American Journal of Infection Control 43 (2015) 1350-3

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Brief report

Utilization and impact of a pulsed-xenon ultraviolet room disinfection system and multidisciplinary care team on *Clostridium difficile* in a long-term acute care facility

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Key Words:
Long-term care
No-touch disinfection
Clostridium difficile
Multidisciplinary teams

Health care–associated transmission of *Clostridium difficile* has been well documented in long-term acute care facilities. This article reports on 2 interventions aimed at reducing the transmission risk: multidisciplinary care teams and no-touch pulsed-xenon disinfection. *C difficile* transmission rates were tracked over a 39-month period while these 2 interventions were implemented. After a baseline period of 1 year, multidisciplinary teams were implemented for an additional 1-year period with a focus on reducing *C difficile* infection. During this time, transmission rates dropped 17% ($P = .91$). In the following 15-month period, the multidisciplinary teams continued, and pulsed-xenon disinfection was added as an adjunct to manual cleaning of patient rooms and common areas. During this time, transmission rates dropped 57% ($P = .02$). These results indicate that the combined use of multidisciplinary teams and pulsed-xenon disinfection can have a significant impact on *C difficile* transmission rates in long-term care facilities.

It has been repeatedly demonstrated in the literature that the health care environment suffers from widespread contamination and extended survival of multidrug-resistant organisms.[1] A number of studies have linked this environmental contamination to an increased risk of health care–associated infections (HAIs).[2,3] For example, a positive culture for *Clostridium difficile* from a prior room occupant has been found to put the subsequent patient at 2.35 times greater risk of acquiring the same infection.[4] Because there is no direct contact between the 2 patients, this prior room occupancy risk can is attributable to environmental acquisition.[5]

Interventions to address HAIs in long-term acute care (LTAC) facilities have posed unique challenges for infection prevention, specifically in the area of enhanced environmental hygiene. Long-term care patients have more compromised immune function than traditional acute care patients and are more likely to be colonized with organisms such as *C difficile*.[6] Many hospitalized patients are transferred to and from LTAC facilities, increasing the likelihood of acquiring *C difficile* infection in the process.[7,8] Infected patients and asymptomatic carriers can shed pathogens onto environmental surfaces.[9] If these surfaces are not properly disinfected, infection can be spread by direct contact or cross-contamination by health care workers. This is especially relevant with *C difficile* infection, which is the leading cause of health care–associated diarrhea.[10] This issue can be compounded in LTAC facilities, where the average length of stay is close to a month, and the communal design of the facilities enhances the interaction among patients.

As a result of the well-described link between environmental contamination and HAI acquisition, health care facilities are now exploring new methods of interrupting transmission. Many of these methods are based on the multidisciplinary approaches recommended in infection prevention best practice guidelines. An additional consideration has been enhancing the effectiveness of environmental disinfection. No-touch disinfection technologies have been developed as an adjunct to manual cleaning practices. The goal of these devices is to complete disinfection of surfaces that

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Conflicts of interest: Authors Simmons, Dale, Stibich, and Stachowiak are employees and shareholders of Xenex Disinfection Services, LLC.

http://dx.doi.org/10.1016/j.ajic.2015.07.029

may have been missed by environmental cleaning staff. Such technologies use hydrogen peroxide vapor, pulsed-xenon ultraviolet light (PX-UV), or mercury ultraviolet light (UV). There are several outcome studies demonstrating reduced infection rates after the implementation of PX-UV, but this evidence has been isolated to acute care facilities.[11-13] To our knowledge, no research exists to date that describes the use of no-touch disinfection in the LTAC setting.

The purpose of this study is to address the effectiveness of 2 hospital-associated (HA) *C difficile* prevention methods implemented over a 3-year period. First, the use of a multidisciplinary prevention team of health care workers dedicated to *C difficile* prevention was assessed. Subsequently, PX-UV was implemented as an enhanced disinfection measure.

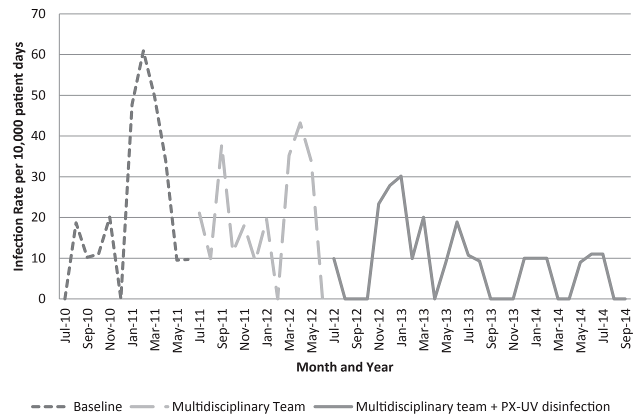

Fig 1. HA-CDI rates expressed per 10,000 patient days by month (July 2010-September 2014). The PX-UV arm was added to a continuing multidisciplinary team approach. *HA-CDI*, Hospital-acquired *Clostridium difficile* infection; *PX-UV*, pulsed-xenon ultraviolet light disinfection.

METHODS

Baseline infection prevention and surveillance

This evaluation was conducted at an urban LTAC hospital in the Southeastern United States. Most patient rooms contain a single bed with a connected private bathroom. Per Centers for Disease Control and Prevention guidelines, facility policy required contact precautions and hand hygiene with soap and water when caring for patients with *C difficile*. After discharge, rooms and bathrooms are terminally cleaned with a sodium hypochlorite solution. *C difficile* infection rates were determined using the National Healthcare Safety Network's infection surveillance reporting criteria. Institutional review board exemption was not sought because the research used existing data. During the 12-month preintervention period, no new infection prevention policies or protocols were implemented.

Multidisciplinary team intervention

A multidisciplinary *C difficile* prevention team was formed in March 2011 and was comprised of staff members from pharmacy, nursing, respiratory therapy, rehabilitation, dietary, laboratory, environmental services, building maintenance, and infectious disease. Before the formation of the prevention team, efforts to control the spread of *C difficile* infection included increasing the visibility of isolation signage using large and brightly colored signs, daily round to assess compliance with isolation practices, re-education for staff on the need for hand hygiene with soap and water when caring for *C difficile* patients, and implementation of disposable patient care equipment in isolation rooms (blood pressure cuffs, stethoscopes, and thermometers).

The multidisciplinary team reviewed available best practice guidelines for prevention of *C difficile* and implemented several new processes in June 2011. An initial measure recommended by the group was the installation of additional sinks on the nursing units in an effort to increase compliance with soap and water hand hygiene. Hand hygiene rates were monitored by hospital staff throughout the study period, and compliance rates did not change over time. Equipment disinfection was reinforced with staff, and sodium hypochlorite wipes were made available in room housing patients with *C difficile* infection. Additional disposable equipment was added for isolation rooms, including lift slings, wash basins and bedside commode liners. The team identified the potential for cross-contamination of mobile work stations and multiuse medication vials during the medication administration process. This was combatted by eliminating the mobile work stations and installing a permanent work station within each patient room. A checklist for terminal cleaning was also implemented, which emphasized steps to reduce cross-contamination during the disinfection process. Finally, clinical staff were re-educated on the signs of *C difficile* infection to ensure that patients were identified and isolated in a timely manner.

PX-UV device

The PX-UV device (Xenex 426i; Xenex Disinfection Services, San Antonio, TX) uses a high-voltage discharge capacitor connected to a xenon flash lamp to release high-intensity, polychromatic pulses of UV light that cover the entire germicidal spectrum (210-280 nm). This novel technology differs from other sources of UV disinfection, which use low-pressure mercury lamps to produce monochromatic UV light.[14] The implementation of these devices has been previously described.[15] The devices are designed to deliver UV light to surfaces throughout the room, with a specific focus on high-touch surfaces. Multiple disinfection positions are used to assure that surfaces are not shadowed from the light. Information about each disinfection cycle is logged by the device and uploaded to an online portal. These data are used to assure that housekeeping staff are placing the robot in the appropriate number of positions for the area they are disinfecting and to track the overall usage within the health care facility.

PX-UV adjunct

One PX-UV device was deployed between July 2012 and September 2014, in addition to the performance improvement programs already implemented by the multidisciplinary team. The PX-UV device was used specifically as an adjunct to standard manual cleaning of patient areas. The usage goal across the LTAC facility included all patient rooms after discharge and communal living areas on a weekly basis, such as dining rooms, rehabilitation areas, and lounges. Device usage was tracked using an on-board data log. On average, the PX-UV device was used to disinfect 85 discharge rooms and communal living areas per month. Disinfection was primarily done in the communal living areas because of the low discharge volume at the facility.

Statistical analysis

HA *C difficile* infection rates for each intervention were compared with infection rates of the directly previous intervention period. Because of the nonparametric nature of our data, comparisons were made using a 2-sample Wilcoxon rank-sum test in Stata

Table 1
Hospital-acquired *Clostridium difficile* infection rates by intervention period

Intervention Phase	Intervention period	Infection rate per 10,000 patient days (no. of cases)	SD	% reduction from previous period	*P* value
No intervention	July 2010- June 2011	23.3 (30)	19.64	NA	NS
C difficile team	July 2011-June 2012	19.3 (23)	14.06	17.3	.91
PX-UV + *C difficile* team	July 2012-September 2014	8.3 (22)	8.88	56.9	.02

NA, not applicable; *PX-UV*, pulsed-xenon ultraviolet light disinfection.

software version 12.1 (StataCorp, College Station, TX). The analysis was sufficiently powered to detect differences between the intervention groups.

RESULTS

During the 12-month preintervention period, the HA *C difficile* infection rate was 23.3 per 10,000 patient days. On the addition of the multidisciplinary team, the HA *C difficile* infection rate dropped 17.3% to 19.3 per 10,000 patient days ($P = .91$). PX-UV was then implemented in July 2012 while the multidisciplinary team approach continued (Fig 1). Over a 15-month period, infection rates dropped 56.9% compared with the baseline year to 8.3 per 10,000 patient days ($P = .02$) (Table 1). Based on these outcomes, it is predicted that the facility was able to prevent 29 HA *C difficile* infections and generate over 210 additional patient bed days within the 15-month intervention. At $13,500 in hospital care costs per case, this could have potentially resulted in net savings of approximately $300,000.[16-23]

DISCUSSION

HA *C difficile* rates during the use of PX-UV in conjunction with the multidisciplinary team were lower than those rates during the multidisciplinary team intervention alone. Based on the available data, it is not possible to determine whether this impact is solely from the addition of PX-UV or from a synergistic effect of the 2 interventions.

The use of PX-UV in the LTAC setting is very different from the applications that have previously been reported in acute care settings. Patients are discharged much less frequently from LTAC facilities; therefore, there is less daily demand for PX-UV for terminal cleaning purposes. Rather, PX-UV was used in high-traffic ancillary and communal living areas. These areas provide an environment where health care workers and patients regularly intermingle, and there are frequent opportunities for environmental contamination and transmission. These data show the potential of enhanced disinfection for impacting the rates of *C difficile* in LTAC facilities and other facilities with different operational patterns than acute care hospitals.

These findings further support the previous research implicating the environment as a factor in the transmission of *C difficile*. Colonized and infected *C difficile* patients will shed large numbers of bacteria into the environment, and these bacteria can persist for months. Because of extended length of stay, lower immune function of patients, and the communal nature of long-term care, it is reasonable to expect that the exposure risk to *C difficile* from the environment is substantial in this care setting. While these results demonstrate that no-touch disinfection could be successfully implemented a single LTAC, more studies are needed to demonstrate that this type of program can be replicated in other LTACs. It may be useful for future research to perform environmental sampling of the patient rooms and communal areas of LTAC facilities to validate the assumption that the communal areas serve as an important reservoir in this care setting.

This study is inherently limited by the quasi-experimental design. The nonrandomized design limits the ability to attribute the reduction in HA *C difficile* solely to the implementation of the PX-UV device. However, these results are corroborated by previous quasi-experimental studies showing reductions in infections after the implementation of PX-UV. This research adds to the body of evidence describing the effectiveness of PX-UV devices and demonstrates that this technology can be successfully implemented in the long-term care setting.

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