American Journal of Infection Control 44 (2016) e157-e161

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Evaluation of a pulsed xenon ultraviolet light device for isolation room disinfection in a United Kingdom hospital

Ian Hosein MD, MBA [a,*], Rosie Madeloso MSc [a], Wijayaratnam Nagaratnam BMS [a], Frank Villamaria MPH [b], Eileen Stock PhD [c,d], Chetan Jinadatha MD, MPH [b,d]

[a] Barking, Havering and Redbridge University Hospitals National Health Service Trust, London, UK
[b] Central Texas Veterans Health Care System, Temple, TX
[c] Center for Applied Health Research, Temple, TX
[d] College of Medicine, Texas A & M University Health Science Center, Bryan, TX

Key Words:
Ultraviolet light
decontamination
hospital infection
technology
innovation
patient flow

Background: Pathogen transmission from contaminated surfaces can cause hospital-associated infections. Although pulsed xenon ultraviolet (PX-UV) light devices have been shown to decrease hospital room bioburden in the United States, their effectiveness in United Kingdom (UK) hospitals is less understood.
Methods: Forty isolation rooms at the Queens Hospital (700 beds) in North London, UK, were sampled for aerobic bacteria after patient discharge, after manual cleaning with a hypochlorous acid–troclosene sodium solution, and after PX-UV disinfection. PX-UV device efficacy on known organisms was tested by exposing inoculated agar plates in a nonpatient care area. Turnaround times for device usage were recorded, and a survey of hospital staff for perceptions of the device was undertaken.
Results: After PX-UV disinfection, the bacterial contamination measured in colony forming units (CFU) decreased by 78.4%, a 91% reduction from initial bioburden levels prior to terminal cleaning. PX-UV exposure resulted in a 5-log CFU reduction for multidrug-resistant organisms (MDROs) on spiked plates. The average device turnaround time was 1 hour, with minimal impact on patient throughput. Ward staff were enthusiastic about device deployment, and device operators reported physical comfort in usage.
Conclusions: PX-UV use decreased bioburden in patient discharge rooms and on agar plates spiked with MDROs. The implementation of the PX-UV device was well received by hospital cleaning and ward staff, with minimal disruption to patient flow.
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Health care–associated infections are estimated to cost the UK National Health Service (NHS) >£1 billion a year.[1] Infections caused by multidrug-resistant organisms (MDROs) and other hospital-associated infections (HAIs) are associated with increased morbidity and mortality and are among the many challenges faced by hospitals striving for better patient safety.[2] Despite the successes in the UK over the last decade in reducing the burden of some infections, such as *Clostridium difficile* infection and methicillin-resistant *Staphylococcus aureus* (MRSA) bloodstream infection, infection prevention and control continues to be challenging in hospitals. Austerity measures, increasing population demands for care, and emerging infection threats, such as from carbapenemase-producing *Enterobacteriaceae* (CPE), require innovative approaches to maintain quality and safety.

The environment provides a reservoir for pathogenic organisms and plays an important role in the transmission of infections, particularly in outbreak situations.[3,4] Therefore, decontamination of patient care areas is now considered to be vital in a comprehensive infection prevention and control program[5] and is critical in preventing transmission of norovirus and *C difficile*.[6]

There may be significant variation in the way manual cleaning with chemicals is performed and its effectiveness, partly because of the complexity of the environment in which these activities take

* Address correspondence to Ian Hosein MD, MBA, Queen Elizabeth Hospital, Gayton Rd, Kings Lynn PE30 4ET, UK.
E-mail address: ian.hosein@qehkl.nhs.uk (I. Hosein).
Funding/Support: Supported by a grant from Sodexo Holdings Limited, London (for costs of the laboratory processing of samples) and the Central Texas Veterans Health Care System, Temple, Texas USA. Xenex Disinfection Services (San Antonio, Texas) loaned 2 pulsed xenon ultraviolet light devices to Barking, Havering, and Redbridge NHS Trust for this research.
Disclaimer: The Research and Innovation Department at Barking, Havering, and Redbridge NHS Trust made helpful suggestions on study design. The views expressed in the article are of the authors and do not represent the views or position of the Department of Veterans Affairs.
Conflicts of Interest: None to report.
Author Contributions: All authors made a significant contribution to the project. C.J., E.S., and F.V. helped with study design, data analysis, and manuscript preparation.

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http://dx.doi.org/10.1016/j.ajic.2016.01.044

place.[6-8] For instance, a study showed that up to 50% of high-touch surfaces within patient areas are often missed during chemical cleaning because of inaccessibility and human error.[9] Therefore, new technologies have begun to be investigated to help supplement the cleaning process with the intention of achieving better assurance of environmental decontamination.[10-13]

Multiple no-touch disinfection devices have been developed for environmental decontamination, and many of these systems are being suggested for adoption in health care facilities in the United States as part of standard decontamination protocols.[14,15] One such no-touch disinfection method involves ultraviolet in the C spectrum light-emitting devices, which use ultraviolet-C light between the wavelengths of 200 and 320 nm, the biocidal spectrum.[16]

Pulsed xenon ultraviolet (PX-UV) light devices (Xenex, San Antonio, TX) have been described previously and studies in the United States indicate microbiologic efficacy of the PX-UV device,[17-19] but the health care environment in the UK is challenging, with a decreasing hospital bed base and a need for faster patient discharges, less single rooms, and significant financial constraints. Therefore, the purpose of the current study was to evaluate the environmental efficacy and feasibility of using this no-touch technology within daily patient care activities in a UK hospital.

METHODS

This prospective study was conducted from July 2014-November 2014 at Queens Hospital (700 beds), a NHS hospital in the Barking, Havering, and Redbridge University Hospitals group in North London, UK, serving a population with a significant elderly proportion with many comorbidities. The study was approved by the hospital's research board. A convenience sample of 40 hospital rooms was selected for this study. Three main outcomes were studied: microbiologic efficacy of the PX-UV device on aerobic bacterial counts, time taken for disinfection, and staff attitudes to the new technology.

Microbiologic efficacy

A comparative study was designed to evaluate the efficacy of the PX-UV device in reducing environmental contamination in postdischarge patient isolation rooms by sampling 5 high-touch surfaces before standard terminal cleaning, after standard terminal cleaning, and after PX-UV disinfection. Patient rooms were selected from acute medical assessment units A and B (there were 6 rooms in each unit). The study rooms were identified through the infection prevention and control database and were selected for use by infection prevention and control staff. The inclusion criteria specified for the study rooms were as follows: (1) it must have been a single occupancy room, (2) it must have been occupied for a minimum of 48 hours, (3) it must have been recently vacated on the same day as the sample collection, and (4) it must have been used as a contact isolation room.

Once the room was identified, baseline microbiologic samples were collected after patient discharge but before standard terminal cleaning. Five high-touch surfaces (bedrail, bathroom handrail, tray table, toilet seat, and bathroom faucet handle) were sampled using 5-mm diameter Trypticase Soy Agar contact plates (Oxoid, Basingstoke, UK). For flat surfaces the press plate method was used,[20] and for curved surfaces a rolling plate technique was used to ensure coverage of the appropriate surface area. After the initial sampling, hospital cleaners performed standard terminal cleaning, using a 1,000 ppm (0.1%) chlorine disinfectant (Actichlor Plus; Ecolab, Cheshire, UK), prepared using 1 effervescent tablet mixed with 1 L of water to produce a hypochlorous acid disinfectant solution with detergent (troclosene sodium). Once the terminal cleaning was completed and surfaces were dry, the second set of environmental samples was collected. Finally, the PX-UV device was deployed and then subsequent environmental samples were taken from the same 5 surfaces. PX-UV device operators and cleaning staff were blinded to the chosen sampling surfaces to prevent any bias or changes in cleaning practices. After sample collection, the Trypticase Soy Agar contact plates were returned to the laboratory, incubated in air at 37°C for 48 hours, and enumerated per the manufacturer's recommendations with the number of colony forming units (CFU) being recorded. Aerobic bacteria, including MRSA, vancomycin-resistant enterococci (VRE), and CPE, will form colonies on Trypticase Soy Agar contact plates, but anaerobic bacteria such as *C difficile* will not.

In each hospital room, the PX-UV device was deployed for 3 cycles: two 5-minute cycles in the living room (1 cycle on each side of the patient bed) and one 5-minute cycle in the bathroom.

The efficacy of the PX-UV device was also evaluated by seeding agar plates with hospital clinical isolates of MRSA, VRE, multidrug-resistant *Acinetobacter*, and CPE. Suspensions of each organism were produced by inoculating the isolate into 5 mL of saline to McFarland turbidity 0.5-1.0. The Miles and Misra method[21] was used for dilution so that the CFUs postincubation could be counted by eye. Agar plates were divided into 6 equal sectors, and 20 μL of each dilution of organism was dropped onto the surface of separate sectors (ie, 1 agar plate had 6 dilutions for one of the test organisms.) Each drop was allowed to spread naturally, and plates were left upright on the bench to air-dry before inversion. In total, 3 sets of plates for each organism were prepared. One set of plates for each organism was immediately incubated once air-dried for 24 hours in air at 37°C as a control. The other 2 sets of plates for each organism were immediately taken to a sluice room (used for body fluid discard; also called a dirty utility room). The agar plates were placed at a surface 20 in above floor level adjacent to each other and at 1.2 m distance from the PX-UV device in the line of sight. One set of plates for each organism was kept covered (further control plate); the other was uncovered (test plate). All plates were exposed to PX-UV light for a 10-minute cycle. All plates were then incubated in air at 37°C for 24 hours.

Analysis of microbiologic samples

Means and frequencies described the total number CFU before and after standard terminal cleaning and after using the PX-UV device, overall and by surface location. Wilcoxon signed-rank tests were used to assess a change in CFU between baseline and after standard terminal cleaning for each surface location. Similarly, a change in CFU after standard terminal cleaning and after the PX-UV device use was assessed (Table 1). To examine a reduction in the presence of CFU with standard terminal cleaning versus no cleaning, or PX-UV disinfection versus standard terminal cleaning, the McNemar test was used to test the null hypothesis of marginal homogeneity. Evidence supporting the alternative hypothesis would suggest that one cleaning method was superior to the other (Table 2). For the seeded agar plates, CFU were recorded and CFU per milliliter were calculated (CFU/mL = number of colonies of a dilution × 50 × dilution factor).

Time studies

To determine the impact of the PX-UV device on isolation room decontamination times (and hence room availability), time studies of the movement and use of the device were conducted. A standard log was used to record when the device was collected from the storage area, how long the device was left waiting at the room before use, device in-use time, and device return time to storage.

Device transport time was standardized to represent the time it takes for the operator to walk from the storage area to the targeted

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