Automated Room Disinfection Technology: A Q&A with William Rutala

William A. Rutala, PhD, MPH, CIC, the associate chief medical officer for the UNC Medical Center; medical director of the Departments of Hospital Epidemiology and Occupational Health Service; and director of the North Carolina Statewide Infection Control Program (SPICE), about the role that automated room disinfection technology plays in environmental hygiene.

Why is rigorous manual cleaning critical before the use of automated room disinfection technology?

WRT: Surface disinfection of noncritical surfaces and equipment is normally performed by manually applying a liquid disinfectant to the surface with a cloth, wipe, or mop. Recent studies have identified substantial opportunities in hospitals to improve the cleaning/disinfection of frequently touched objects in the patient's immediate environment. For example, of 20,646 standardized environmental surfaces (14 types of objects), only 9,390 (46 percent) were cleaned by terminal room cleaning/disinfection. Studies have also shown that patients admitted to rooms previously occupied by patients infected or colonized with methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant enterococci (VRE), and Clostridium difficile (C. difficile) are at significant risk of acquiring these organisms from contaminated environmental surfaces. These data have led to the development of room decontamination units that address the lack of thoroughness of terminal cleaning/disinfection activities in patient rooms. The rationale for rigorous manual cleaning/disinfection before the use of ultraviolet-C (UV-C) technology is that organic material can interfere with disinfection technologies, including UV-C. Thus, surfaces must be cleaned/disinfected prior to "no touch" room decontamination technology such as UV-C.

Has the shadowed-areas dilemma been addressed by new generations of UV-C technology, or is this still an unresolved issue? What are the potential disadvantages/challenges to UV-C technology and what are some best practices for optimal use of and improved outcomes from these devices?

WRT: Since UV-C is less effective in shadowed or indirect line-of-sight areas, some UV-C devices have monitored UV-C in shadowed areas. Several studies have demonstrated a greater log_{10} reduction with direct line-of-sight compared to shadowed or indirect line-of-sight. For example, one study, using a device with UV sensors, found UV-C radiation was more effective when there was a direct line-of-sight to the contaminant, but meaningful reductions (3.3-3.9 mean log_{10} reduction for bacteria) occurred when the contaminant was "shadowed" and not directly exposed to the UV-C (e.g., back of computer, back of the head of bed).

What are some of the disadvantages or challenges associated with UV-C?

WRT: All technologies and products have advantages and disadvantages. Some of the challenges associated with UV-C include:

- All patients and staff must be removed from the room prior to decontamination
- Decontamination can only be accomplished at terminal disinfection
- Capital equipment costs are high

UV-C has long been positioned as an adjunct measure to proper and rigorous surface cleaning and disinfection; is there reason to believe that it could eventually supplant manual cleaning, or will it always be supplemental?

WRT: There is no reason to believe that UV-C would eventually supplant manual cleaning/disinfection. UV-C will likely remain supplemental to manual cleaning/disinfection with "no-touch" room decontamination technologies following the process as a second step. Since there is no technology currently available that will effectively clean elevated, irregular surfaces in a patient room or dirt and debris, manual cleaning/disinfection is key.

While one study demonstrated that UV-C reduced aerobac bacterial counts in the absence of manual cleaning/disinfection, this data should not support the abandonment of manual disinfection as it removes dirt and debris that are not eliminated by "no touch" technologies.

However, there likely will be improvements, including mechanical robots, that reduce staff time. Robots have already assisted healthcare staff in a variety of tasks such as transporting supplies and medications. It is plausible a robot can transport a UV-C device between rooms, find the geometric center of the room, activate the UV-C system and ensure the room is blocked to entry from patients and staff while operating.
• UV-C does not remove dust and stains which are important to patients and visitors, and hence cleaning and disinfection must precede UV room decontamination.
• Sensitivity to parameters (e.g., wavelength, UV dose delivered, distance, time).
• Requires equipment and furniture be moved away from walls.

**Q&A**

What are some best practices for optimal use of and improved outcomes from these devices?

**WRK**: Over the last decade, multiple trials have assessed the efficacy of "no-touch" units for reducing healthcare-associated infections (HAIs). There are at least six clinical trials that demonstrate a reduction of HAIs with the use of hydrogen peroxide systems and seven that demonstrate a reduction in HAIs with UV-C. One study showed enhanced room decontamination strategies (i.e., bleach and/or UV-C decontamination) decreased the clinical incidence of acquisition of target multidrug-resistant organisms (i.e., MRSA, VRE, C. difficile) by 10 to 36% (p<0.05). 35 Comparing the best strategy with the worst strategy (i.e., spray vs spray/UV) revealed that a reduction of 54 percent in epidemiologically important pathogens (i.e., 6.08 CFU per room vs 3.4 CFU per room) led to a 35 percent decrease in colonization/infection (2.3 percent vs 1.5 percent). These data demonstrated a decrease in room contamination was associated with a reduction in patient colonization/infection. Based on this, hospitals should use a "no-touch" device for terminal room decontamination, after discharge of patients on Contact Precautions. Given the multitude of options, Infection preventionists should read the peer-reviewed literature and purchase devices with demonstrated bactericidal capability, and ideally those shown to reduce HAI. 36

**WRK**: What are the advantages of UV-C technology?

**WRK**: Over the last decade, substantial scientific evidence indicates contamination of environmental surfaces in hospital rooms plays an important role in the transmission of key healthcare-associated pathogens. A growing number of clinical studies have demonstrated that ultraviolet devices and other "no-touch" technologies when used for terminal disinfection can reduce colonization or HAIs in patients admitted to these hospital rooms. 37 UV-C systems' advantages include:

- Studies show use of UV-C reduces HAIs.
- Reliable microbicidal activity against a wide range of healthcare-associated pathogens.
- Room surfaces and equipment decontaminated.
- Room decontamination is rapid (5-25 minutes) for vegetative bacteria.
- Effective against C. difficile spores, although requires longer exposure (10-50 minutes).
- HVAC (heating, ventilation, and air conditioning) system does not need to be disabled and the room does not need to be sealed.
- UV is residue free and does not give rise to health or safety concerns.

**WRK**: Good distribution in the room of UV energy via an automated monitoring system.

**WRK**: No consumable products so operating costs are low (only cost = acquisition and staff time).

**WRK**: There have been many claims made by manufacturers of UV-C technology, some of which have been refuted by studies, some have been confirmed by science – how do end users cut through all of this "white noise" and focus on the science?

**WRK**: Research shows that surfaces in hospital rooms are often insufficiently cleaned during terminal cleaning/disinfection. Although methods of assessing the adequacy of cleaning/disinfection varied (e.g., adenosine triphosphate bioluminescence, fluorescent dye), studies have demonstrated that <50 percent of room surfaces were properly cleaned. Numerous reviews concluded that improved cleaning/disinfection leads to reductions in HAI. 38 Importantly, the studies that have assessed interventions to improve cleaning/disinfection have reported that after the intervention, approximately 5 percent to 30 percent of surfaces remain potentially contaminated. Besides the demonstrated failure of interventions to achieve consistent and high rates of cleaning and disinfection of room surfaces, new “no-touch” methods of room disinfection have been developed. 39

When focusing on the science, there appears to be substantial consistency across many studies regarding the effectiveness of UV-C. However, it is worth noting that most studies have used the same device with only a few of the commercially available devices having actually been studied. Notably, the time needed to inactivate pathogens has been shown to be shortened by use of UV reflective wall paint for multiple different UV-C devices. 40

As mentioned above, data shows that hospitals will benefit from using a “no-touch” device for terminal room decontamination. The key is to ensure the “no-touch” device chosen has demonstrated the ability to reduce HAIs. 41

**WRK**: This technology can be expensive; how can end users make a business case to their institutional leadership?

**WRK**: It has been estimated that 1.7 million patients develop a HAI each year in the United States, causing or contributing to the death of nearly 100,000 people. Excellent evidence in scientific literature shows that environmental contamination plays an important role in the transmission of several key healthcare-associated pathogens including MRSA, VRE, Acinetobacter and C. difficile. The problem is multiple studies have demonstrated that surfaces in hospital rooms poorly cleaned during terminal cleaning/disinfection put the next patient at risk for the previous patient’s pathogen. It is promising, however, that “no-touch” technology used for terminal disinfection has been shown to reduce 10 percent to 30 percent of colonization/infection in patients admitted. 42

Although a formal analysis should be done, one can estimate the cost avoided by this technology. For example,
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if three UV-C units were purchased and three environmental services staff were hired to transport and operate the unit, the first-year cost would be approximately $405,000 (covering equipment and personnel) and the second-year cost would be approximately $150,000 (staff only). If the UV-C reduced HAs for patients on Contact Precautions (approximately 20 percent of patients) by 10 percent to 30 percent as demonstrated in a randomized trial, the number of infections prevented in a 500-bed hospital with an infection rate of about 4 per 1,000 patient days would be approximately 18-55 per year. If each HA cost $24,000 on average, the hospital would need to prevent only 23 HAs in the first two years to cover the acquisition and operational costs of the UV-C program for two years. If the hospital prevented 10 percent of infections per year (18 per year) for two years, the cost savings would be $399,000. If 30 percent of infections were prevented per year ($55 per year for two years), the cost savings would be $2,095,000. In an independent analysis, Pegues, et al. calculated a cost savings for C. difficile of $348,528 to $1,537,000 per fiscal year.

What is the next frontier for this technology in terms of the clinical/cleaning challenges that can be addressed?

WR: While “no-touch” technologies are effective, they have limits as they require rooms without people. Also, surfaces in patients’ rooms can rapidly become re-contaminated and may be perpetually contaminated despite room cleaning/disinfection. The hands of healthcare providers can become colonized by touching contaminated environmental surfaces and patient-care equipment and can transfer pathogens by inadequate hand hygiene or inappropriate glove use. Since routine disinfection of room surfaces is frequently inadequate, continuous room decontamination methods are being evaluated. This technology is intended to make surfaces hygienically clean (not sterile), and free of pathogens in sufficient numbers to prevent human disease. The technologies include: visible light disinfection (high-intensity narrow-spectrum light); low-concentration hydrogen peroxide; continuously active disinfectants; and self-disinfecting surfaces (e.g., copper). These methods are under active investigation and need to be assessed for their ability to reduce HAs.

References:

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