

In Vitro Evaluation of a UVC Based Shoe Sole Decontamination Device to Reduce Pathogen Colonization on Floors, Surfaces and Patients

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ABSTRACT (updated)

Background: Few infection control resources are devoted to control transfer of potentially pathogenic organisms from shoe bottoms. Recently, a UVC decontamination device has become available that delivers germicidal UVC radiation to shoe bottoms. The objective of this study was to demonstrate that shoe soles can be vectors for healthcare associated infection and that a UVC shoe bottom decontamination device would be effective at decreasing this risk.

Methods: Three clinical bacterial strains *Staphylococcus aureus* (SA 168), *Enterococcus faecalis*, and *Escherichia coli* (ATCC 25922), and a non-toxicogenic strain of *C. difficile* (ATCC 700057) were spiked onto standardized rubber soled shoe bottoms and then randomly selected to UVC exposure or no UVC exposure. Experiments were performed to test the efficacy of the UVC device to decontaminate shoe sole bottoms, flooring, and colonization of a simulated healthcare environment and patient.

Results: The UVC device significantly decreased shoe sole contamination for all tested bacterial species ($p < 0.01$ for each species). Shoe sole exposure to the UVC device significantly decreased floor contamination for all floor types and species tested ($p < 0.01$, for all experiments). Log₁₀ reduction was the highest for *E. coli* (2.6 ± 0.79) followed by *E. faecalis* (2.19 ± 0.68), *S. aureus* (1.74 ± 0.88), and *C. difficile* (0.42 ± 0.54) ($p < 0.0001$, all analyses). Exposure of shoe soles to the UVC device significantly decreased contamination (mean log₁₀ reduction: 2.79 ± 1.25 ; $p < 0.0001$). Proportions of samples from furniture, bed, and patient samples decreased from 96-100% positive in controls compared to 5-8% in UVC device experiments ($p < 0.0001$, for all analyses).

Conclusion: A UVC decontamination device was shown to reduce CFU counts of relevant pathogenic organism from shoe soles with subsequent decreased colonization of floors, healthcare equipment and furniture, beds, and a patient dummy.

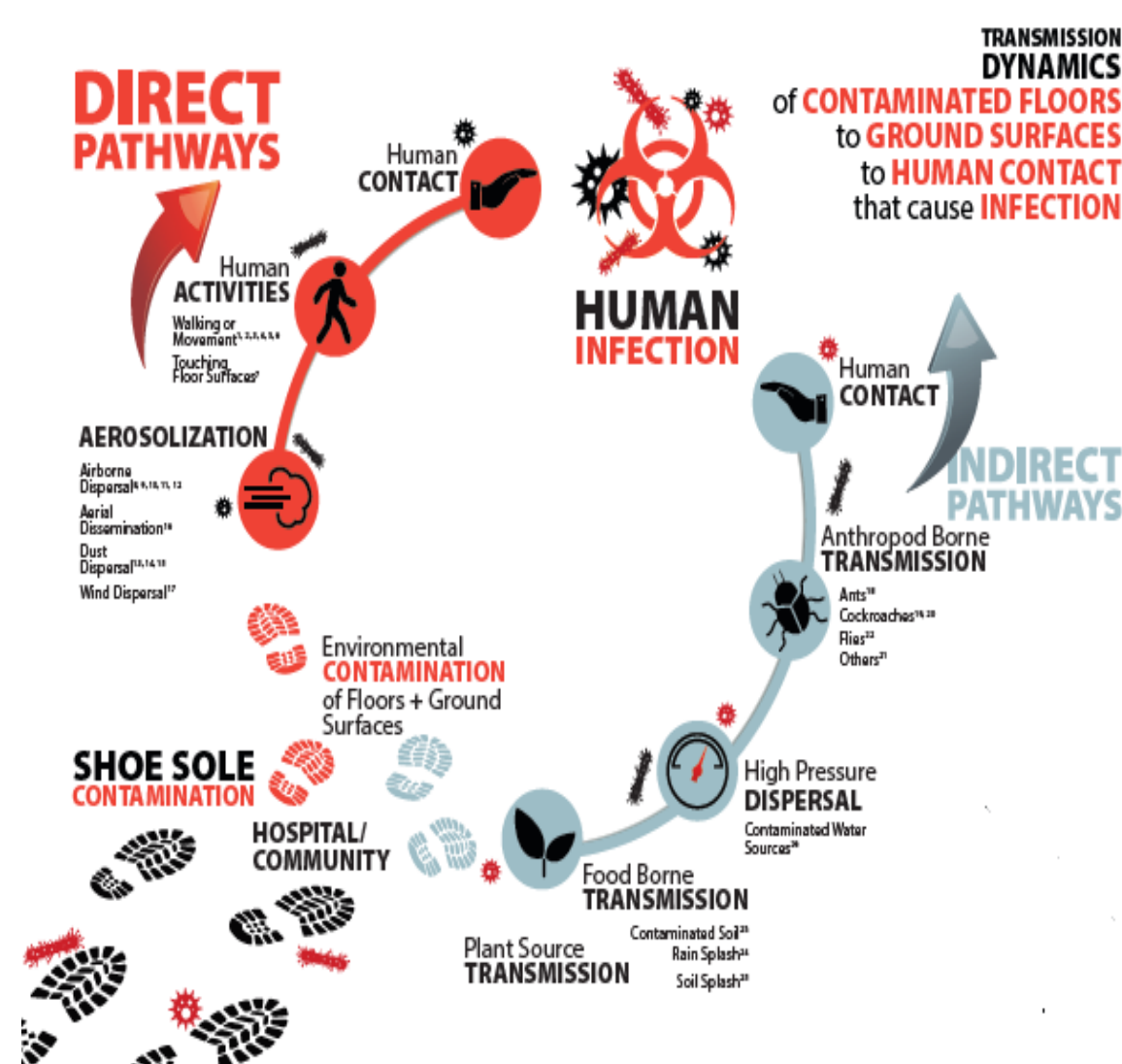
OBJECTIVE

To determine the in vitro efficacy of an UVC based shoe sole decontamination device on decontaminating shoe bottoms and decreasing the transmission/colonization risk of indicator bacteria to health care environs.

BACKGROUND

- Healthcare associated infections (HAIs) are one of the leading cause of morbidity and mortality in US and worldwide (1 out of every 25 patients).
- HAIs account for \$25 to \$31.5 billion health care cost each year.
- Shoe-soles have been found to be highly contaminated with various microbial pathogens and are an important source of HAIs.
- Effective cleaning of shoe soles may be an important strategy in primary prevention of various HAIs including *Vancomycin Resistant Enterococci* (VRE), *Methicillin Resistant Staphylococcus Aureus* (MRSA) and *Clostridium difficile*.
- Currently there is no effective decontamination strategy for shoe-soles.

MECHANISM OF SHOE SOLE MEDIATED INFECTION



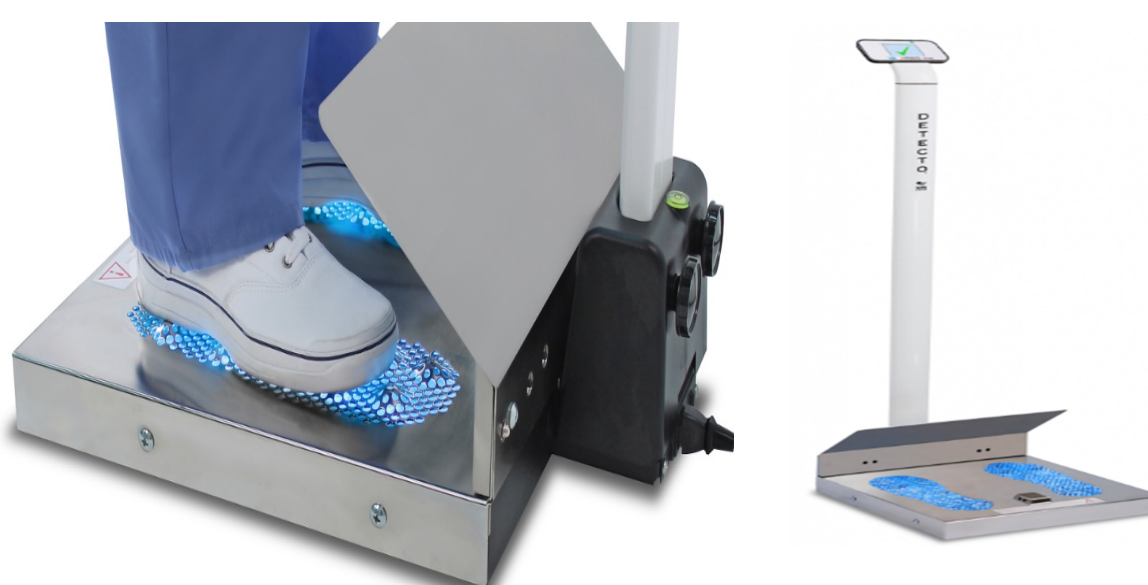
METHODS

HealthySole (HS) Plus Device

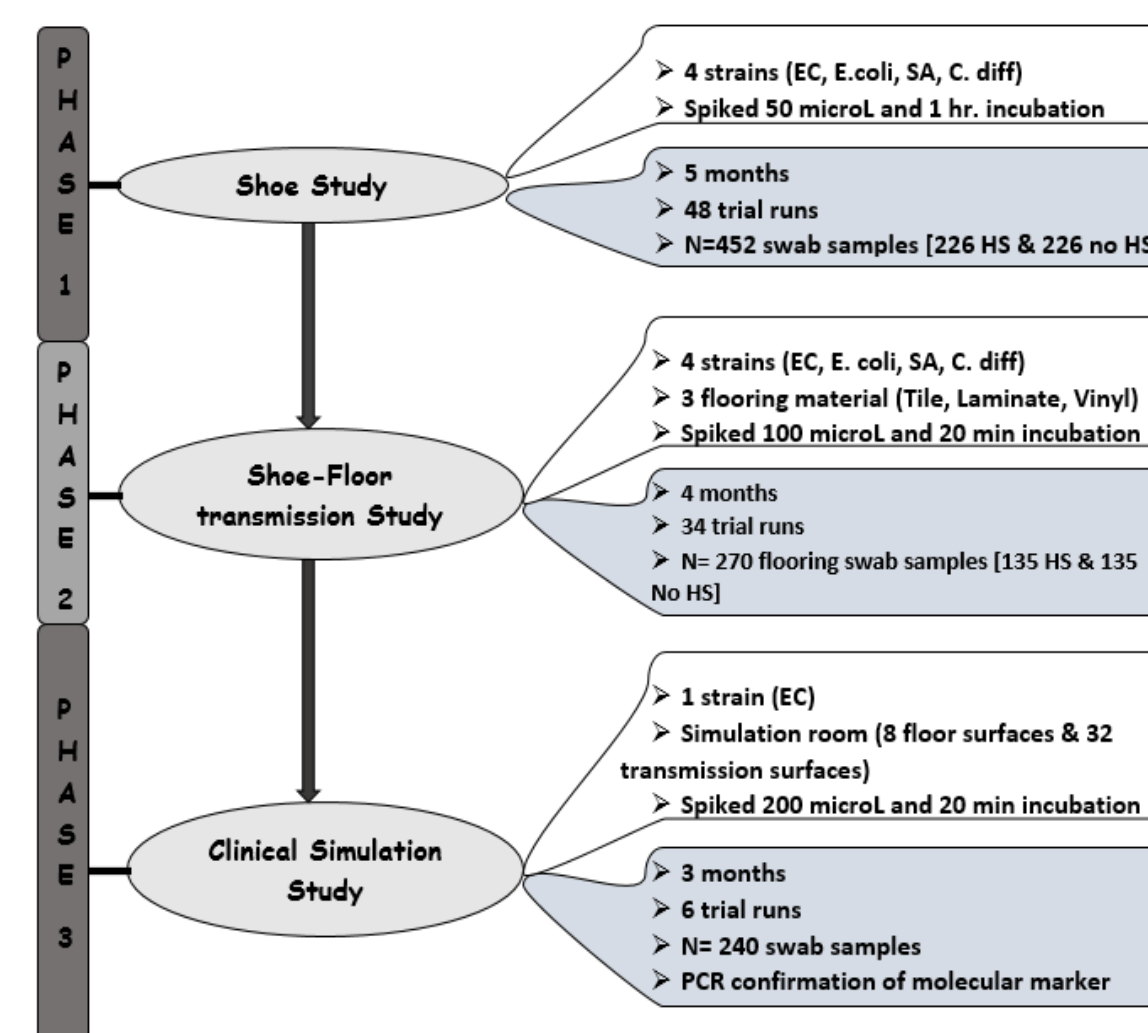
Device Specification

- UVC lamp with plasma stable and plastic encapsulated technology
- UV view top plate reflects and retracts UV rays for effective killing
- Disinfection time – 8 sec
- Shoe sole disinfection

UVC – Ultraviolet radiation with wavelengths between 200 and 290 nm



Study flow diagram



RESULTS

Table1. Mean log₁₀ difference in CFU counts on flooring surfaces in UVC exposed shoes vs. controls

Species	Flooring	N	Mean log ₁₀ difference in CFU count on flooring (UVC device vs. control)	P value
<i>S. aureus</i>	Vinyl	20	1.85±0.55	<0.0001
	Tile	20	1.56±1.33	0.017
	Laminate	20	1.8±0.57	<0.0001
<i>E. coli</i>	Vinyl	20	2.63±0.79	<0.0001
	Tile	20	2.69±0.88	<0.0001
	Laminate	20	2.48±0.62	<0.0001
<i>E. faecalis</i>	Vinyl	20	2.16±0.85	<0.0001
	Tile	20	2.11±0.61	<0.0001
	Laminate	20	2.29±0.60	<0.0001
<i>C. difficile</i>	Vinyl	30	0.34±0.33	0.0093
	Tile	30	0.55±0.56	0.013
	Laminate	30	0.43±0.45	0.016

Figure 1. Randomized, blinded, clinical simulation study of shoe soles exposed to UVC device vs. controls.

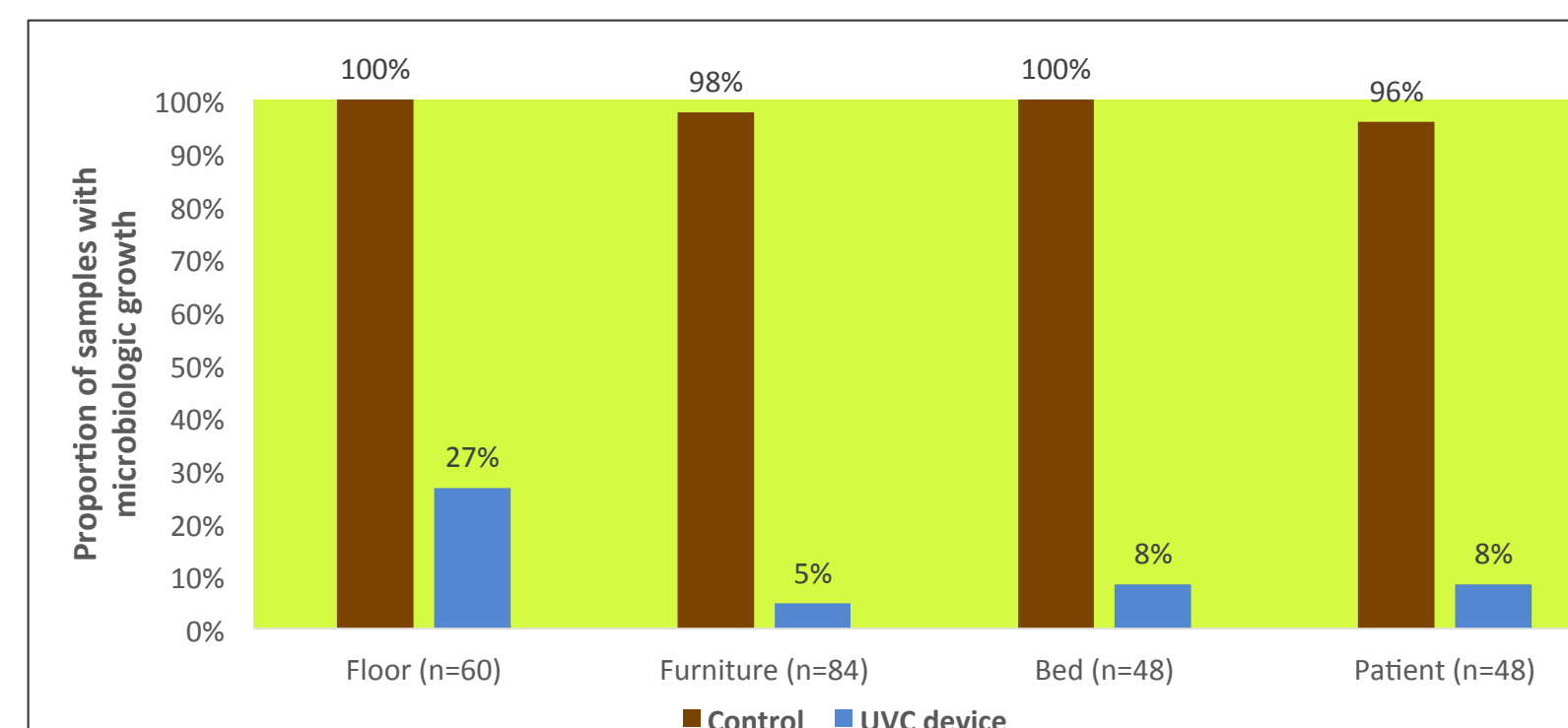
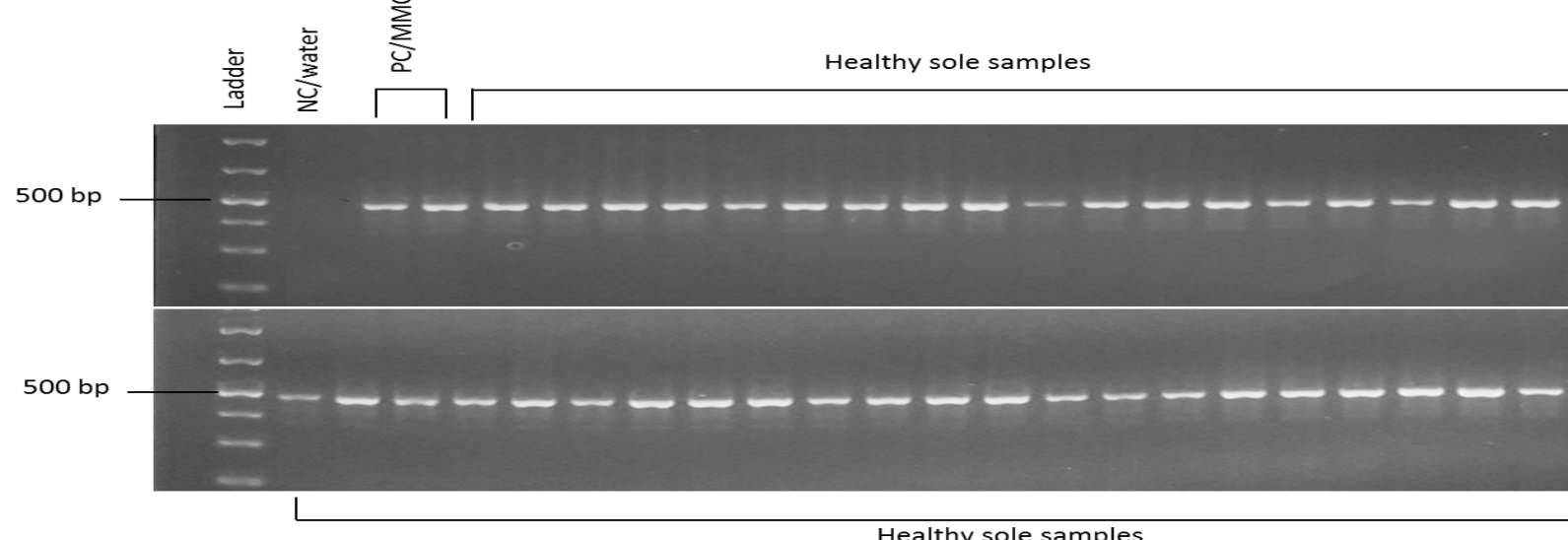


Figure 2. PCR amplification of van C2/C3 gene positive *Enterococcus* species



SUMMARY

- The UVC device significantly decreased shoe sole contamination for all tested bacterial species
- In shoe soles exposed to the UVC device, log₁₀ reduction was highest for *E. coli* (2.81 ± 0.80) followed by *S. aureus* (2.67 ± 0.81), *E. faecalis* (2.10 ± 0.62), and *C. difficile* (0.42 ± 0.68) ($P < 0.01$)
- Shoe sole exposure to the UVC device significantly decreased floor contamination with Log₁₀ reduction highest for *E. coli* (2.6 ± 0.79) followed by *E. faecalis* (2.19 ± 0.68), *S. aureus* (1.74 ± 0.88), and *C. difficile* (0.42 ± 0.54) ($p < 0.0001$, all analyses).
- In Clinical simulation experiments, exposure of shoe soles to the UVC device significantly decreased contamination compared to control (mean log₁₀ reduction: 2.79 ± 1.25 ; $p < 0.0001$).

CONCLUSION

- This UVC based device was shown to reduce CFU counts of relevant pathogenic organisms on shoe soles with subsequent decreased transmission to floorings and health care environs.
- UVC based shoe sole decontamination device may have a potential role in the control of HAIs.

REFERENCES

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HealthySole Plus (HealthySole LLC, Minden NV)