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SHORT REPORT

Analyzing the process of implementing pulsed-xenon ultraviolet light for environmental disinfection

Kazuaki Jindai[1,2,3], Jackson Musuuza[4,6], Timothy Hess[1], Sarah Van Hoof[5], John Marx[5], Michelle Schmitz[5], Nasia Safdar[1,6]

1. Section of Infectious Diseases, Department of Medicine, University of Wisconsin School of Medicine and Public Health, Madison, WI;
2. Veterans Affairs Portland Healthcare System, Portland, OR;
3. School of Public health, Oregon Health & Science University, Portland, OR;
4. Institute for Clinical and Translational Research, University of Wisconsin School of Medicine and Public Health, Madison WI;
5. Department of Infection Control, University of Wisconsin Hospital and Clinics, Madison WI;
6. The William S. Middleton Memorial Veterans Affairs Medical Center, Madison, WI

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Introduction

Many system level factors impact whether an intervention is successfully implemented.[1,2] Human factors engineering principles can help to identify and manage complex interactions among technology, health care workers and health care systems in infection prevention and control practice.[3,4]

The Systems Engineering Initiatives for Patient Safety (SEIPS) model is an innovative human factors engineering approach that allows us to understand structures, processes and outcomes, and how they interact in health care.[5] The SEIPS model focuses on five interacting elements of the work system and how they interact to affect processes and the resulting patient and organizational outcomes.

Corresponding Author
Dr Nasia Safdar,
University of Wisconsin Hospitals and Clinics
Email: ns2@medicine.wisc.edu

We used the SEIPS model as the main framework to examine obstacles and facilitators to the implementation of portable pulsed-xenon ultraviolet (PX-UV) devices used for environmental disinfection. We also examined the impact of this intervention on hospital acquired *Clostridium difficile* infection (HACDI) rates at a unit level.

Material and Methods

This quality improvement project (institutional review board exempted) was conducted at 566-bed academic tertiary medical centre from September 2011 through March 2013. We included eight units which, at baseline, had received the following infection control measures to prevent in-hospital *Clostridium difficile* infection: 1) monitoring and feedback of environmental cleaning using the fluorescent marker system (EnCompass™; Ecolab, St. Paul, Minnesota), and 2) daily sodium hypochlorite bleach (Dispatch®; Clorox, Oakland, California).

Treatment

Among the eight units, rooms in four units where HACDI occurrence (disease onset >72 hours post admission) was above the mean hospital rate concurrently received cleaning with a PX-UV device (Xenex®; Xenex Disinfection Service, San Antonio, Texas, USA) (treatment units). The other four units served as control units. Treatment units consisted of an acute general medicine care unit, a cardiothoracic/pulmonary unit with mixed intensive and general care, a haematology/oncology unit and a solid organ transplant unit. The control units were the vascular surgery, neuro-intensive care, general surgery and medical/surgical intensive care units.

Design

As the environmental services staff (ESS) are one of the most important drivers for implementing infection control practice,[6] we conducted a focus group with the ESS evaluating their perceptions, the work flow for cleaning a room for a patient with HACDI, and what barriers and facilitators exist in their room cleaning job. The probes for the focus group were developed using the SEIPS model. The focus group was conducted during a scheduled meeting time for ESS. A total of 26 ESS personnel participated and the focus group discussion lasted for about 45 minutes. The focus group discussion data were transcribed and organised into themes using the SEIPS model.

We also assessed the clinical effectiveness of PX-UV usage in decreasing the rate of HACDI with a retrospective pre-post design, comparing treatment and control units. Compliance with PX-UV device treatment and thoroughness of cleaning were measured by a fluorescent marker system. No environmental samples were collected.

Statistical analysis

A Poisson regression model was used to evaluate HACDI rates. We conducted two analyses: 1) included all eight units over time, 2) only included the four treatment units— to evaluate the change from the pre-intervention period. Adjusted incidence rate ratios for PX-UV treatment and 95% confidence intervals (CIs) were calculated.

Results

Data were collected from four treatment and four control units over a period of 18 months, with three months of pre-treatment data and 15 months of post-treatment data. Compliance with PX-UV treatment (documentation of whether or not PX-UV treatment was done) remained greater than 90% during this project during the early period of implementation. The average of the thoroughness of cleaning, using a fluorescent marker system, pre and post treatment periods in treatment units were 83.0% and 83.7% respectively, and control units were 87.9% throughout the project period. Among treatment units, the HACDI rates were 22/10,000 patient-days and 20/10,000 patient-days before and after PX-UV treatment implementation respectively, whereas the rate was 23/10,000 patient-days throughout the project period in the control units. The HACDI incidence rate in the treatment units was not significantly different from control units (Incident Rate Ratio (IRR) 0.83, 95% CI 0.56-1.24). In addition, the HACDI incidence rate was not statistically different between the pre-post treatment periods (IRR 0.83, 95% CI 0.53-1.30) within treatment units.

Figure 1 shows application of the SEIPS model to identify key elements involved in using the portable PX-UV device. The results of the focus group are

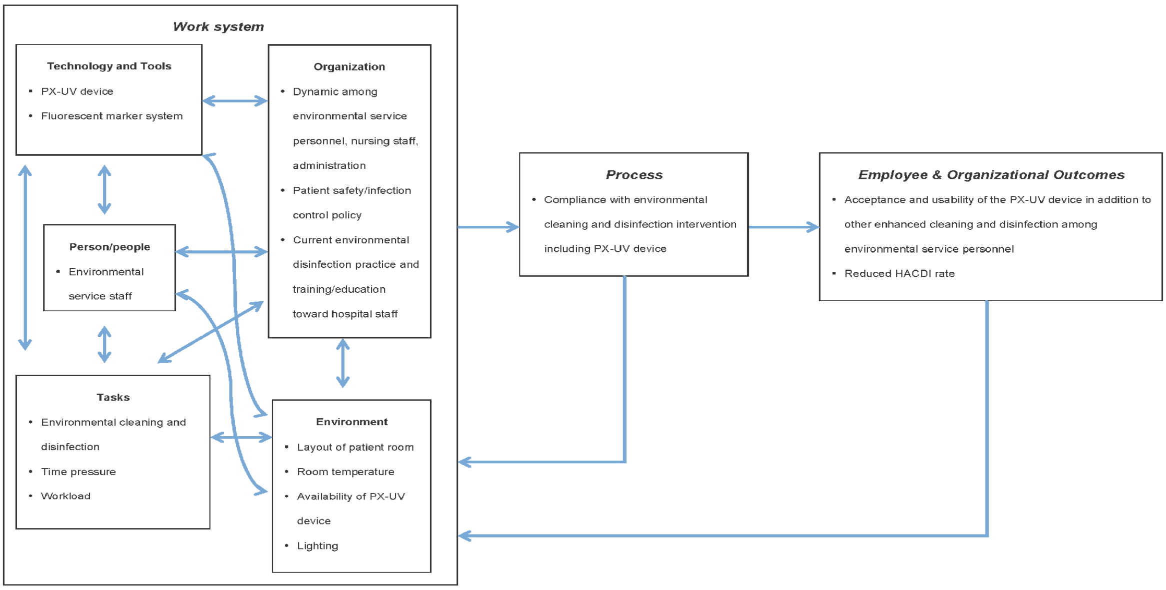

Figure 1. Application of the Systems Engineering Initiatives for Patient Safety model to identify elements involved in using the portable PX-UV device

PX-UV, pulsed-xenon ultraviolet; HACDI, hospital acquired *Clostridium difficile* infection

summarised in Table I according to the themes of the SEIPS model. In general, ESS perceived use of the machine as increasing cleaning time, and had concerns about increased mechanical failure with PX-UV. However, they were aware of its potential importance as infection prevention intervention.

Discussion

We found that in our institution, with daily and terminal bleach cleaning of all rooms in high CDI units, no additive benefit from PX-UV treatment on HACDI rates was observed. This result differs from three prior quasi-experimental studies assessing microbiologic and clinical impact of "no-touch" ultraviolet device on *Clostridium difficile*.[7-9] Similar to our project, a recent multi-centre study did not show an effect of terminal cleaning with an ultraviolet C device on the incidence of HACDI.[10]

With the SEIPS model we demonstrated that, while generally easy to use, there were multiple work system barriers associated with the device. These were mainly organisational issues such as mechanical failures and increased cleaning time. Findings of our project suggest that ESS's perception of PX-UV device as an encumbrance may pose a barrier to use. Examining the implementation of PX-UV devices in addition to their effectiveness may help adoption and uptake by institutions.

Our study had limitations. Our project could have underestimated the effect of PX-UV because of a small sample size. Also with infection control there are several interventions such as contact isolation which continuously occur for infection prevention. It is possible that some of these efforts could have been heightened during the period of the study. However, we are not aware of another novel infection prevention intervention that happened during the project period.

In conclusion, evaluation of the work system around cleaning and disinfection is important when evaluating novel disinfection approaches. A systems engineering approach allows a comprehensive assessment of the perceptions of the end users and other stakeholders in environmental cleaning and infection prevention.

Table I. Focus Group Results

Key work system components	Main themes
Person	The ESS personnel believed that the PX-UV device had additional value beyond bleach.
Tasks	The main concern raised under tasks is that using the PX-UV device increased the time needed for the cleaning process. Some felt that this might compel them to take shortcuts to finish all the rooms assigned to them.
Tools and Technologies	The ESS personnel reported that due to a limited number of machines, not all rooms underwent the intervention. Equipment breakdown due to sensor malfunction was a common event.
Physical Environment	The ESS personnel reported that there was considerable clutter in the patient rooms which interfered with the use of the PX-UV device and the cleaning process in general.
Organisation	The ESS reported that they received adequate training in using the PX-UV device. They also reported that they received weekly feedback about their cleaning after their supervisors conducted the cleaning monitoring using the fluorescent marker system.

ESS: environmental service staff; PX-UV: pulsed-xenon ultraviolet

Evaluation of barriers and facilitators to implementation is essential for the implementation of complex interventions such as environmental disinfection using PX-UV.

Reference

1. Saint S, Kowalski CP, Forman J, *et al*. A multicenter qualitative study on preventing hospital-acquired urinary tract infection in US hospitals. *Infect Control Hosp Epidemiol* 2008; **29:** 333-341.
2. Yanke E, Carayon P, Safdar N. Translating evidence into practice using a systems engineering framework for infection prevention. *Infect Control Hosp Epidemiol* 2014; **35:** 1176-1182.
3. Yanke E, Zellmer C, Van Hoof S, Moriarty H, Carayon P, Safdar N. Understanding the current state of infection prevention to prevent *Clostridium difficile* infection: A human factors and systems engineering approach. *Am J Infect Control* 2015; **43:** 241-247.
4. Anderson J, Gosbee LL, Bessesen M, Williams L. Using human factors engineering to improve the effectiveness of infection prevention and control. *Crit Care Med* 2010; **38:** S269-281.
5. Carayon P, Schoofs Hundt A, Karsh BT, *et al.* Work system design for patient safety: the SEIPS model. *Qual Saf Health Care* 2006; **15 Suppl 1:** i50-58.
6. Zoutman DE, Ford BD, Sopha K. Working relationships of infection prevention and control programs and environmental services and associations with antibiotic-resistant organisms in Canadian acute care hospitals. *Am J Infect Control* 2014; **42:** 349-352.
7. Anderson DJ, Gergen MF, Smathers E, *et al*. Decontamination of targeted pathogens from patient rooms using an automated ultraviolet-C-emitting device. *Infect Control Hosp Epidemiol* 2013; **34:** 466-471.
8. Otter JA, Yezli S, Perl TM, Barbut F, French GL. The role of ‘no-touch’ automated room disinfection systems in infection prevention and control. *J Hosp Infect* 2013; **83:** 1-13.
9. Levin J, Riley LS, Parrish C, English D, Ahn S. The effect of portable pulsed xenon ultraviolet light after terminal cleaning on hospital-associated *Clostridium difficile* infection in a community hospital. *Am J Infect Control* 2013; **41:** 746-748.
10. Anderson DJ, Chen LF, Weber DJ, *et al*. The benefits of enhanced terminal room (betr) disinfection study: a cluster randomized, multicenter crossover study with 2x2 factorial design to evaluate the impact of enhanced terminal room disinfection on acquisition and infection caused by multidrug-resistant organisms (MDRO). IDWeek 2015; October 9th, 2015; San Diego, Calfornia