingly performed for infection prevention. Many C&D products contain respiratory irritants. The objective of this study was to evaluate 2 commercial products for C&D effectiveness on common household surfaces in seniors' homes.

Methods: Two C&D visits were conducted in 46 seniors' homes. One visit applied a bleach-containing cleaning product and the other applied an environmentally preferable product. Before and after C&D, the study team performed organic soil bioluminometer measurements on surfaces and collected cotton swab and wipe samples for total bacteria count, *Staphylococcus aureus*, and *Clostridium difficile* identification.

Results: Both products removed microorganisms from tested surfaces. *S aureus* was found in 7 households, 1 strain of which was methicillin-resistant. Both products removed *S aureus* from all surfaces. Bleach-containing products removed somewhat more soil than environmentally preferable products, although results were statistically significant for only 1 surface.

Conclusions: The study showed similar, not identical, C&D performance for 2 cleaning products with potentially different consequences for respiratory health. Additional research is needed to develop robust recommendations for safe, effective C&D in home care.

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The rapidly aging US population and increasingly complex medical conditions managed at home demand more home-based providers for medical and social assistance care. Home care (HC) aides, who work in 1 of the fastest growing occupations in the United States, perform a wide range of services, including personal care of clients (such as showering and bathing) and homemaking,

particularly cleaning and disinfection (C&D).^{1,2} Cleaning is a significant part of aides' work. In our recent survey in Massachusetts,² we found that 80% of nearly 3,500 HC aide visits involved cleaning a bathroom or kitchen with 24% of visits involving bleach and an additional 23% involving ammonia or other strong chemical.

Although cleaning tasks are performed to remove soil, dirt, and dust from home surfaces, they are also increasingly performed for infection prevention. One reason for the focus on disinfection is concern for infections in home health care³ and the rise in prevalence of drug-resistant pathogens, such as methicillin-resistant *Staphylococcus aureus* (MRSA) both in hospitals and in the community.^{4,5} *Clostridium difficile* is the major cause of enteric infections among elderly persons.⁶ Patients returning home after exposures at facility-based health care settings can be carriers, which further compromises the health of home-based caregivers. Whereas cleaning removes soil, disinfection eliminates most recognized

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pathogenic microorganisms.^{4,7,8} Increasingly, commercial products are formulated to accomplish C&D in 1 step. There are guidelines for C&D in hospitals and outpatient settings^{7,8}; however, no guidelines exist for HC C&D.⁹

Complicating the choice of products to use for C&D, there is growing evidence that exposures to some common C&D products cause or exacerbate respiratory illnesses, including asthma and chronic bronchitis among janitors, domestic cleaners, and health care workers with regular exposure to cleaning products.⁹⁻¹⁷ Indeed, cleaning products are among the leading causes of occupational asthma.¹⁸⁻²⁰ Because of high volatility, spray application, and use in small and poorly ventilated spaces, there is concern that some C&D product exposures may be sufficient to increase respiratory illness risks among HC aides who clean and disinfect clients' homes. This may at least partially explain the finding that HC aides in Massachusetts had twice the prevalence of asthma compared with all other workers (20% vs 10%) in the Behavioral Risk Factor Surveillance Survey, 2011-2014.²¹

Concerns about adverse human and environmental health effects of C&D products have led to the development of so-called green cleaning products. In fact, there are several different terms used for these products by manufacturers, marketers, and environmental services professional groups, such as environmentally friendly, environmentally preferable, and green. It is important to note that there is still no accepted official definition of green. The 1998 US Executive Order 13101²² defined environmentally preferable as "products or services that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose." Despite the fact that there is no standard definition for the general concept of green, including a green cleaning product, this sector of the consumer products market is rapidly growing and some hospitals and other institutions have adopted initiatives such as green cleaning programs. Based on toxicologic screenings, there is limited evidence on how green cleaning products influence human health. Additionally, little is known about whether green cleaning products are as effective as conventional products for disinfecting as well as for cleaning in actual home and health care settings.^{4,9} The American Society for Healthcare Environmental Services has recommended²³ that the green cleaning definition be expanded to address the efficacy of infection control and prevention "towards effective products with the fewest adverse effects on human health and the environment."

The objective of our study was to evaluate the effectiveness of alternative commercial products for C&D of common household touch points under conditions typical of a visit by an HC aide in the homes of residents in senior housing complexes. Two commonly available products were compared, a conventional cleaner containing chlorine bleach, and another marketed as green. For the purposes of this article, environmentally preferable will be used rather than green. The study was informed by a laboratory investigation that tested 3 products for C&D efficacy under controlled conditions with known sample contamination, including the 2 products used in this field study⁴ and a qualitative investigation of 9 focus groups of HC aides and 7 in-depth interviews with HC managers to characterize HC C&D practices and products so that these could be applied in the present study. The findings of the qualitative study will be reported elsewhere.

METHODS

The sampling and culture methods of this study are based on previously published literature.²⁴⁻²⁸ The study was approved by the University of Massachusetts Lowell Institutional Review Board. All participants signed an informed consent form. Three local senior housing complexes in Massachusetts were recruited as research study

sites. With the assistance of the housing authorities, our study team recruited and visited 46 homes between January and September 2016.

A team of 3 researchers conducted 2 visits at each home, at least 1 week apart. During 1 visit, a bleach-containing (BC) product was used (Clorox Cleanup Cleaner + Bleach; The Clorox Company, Oakland, CA) and the other visit tested an environmentally preferable (EP) product (Seventh Generation Disinfecting Multi-Surface Cleaner; Seventh Generation Inc, Burlington, VT). The research team members have no relationship with the manufacturers of these products. The cleaning products were purchased at a local grocery store. The BC product was selected based on input from HC aides who participated in focus groups to identify commonly used C&D products. HC aides reported very infrequent use of green products and the EP product selected for this study was based on common availability in grocery stores. The efficacy of these 2 products was evaluated in an earlier laboratory pilot investigation, which has been reported elsewhere.⁴ Residents were not told the names of the products or which type was applied during a visit. The order of product use (first visit vs second visit) was randomized.

Residents received a \$40 cash incentive for the first visit and \$60 for the second visit. A study visit lasted no more than 45 minutes. The team members wore disposable shoe covers during the entire study visit to protect residents' floors as well as gloves during sampling and cleaning to protect samples from hand contamination. Eight high-touch surfaces were sampled in each home: 4 surfaces in the kitchen (sink, counter, floor, and faucet) and 4 surfaces in the bathroom (tub or shower, toilet seat, floor, and faucet). Analyses included rapid measurements of organic soil (hereafter called soil), including bacteria, food residue, and human cells using an ATP luminometer (SystemSure Plus, Hygiene, Camarillo, CA); total aerobic plate counts (TAPC) as a measure of overall bacterial contamination and disinfection effectiveness; the presence of *S aureus*, differentiating MRSA and methicillin-susceptible *S aureus* (MSSA) strains after isolation, as an indicator of a significant pathogen; and the presence of *C difficile*, differentiating nontoxigenic and toxigenic strains.

The bathroom and kitchen faucets were sampled for TAPC and *S aureus* only, by rubbing the entire surface of the handle with a sterile swab premoistened with D/E Neutralization Broth (Becton, Dickinson and Company, Franklin Lakes, NJ) to stop the activity of any residual disinfectant.

The toilet seat and bathroom floor next to the toilet were sampled for *C difficile* only, using Swiffer Sweeper dry cloths (Procter & Gamble, Cincinnati, OH), which pick up dust and soil electrostatically.²⁷ The toilet seat was split into left and right sides and 1 entire side was wiped before and after cleaning. The floor next to the toilet was sampled using a template with 20 cm × 20 cm (400 cm² in total) sampling areas, 1 for precleaning and 1 for postcleaning. The entire template area was wiped with a Swiffer cloth.

The kitchen floor, counter, sink, and bathroom tub or shower were sampled for ATP, TAPC, and *S aureus*. A 4-section sampling template was used to define the sample area (20 × 20 cm), with separate areas for ATP and swab sampling, as well as precleaning and postcleaning. ATP luminometer measurements were performed using Ultrasnap ATP Test swabs (Hygiene) following the manufacturer's instructions. Sterile swabs, premoistened in D/E Broth were used for TAPC and *S aureus* sampling.

After all precleaning samples were taken, a brief spot cleaning was performed on all surfaces: cleaning product was sprayed directly on the surface and wiped immediately with a paper towel, to model actual home cleaning methods. After 10 minutes to allow the product to dry, postcleaning samples were taken. After sampling, swabs were placed in 1 mL D/E Neutralization Broth, Swiffers

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