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Brief Report

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

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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*=.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.

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,[1-8] 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.[9] Because viral pathogens are known to persist on inanimate surfaces,[10] 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.[3,7,8] 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

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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.

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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
With UV-C	41	9387	0.00437	95% CI for difference: (0.00116, 0.00561)
				Test for difference = 0 (vs ≠ 0): Z = 3.00 P-Value = .003

UV-C, ultraviolet-C.

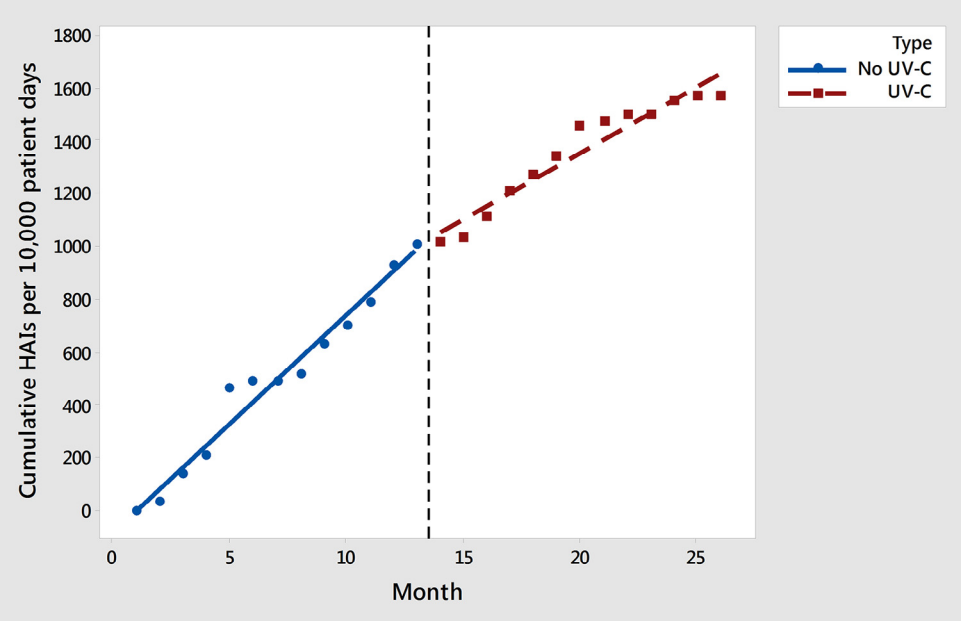

Fig 1. Cumulative hospital-acquired infection (HAI) rate versus months. The solid line with circle markers indicates the cumulative infection incidence rate during the period prior to ultraviolet-C (UV-C) deployment, whereas the dashed line with square markers indicates the cumulative infection incidence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

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