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Major Article

# Environmental effectiveness of pulsed-xenon light in the operating room

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***Background:*** Manual cleaning and disinfection of the operating room (OR) environment may be inadequate due to human error. No-touch technologies, such as pulsed-xenon ultraviolet light (PX-UV), can be used as an adjunct to manual cleaning processes to reduce surface contamination in the OR. This article reports the cumulative results from 23 hospitals across the United States that performed microbiologic validation of PX-UV disinfection after manual cleaning.

***Methods:*** We obtained samples from 732 high-touch surfaces in 136 ORs at 23 hospitals, after manual terminal cleaning, and again after PX-UV disinfection (n = 1464 surface samples). Samples were enumerated after incubation, and the results are reported as total colony-forming units (CFU).

***Results:*** The average CFU after manual cleaning ranged from 5.8 to 34.37, and after PX-UV, from 0.69 to 6.43. With manual cleaning alone, 67% of surfaces were still positive for CFUs; after PX-UV disinfection, that number decreased to 38% of all sampled surfaces—a 44% reduction. When comparing manual cleaning to PX-UV, the reduction in CFU count was statistically significant.

***Conclusion:*** When used after the manual cleaning process, the PX-UV device significantly reduced contamination on high-touch surfaces in the OR.



## BACKGROUND

Current literature demonstrates that manual cleaning and disinfection of the operating room (OR) environment may be inadequate.[1] Human error inherent in the manual cleaning process results in only half of the surfaces in the OR environment being disinfected throughout the day, with the remaining surfaces having persistent contamination with pathogenic organisms. In the inpatient environment, these residual pathogens have the potential to increase the risk of infection transmission from contaminated surfaces to patients who inhabit the room during their hospital stay.[2,3] In fact, the direct relationship between surfaces contaminated with pathogens and increased risk for infection acquisition has been repeatedly demonstrated in the inpatient environment.[4-6] Similar evidence of this relationship is emerging for ORs.

A review of literature demonstrates that possible residual contamination in ORs may contribute to surgical site infections (SSIs), which are one of the most prevalent hospital-acquired infections (HAIs), representing 22% of all HAIs.[7,8] There is evidence that the environment plays a role in the transmission of SSIs.[9] Figure 1 shows a proposed mechanism for how pathogens move from contaminated surfaces to the patient or the sterile field, leading to the development of an infection. In essence, residual contamination left on surfaces across the OR after manual cleaning can be disturbed and aerosolized by movements of staff members or equipment prior to or during the surgical procedure.[11] These aerosolized particles can then settle onto sterile instruments or the sterile field, onto high-touch surfaces leading to hand contamination, or into the surgical wound itself. Even small movements, such as the surgeon bending at the waist, have been shown to significantly increase the level of aerosolized particles contaminating the sterile surgical field.[12] The recommended number of air exchanges per hour (>15) in the OR may be inadequate to capture all aerosolized organisms efficiently. A recent study of SSI risk factors found that settle plates placed in an undisturbed OR overnight produced 15 CFU/ft$^2$ per hour, but the CFU levels drastically increased to 300-400 CFU/ft$^2$ per hour when OR personnel were present.[13] Edmiston et al. found that air samples

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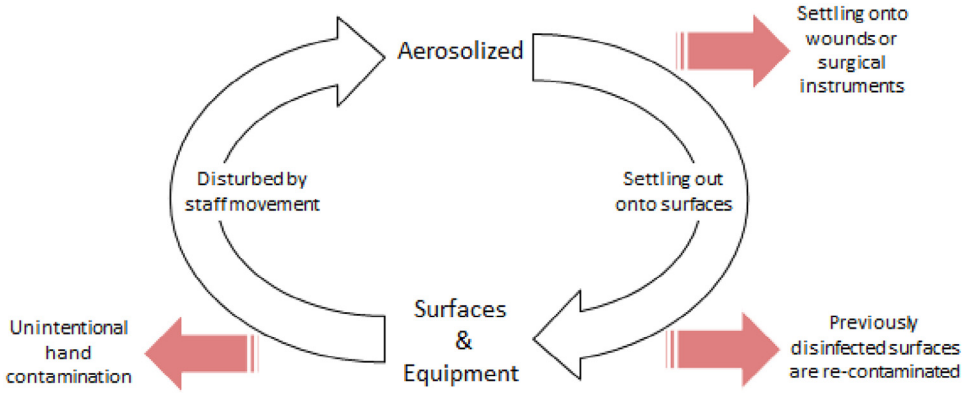


**Fig 1.** Proposed mechanisms for dispersal of environmental contaminants across the surgical field. Image from Simmons et al.[10]

taken adjacent to the operative field showed growth of both pathogenic and opportunistic organisms.[14] The relationship between air and surface contamination, and surgical site contamination, has also been demonstrated in more recent research.[15] The presence of pathogens on surfaces has been shown to increase the contamination rates of healthcare workers' hands, both bare and gloved.[16,17]

One method to interrupt this cycle of aerosolization and recontamination is to reduce the burden of residual pathogens remaining on environmental surfaces through the use of mobile no-touch disinfection technologies, such as ultraviolet (UV) light disinfection systems and hydrogen peroxide vapor systems. Reducing the initial bacterial load on surfaces reduces the amount of bacteria available to be aerosolized and redistributed throughout the patient room and OR. Association for periOperative Registered Nurses guidelines currently state that emerging no-touch technologies may be considered as an adjunct to terminal manual cleaning processes, but additional research is needed.[18] One type of UV system using pulsed-xenon ultraviolet (PX-UV) light has demonstrated efficacy beyond manual disinfection alone in the acute care inpatient setting[19-21] and could serve the same purpose after terminal manual OR cleaning.

As part of the product selection process, hospitals interested in implementing PX-UV disinfection in the OR perform microbiologic validation to test the effectiveness of no-touch disinfection as an adjunct to manual cleaning. The purpose of this article is to report on the cumulative results of this validation process from 23 hospitals across the United States.

## MATERIALS AND METHODS

### *Study sites*

Facilities included in this study are from a convenience sample of hospitals that elected to conduct microbiologic validation of PX-UV disinfection systems as a part of their product selection process. We collected data from 23 facilities with 136 ORs. The 23 facilities included 22 short-term acute care facilities and 1 ambulatory surgical center. The short-term acute care hospitals range from 106 to 844 licensed beds (median = 336) and 5 to 30 ORs (median = 12). We analyzed 732 high-touch surface samples after manual terminal cleaning, and after PX-UV disinfection, for a total of 1464 data points.

### *Manual disinfection processes*

Cleaning staff performed routine terminal manual cleaning at the end of the day using standard disinfectants and following current protocols at each of the study hospitals. To prevent any changes in normal cleaning behaviors, assurance was given to cleaning staff that the environmental testing results would be non-punitive.

**Fig 2.** Placement of PX-UV disinfection system for terminal cleaning of operating rooms

### *PX-UV disinfection process*

The PX-UV device uses a xenon flash lamp technology to produce pulses of intense, broad-spectrum germicidal UV light (200-320 nm) of short duration.[22] Prior to use, terminal manual cleaning removes visible contamination and residual surface protein load, allowing for optimal UV efficacy. The PX-UV system is placed in the room at the head of the OR bed. For the initial setup, equipment and carts are maneuvered to reduce shadowing and to optimize direct line-of-sight exposure. The device is activated through the user interface and set to run a complete cycle. Once this cycle is complete, the system is placed on the opposite side of the bed and run for another complete cycle (see Fig 2). Generally, ORs under 400 square feet will require 5-minute cycles, and ORs larger than 400 square feet will require 10-minute cycles, to account for differences in proximity to high-touch surfaces and equipment.

### *Sampling methods*

All samples were collected using 25-cm$^2$ tryptic soy agar Rodac plates (Hardy Diagnostics, item number P34). To avoid sampling the same physical area twice, the post-manual cleaning samples were taken from the left-hand side of the sampled surface, and the post-PX-UV disinfection samples were taken from the right-hand side.