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Brief report

The effect of portable pulsed xenon ultraviolet light after terminal cleaning on hospital-associated *Clostridium difficile* infection in a community hospital

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There is evidence that contamination of patient rooms from previous occupants is associated with hospital-associated *Clostridium difficile* infection (HA-CDI). During January 2011, the use of 2 portable pulsed xenon ultraviolet light devices (PPX-UV) to disinfect patient rooms was added to routine hospital discharge cleaning in a community hospital. In 2010, the HA-CDI rate was 9.46 per 10,000 patient-days; in 2011, the HA-CDI rates was 4.45 per 10,000 patient-days (53% reduction, $P = .01$). The number of deaths and colectomies attributable to hospital-associated *C difficile* infection also declined dramatically.

There is mounting evidence that contamination of patient rooms from previous occupants is associated with hospital-associated *Clostridium difficile* infection (HA-CDI).[1,2] A number of environmental interventions have been introduced to attempt to decrease *C difficile* transmission within hospitals. Although guidelines published by the Society for Healthcare Epidemiology of America (SHEA)[3] for CDI were followed in our hospital, CDI remained a concerning clinical issue These guidelines include, for *C difficile* rooms, the use of chlorine-based agents for daily and terminal cleaning of rooms where patients with *C difficile* are housed, contact precaution measures for the duration of the hospital stay, and use of soap and water for hand hygiene. We had also implemented enhanced education on improved cleaning techniques and competency evaluations for our environmental services (ES) workers prior to the use of the ultraviolet (UV) light.

Rutala and Weber[2] state that "new technologies hold the promise for improved disinfection of rooms with *C difficile* surface contamination." Specifically, both Rutala et al[4] and Nerandzic et al[5] showed that UV light treatment has the potential to lower environmental *C difficile* contamination levels in patient rooms. Both Boyce et al[6] and Stibich et al[7] demonstrated the effectiveness of portable UV light devices on deactivating *C difficile* endospores. To date, however, no one has demonstrated clinical impact on facility-wide HA-CDI with the use of automated environmental decontamination technology. We report a significant decrease in the HA-CDI rate, as well as in the number of both CDI-related deaths and CDI-related colectomies after hospital-wide implementation of portable pulsed xenon UV (PPX-UV).

METHODS

Cooley Dickinson Hospital is a 140-bed acute care community hospital in western Massachusetts with mostly single-bed rooms. During January 2011, the use of 2 PPX-UV devices (Xenex Healthcare Services, San Antonio, TX) to disinfect patient rooms was introduced. Rooms and bathrooms were terminally cleaned as usual with a hospital-grade disinfectant product (ph7Q Ultra; Betco Corporation, Toledo, OH) in most rooms and a chlorine-based product (Clorox Clean-up and Clorox Germ Wipes; The Clorox Company, Oakland, CA) in *C difficile* rooms. This was followed by the use of PPX-UV, for three 7-minute exposures (once in the bathroom and then in 2 locations in the main patient room). The overall room turn-over time was extended by approximately 15 minutes over a standard terminal cleaning because cleaning could continue in the main room during PPX-UV treatment of the bathroom.

PPX-UV devices were also used in the operating suites (nights), emergency department (early mornings), and other clinical areas as available. Surveillance for HA-CDI (hospital onset plus community onset) using SHEA definitions[3] continued as per Infection

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Prevention Department routine. No environmental sampling was performed.

Description and cost of the device

The PPX-UV device contains a xenon flash lamp that emits a broad spectrum of light covering the germicidal, or ultraviolet-C (UV-C), spectrum of 200 to 280 nm as well as the visible light spectrum. The device weighs approximately 150 pounds and is approximately 20 inches wide by 30 inches long by 38 inches high. The PPX-UV system produces a pulsed flash at a frequency of 1.5 Hz with an approximate output of 505 J per pulse and a duration of less than 360 μs. The device is operated remotely by ES personnel in the hallway just outside the patient room and includes safety features such as motion sensors, which turn off the device if the door is opened. The operating time for the device for *C difficile* deactivation was 7 minutes per position. Leasing 2 machines cost less than $5,000 per month.

Baseline infection prevention policies and ES procedures

Throughout the study period, our policy followed SHEA guidelines including use of chlorine-based agents for terminal cleaning of *C difficile* rooms, use of soap and water for hand hygiene, and contact precautions for the duration of the hospital stay. Patients were put on contact precautions when *C difficile* infection was suspected but not necessarily proven. Adherence to policy was not measured. No new infection prevention policies or protocols were pursued during the intervention year.

There was no real-time antibiotic stewardship before or during the intervention. However, ciprofloxacin was added to the formulary in early 2010, with a decline in levofloxacin use and total quinolone use. As noted in Table 1, levofloxacin use (adjusted for patient-days) declined 38.6% with a rise in ciprofloxacin use, and total quinolone use declined 14.8% during the year prior to the intervention. During the intervention year, levofloxacin use continued to fall, although more modestly, and total quinolone use fell minimally. No new formulary initiatives were pursued during the intervention year.

In the previous 2 years, ES workers were educated to standardize cleaning practices and were taught about the role of environmental contamination in transmitting infections. In addition, an improved communication system (using beeper messages to alert ES staff when a room needed to be cleaned) was implemented to increase efficiency in room turnover and to inform housekeepers when chlorine-based products were needed.

PPX-UV implementation

The PPX-UV device utilization was prioritized as follows: discharged contact precaution rooms, intensive care unit rooms, and other medical/surgical/labor and delivery rooms (with the goal of using the PPX-UV device in every room after patient discharge), and in operating rooms, emergency department rooms, and on shared medical equipment when possible. No new ES workers were hired to implement this protocol.

Testing for and diagnosing C difficile

In early 2009 in-house testing for *C difficile* was changed from a toxin A-only enzyme immunoassay card test to the Meridian Immunocard Toxins A and B (Meridian, Charlotte, NC), with occasional use of a send-out polymerase chain reaction (PCR) test (Real-time PCR using LightCycler and Fluorescent Resonance Energy Transfer; Mayo, Rochester, MN). In 2011 results from (more frequently used) PCR tests were also included in the data. The definition we used for HA-CDI[3] did not change over the study periods. Genotyping was not performed.

Table 1
Quinolone use 2009-2011

Year	Quinolone-days	Quinolone-days/patient-days × 100 (Q/P)	Percent change (Q/P) from previous year
2009			
Ciprofloxacin-days	88.5	0.24	
Levofloxacin-days	4,848	13.2	
Total quinolone-days	4,936.5	13.5	
2010			
Ciprofloxacin-days	1,215.5	3.5	+1,358%
Levofloxacin-days	2,819	8.1	−38.6%
Total quinolone-days	4,034.5	11.5	−14.8%
2011			
Ciprofloxacin-days	1,527.5	4.5	+28.5%
Levofloxacin-days	2,265	6.7	−17.3%
Total quinolone-days	3,792.5	11.2	−2.6%

NOTE. Ciprofloxacin-days = ciprofloxacin doses administered divided by 2. Levofloxacin-days = levofloxacin doses administered. Quinolone-days = ciprofloxacin days + levaquin days.

Statistical analysis

HA-CDI rates were compared using a 1-tailed *t* test calculated using Stata Data Analysis and Statistical Software (STATA Corp, College Station, TX).

RESULTS

HA-CDI rates

The HA-CDI rate per 10,000 patient-days was reduced from 9.46 in 2010 to 4.45 in 2011 (53% reduction; $P = .01$; 95% confidence interval: 6.40-12.4; $t = 2.491$). Previously rates were stable at an average of 9.22 for the years 2008 to 2010 (compared with 2011, 52% reduction; $P = .002$; 95% confidence interval: 7.58-10.8; $t = 2.97$). It should be noted that, of the 15 patients who were diagnosed with HA-CDI in 2011, 11 (73%) were placed in rooms that had *not* been treated with the PPX-UV device prior to occupation. Overall, 56% of discharged rooms received the UV light treatment. One reason some rooms were not treated was the simultaneous discharge of a number of patients and the limited number of devices. In addition, whereas most of our rooms are single occupancy, occasionally 2-bed rooms with 1 patient remaining could not be fully treated, although often the bathroom was treated. The at-risk population at our facility had a fairly stable median age (57.5-58.4 years), and our patient acuity index rose slightly (see Table 2).

Death and colectomy

During 2011, there was 1 attributable death, and there were no attributable colectomies, whereas there were 6 and 3, respectively, in 2010; 8 and 1, respectively, in 2009; and 4 and 1, respectively, in 2008.

DISCUSSION

The HA-CDI rate in 2011, during the use of PPX-UV, was significantly lower than during the previous 1 year and than the average of the previous 3 years. The inclusion of PCR data in 2011 would have increased our rate of positive tests, if all other factors were the

Table 2
Annual hospital and *C difficile* data

	2008	2009	2010	2011
Number HA-CDI patients	32	36	33	15
Number HA-CDI attributable deaths	4	8	6	1
Number HA-CDI attributable colectomies	1	1	3	0
Rate HA-CDI per 10,000 patient-days	8.36	9.85	9.46	4.45*
Rate of death for HA-CDI patients (number deaths/total HA-CDI)	0.13	0.22	0.18	0.067
Rate of colectomy for HA-CDI patients (number colectomies/total HA-CDI)	0.03	0.03	0.09	0.0
Number of community-associated CDI (inpatient and outpatient)	46	66	62	58
Percentage of discharge rooms treated with PPX-UV	0	0	0	56
Number (%) of HA-CDI patients whose rooms were *not* treated with PPX-UV prior to admission	32 (100)	36 (100)	33 (100)	11 (73)
Hospital patient-days	38,263	36,540	34,870	33,687
Hospital average age	57.9	58.4	57.5	58.3
Hospital acuity index (Diagnosis-related group case weight, Centers for Medicare and Medicaid Services)	0.0953	1.1265	1.1315	1.1386

*Comparison of HA-CDI rate in 2010 vs 2011: 53% reduction, $P = .01$; 95% confidence interval: 6.40-12.4; $t = 2.491$. The average HA-CDI rate for 2008-2010 was 9.22. Comparison of this rate with 2011 rate: 52% reduction; $P = .002$; 95% confidence interval: 7.58-10.8; $t = 2.97$.

same, thus making a change in data collection or testing unlikely to have accounted for our results. Hospital average age and acuity index increased slightly between 2010 and 2011, which probably would have increased patient risk for HA-CDI (see Table 2).

Because antibiotic use—in particular levofloxacin—may be a risk factor for the development of HA-CDI,[8] our quinolone usage was evaluated (see Table 1). Total quinolone use fell prior to the implementation of PPX-UV but remained relatively stable between the 1 year prior and the intervention year. Interestingly, levofloxacin use declined significantly during the previous 1 year (2010) without a major change in HA-CDI compared with the prior year (2009). Levofloxacin use continued to decline modestly in the study year, with a rise in ciprofloxacin use compared with the previous year. Given that a dramatic decline in levofloxacin use did not appear to affect the HA-CDI rate between 2009 and 2010, it appears unlikely that further changes in quinolone use accounted for the significant change in HA-CDI during the study year.

The total number of HA-CDI-related deaths and colectomies decreased substantially, with no colectomies attributable to HA-CDI occurring during the intervention year. Additionally, the rate of death because of HA-CDI declined. This may be attributable to the decrease in number of cases and/or to the severity of cases.

Whereas the goal was to use PPX-UV in every room at terminal cleaning, discharges often occurred simultaneously. With only 2 devices, and patients waiting to be admitted, some rooms were not treated. However, vacated precaution rooms were given priority for treatment with PPX-UV. In addition, there are approximately 30 rooms that may have double occupancy when the census is high. Because people should not be exposed to the PPX-UV light, 2-bed rooms vacated by 1 patient but housing the second could not be treated, although in those situations ES staff often used the device in the bathroom only.

Prior to implementation of PPX-UV, ES workers were trained in the use of the device as well as the important role the workers play in preventing illness and death. Although adding PPX-UV to their routine did increase their workload, as a group they felt great pride in being a part of the infection prevention team and playing an enhanced role in patient care. Although there were some initial issues with bulb longevity, the use of PPX-UV was quickly and easily integrated into the ES work schedule without additional staff.

The quasiexperimental design of this study makes definitive declaration of cause and effect impossible. Besides a continued decrease in the use of levofloxacin and an increase in ciprofloxacin use, no other significant antibiotic usage or infection prevention policy changes were known to occur. In addition, whereas the total number of subjects under surveillance was large, the total number of subjects with HA-CDI was small. The study does reflect, however, the successful implementation of this new technology in a real-world setting, with improved patient outcomes.

The dramatic reduction in infection, death, and colectomy due to HA-CDI after PPX-UV was added to standard infection prevention interventions makes this technique well worth investigating further in a large center with well-controlled variables.

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