Acta Scientific Microbiology (ISSN: 2581-3226)

Volume 8 Issue 1 January 2025

Research Article

# A Descriptive Analysis of Enhanced Disinfection Protocols in Reducing *Pseudomonas aeruginosa* Infection Rates in Hospitalized Patients

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**DOI:** 10.31080/ASMI.2025.07.1471

**Received:** November 26, 2024

**Published:** December 30, 2024



## Abstract

Healthcare-associated infections (HAIs) caused by *Pseudomonas aeruginosa* remain a significant concern in hospital environments, due to the pathogen's resistance to antibiotics and its ability to form persistent biofilms on surfaces. Advanced disinfection technologies, like ultraviolet-C (UV-C) light and pulsed xenon UV (PX-UV), have shown potential as solutions to these challenges. This study performed a descriptive analysis of five selected studies evaluating how effective these methods are in reducing *P. aeruginosa* contamination on hospital surfaces. The studies, conducted in China, United States, and Brazil, focused on UV-C and PX-UV disinfection methods in varied healthcare settings, with sample sizes ranging from 7 to 203 surfaces. The average reduction in colony-forming units (CFUs) was 83.4%, with individual study results ranging from 44% to 100%. UV-C showed consistent efficacy (75-99%) across different settings, while PX-UV demonstrated greater variability (44-100%). The findings underline the need to integrate advanced disinfection methods with manual cleaning protocols to improve outcomes. This analysis highlights the importance of optimizing disinfection practices and tailoring them to healthcare settings for effective infection preventions.

**Keywords:** *Pseudomonas aeruginosa*; Hospital Disinfection; Ultraviolet Disinfection; Infection Control

## Introduction

Healthcare-associated infections (HAIs) are still a huge problem worldwide, with *Pseudomonas aeruginosa* recognized as one of the causes because of the high resistance to antibiotics and the ability to form resistant biofilms on hospital surfaces [1,2]. This opportunistic pathogen has a significant risk in intensive care units (ICUs),especially in immunocompromised and critically ill patients [3]. Traditional cleaning protocols and disinfection protocols are often insufficient to eliminate *P. aeruginosa*, necessitating the adoption of advanced disinfection methods [4].

Technologies such as ultraviolet-C (UV-C) light and pulsed xenon UV (PX-UV) have been investigated for their effectiveness in healthcare environments, particularly in high-touch and high-risk areas [5,6]. UV-C disinfection works by emitting light at wavelengths that damage microbial DNA and RNA, resulting in cell death. PX-UV, onthe other hand, utilizes high-intensity pulses of xenon light that generate a road-spectrum germicidal effect, which has demonstrated significant efficacy in reducing multidrug-resistant organisms (MDROs) in various studies [7].

Recent research has shown that enhanced disinfection protocols incorporating thesetechnologies can achieve substantial microbial load reductions on hospital surfaces. For example, UV-C has been shown to decrease pathogen presence on critical surfaces, while PX-UV has demonstrated similar effectiveness in reducing pathogen load, potentially decreasing HAIs [8,9].

Given the variations in reported efficacy and the critical need for effective infection control, this study aims by systematically examining current evidence to conduct a descriptive analysis of improved disinfection protocols focusing on *Pseudomonas aeruginosa* in hospital environments.

## Methods

### Study design

This study employed a descriptive analysis to compare findings from selected studies evaluating the effectiveness of enhanced disinfection protocols in reducing *Pseudomonas aeruginosa* contamination and infection rates in hospital environments.

### Research strategy

A systematic literature analysis and review was performed to identify relevant publications and a search was conducted in the databases: PubMed, Google Scholar and Cochrane Library. The search terms were: ("*Pseudomonas aeruginosa*" OR "hospital infection") AND ("enhanced disinfection" OR "UV light" OR "hydrogen peroxide vapor" OR "advanced cleaning protocols") AND ("infection rate" OR "reduction of infection" OR "hospital-acquired infections" OR "nosocomial infections"). The search was restricted to articles published between 1 January 2017 and 31 August 2024 only in English language. A flowchart of the search strategy is presented in Figure 1.

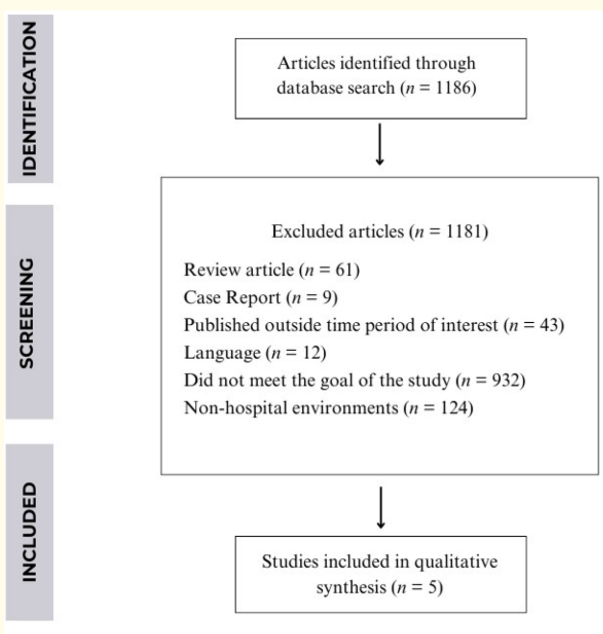


**Figure 1.** Flowchart of selection process of studies

**Figure 1**

### Eligibility criteria

Studies that reported quantitative outcomes such as CFU reduction or infection ratesspecifically focused on *Pseudomonas aeruginosa* or included it as part of their analysis were included. These studies also emphasized UV-C or PX-UV disinfection methods in hospital or healthcare environments.

Publications were excluded if they did not report specific outcomes for *Pseudomonasaeruginosa*, were reviews, editorials, letters, news, case report, guidelines or focused on non-hospital environments.

### Data extraction

For the selected studies, data were systematically extracted and organized in Table 1. The extracted data included author, year, and country, method of disinfection,control group, CFU reduction, sample size, and quantitative results.

Descriptive statistics were used to summarize the findings from the selected studies. The mean CFU reduction, minimum and maximum reductions, and standard deviation were calculated to evaluate the overall effectiveness of the disinfection methods. Additionally, trends in the efficacy of UV-C and PX-UV technologies were compared to identify patterns and practical implications for infection prevention in healthcare settings.

## Results

A total of 1168 publications were identified through the database searches. Of these,5 articles meet all eligibility criteria and were selected for this comparative study (Figure 1).

**Table 1:** Characteristics of selected studies evaluating enhanced disinfection protocols for *Pseudomonas aeruginosa* in hospital settings.

| Study | Country | Method of Disinfection | Control Group | Outcome Measure | Sample Size | Results |
|---|---|---|---|---|---|---|
| Chen., *et al.* 2019 | China | PX-UV | Manual cleaning | CFU reduction | 27 surfaces | 100% |
| Allen., *et al.* 2019 | USA | UV-C | Manual cleaning | CFU reduction | 7 surfaces | 99% |
| Correa., *et al.* 2017 | Brazil | UV-C | No cleaning | CFU reduction | 10 surfaces | 75% |
| Green., *et al.* 2016 | USA | PX-UV | Manual cleaning | CFU reduction | 110 surfaces | 44% |
| Gostine., *et al.* 2016 | USA | UV-C | Manual cleaning | CFU reduction | 203 surfaces | 99% |

The final data extraction (Table 1) included five studies conducted in China [10], United States [11-13], and Brazil [14], evaluating the effectiveness of enhanced disinfection protocols, including ultraviolet-C (UV-C) and pulsed xenon UV (PX-UV), in reducing *Pseudomonas aeruginosa* contamination on hospital surfaces. The sample sizes ranged from 7 to 203 surfaces, reflecting a variety of healthcare settings and disinfection contexts.

The mean reduction in colony-forming units (CFUs) across all studies was 83.4% (Figure 2), with a standard deviation of 24.97% (Figure 3). The observed reductions ranged from 44% in a United States based ICU study using PX-UV to a complete 100% reduction reported in a study conducted in China using PX-UV on 27 surfaces. UV-C disinfection achieved reductions ranging from 75% to 99%, demonstrating consistent efficacy across studies. The variability in reduction rates suggests that factors such as the type of disinfection technology, surface material, and cleaning protocol may influence outcomes.

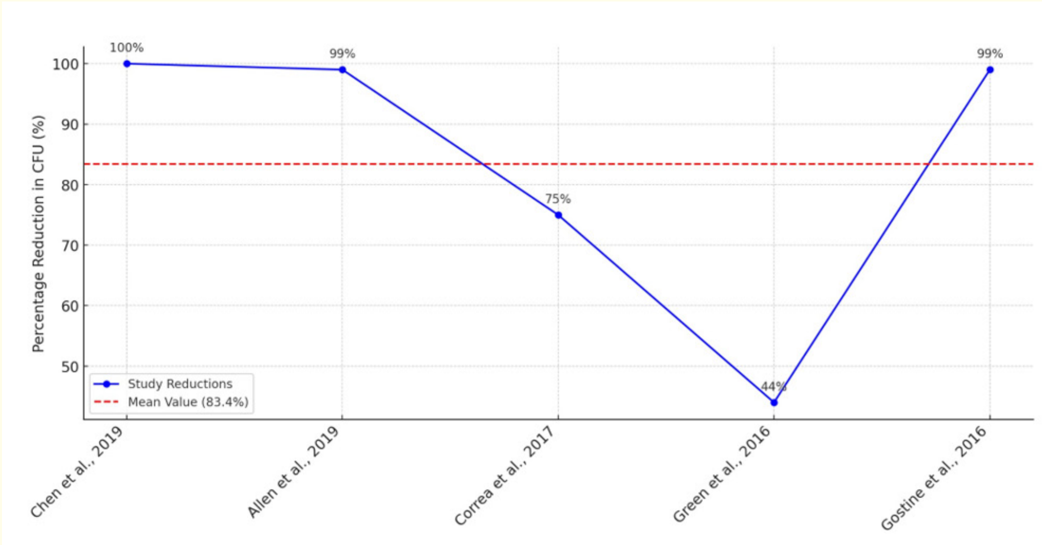


**Figure 2:** Percentage reduction of colony-forming units (CFU) observed across different studies.

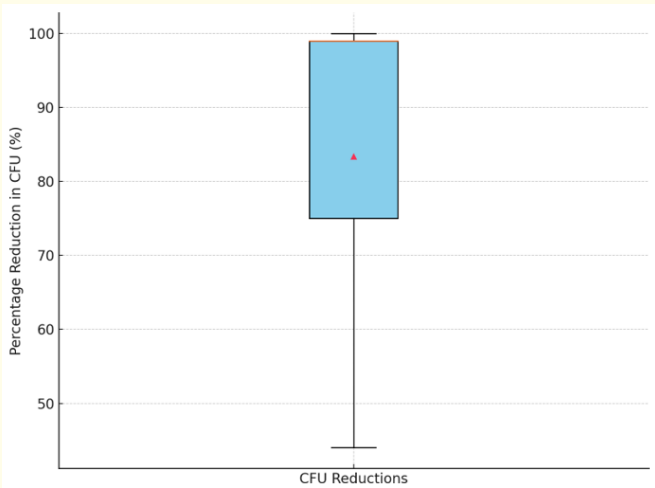


**Figure 3:** Variability in colony-forming units (CFU) percentage reduction.

When comparing the two primary disinfection methods, PX-UV demonstrated higher variability in its effectiveness. The study by Chen., *et al*. (2019) reported a 100% reduction using PX-UV, whereas Green., *et al*. (2016) reported only a 44% reductionin a burn ICU setting. In contrast, UV-C disinfection showed more consistent results, with three studies reporting reductions of 75%, 99%, and 99%, respectively. This consistency suggests that UV-C may be a more reliable option for surface disinfection in diverse hospital environments.

The studies also highlighted differences in efficacy based on the type of surface and clinical context. For example, Gostine., *et al*. (2016) focused on keyboards in ICU settings and achieved a 99% CFU reduction with UV-C disinfection. Similarly, Allen., *et al*. (2019) demonstrated a 99% reduction in room surfaces in a cystic fibrosis clinic, emphasizing the potential of UV-C in reducing contamination in high-touch areas critical for infection control. By contrast, Correa., *et al*. (2017) achieved a 75% reduction without manual pre-cleaning, highlighting the importance of combining manual and enhanced disinfection protocols for optimal results.

## Discussion

This descriptive analysis highlights the significant potential of enhanced disinfection protocols, specifically ultraviolet-C (UV-C) and pulsed xenon UV (PX-UV), in reducing *Pseudomonas aeruginosa* contamination in hospital environments. Across the five selected studies, reductions in colony-forming units (CFUs) ranged from 44%to 100%, with an average reduction of 83.4%. These findings underscore the efficacyof advanced UV-based disinfection methods but also reveal variations influenced by environmental and methodological factors.

UV-C disinfection demonstrated consistent efficacy across the studies, achieving reductions between 75% and 99%. This consistency aligns with broader literature highlighting UV-C as a reliable method for decontaminating high-touch surfaces in healthcare settings [11,12]. For instance, Gostine., *et al*. (2016) achieved a 99% CFU reduction on ICU keyboards, while Allen., *et al*. (2019) demonstrated similar results on in-room surfaces. These findings suggest that UV-C is a robust and practical addition to standard manual cleaning protocols, particularly in high-risk areas. Rutala and Weber (2013) further emphasize UV-C's effectiveness in achieving thorough decontamination of high-touch surfaces.

In contrast, PX-UV exhibited greater variability, with CFU reductions ranging from 44% to 100%. The 100% reduction reported by Chen., *et al*. (2019) demonstrates PX-UV's potential under optimal conditions, whereas the lower efficacy observed in Green., *et al*. (2016) highlights the influence of environmental and procedural factors. Literature supports the notion that PX-UV's effectiveness is sensitive to factors such as surface type, room configuration, and operational protocols. For example, Nerandzic., *et al*. (2015) and Cadnum., *et al*. (2016) found that PX-UV was effective in reducing microbial contamination on high-touch surfaces but noted variability depending on application conditions.

The variability in reduction rates across studies highlights the importance of integrating UV-based disinfection technologies with existing manual cleaning protocols. For instance, Correa., *et al*. (2017) reported a lower reduction rate (75%) in the absence of manual pre-cleaning, emphasizing the synergistic effect of combining these methods. This finding is consistent with Otter., *et al*. (2013), who argue that automated disinfection systems like UV-C and PX-UV perform best when used as complementary tools alongside manual cleaning practices.

Beyond *Pseudomonas aeruginosa*, UV-C and PX-UV technologies have demonstrated effectiveness against a wide range of healthcare-associated pathogens, including *Clostridium difficile* and *Klebsiella pneumoniae*. This broader applicability reinforces their potential role in comprehensive infection prevention strategies [14,19]. Nevertheless, the variability in results among studies reflects the challenges of standardizing disinfection practices across diverse hospital environments.

## Conclusion

In conclusion, enhanced disinfection protocols using UV-C and PX-UV demonstrate significant promise in reducing *Pseudomonas aeruginosa* contamination on hospital surfaces. While UV-C appears more consistent across diverse contexts, PX-UV offers high potential under optimal conditions but requires careful implementation. These findings highlight the importance of advanced disinfection technologies in infection prevention in healthcare environments.

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