Use of Light for HAI Reduction

John M. Boyce[1]

[1]J.M. Boyce Consulting, LLC, Middletown, CT

*Corresponding author: jmboyce69@gmail.com

The emergence of *Clostridioides difficile* and multidrug-resistant organisms (MDROs) such as methicillin-resistant *S. aureus* (MRSA) and vancomycin-resistant enterococci (VRE) and their persistence on commonly touched surfaces despite routine disinfection practices led to the introduction of "no-touch" technologies including mobile ultraviolet light (UV) devices to supplement manual disinfection of surfaces and reduce healthcare-associated infections (HAIs).

Early studies showed that an automated mobile UV-C device with on-board sensors was able to kill vegetative bacteria such as MRSA and VRE and *C. difficile* spores on inoculated carriers and on commonly touched surfaces in patient rooms [1, 2]. On average, the device reduced MRSA and VRE by > 3-4 $\log_{10}$ colony forming units at a reflected dose of 22,000 uWsec/cm^2 and *C. difficile* spores by > 2-3 $\log_{10}$. Log_{10} reductions were greater on surfaces in direct line of sight of the device than on surfaces in shadowed areas (indirect light). Cadnum et al. evaluated several test method variables and demonstrated that the type and size of carriers, method of carrier inoculation, test organism (MRSA vs *C. difficile*), orientation of carriers (in parallel vs perpendicular to the device) and organic load can influence the $\log_{10}$ reductions achieved [3].

Several subsequent studies used quantitative radiometers to demonstrate that UV-C intensity and doses delivered to various surfaces in patient rooms vary tremendously based on distance from and orientation relative to the device, and exposure to direct vs indirect light. Log_{10} reductions achieved were correlated to intensity and doses delivered [4, 5]. Qualitative colorimetric dose indicators designed to determine if target pathogens on surfaces received adequate doses appear to be inexpensive, useful alternatives to radiometers [4, 6].

Nine studies (3 utilized UV-C and 6 used pulsed-xenon [PX-UV]) evaluated the impact of UV light on colonization and/or infection due to MDROs (Table) [7 – 16]. Of 8 trials performed in single facilities with variable design and duration, 5 yielded significant reductions in MDROs and/or *C. difficle* infection (CDI). The most rigorous study, a cluster-randomized trial, used UV-C in rooms after discharge of patients with MDROs and assessed acquisition or infection among patients admitted to those rooms. The incidence of target organisms among exposed patients was significantly lower when UV was added to standard disinfection [9]. Hospital-wide acquisition of *C. difficile* and VRE were reduced significantly ($p = 0.03$ and $p = 0.048$, respectively) [10].

Few publications have reported comparisons of different devices, which makes decisions regarding device selection problematic. PX-UV devices yield lower $\log_{10}$ reductions than devices emitting UV-C. Research needs include additional studies of the following: UV doses achieved on various surfaces in patient rooms, comparative efficacy of various devices (preferably using standard methodology), performance of colorimetric dose indicators, and the impact of UV devices on MDRO transmission and the incidence of HAIs.

Table. Studies evaluating the impact of UV light on healthcare-associated infections (HAIs)

Year	1st Author	UV Type	Setting	Findings
2013	Sitzlar	UV-C	Hospital-wide	UV did not contribute to reduced CDI, as enhanced daily cleaning yielded negative cultures before UV use
2017	Pegues	UV-C	3 Hematology Oncology units	UV in CDI & Contact Precautions rooms reduced CDI incidence by 25% ($p = 0.03$)
2017 2018	Anderson	UV-C	9-Hospital RCT	Acquisition of target organisms was reduced in patients exposed to high-risk rooms ($p = 0.36$). Hospital-wide *C. difficile* ($p = 0.03$) and VRE ($p = 0.048$) were reduced significantly
2013	Levin	PX-UV	Hospital-wide	UV use in 56% of discharges resulted in a 53% reduction in CDI incidence
2014	Haas	PX-UV	Hospital-wide	UV use in 76% of Contact Precaution room discharges & other high-risk areas significantly reduced MDROs + CDI by 20%.
2015	Miller	PX-UV	Long-Term Acute Care Facility	Use of multidisciplinary team followed by UV disinfection of all discharges + communal areas reduced CDI incidence by 57%
2016	Vianna	PX-UV	Intensive Care Unit	UV of all discharges from ICU & non-ICU CDI rooms significantly reduced VRE in ICU and CDI on non-ICU units
2017	Green	PX-UV	Burn unit	UV reduced environmental contamination, but did not significantly reduce HAIs
2019	Brite	PX-UV	Bone marrow transplant unit	UV did not significantly reduce VRE or CDI among stem cell transplant recipients

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