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Brief Report

Efficacy of a novel ultraviolet light-emitting diode device for decontamination of shared pens in a health care setting

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Shared pens and styluses are a potential source for transmission of health care–associated pathogens and respiratory viruses in health care facilities. A novel ultraviolet light-emitting diode device was effective in reducing bacteria and viruses inoculated on pens and in reducing methicillin-resistant *Staphylococcus aureus* transferred to pens by colonized patients. The device could be useful in reducing the risk of transmission of pathogens by shared writing utensils.

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BACKGROUND

Contaminated writing utensils are a potential source for transmission of health care–associated pathogens and respiratory viruses in health care facilities. A variety of potentially pathogenic microorganisms, including methicillin-resistant *Staphylococcus aureus* (MRSA) and *Enterococcus* species, have been cultured from pens in health care settings.[1-5] In the setting of an MRSA outbreak, 25% of pens sampled were positive for MRSA strains with resistance patterns similar to the outbreak strain.[1] In an outpatient clinic, inoculation of the benign virus bacteriophage MS2 onto a shared pen in the waiting room resulted in spreading to 73% of sites tested, including hands and fomites.[4]

Wiping pens with disinfectant wipes is effective, but decontamination of pens is rarely performed in clinical settings.[5,6] In a survey, 45% of nursing students reported never cleaning writing devices during their clinical practice, and 30% reported using alcohol wipes.[6] Thus, there is a need for innovative approaches that can be automated and applied after each pen use. In addition, because alcohol disinfectants lack sporicidal activity, there is a need for approaches that can reduce *Clostridioides difficile* spores. In this study, we tested the effectiveness of a novel device for pen decontamination that uses ultraviolet-C (UV-C) light produced by light-emitting diodes (LEDs).

METHODS

The Steri-Write system (Steri-Write; North Canton, OH) is a small (12 inches tall × 9 inches wide × 4.5 inches deep) portable device designed for semiautomated pen decontamination and dispensing (Fig 1). The device contains 4 LEDs that emit 265-nm UV-C. Each LED emits 25 mW at the bulb surface. Pens placed in the top of the device are automatically loaded onto a conveyer system that rotates the pens to provide UV-C exposure to all sides for a total exposure time of 30 or 90 seconds. After cycle completion, decontaminated pens are dispensed at the base of the device.

In the laboratory, we tested the efficacy of the device against 1 strain each of MRSA (a clinical isolate with pulsed-field gel electrophoresis type USA400), carbapenem-resistant *Escherichia coli* (New Delhi metallo-β-lactamase-1–producing strain), *C difficile* spores (American Type Culture Collection number 43598), vancomycin-resistant *Enterococcus* (VRE) (a clinical VanB-type VRE isolate from the Cleveland VA Medical Center), *Candida auris* (Centers for Disease Control and Prevention strain 0381), the non-enveloped bacteriophage MS2 (American Type Culture Collection 15597-B1, and the

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Fig 1. Steri-Write device. Pens placed in the top of the device are automatically loaded onto a conveyer system that rotates the pens to provide ultraviolet-C exposure to all sides for a total exposure time of 30 or 90 seconds. After cycle completion, decontaminated pens are dispensed at the base of the device.

enveloped bacteriophage Phi X174 (American Type Culture Collection 13706-B1) using a modification of the American Society for Testing and Materials standard quantitative carrier disk test method (ASTM E-2197-02).[7]

The bacteriophages were propagated in *E coli* as previously described.[8] Ten-microliter aliquots containing 10^6 $\log_{10}$ colony-forming units (CFUs) or plaque-forming units (PFUs) of the organisms in 5% fetal calf serum were inoculated onto clean pens and allowed to air dry for 30 minutes. The pens were exposed to UV-C cycles of 30 or 90 seconds and then sampled with premoistened swabs that were vortexed for 1 minute in 2000 μL phosphate-buffered saline with 0.02% Tween. Serial dilutions were plated on selective media and $\log_{10}$ CFU or PFU reductions were calculated by comparing recovery from writing utensils after decontamination versus untreated controls. For each organism, triplicate samples were tested, and reductions for the 30- and 90-second exposures were compared by Student *t*-test.

To assess the efficacy of the device for elimination of pathogen contamination in clinical settings, we tested the ability of the device to eliminate MRSA contamination transferred to pens by colonized patients. Hospitalized MRSA-colonized patients used 2 clean pens to sign a document, with the use of each pen lasting approximately 30 seconds. One pen was cultured as previously described without decontamination, and the other was cultured after exposure to a 90-second cycle in the Steri-Write device. Fisher exact test was used to compare the proportions of contamination, and Student *t*-test was used to compare the mean numbers of colonies recovered for treated versus untreated pens. For a subset of the MRSA carriers, we also assessed the potential for MRSA to be transferred from pens to the hands of a second user. For this assessment, research personnel wearing sterile gloves received pens from patients and used them for writing as described previously; the gloved hands were sampled using premoistened swabs and processed as described previously. The facility's institutional review board approved the study protocol.

RESULTS

Figure 2 shows the efficacy of 30- and 90-second UV-C cycles in reducing pathogens on inoculated pens. The 90-second exposure was significantly more effective than the 30-second exposure in reducing *C auris*, VRE, MRSA, and bacteriophage Phi X174. With the

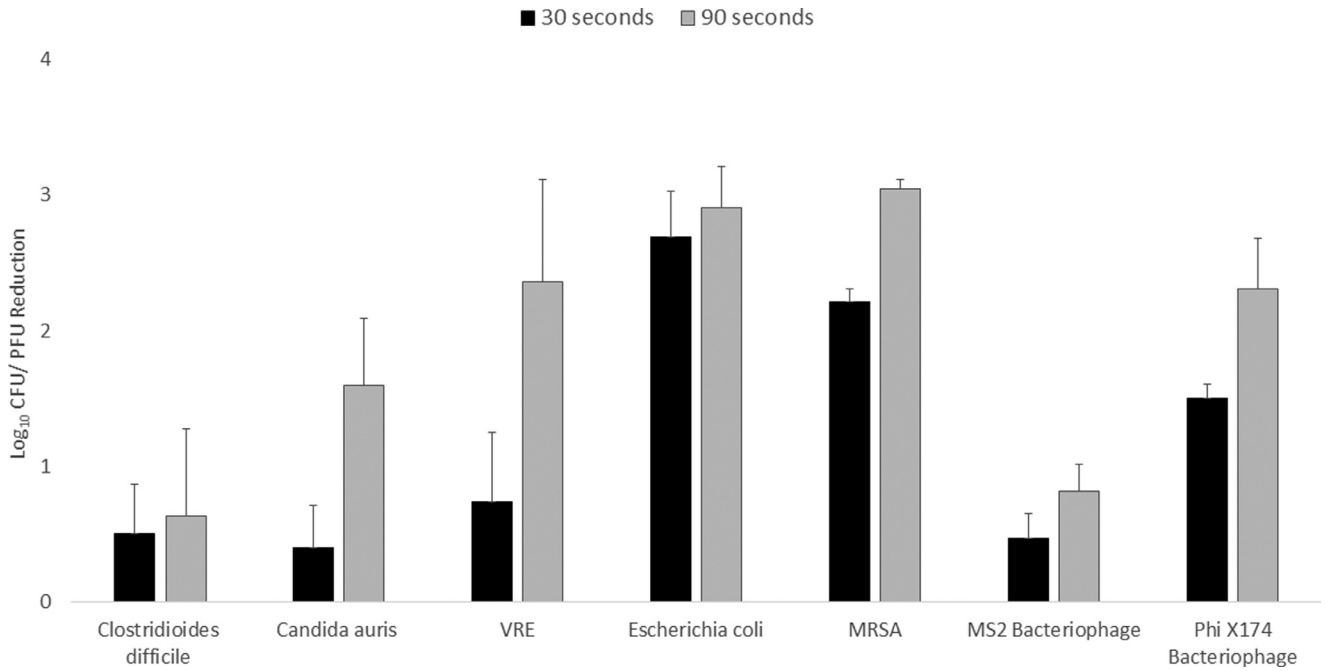

Fig 2. Efficacy of 30- and 90-second ultraviolet-C cycles in reducing pathogens on inoculated pens. *MRSA*, methicillin-resistant *Staphylococcus aureus*; *VRE*, vancomycin-resistant *Enterococcus*.

90-second exposure, recovery of VRE, MRSA, *E coli*, and Phi X174 were reduced by >2 log, whereas *C difficile* spores, bacteriophage MS2, and *C auris* were not. A total of 69 MRSA-colonized patients participated in the assessment of the efficacy of the 90-second UV-C cycle in reducing MRSA contamination transferred to pens. In comparison to untreated control pens, the 90-second UV-C cycle reduced the frequency of recovery of MRSA from 14 of the 69 participants (20%) to 2 (3%) ($P = .056$), and the mean number of MRSA colonies was reduced from 11 (range, 1-58 CFU) to 1.5 (range, 1-2 CFU) ($P = .001$). With regard to the assessment of transfer of MRSA from the hands of patients to pens and then to the hands of subsequent users, we found that MRSA was acquired on the hands of 5 of 17 (29%) personnel using a pen that had been used by a colonized patient. The mean number of MRSA recovered from the pens used by personnel was 31 (range, 1-98 CFU).

DISCUSSION

Shared pens and styluses are a potential source for pathogen transmission but are rarely cleaned. In the current study, we demonstrated that a novel semiautomated device emitting UV-C produced by LEDs was effective in reducing non-spore-forming bacteria and the enveloped virus Phi X174 inoculated on pens and in reducing MRSA transferred to pens by colonized patients. A 90-second UV-C cycle was more effective than a 30-second cycle. Our results suggest that the device could be useful in reducing the risk for transmission of pathogens by shared writing utensils.

The fact that the device had relatively limited activity against *C difficile* spores, *C auris*, and the non-enveloped virus MS2 is consistent with previous studies demonstrating reduced susceptibility of these organisms to UV-C.[9] In settings where such organisms are a concern, the device could be adjusted to provide a longer UV-C cycle. It should also be noted that, in real-world settings, pens would receive repeated dosing, which might eliminate residual contaminating organisms.

One novel aspect of the device is that it uses UV-C generated by LEDs. LEDs are well suited for decontamination of small items such as pens because of their compact size compared to low-pressure mercury bulbs.[10] LEDs have other potential advantages as a UV-C source, including lower energy requirement, long lifespan, minimal warm-up time, and allowing precise selection of the wavelength emitted.[10] LEDs may also offer some safety advantages, as they do not contain mercury and are sturdier than mercury bulbs.

Our study has some limitations. We tested only one UV-C cycle, whereas in clinical settings pens could receive numerous cycles per day. We did not test the efficacy of the device for decontamination of styluses. We did not compare the efficacy of the device with wiping with a disinfectant wipe. In practice, however, wiping of pens is uncommon. Finally, we did not include an assessment of the impact of factors such as relative humidity, temperature, or dust on the LED surface on the efficacy of decontamination.

CONCLUSIONS

We found that a novel UV-C device was effective in reducing contamination with non-spore-forming bacteria and an enveloped virus on pens. We recommend that additional studies be performed in health care settings to evaluate the efficacy of the device in reducing transmission of pathogens by shared writing utensils.

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