

## Journey on Environmental Cleaning to UV-C Disinfection to Minimize HAI Cross-Transmission Risk at The Ohio State University

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**Background:** Healthcare associated infections (HAIs) are infections that patients acquire during the course of receiving treatment for other conditions and are not present or incubating prior to admission to a healthcare facility [1]. Major organisms associated with HAIs include: methicillin resistant *Staphylococcus aureus* (MRSA), Vancomycin resistant enterococci (VRE), Carbapenem Resistant Enterobacteriaceae (CRE) including *Klebsiella pneumonia* (CR-Kp), *Acinetobacter baumannii*, and *Clostridioides difficile* (*C. difficile*). CRE and *C. difficile* remain “urgent threats” according to the Centers for Disease Control and Prevention, in both the 2013 and 2019 Antibiotic Resistant Threat Reports [2]. Reducing the risk of HAIs demands a multi-faceted approach with emphasis on hand hygiene, antimicrobial stewardship, isolation precautions and environmental cleaning and disinfection. The environment of a hospital room is frequently colonized with organisms of the previous occupant(s)[3]. The aim of our work is to share research on environmental cleaning observations, initial single UV-C emitter findings and in-hospital studies of UV-C disinfection with Surfacide™, healthcare onset *C. difficile* infections (HO-CDI) and implementation of a multi-emitter UV-C system over the initial four years.

**Methods:** Hospital in-patient care units with the highest rates of HO-CDI were chosen for one observer to make observations of the environmental surfaces (EVS) staff, while cleaning the patient care rooms over 5 non-consecutive years. A checklist was created to validate the cleaning techniques: adequate, attempted but inadequate, not attempted and wrong cleaning solution. Data was collated over the 5 years [4].

For UV-C study, surfaces were inoculated with spores of *C. difficile* ( $10^5$  Colony forming units-CFUs/cm<sup>2</sup>), VRE ( $10^6$  CFUs/cm<sup>2</sup>), MRSA and *A. baumannii* ( $10^7$  CFUs/cm<sup>2</sup>) and CR-Kp ( $10^9$  CFUs/cm<sup>2</sup>). One UV-C disinfection emitter (Surfacide™) was deployed against 4 different surfaces to assess the amount of energy necessary to decrease the organism burden. Surfaces were exposed to varying levels of UV-C energy in mJ based on time and distance from the emitter to assess for eradication of organisms[5]. At the conclusion of the initial study emitters were re-designed to deliver more energy. Microbes were again inoculated on 4 surfaces: soft and hard plastic, ceramic, stainless steel and these coupons were placed in the location and orientation at 6 unique sites in a hospital room. Log reductions were determined.

A study was performed in terminally bleach cleaned rooms previously occupied by a patient with *C. difficile* infection to assess for presence of *C. difficile* spores, post bleach vs. bleach + UV-C, (<10CFUs vs  $\geq 10$ CFUs), respectively for each, on 9 frequently touched surfaces.

Over 4 years, cases of HO-CDI by rate and standardized infection ratio (SIR) were confirmed; EVS staffing and UV-C cycles deployed were collated. Hand hygiene, antimicrobial stewardship, and isolation were unchanged; only variable was incorporation of multiple UV-C devices.

**Results:** Real time observations of in-hospital room cleaning improved with more surfaces with “adequate” cleaning, however, results were sub-optimal. In year 5, fluorescent monitoring and room cultures for *C. difficile* pre and post cleaning were performed. Initial evaluation of UV-C

disinfection with a single Surfacide™ emitter delivering energy at 4 and 8 feet was inadequate for *C. difficile* spores. Redesign of emitters to deliver at least 1500 mJ/emitter, led to 1.5 to 3 log reductions for high inoculums of all organisms tested. Evaluation of 9 hospital room surfaces after bleach cleaning: 13% of surfaces grew *C. difficile*; after UV-C there was near zero (0.4%) *C. difficile* on surfaces. [6] HO-CDI rates and SIRs have continued to improve. Additional UV-C systems are aligned with EVS staffing and UV-C treatments have expanded to meet the requests.

**Conclusions:** Real time observations of in-hospital room cleaning led to additional efforts for monitoring and implementation of this multi-emitter system. Rooms that house patients with *C. difficile* undergo daily UV-C disinfection of bathrooms and all terminal (discharge) room cleanings. This multi-emitter UV-C system overcomes distance and shadows and has proved efficacious for decreasing the risk for development of HO-CDI from the environment.

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