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Major Article

Perceptions of Patients, Health Care Workers, and Environmental Services Staff Regarding Ultraviolet Light Room Decontamination Devices

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Ultraviolet-C light decontamination
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Background: Mobile ultraviolet C (UV-C) room decontamination devices are widely used in health care facilities; however, there is limited information on the perceptions of patients, health care workers (HCWs), and environmental services staff (EVS-staff) regarding their use for environmental decontamination.

Methods: An anonymous questionnaire was administered to participants in 4 medical/surgical units of a tertiary care hospital where UV-C devices were deployed for a 6-month period. Survey questions assessed perceptions regarding the importance of environmental disinfection, effectiveness of UV-C decontamination, willingness to delay hospital admission in order to use UV-C, and safety of UV-C devices.

Results: Questionnaires were completed by 102 patients, 130 HCWs, and 47 EVS-staff. All of the HCWs and EVS-staff and 99% of the patients agreed that environmental disinfection is important to reduce the risk of exposure from contaminated surfaces. Ninety-eight percent of the EVS-staff, 89% of the HCWs, and 96% of the patients felt that the use of UV-C as an adjunct to routine cleaning increased confidence that rooms are clean. Ninety-four percent of the EVS-staff, 85% of the HCWs, and 90% of the patients expressed a willingness to delay being admitted to a room in order to have UV-C decontamination completed. Seventy-nine percent of the EVS-staff, 76% of the HCWs, and 86% of the patients had no concerns about the safety of UV-C devices.

Conclusions: Patients, HCWs, and EVS-staff agreed that environmental disinfection is important and that UV-C devices are efficacious and safe. Educational tools are needed to allay safety concerns expressed by a minority of HCWs and EVS-staff.

BACKGROUND

Hospital-acquired infections (HAIs) contribute significantly to morbidity and mortality, with approximately 75,000 people dying from HAIs each year in the United States.[1] HAIs also have a significant financial impact, as annual costs have been estimated to range from $10 billion to $45 billion.[2,3] Many of the HAI-causing pathogens, including the more lethal multidrug resistant organisms (MDROs), can survive in the health care environment for days and weeks and contribute to further transmission and contamination.[4] Over the past few years, hospitals have employed multiple interventions to disinfect patient rooms, including the use of no-touch technologies such

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as ultraviolet C (UV-C) light irradiation and vaporized/aerosolized hydrogen peroxide.[5]

UV-C light decontamination of hospital rooms has been studied as a potential intervention to reduce the incidence of HAIs. Previous studies have demonstrated a significant reduction of pathogens in air, on surfaces, and on instrumentation after UV light decontamination.[6,7] A few more recent studies have demonstrated that implementation of UV light technology in hospital settings has been associated with a significant reduction in HAIs, including MDROs such as *Clostridium difficile* and vancomycin-resistant *Enterococcus*.[8,9]

Despite the beneficial impacts of UV light technology on infection control, skepticism remains among patients, health care workers (HCWs), and environmental services staff (EVS-staff) regarding the efficacy and safety of UV light technology as a means of decontamination. Some of this skepticism is in part related to challenges associated with implementing a UV device in a hospital's cleaning protocol.[10] A study published in 2018 found that daily UV-C decontamination was acceptable to most patients; only 17% of patients and 25% of HCWs did not agree that UV-C light helps protect against infections.[11] As hospitals nationwide continue to implement UV-C decontamination protocols as part of terminal cleaning, it is critical for the health care community to have a clearer understanding of how individuals perceive its safety and efficacy in order to address some of the challenges associated with its implementation.[6] We conducted a prospective study to evaluate the perceptions of patients, HCWs, and EVS-staff regarding UV-C light as a method of room decontamination in hospitals using survey tools.

METHODS

The study was approved by the institutional review board of the Cleveland Clinic with a waiver for written informed consent. All participants were provided with a study information sheet and were informed that they could withdraw from the study at any time.

Study participants and setting

The study was conducted from October 2015 to March 2016, corresponding to a 6-month period in which UV-C decontamination was being used as part of a randomized controlled trial to determine if adjunctive use of UV-C decontamination in patient rooms reduces rates of HAIs, including *C difficile* infection. All HCWs (nursing personnel, ancillary staff, physicians) and EVS-staff working on the 4 medical/surgical units on which the UV-C devices were deployed at Cleveland Clinic were eligible to participate. Similarly, all patients admitted to the 4 medical/surgical units were eligible to participate in the survey. All surveys were administered by research staff not involved with direct patient care. Willing survey participants were interviewed by research staff via an anonymous, self-completed questionnaire in order to gain insight on their perspectives regarding the use of UV-C light for hospital room decontamination. No identifiers linked respondents to their responses, and all participants were assured of confidentiality. Each participant was only surveyed once, and there was no financial incentive to complete the survey.

UV-C decontamination devices

UV-C decontamination was performed as part of terminal discharge cleaning using 2 commercially available devices: Clorox Healthcare Optimum-UV Enlight System (The Clorox Company; Oakland, CA) and Pathogon UV Disinfection System (Steris Corporation; Mentor, OH). During the period when UV-C was used, tent cards were placed in patient rooms noting that the room was disinfected with an automated device using light and providing a picture of the device, as described previously.[8] Before the survey was administered, patients were informed about the use of UV-C devices for cleaning their rooms. EVS-staff and HCWs were made aware of the UV-C devices at staff and group meetings before the start of the study. The cycle time for each of the devices was determined by the manufacturer and was based on the size of the room and configuration.

Survey

The survey instrument was developed based on literature review and interviews with experts in the field of infection control. We piloted the survey on 5 HCWs from another institution by soliciting their input and feedback. Each survey was limited to 4 questions, and subjects were asked to answer using a 5-point Likert scale: "strongly agree," "agree," "neutral" (neither agree nor disagree), "disagree," or "strongly disagree." No additional information was collected from any of the participants.

EVS-staff and HCWs were asked their opinions regarding the following items:

1. It is important that hospital rooms be cleaned well to reduce the risk that patients will pick up an infection from contaminated surfaces.
2. Using an ultraviolet light device in addition to routine cleaning gives me more confidence that patient rooms are safe for patients.
3. I am willing to delay having rooms ready to receive new admissions by one-half hour in order to have ultraviolet light disinfection completed.
4. I don't have concerns about the safety of the ultraviolet light device.

Patients were asked their opinions regarding the following items:

1. When I am in the hospital, it is important that my room is cleaned well before I am admitted to reduce the risk that I will pick up an infection.
2. Knowing that my room was disinfected with an ultraviolet light device in addition to routine cleaning gives me more confidence that it is clean.
3. I would be willing to delay my room being available for one-half hour in order to have ultraviolet light disinfection completed.
4. I don't have any concerns about the safety of the ultraviolet light device.

Data analysis

Descriptive analysis was performed using OriginPro 9.1 (OriginLab Corporation; Northampton, MA). For each of the questions, the percentage of patients, HCWs, and EVS-staff expressing a preference was calculated.

RESULTS

A total of 279 participants completed the survey, including 102 patients, 130 HCWs, and 47 EVS-staff. One patient and one EVS-staff refused to participate in the survey. All participants completed the full survey, and there was no missing data. With regard to the importance of hospital rooms being cleaned prior to the patient being admitted to reduce the risk of infection from contaminated surfaces, 100% of EVS-staff and HCWs and 95% of patients strongly agreed; 4% of patients agreed and 1% neither agreed nor disagreed (Fig 1A).

When asked whether the addition of a UV-C light device in addition to routine cleaning gives more confidence about hospital rooms being safer, 79% of patients, 65% of HCWs, and 89% of EVS-staff agreed strongly; however, less than 10% of HCWs and 2% of patients and EVS-staff neither agreed nor disagreed (Fig 1B).

On the question about the willingness to delay patient room availability by one-half hour to complete UV-C light disinfection, 61% of

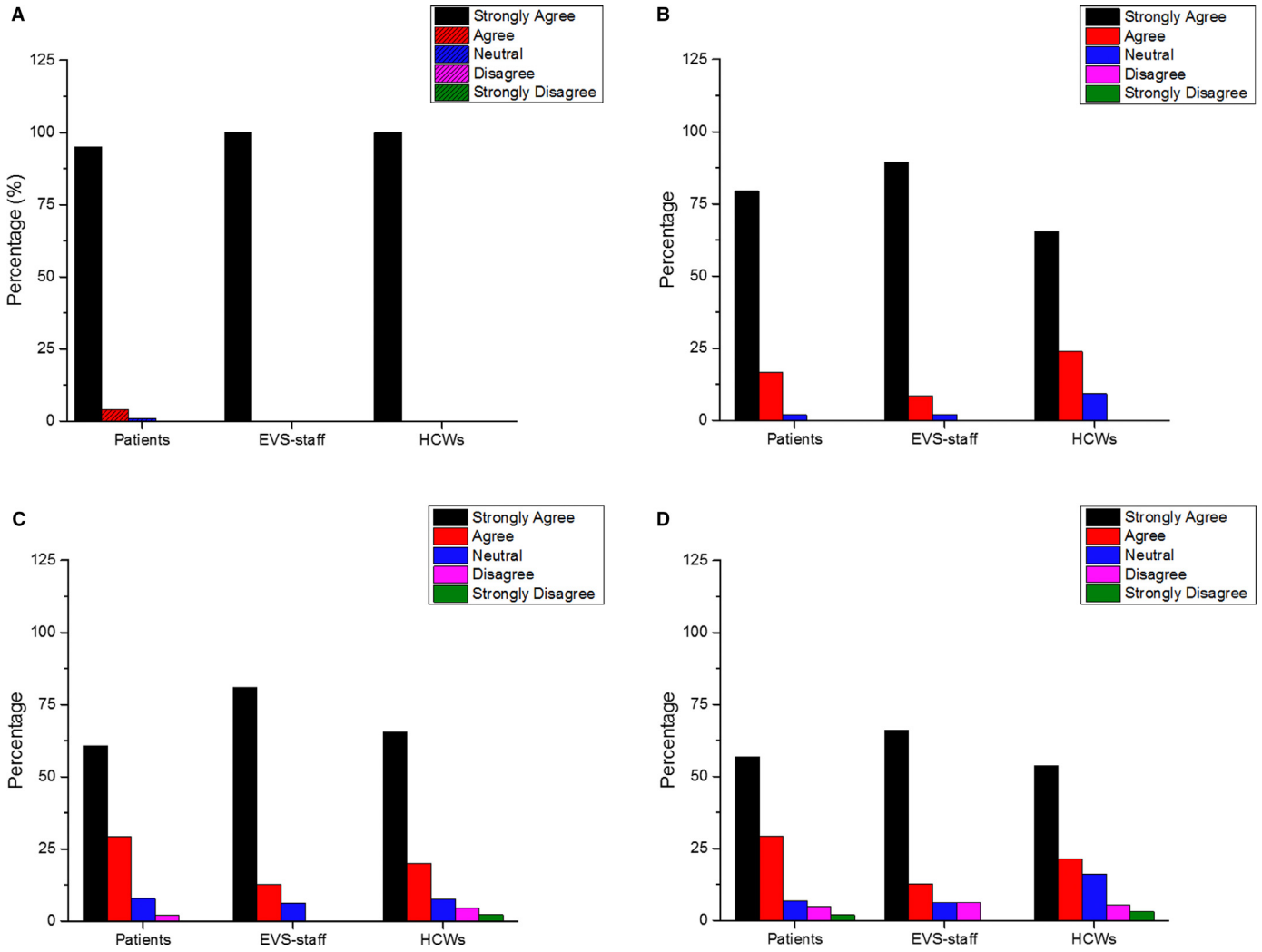

Fig 1. Opinions of patients, environmental service staff, and health care workers on (A) whether or not cleaning hospital rooms prior to patient admission reduces the risk of infection from contaminated surfaces; (B) whether or not adding an UV-C light device to routine cleaning gives more confidence about hospital rooms being safer; (C) whether or not they would be willing to delay patient room availability by one-half hour to complete UV-C light disinfection; and (D) not having any concerns about the safety of the UV-C decontamination device. *EVS-staff*, environmental service staff; *HCWs*, health care workers; *UV-C*, ultraviolet C.

patients, 65% of HCWs, and 81% of EVS-staff strongly agreed, and 29%, 13%, and 20% agreed, respectively. However, about 2% of patients and 5% of HCWs disagreed, and an additional 2% of HCWs strongly disagreed (Fig 1C).

On the question relating to not having any concerns about the safety of the UV-C device, 57% of patients, 54% of HCWs, and 66% of EVS-staff strongly agreed, and 29%, 13%, and 22% agreed, respectively. However, 5% of patients, 5% of HCWs, and 6% of EVS-staff disagreed, and 2% of patients and 3% of HCWs strongly disagreed (Fig 1D).

DISCUSSION

In a tertiary care hospital, we found that a majority of patients, HCWs, and EVS-staff perceived the use of UV-C light decontamination as beneficial in preventing infection. Furthermore, when weighing the potential delay in room turnover time against the potential benefits of UV-C light for terminal room decontamination, most patients, HCWs, and EVS-staff agreed that the potential benefits of UV-C light outweigh the operational concerns. Similarly, a majority of participants agreed that UV-C light technology does not bear any significant safety concerns.

Our findings are consistent with a previous study in demonstrating that most patients have a favorable view of UV-C light technology. The perception that UV-C might contribute to a culture of safety is significant, as prior research has demonstrated a strong correlation between patients' engagement in and satisfaction with their care and patient-reported safety assessments.[12] Indeed, Isaac et al[13] identified a significant relationship between the frequency of HAIs at a hospital and patients' perceptions of a clean and quiet hospital environment on Hospital Consumer Assessment of Healthcare Providers and Systems assessments. Increased patient awareness of hospital disinfection and decontamination procedures against HAIs can potentially improve patient engagement and satisfaction and make the use of UV-C more acceptable. To increase patient awareness of the UV-C decontamination procedures in our study, tent cards were placed in hospital rooms informing patients that the room was disinfected with an automated UV-C light device and showing a picture of the device.

We also found that a vast majority of patients, HCWs, and EVS-staff agreed that they would be willing to accept a one-half hour delay due to the use of UV-C light for terminal room decontamination. Although the average usage time of UV-C light is around 33 minutes, a prior study did not find a difference in average

emergency department waiting times when UV-C light was used and, in fact, estimated a direct cost savings of over $1.2 million in 1 year at a single community hospital.[14,15]

Although most patients, HCWs, and EVS-staff in our study felt that UV-C light technology did not pose a safety concern, a minority of people did not feel that UV-C light was safe. Of note, some participants in prior studies have reported the presence of a strong odor in rooms after UV-C light decontamination, which can be confusing and concerning to patients and staff members. One study found that 5% of patients refused UV-C light on the basis of the odor, and another noted that 53% of nurse managers reported complaints from staff concerning odor when UV devices were being used.[11,15] The odor may contribute to how patients, HCWs, and EVS-staff perceive the safety of UV-C light technology, especially if the reason for the odor is unclear to them. A potential solution to this concern is to provide education to patients and staff members, which has been shown to reduce complaints from patients and staff regarding the odor following the use of UV devices.[15] The role of education is further supported by a study evaluating EVS-staff members' perspectives on disinfection; 27% of the EVS-staff expressed often or always worrying that cleaning products may be harmful to them, and 72% reported an interest in further education on safety and infections.[16] By promoting safety protocols and educational tools for patients and staff while using UV light technology, we can minimize risk and allay safety concerns.

Major strengths of our study include that our findings are consistent with and build upon previous literature. Our study included a relatively large participant population of patients, HCWs, and EVS-staff. The study was designed with a clearly identified population of interest and included diverse recruitment strategies to minimize sampling error. Finally, the study utilized a simple, user-friendly survey design to minimize measurement error. On the other hand, our study has several limitations. First, surveys were administered by an interviewer in person, which introduces the risk of interviewer effects on the participant. Second, our study occurred at a large, tertiary care center during the course of a randomized controlled trial when significant resources were invested in the use of UV-C light disinfection strategies, meaning that some of our findings may not be generalizable to other hospital settings, and participants' perceptions may have been influenced by the concurrent study. In addition, the study utilized convenience sampling, which may impact the ability of the study population to be compared to the general hospital population. Another potential limitation is that our surveys focused on the beliefs of individuals but did not directly assess the knowledge of participants.

CONCLUSIONS

Our study found that a vast majority of patients, HCWs, and EVS-staff believe that UV-C light technology is helpful in preventing infections. This result was further supported by the finding that most participants were willing to delay room turnover by one-half hour to allow the use of UV-C light to decontaminate the rooms. These results are encouraging for hospitals considering the use of UV-C light to reduce the risk of HAIs and, specifically, MDROs. Additionally, a majority of patients, HCWs, and EVS-staff considered UV-C light to be safe. Through continued education and clear safety protocols, we can continue to address safety concerns and improve perceptions of UV-C light technology. Further studies are necessary to clarify the impact of various strategies on the perception of UV-C light as a means of decontamination in hospitals.

References

1. Magill SS, Edwards JR, Bamberg W, Beldavs ZG, Dumyati G, Kainer MA, et al. Multistate point-prevalence survey of health care-associated infections. N Engl J Med 2014;370:1198-208.
2. Lobdell KW, Stamou S, Sanchez JA. Hospital-acquired infections. Surg Clin North Am 2012;92:65-77.
3. Zimlichman E, Henderson D, Tamir O, Franz C, Song P, Yamin CK, et al. Health care-associated infections: a meta-analysis of costs and financial impact on the US health care system. JAMA Intern Med 2013;173:2039-46.
4. Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. Infect Control Hosp Epidemiol 2011;32:687-99.
5. Dancer SJ. Controlling hospital-acquired infection: focus on the role of the environment and new technologies for decontamination. Clin Microbiol Rev 2014;27:665-90.
6. Weber DJ, Anderson D, Rutala WA. The role of the surface environment in healthcare-associated infections. Curr Opin Infect Dis 2013;26:338-44.
7. Ethington T, Newsome S, Waugh J, Lee LD. Cleaning the air with ultraviolet germicidal irradiation lessened contact infections in a long-term acute care hospital. Am J Infect Control 2018;46:482-6.
8. Anderson DJ, Moehring RW, Weber DJ, Lewis SS, Chen LF, Schwab JC, et al. Effectiveness of targeted enhanced terminal room disinfection on hospital-wide acquisition and infection with multidrug-resistant organisms and *Clostridium difficile*: a secondary analysis of a multicentre cluster randomised controlled trial with crossover design (BETR Disinfection). Lancet Infect Dis 2018;18:845-53.
9. Napolitano NA, Mahapatra T, Tang W. The effectiveness of UV-C radiation for facility-wide environmental disinfection to reduce health care-acquired infections. Am J Infect Control 2015;43:1342-6.
10. 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.
11. Rock C, Curless MS, Carson KA, Nowakowski E, Scheeler V, Maragakis LL. Patient and health care worker perceptions of daily use of ultraviolet-C technology as an adjunct to daily cleaning in an academic hospital: secondary study of ultraviolet-C light evaluation as an adjunct to removing multi-drug resistant organisms. Am J Infect Control 2018;46:348-9.
12. Kagan I, Porat N, Barnoy S. The quality and safety culture in general hospitals: patients', physicians' and nurses' evaluation of its effect on patient satisfaction. Int J Qual Health Care 2019;31:261-8.
13. Isaac T, Zaslavsky AM, Cleary PD, Landon BE. The relationship between patients' perception of care and measures of hospital quality and safety. Health Serv Res 2010;45:1024-40.
14. Raggi R, Archulet K, Haag CW, Tang W. Clinical, operational, and financial impact of an ultraviolet-C terminal disinfection intervention at a community hospital. Am J Infect Control 2018;46:1224-9.
15. Anderson DJ, Knelson LP, Moehring RW, Lewis SS, Weber DJ, Chen LF, et al. Implementation lessons learned from the Benefits of Enhanced Terminal Room (BETR) Disinfection study: process and perceptions of enhanced disinfection with ultraviolet disinfection devices. Infect Control Hosp Epidemiol 2018;39:157-63.
16. Bernstein DA, Salsgiver E, Simon MS, Greendyke W, Eiras DP, Ito M, et al. Understanding barriers to optimal cleaning and disinfection in hospitals: a knowledge, attitudes, and practices survey of environmental services workers. Infect Control Hosp Epidemiol 2016;37:1492-5.