



## Brief Report

# The effect of ultraviolet-C technology on viral infection incidence in a pediatric long-term care facility



Marianne Pavia MS, BS, CIC, FAPIC <sup>a</sup>, Edwin Simpser MD <sup>a</sup>, Melissa Becker MS <sup>a</sup>,  
W. Keith Mainquist PhD <sup>b</sup>, Katherine A. Velez PhD <sup>b,\*</sup>

<sup>a</sup> St. Mary's Hospital for Children, Bayside, NY

<sup>b</sup> The Clorox Company, Oakland, CA

---

**Key Words:**

Ultraviolet  
Long-term care  
Disinfection  
Viral infection  
Hospital-acquired infection  
Pediatrics

---

Ultraviolet-C (UV-C) technology implementation was associated with a 44% reduction in viral infection incidence among pediatric patients in a long-term care facility (incidence rate ratio, 0.56; 95% confidence interval, 0.37-0.84;  $P=0.003$ ). UV-C was included as an adjunct to standard cleaning protocols over a 12-month period; no other new interventions were introduced during this time. The results suggest that UV-C technology is a potentially important component of eliminating the environment as a source of viral infections.

© 2018 Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

---

Ultraviolet-C (UV-C) disinfection devices have been shown to be associated with a reduction in hospital-acquired infections (HAIs) caused by bacteria as well as bacterial pathogen load on surfaces,<sup>1-8</sup> but these devices have not been thoroughly examined for effectiveness in reducing viral infections. Pediatric patients in particular are at risk for respiratory illnesses caused by viruses such as influenza, rhinovirus, enterovirus, and human metapneumovirus. These viral infections are especially problematic for patients with already weakened immune systems due to existing illness.

Viruses can transmit via several routes—via person-to-person contact, through biological and non-biological vectors, through contact with fomites harboring viral pathogens, or via aerosolized droplets.<sup>9</sup> Because viral pathogens are known to persist on inanimate surfaces,<sup>10</sup> manual disinfection of these surfaces is crucial to maintaining a clean environment, especially for long-term care patients. Adjunct technologies such as UV-C have been shown to reduce the bioburden even further, particularly on surfaces that are hard to reach or clean manually.<sup>3,7,8</sup> Other practices such as hand hygiene and antibiotic stewardship are crucial to keeping infection rates low, but disinfection technologies like UV-C can help eliminate the environment as a source of infection.

## MATERIALS AND METHODS

The objective of this study was to examine the effect of UV-C technology on viral pathogen infection incidence among pediatric patients at St. Mary's Children's Hospital, a 97-bed facility located in Bayside, New York. Patients at this facility typically have special needs or other medical complexities, such as chronic illnesses and injuries that require long-term care. Respiratory infections further complicate this immune-compromised population, and outbreaks can occur due to the proximity of patients to each other within the facility.

UV-C technology was deployed at St. Mary's during an approximately 12-month period, from February 2016 to January 2017. Disinfection was focused on the toddler unit, which was known to have the highest HAI rates in the facility at the time of the intervention. A single UV-C device was deployed in 5 of the 12 toddler unit rooms, which house a total of 12 patients, in addition to 2 common areas. The other 7 toddler rooms were cleaned using standard manual disinfection protocols only and were not treated with UV-C during the study period. Patient rooms were treated with UV-C on a rotating schedule to ensure even coverage of each room (ie, the UV-C schedule was alternated weekly such that rooms received either 2 or 3 treatments per week). Common areas were treated daily 3 times per week, excluding holidays. Manufacturer recommendations for cycle times and number of cycles were followed (ie, a patient room with 1 bed received 2 5-minute cycles, with the device placed on either side of the bed, and 1 additional 5-minute cycle in the bathroom; rooms with additional beds received

---

\* Address correspondence to Katherine A. Velez, PhD, 4900 Johnson Drive, Pleasanton, CA 94588

E-mail address: [katherine.velez@clorox.com](mailto:katherine.velez@clorox.com) (K.A. Velez).

1 additional 5-minute cycle per additional bed). Rooms and common areas were disinfected with quaternary ammonium disinfectants prior to treatment with UV-C. To ensure their safety, all patients were removed from rooms and common areas prior to UV-C treatment.

Viral respiratory infections were identified using reverse transcription PCR (BioFire® FilmArray®) on samples from patients placed on contact/droplet precautions. Viruses identified included influenza, rhinovirus, enterovirus, and human metapneumovirus. Infection incidence data were collected in an electronic medical record, and infection rates were calculated monthly throughout the course of the study. At the conclusion of the study, infection incidence data were analyzed using MedCalc Statistical Software version 18 (MedCalc Software bvba, Ostend, Belgium; <http://www.medcalc.org>; 2018) and Minitab® 17.3.1.

**RESULTS**

Comparing the 12-month UV-C deployment period with the prior 12-month period when UV-C was not deployed, a 44% unadjusted reduction in overall viral infection incidence was found ( $P = .003$ , based on the 2-sample Poisson rate test; see Table 1), corresponding to an incidence rate ratio of 0.56 (95% confidence interval [CI]: 0.37-0.84). Patient days per month remained approximately constant (average, 722) throughout the study period.

Additionally, segmented regression was used to analyze the 2 parts of the interrupted time series (Fig 1), which demonstrated a 44% reduction in slope (HAIs/10,000 patient-days) with the use of UV-C (82.0 HAIs/10,000 patient days, 95% CI: 72.5-91.5, with no UV-C

compared to 50.3 HAIs/10,000 patient days, 95% CI: 41.0-59.6, with UV-C).

**DISCUSSION**

No other new interventions were implemented during the study period, suggesting that the decrease in viral infection incidence was due solely to the addition of UV-C to disinfection protocols. Viral pathogens are generally transmitted via aerosolized droplets but can also survive and be transmitted via contact with fomites. This study demonstrated that UV-C can help reduce viral infection incidence rates.

We also examined the cumulative infection incidence and found that UV-C had a potentially compounding benefit when used over time. This analysis showed an initial induction period in which little difference in cumulative infection incidence was seen when first deploying UV-C, which was then followed by divergence in infection incidence. This suggests that each month's UV-C use builds on the benefit (ie, pathogen reduction) of use in the previous month. The time needed for the hospital staff to become fully proficient in the recommended protocol for use of the UV-C device could also have affected the compounding effect of UV-C.

**Acknowledgments**

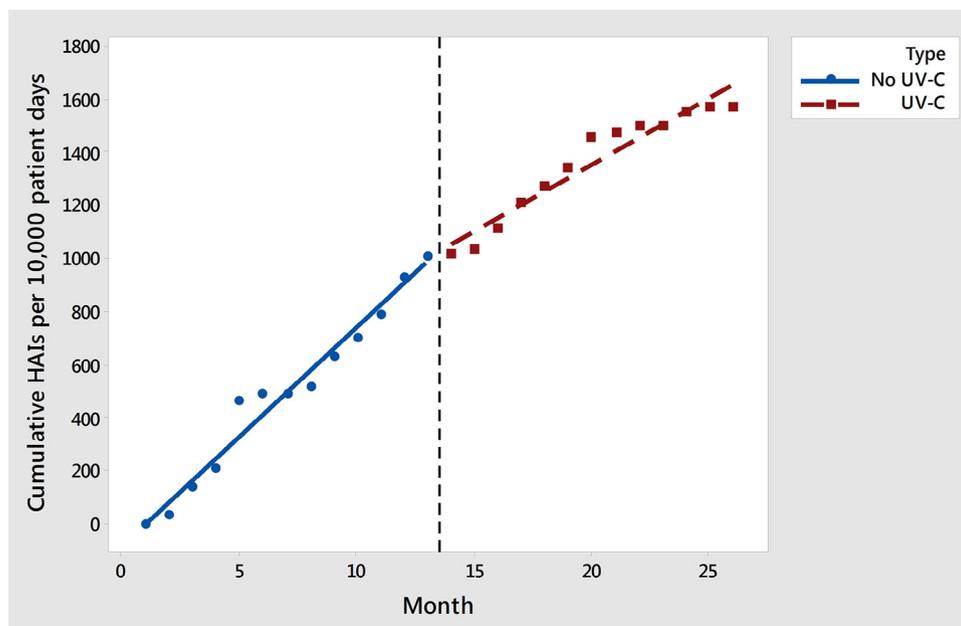
The authors thank Clorox Healthcare™ for providing the UV-C device (The Clorox Healthcare® Optimum-UV® System) and St. Mary's Hospital for Children staff for participation in the study, with

**Table 1**

Test and confidence interval (CI) for 2-sample Poisson rates for 12-month period "No UV-C" and 12-month period "With UV-C," calculated using Minitab® 17.3.1

| Variable  | Total occurrences | Patient days | Rate of occurrence | Summary statistics  |
|-----------|-------------------|--------------|--------------------|---|
| No UV-C   | 73                | 9418         | 0.00775            | Difference [rate (No UV-C) – rate (With UV-C)]: 0.00338<br>95% CI for difference: (0.00116, 0.00561)<br>Test for difference = 0 (vs ≠ 0): Z = 3.00 P-Value = .003 |
| With UV-C | 41                | 9387         | 0.00437            |   |

UV-C, ultraviolet-C.



**Fig 1.** Cumulative hospital-acquired infection (HAI) rate versus months. The solid line with circle markers indicates the cumulative infection incidence rate during the period prior to ultraviolet-C (UV-C) deployment, whereas the dashed line with square markers indicates the cumulative infection incidence rate during UV-C deployment. The vertical dashed line represents the start of the intervention.

special thanks to the St. Mary's Hospital for Children Environmental Services department.

## References

1. Anderson DJ, Chen LF, Weber DJ, Moehring RW, Lewis SS, Triplett PF, et al. Enhanced terminal room disinfection and acquisition and infection caused by multidrug-resistant organisms and *Clostridium difficile* (the Benefits of Enhanced Terminal Room Disinfection study): a cluster-randomised, multicentre, crossover study. *Lancet* 2017;389:805-14. Available from: <http://linkinghub.elsevier.com/retrieve/pii/S0140673616315884>. [Internet].
2. Haas JP, Menz J, Dusza S, Montecalvo MA. Implementation and impact of ultraviolet environmental disinfection in an acute care setting. *Am J Infect Control* 2014;42:586-90.
3. Kanamori H, Rutala WA, Gergen MF, Weber DJ. Patient room decontamination against carbapenem-resistant enterobacteriaceae and methicillin-resistant staphylococcus aureus using a fixed cycle-time ultraviolet-c device and two different radiation designs. *Infect Control Hosp Epidemiol* 2016;1-3.
4. Kovach CR, Taneli Y, Neiman T, Dyer EM, Arzaga AJA, Kelber ST. Evaluation of an ultraviolet room disinfection protocol to decrease nursing home microbial burden, infection and hospitalization rates. *BMC Infect Dis* 2017;17:186.
5. Nagaraja A, Visintainer P, Haas JP, Menz J, Wormser GP, Montecalvo MA. *Clostridium difficile* infections before and during use of ultraviolet disinfection. *Am J Infect Control* 2015;43:940-5.
6. Pegues DA, Han J, Gilmar C, McDonnell B, Gaynes S. Impact of ultraviolet germicidal irradiation for no-touch terminal room disinfection on *clostridium difficile* infection incidence among hematology-oncology patients. *Infect Control Hosp Epidemiol* 2017;38:39-44.
7. Rock C, Curless MS, Nowakowski E, Ross T, Carson KA, Trexler P, et al. UV-C light disinfection of carbapenem-resistant enterobacteriaceae from high-touch surfaces in a patient room and bathroom. *Infect Control Hosp Epidemiol* 2016;1-2.
8. Rutala WA, Gergen MF, Tande BM, Weber DJ. Room decontamination using an ultraviolet-C device with short ultraviolet exposure time. *Infect Control Hosp Epidemiol* 2014;35:1070-2.
9. Tortora GJ, Funke BR, Case CL. *Microbiology: an introduction*. 12nd ed. Pearson; 2016.
10. Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. *BMC Infect Dis* 2006;6:130.

### Coming Soon in AJIC

Validity of administrative data in identifying complex surgical site infections from a population based cohort following primary hip and knee arthroplasty in Alberta, Canada

Clinical epidemiology of carbapenem-resistant Gram-negative sepsis among hospitalized patients: shifting burden of disease?

Latex glove use among health care workers in Australia