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Concise Communication

A randomized trial of ultraviolet-C (UV-C) light versus sodium hypochlorite delivered by an electrostatic sprayer for adjunctive decontamination of hospital rooms

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Abstract

In a randomized trial, adjunctive ultraviolet-C light treatment with a room decontamination device and sodium hypochlorite delivered via an electrostatic sprayer were similarly effective in significantly reducing residual healthcare-associated pathogen contamination on floors and high-touch surfaces after manual cleaning and disinfection. Less time until the room was ready to be occupied by another patient was required for electrostatic spraying.

"No-touch" decontamination devices are increasingly used as an adjunct to standard cleaning and disinfection in healthcare facilities.[1,2] The use of technologies, such as ultraviolet-C (UV-C) light, reduces contamination of surfaces and may reduce colonization or infection with healthcare-associated pathogens.[1–3] In a recent study, application of sodium hypochlorite disinfectant using an electrostatic sprayer provided rapid decontamination of portable equipment and wheelchairs.[4] Here, we conducted a pilot study to compare the effectiveness of this technology to a UV-C light room decontamination device in reducing residual contamination on high-touch surfaces and floors after manual cleaning and disinfection of hospital rooms. Floors were included due to evidence that floor contamination could be an underappreciated source of pathogen transmission.[5–8]

Methods

Study setting

During the 3-month study period, environmental services (EVS) personnel at the Cleveland VA Medical Center used an improved hydrogen peroxide disinfectant applied with microfiber cloths in non–*Clostridioides difficile* infection (CDI) rooms. Floors were mopped with a detergent (Prominence Heavy Duty Floor Cleaner, Diversey, Fort Mill, SC).

Randomized trial of UV-C versus electrostatic sprayer devices

After completion of manual cleaning and disinfection by EVS personnel, 40 non-CDI single-patient hospital rooms were randomized by block randomization to either UV-C (N = 20 rooms) or electrostatic spraying of sodium hypochlorite (N = 20 rooms). One research staff member (MC) operated the devices. EVS personnel were not aware of the study.

The UV-C device was a UVDI-360 Room Sanitizer (UltraViolet Devices, Santa Clarita, CA) that was operated for 5 minutes on each side of the bed and in the bathroom.[9] The wheeled electrostatic sprayer device (Clorox Total 360 System-Electrostatic Sprayer, Clorox, Oakland, CA) was plugged into an electrical outlet. A hand-held nozzle was used to direct a fine mist of Spore Defense Cleaner Disinfectant (Clorox) containing 0.25% sodium hypochlorite at a distance of 30–60 cm onto all room and bathroom high-touch surfaces and on the entire surface area of the floor.[4] Surfaces were allowed to air dry. Enough disinfectant was applied to allow all surfaces to remain visibly wet for 2 minutes or longer.

The time required to use each technology was measured for the first 5 rooms. The total time extended from when the device entered the room until the room was ready to be occupied by a patient. For the sprayer, the room was considered ready when the surfaces were dry.

Microbiology

Before and after use of the UV-C or electrostatic sprayer devices, cultures were collected from high-touch surfaces and the floor with cellulose sponges (Sponge Stick with neutralizing buffer, 3M, St Paul, MN). Three sets of high-touch standardized surfaces were
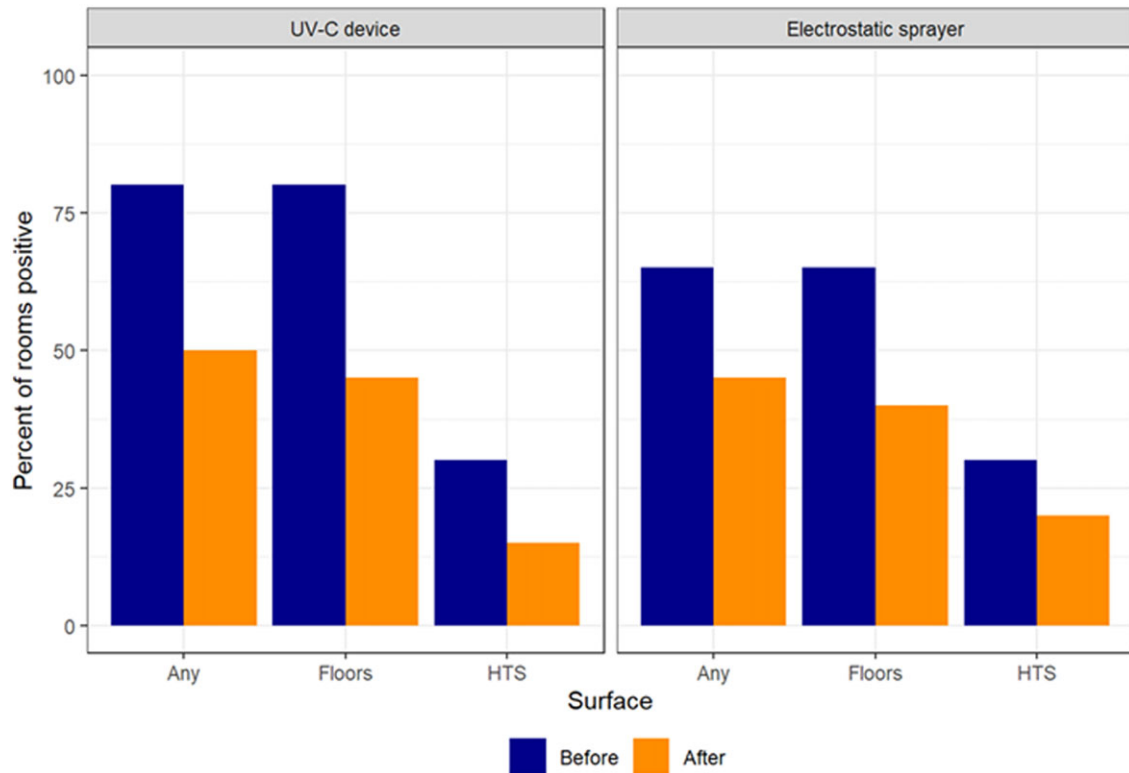
Fig. 1. Percentages of rooms with positive cultures for 1 or more healthcare-associated pathogens before versus after treatment with the ultraviolet-C (UV-C) light device or the electrostatic sprayer. Note. HTS, high-touch surface.

cultured: bed rail (60×60-cm areas before and after decontamination) and bedside table (60×60-cm areas before and after decontamination), call button and telephone (half sampled before and half after decontamination), and toilet seat and bathroom handrail (half sampled before and half after decontamination). Floor cultures were collected before and after decontamination from standardized 60×60-cm areas of the room (between the door and patient bed) and bathroom (between the door and toilet). The sponges were processed as previously described except broth enrichment cultures were not performed.[10] Aliquots were plated on selective media for recovery of MRSA, VRE, and toxigenic *C. difficile*.[10] The numbers of colonies recovered from selective media plates consistent with each pathogen were counted.[10]

Data analysis

The primary outcome was reduction in contamination of rooms with a composite of the 3 pathogens based on total colony-forming units (CFU) recovered. Secondary outcomes included the reduction in the percentage of rooms contaminated with 1 or more pathogens, and the reductions in the percentage and CFU contamination by individual pathogens and surface type. A generalized linear mixed model was estimated to compare the probability of contamination before versus after decontamination, including adjustment for type of surface and pathogen. Using the linear mixed model, odds ratios and 95% confidence intervals were calculated for reductions in contamination before versus after use of each device. Wilcoxon signed-rank tests were used to compare the total CFU recovered before versus after decontamination. Based on previous studies, we estimated that the UV-C device would reduce the total CFU recovered for the 3 pathogens by 88%.[1,3] Assuming

similar contamination across devices before cleaning, 20 rooms per group provided 80% power to detect a difference between devices of 75% versus 88% CFU reduction.

Results

Figure 1 shows the percentages of rooms with positive cultures for 1 or more pathogens before versus after adjunctive decontamination. Floors were contaminated more often than high-touch surfaces. Both technologies significantly reduced the probability of contamination after versus before treatment. For UV-C, the odds ratio was 0.24 (95% confidence interval [CI], 0.10–0.54; $P = .0008$). For the electrostatic sprayer, the odds ratio was 0.29 (95% CI, 0.13–0.62; $P = .002$). In the generalized linear mixed model, there was no significant difference in the percentage of rooms with contamination for the 2 technologies overall or for floors and high-touch surfaces considered separately.

Figure 2 shows box plots of the CFUs recovered before versus after treatment for a composite of all organisms and for individual pathogens. Before treatment, the number of CFUs recovered from floors was higher than the number recovered from high-touch surfaces (median, 2 versus 0, respectively). Using paired nonparametric Wilcoxon signed-rank tests, both technologies resulted in a significant downward shift in the CFU recovered. For UV-C, the V statistic was 105 ($P = .001$), and for the electrostatic sprayer, the V statistic was 91 ($P = .002$), with no significant difference in the CFU reductions achieved (Wilcoxon test statistic = 182.5; $P = .64$).

For the UV-C device, the average total time until the room was ready to be occupied by another patient was 23.8 minutes (range, 21.9–26.1), and for the electrostatic sprayer, the average total time was 20.4 minutes (range, 19.3–22.8; $P = .007$). For the electrostatic
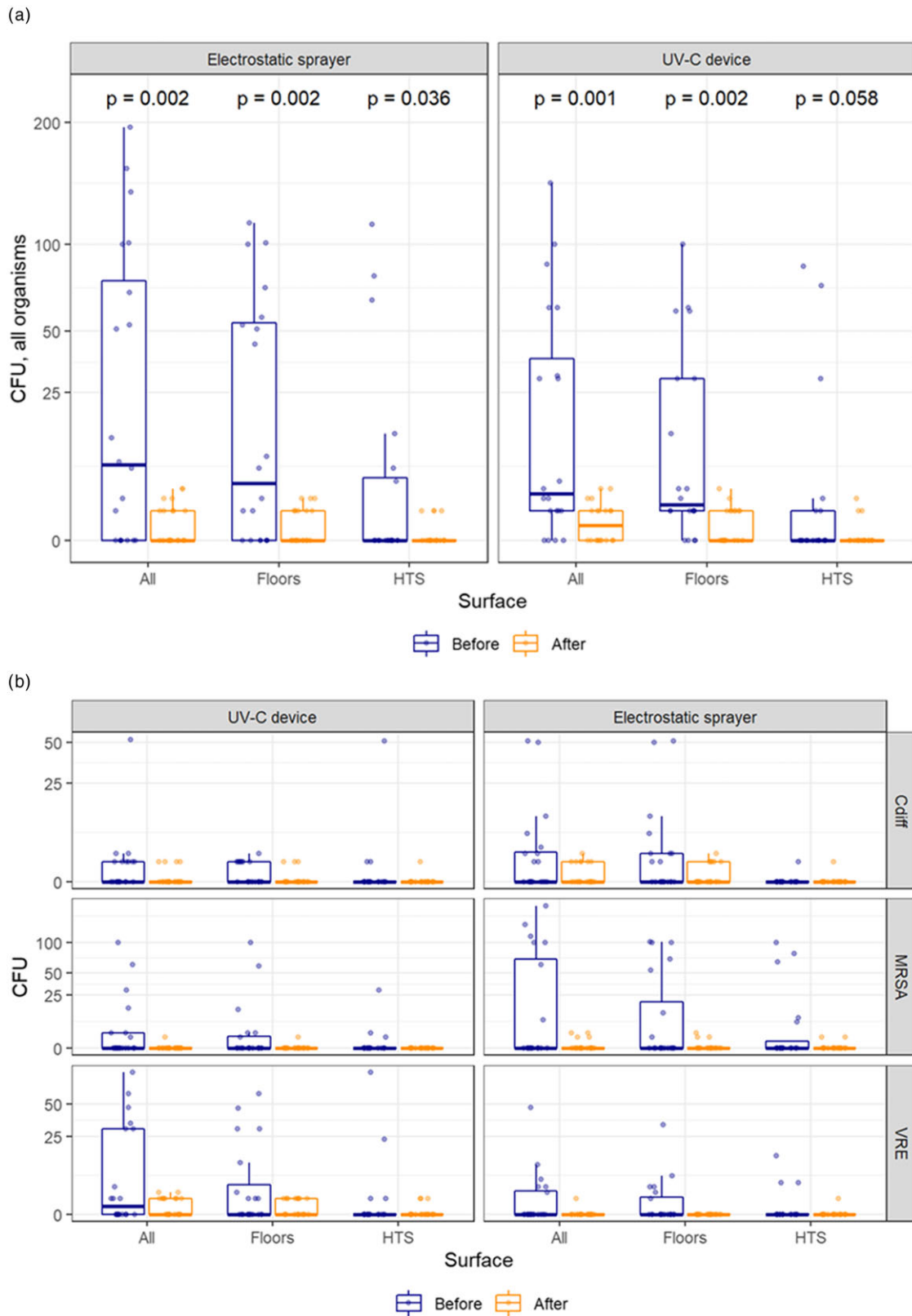
(a)

(b)

Fig. 2. Colony-forming units (CFUs) recovered with Tukey boxplot overlay before versus after treatment with ultraviolet-C (UV-C) light or sodium hypochlorite applied with an electrostatic sprayer, both for a composite of all organisms (A) and for individual pathogens (B). The top and bottom of the boxes indicate the interquartile range (IQR) and the middle horizontal line the median. Whisker end points extend to last value within 1.5 times the IQR above the third quartile or below the first quartile. Note. C diff, *Clostridioides difficile*; VRE, vancomycin-resistant enterococci; and MRSA, methicillin-resistant *Staphylococcus aureus*.

sprayer, the total time included an average of 8.2 minutes (range, 6.1–10.2) to operate the device and 12.4 minutes (range, 9.1–16.7 minutes) for air drying.

Discussion

High-touch surfaces and floors in patient rooms were frequently contaminated with healthcare-associated pathogens, even after manual cleaning and disinfection. Sodium hypochlorite delivered via an electrostatic sprayer and UV-C light were similarly effective in reducing residual contamination. The electrostatic spray technology required less overall time until the room was ready to be occupied by another patient than the UV-C device. These results suggest that the electrostatic sprayer technology could provide an effective and efficient adjunct to manual cleaning and disinfection.

In addition to efficacy and time requirements, ease of use, safety, and potential to damage surfaces are important considerations when assessing decontamination technologies. Personnel using the electrostatic sprayer device considered it relatively easy to use. According to the manufacturer, the dilute bleach solution is safe when sprayed with no requirement for protective equipment, but goggles are recommended.[4] The product left minimal to no residue, and there was no evidence of damage to surfaces during the study.

Our study had several limitations. Both technologies were operated by research personnel rather than environmental services personnel. Because the electrostatic sprayer is dependent on correct application, it is possible that the device could be less effective than UV-C in real-world settings with suboptimal application. Although there was no evidence of damage to surfaces, additional evaluations with repeated applications are needed. Only 3 pathogens were included in the assessment of contamination. Finally, the number of rooms studied did not provide sufficient power to exclude the possibility of substantial differences in the efficacy of the technologies.

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