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Brief report

Evaluation of an enclosed ultraviolet-C radiation device for decontamination of mobile handheld devices

J. Itty Mathew MLS [a], Jennifer L. Cadnum BS [a,b], Thriveen Sankar MS, MNO [a,b], Annette L. Jencson CIC [b], Sirisha Kundrapu MD [a], Curtis J. Donskey MD [a,c,*]

[a] Case Western Reserve University School of Medicine, Cleveland, OH
[b] Research Service, Cleveland VA Medical Center, Cleveland, OH
[c] Geriatric Research, Education, and Clinical Center, Cleveland Veterans Affairs Medical Center, Cleveland, OH

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Mobile handheld devices used in health care settings may become contaminated with health care–associated pathogens. We demonstrated that an enclosed ultraviolet-C radiation device was effective in rapidly reducing methicillin-resistant *Staphylococcus aureus*, and with longer exposure times, *Clostridium difficile* spores, on glass slides and reducing contamination on in-use mobile handheld devices.

Mobile handheld devices (MHDs) are ubiquitous in health care settings, both for personal use and for delivery of patient care.[1] These devices may become contaminated with pathogenic bacteria that can be transmitted to the hands of health care personnel.[2] Wipes moistened with alcohol or bleach are effective in reducing levels of pathogenic bacterial load on MHDs,[3-5] and wipes moistened with saline or water may be similarly effective because of mechanical removal.[3] However, several studies have demonstrated that most health care personnel do not regularly clean their phones.[6] Moreover, device manufacturers discourage wiping of MHDs with disinfectants or abrasive materials of any kind because they may negatively affect screen quality.[7] Therefore, there is a need for rapid and easy-to-use methods that are effective for decontamination of MHDs without disturbing device integrity. Here, we examined the efficacy of an enclosed ultraviolet-C (UV-C) radiation device for decontamination of MHDs.

METHODS

The Sky 6Xi device (Daylight Medical, Middleburg Heights, OH) is an enclosed box measuring 0.8 cm × 38.1 cm × 13.3 cm, with a conveyer belt that delivers UV-C radiation in close proximity to MHDs (eg, tablet, personal computers, cell phones). Placement of mobile devices inside the Sky 6Xi device activates a conveyer belt that moves devices between 2 UV-C bulbs that are in close proximity to the surface of the device (~10 mm) and shielded from the user. The bulbs generate light at a wavelength of 254 nm. At the standard setting, the conveyer belt moves at a speed of 0.4 in/s, providing an intensity of approximately 100 Mw/cm^2, and requires approximately 15 and 50 seconds to decontaminate a standard cell phone and tablet, respectively. The device can also be set at 2 slower speed settings, termed Max Defense and Super Max Defense, designed to provide greater activity against spores. The Max Defense and Super Max Defense settings have conveyer speeds of 0.18 and 0.1 in/s, which yield approximately 215 and 380 Mw/cm^2 and require approximately 46 and 77 seconds to decontaminate a cell phone and 95 and 147 seconds to decontaminate a tablet, respectively.

We examined the efficacy of the Sky 6Xi device against methicillin-resistant *Staphylococcus aureus* (MRSA) and *Clostridium difficile* spores on glass slides with and without organic load using a modification of the ASTM's Standard Quantitative Carrier Disk Test Method (ASTM E-2197-02).[8] Organic load included a mixture of tryptone, bovine serum albumin, and bovine mucin prepared as described in ASTM E-2197-02.[8]

Three strains of each organism were studied. *C difficile* strains included American Type Culture Collection strain 43593, VA 17

* Address correspondence to Curtis J. Donskey, MD, Geriatric Research, Education, and Clinical Center 1110W, Cleveland VA Medical Center, 10701 East Blvd, Cleveland, OH 44106.
E-mail address: curtisd123@yahoo.com (C.J. Donskey).
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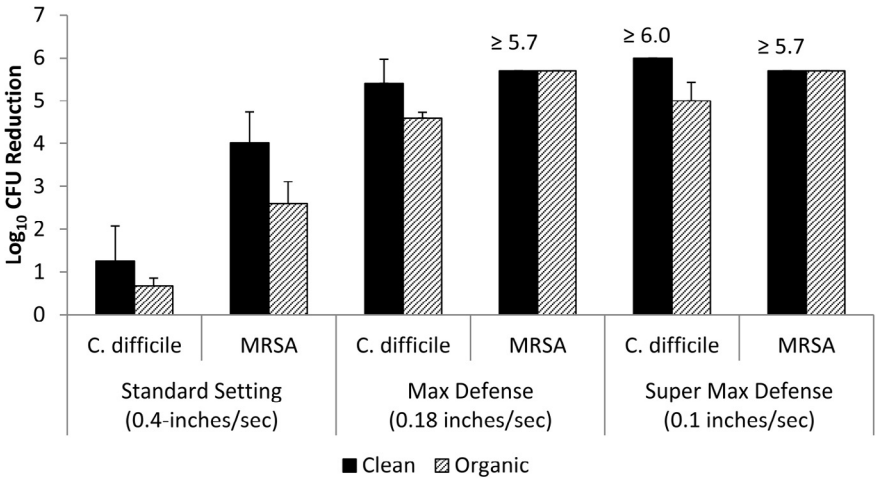

Fig 1. Mean reduction (log_{10} colony forming units [CFU]) in recovery of methicillin-resistant *Staphylococcus aureus* (MRSA) (2 strains) and *Clostridium difficile* (3 strains) spores from glass slides after use of the Sky 6Xi ultraviolet-C decontamination device at different conveyer belt speed settings termed Standard, Max Defense, and Super Max Defense, with or without organic load.[8]

(a restriction endonuclease analysis type BI strain), and VA 11 (a restriction endonuclease analysis type J strain). MRSA strains included 2 clinical isolates with pulsed-field gel electrophoresis types USA300 and USA800, and one American Type Culture Collection strain (43300). Glass slides were affixed onto a 4 × 6-in rectangular cardboard surface simulating the size of a tablet, placed inside an ultraviolet-permeable polypropylene sleeve provided by the manufacturer and either exposed to a decontamination cycle in the Sky 6Xi unit or not exposed (control). The carriers were neutralized with 5 mL of Dey-Engley neutralizer (Remel Products, Lenexa, KS). Serially diluted specimens were plated onto prereduced *C difficile* brucella agar[9] or CHROMagar (BD, Cockeysville, MD) containing 6 mg/mL cefoxitin to quantify *C difficile* spores and MRSA, respectively. Log_{10} colony forming unit (CFU) reductions were calculated by comparing the log_{10} CFU recovered from carriers after Sky 6Xi decontamination versus untreated controls. Experiments were performed in triplicate.

To assess real-world efficacy of the device, we cultured 50 MHDs of health care staff before and after decontamination with the device at the standard setting. One half of the surface area of each MHD was cultured using a sterile BBL CultureSwab (BD) before use of the Sky 6Xi device, and the other half was cultured after decontamination. Swabs were plated on CHROMagar, MacConkey agar, and trypticase soy agar containing 5% sheep blood (BD) to quantify MRSA, facultative and aerobic gram-negative bacilli, and total aerobic colony counts, respectively. Swabs were then inoculated into prereduced *C difficile* brucella broth for detection of *C difficile*.[9]

RESULTS

Figure 1 shows the mean log_{10} CFU/cm^2 reductions of MRSA and *C difficile* spores on glass slides. Because there were no significant differences in results for different strains, the data for 2 MRSA and 3 *C difficile* strains were pooled. At the standard setting in the absence of organic load, the Sky 6Xi device reduced MRSA and *C difficile* spores by >4 and >1 log, respectively; the reduction in MRSA was significantly reduced in the presence of organic load. At the slower conveyer speeds, MRSA was reduced by >5.7 log and *C. difficile* spores by >5.4 log in the absence of organic load. At the slower conveyer speeds, the reduction in *C difficile* spores, but not MRSA, was significantly reduced in the presence of organic load.

Table 1 shows the efficacy of the device at the standard setting in reducing contamination of MHDs of health care personnel. Fourteen percent of devices had contamination with ≥1 of the potential pathogens. The use of the device resulted in significant reductions in aerobic bacteria and in the pathogens cultured. There was no evidence of adverse effects to the devices.

DISCUSSION

We found that an enclosed UV-C device designed for decontamination of MHDs was effective in rapidly reducing MRSA, and to a lesser degree, *C difficile* spores, in a laboratory testing. At slower conveyer speeds, *C difficile* spores were reduced by ≥4.6 log, even in the presence of organic material. Consistent with previous studies,[2-6] we found that 14% of MHDs being used by health care

Table 1
Contamination of 50 mobile handheld devices before versus after treatment with the ultraviolet-C decontamination device

	n (%)			Mean CFU (range)		
Bacteria	Before	After	*P* value	Before	After	*P* value
Total aerobic and facultative bacteria	46 (90)	9 (18)	<.0001	46.5 (1-564)	0.4 (1-8)	.002
Gram-negative bacilli	1 (2)	0 (0)	1.0	6 (2-10)	0 (0)	–
Clostridium difficile	2 (4)	0 (0)	.49	ND*	ND	–
Methicillin-resistant *Staphylococcus aureus*	4 (8)	0 (0)	.12	5.8 (1-20)	0 (0)	–
Any potential pathogen†	7 (14)	0 (0)	.01	–	–	–

CFU, colony forming units; *ND*, no data.
**C difficile* cultures were nonquantitative.
†Any potential pathogen included gram-negative bacilli, *C difficile*, or methicillin-resistant *S aureus*.

personnel were contaminated with low levels of ≥1 health care–associated pathogen. The UV-C device was effective in significantly reducing contamination on the MHDs. Our results suggest that the UV-C device may provide a useful no-touch option for rapid and effective disinfection of MHDs.

The time required for disinfection of MHDs (15-77 seconds for cell phones, and 50-147 seconds for a tablet) was much shorter than the typical cycle times recommended for room disinfection (ie, ≥10 minutes).[10] This discrepancy reflects the fact that the efficacy of UV-C decreases markedly as the distance from the bulbs is increased.[10] Although the standard setting conveyer speed was very effective in reducing MRSA, the fact that *C difficile* spores were reduced by only approximately 1 log suggests that the longer exposure times might be beneficial, particularly in settings where spore contamination is a major concern.

Our study has some limitations. Our laboratory testing included only 2 pathogens, and a limited number of in-use MHDs were cultured. We did not test the efficacy of the slower conveyer speeds for decontamination of MHDs of personnel. We did not identify gram-negative bacilli recovered from MHDs to determine their pathogenic potential. In addition, we did not compare the effectiveness of the device with other methods that have been shown to be effective for decontamination of MHDs. There is a need for future studies to compare the use of the UV-C device with approaches such as wipes moistened with saline or water that are unlikely to adversely affect screen quality.

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