Use of Light for HAI Reduction

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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. difficile* 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)

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

References
1. Nerandzic MM et al. BMC Infect Dis 2010;10:197