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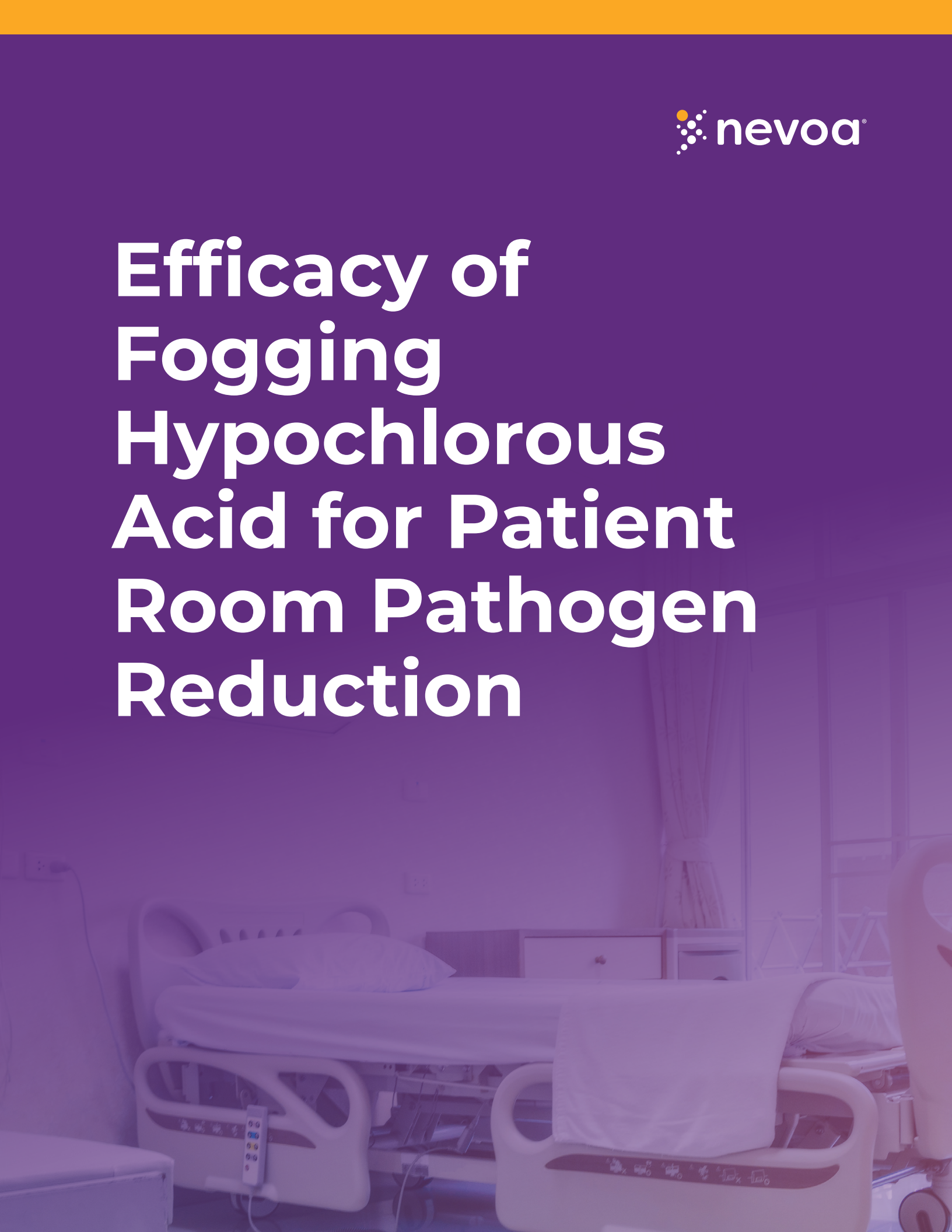
# Efficacy of Fogging Hypochlorous Acid for Patient Room Pathogen Reduction



## INTRODUCTION

Prevention of healthcare associated infections (HAIs) remains a priority for hospitals and healthcare facilities. Every year nearly 1.7 million hospitalized patients acquire an HAI while being treated for another health issue, and more than 98,000 patients die due to these infections.[1]

A common challenge with many solutions used to eliminate pathogens in patient rooms is human variability and the potential for human error. Solutions like manual cleaning and electrostatic spraying rely on an individual to manually wipe down or spray a room. Effectiveness is dependent upon using proper dilution ratios, proper technique and the proper waiting period for adequate wet time. This study seeks to take human variability out of the equation by focusing on an automated, easily repeatable solution: whole-room fogging.

Studies suggest that infection control practices including the use of whole room fogging of disinfectants will eliminate surface pathogens and minimize the opportunity for pathogen transfer.[2] This study investigated the use of the Nevoa Nimbus automated fogging technology and Microburst™ hypochlorous acid (HOCl) solution for the disinfection and reduction of surface pathogens during patient room terminal cleaning.

## BACKGROUND

One of the most frequent adverse effects of hospitalization is for the patient to develop a healthcare associated infection (HAI) during their stay. Environmental contamination has contributed significantly to pathogen transmission in major infection outbreaks of Methicillin-resistant Staphylococcus aureus (MRSA), Vancomycin-resistant enterococci (VRE), Clostridioides difficile (C. diff), and more recently, Acinetobacter baumannii.[3]

The emergence of Candida auris, a transmittable fungus, is now considered one of the most serious problems associated with infection control practices in the hospital.[4] There is documented evidence that the risk of patient colonization and infection increases significantly if the patient occupies a room that was previously occupied by an infected or colonized patient. Eliminating pathogens from patient room surfaces is essential for the prevention of HAIs.

***Every day, 1 in 31 hospital patients and 1 in 43 nursing home residents develop an HAI according to the Centers for Disease Control (CDC).[5]***

HAIs threaten a patient's safety. They frequently require extensive clinical care, longer hospitalization times and burden the healthcare system with excessive costs. The infected patient also has a more likely chance of hospital readmission and higher incidence of mortality.

Hospitals are estimated to spend between US $28 and 45 billion dollars annually for the treatment of HAIs.[6] To lower the risk of developing an HAI and improve patient outcomes, healthcare facilities continue to design robust infection prevention strategies including the use of tracking and surveillance systems as well as incorporating new, evidence based, disinfection technologies into their protocols.

Environmental room cleaning immediately following patient discharge has widely been considered a standard of practice to assist with the prevention of HAIs. However, strong evidence supports that there are notable gaps in the manual disinfection practices of high-touch environmental surfaces within the same facility. Contaminated surfaces play a major role in the development of infections via direct or indirect pathogen transfer. Several studies have shown that manual cleaning of surfaces is suboptimal with less than 50% being effectively cleaned, primarily due to the variability of human application.[7]

## SOLUTION

In order to support manual cleaning techniques, reduce surface bioburden in patient rooms and minimize the opportunity for pathogen transfer, the Touchpoint Support Services team collaborated with Infection Prevention to incorporate the use of Nimbus automated fogging technology with Microburst™ disinfectant. The fogging technology was used in a 612-bed critical access hospital in Detroit, Michigan, as part of the terminal cleaning practices in its medical intensive care unit (MICU) patient rooms and adjacent stepdown unit (4W).

Microburst™ is an EPA registered, hospital-grade disinfectant whose primary ingredient is hypochlorous acid (HOCl). The atomization of HOCl for whole-room disinfection via Nimbus technology has been proven to be effective against common viral, bacterial and fungi pathogens including spores and C. auris.[8]

The adjunct automated disinfection process of atomized Microburst™ via Nimbus was incorporated into the hospital's terminal room clean due to the lack of satisfactory results from the facility's previous use of manual cleaning and electrostatic spraying. Nimbus technology was chosen to replace electrostatic spraying for both its efficiency and consistency, as the automated system removes human application variability. Unlike electrostatic spraying, which relies on a human to manually spray every surface and ensure adequate wet time, using Nimbus is an automated process that delivers repeatable, complete and consistent surface disinfection. UV was not considered due to prior experience with lack of efficacy.

# METHODOLOGY

Nimbus fogging of Microburst™ protocol was developed to be used for all patient discharges and transfers in the medical intensive care unit (MICU) and on a selected patient unit (4W) for a period of 90 days. Environmental Service (EVS) staff members were trained on the products and manufacturer's instructions for use (IFU). Fogging of patient rooms occurred upon completion of standard policy cleaning, and after the room's final floor mop out.

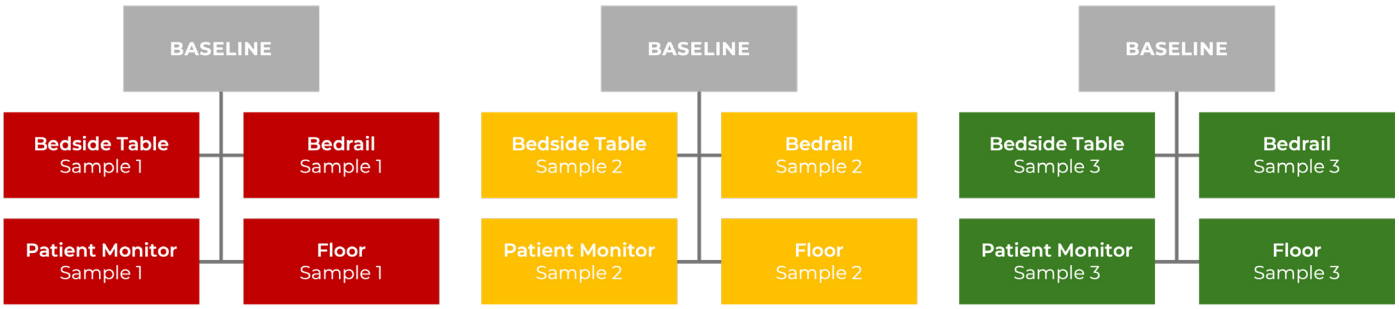
The MICU and 4W stepdown room configurations and dimensions were assessed. A 30-minute automated Nimbus cycle time was programmed for MICU rooms and a 29-minute cycle was assigned for 4W rooms and operationalized.

To demonstrate the effectiveness of the disinfection fogging protocol for the reduction of aerobic bioburden, swab sample testing of three predetermined, high-touch surface locations was conducted at three different selected times for 20 discharge rooms. Baseline samples were collected immediately after patient discharge, ten minutes post manual cleaning and ten minutes after the Microburst™ fog application.

Sampled surfaces included: patient bedside table, bed rail, patient monitor and floor (Figure 1). The aseptic, 3M™ quick swab system consisting of a five-inch, rayon-tipped swab with a letheen neutralizing buffer that facilitates the recovery of bacteria was used for collection sampling per manufacturer's instructions for use. A sampling area of 100 cm2 was selected. Samples were labeled with date, time, sequence, and room number location then logged on a designated collection form and immediately refrigerated.

A total of 240 samples from 20 discharge rooms were obtained and cultured on 3M Petrifilm™ plates. For chain of custody exactness and consistency, one trained individual conducted all surface sampling collection. Inoculated plates were processed, labeled and photographed at an independent location. Samples were incubated according to lab protocol and manufacturer's instructions. Colony forming unit (CFU) counts were documented and counted in triplicate for accuracy.

**FIGURE 1:** Sequence and Location Model




# DATA HANDLING

Raw counts were transformed by multiplying the result by the dilution factor (10) and dividing by the surface area to report the results in CFU/cm 2. In situations where the colonies on the Petrifilm™ were too numerous to count (TNTC), a representative square in the Petrifilm™ grid was counted and the result multiplied by 20, per the manufacturer's instructions, to provide an estimated count for the purposes of calculating percent reduction and log reduction.

Once the Nimbus cycle was initiated, the operator was **free to leave the patient room and perform other EVS standard tasks.**

In situations where the bioburden on a surface was insufficient to calculate a log reduction, the result is reported as the maximum calculable value with a ">" (greater than) symbol to denote that the performance of the cleaning method was more robust than what can be calculated mathematically. In situations where the number of colony-forming units on the Petrifilm™ were above or below the limit of quantitation (< 10 CFU or > 300 CFU) for the Petrifilm™, these data are flagged accordingly but are otherwise included in the analysis.

In situations where a disinfection step "created" more bioburden compared to the baseline result, this is most likely due to ineffective manual cleaning where soil was spread around instead of being removed. As it relates to the Nimbus, the technology is not capable of increasing bioburden on surfaces. In the rare instances where bioburden increased, this is likely due to the result of human activity in the test area during the study (such as walking on the floor post manual cleaning). It can also be a result of inherent bias in sampling, where adjacent surfaces to the previously sampled surfaces must be sampled to avoid the unintended yet real effect of the sampling process itself removing bioburden.

## RESULTS

Over the course of a two-week period, a total of 240 samples were collected and analyzed from 20 random discharge rooms. Fourteen of the rooms were in MICU and the remaining six rooms were located on the 4W stepdown unit. Over 23,000 CFUs were cultured from the four locations sampled in the twenty rooms. The summarized data are presented in Table 1.

**TABLE 1:** Aerobic Colony Count Comparison Data

| Aerobic Colony Count | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Average Colony Forming Units (CFU/cm²) by Surface | | | | Percent Change | | Log Reduction | | |
| Location | Baseline | After Manual Clean | After Nimbus | Average Manual Clean from Baseline Reduction | Average Nimbus from Manual Clean Reduction | Average Manual Clean Log Reduction from Baseline | Average Nimbus Log Reduction from Manual Clean | Maximum Nimbus Log Reduction from Manual Clean |
| Floor | 46.32 | 39.19 | 0.85 | -15.39% | -97.84% | 0.07 | 1.67 | 3.32 |
| Bed Rail | 42.81 | 14.39 | 0.21 | -66.39% | -98.57% | 0.47 | 1.85 | 2.16 |
| Bedside Table | 27.75 | 1.82 | 0.06 | -93.44% | -96.70% | 1.18 | 1.48 | 2.00 |
| Monitor | 4.59 | 4.33 | 0.09 | -5.67% | -97.92% | 0.03 | 1.68 | > 1.79 |
| **Grand Total** | **30.36** | **14.93** | **0.30** | **-50.83%** | **-97.99%** | **0.31** | **1.70** | N/A |

## BASELINE

The floor had the highest average bioburden (46.32 CFU/cm2), followed by the bed rail (42.81 CFU/cm2), bedside table (27.75 CFU/cm2), and monitor (4.59 CFU/cm2). On average, baseline pre-cleaning surfaces were sufficiently soiled for the purposes of this study.

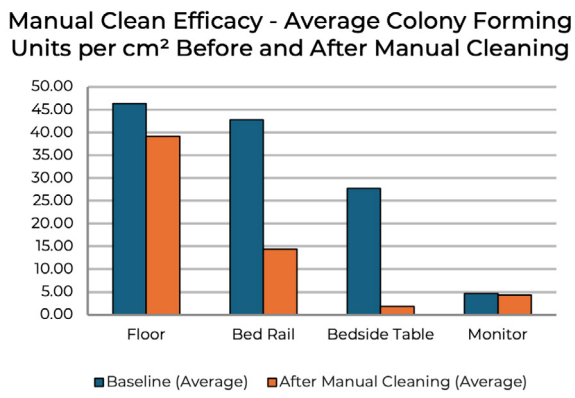
**Below 2.5 CFU/cm2** is considered an industry standard criterion for cleanliness inspections.[9]

## AFTER MANUAL CLEANING

The floor had the highest average bioburden (39.19 CFU/cm2) after manual cleaning, followed by the bed rail (14.39 CFU/cm2), patient monitor (4.33 CFU/cm2), and finally the bedside table (1.82 CFU/cm2). Applying the 2.5 CFU/cm2 cleanliness criterion, only the bedside tables, on average, were sufficiently clean prior to disinfection with Nimbus.

Overall, manual cleaning only reduced the bioburden by an average of 50%, with significant variation in the bioburden reduction depending on the surface type. Based on the data, bedside tables appeared to be the easiest to successfully clean (a 93.44% reduction in bioburden), while monitors, floors, and bed rails were more difficult to clean (5.69%, 15.39%, and 66.39% reduction in bioburden, respectively) (Figure 2).

**Figure 2:** Manual Cleaning Efficacy by Average Colony Forming Units

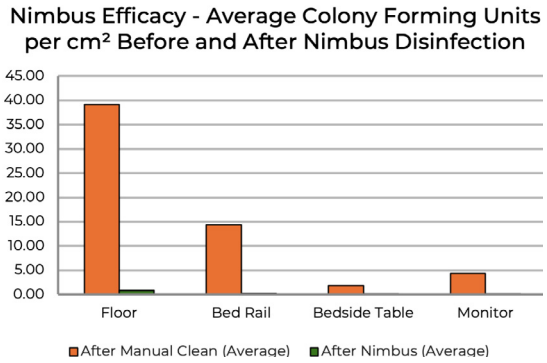


## AFTER NIMBUS DISINFECTION

The floor had the highest average bioburden (0.85 CFU/cm2) after disinfection with Nimbus, followed by the bed rail (0.21 CFU/cm2), monitor (0.09 CFU/cm2), and the bedside table (0.06 CFU/cm2). Applying the 2.5 CFU/cm2 cleanliness criterion, all surfaces tested that were disinfected by the Nimbus exceeded the cleanliness criterion.

***The adjunct use of the Nimbus and atomized Microburst™ solution delivered an average additional 97.99% CFU reduction beyond manual cleaning. Based on the data, Nimbus achieved percent reductions of > 96.70% on all surfaces, demonstrating the efficacy of the fogging technology (Figure 3).***

**Figure 3:** Nimbus Efficacy by Average Colony Forming Units




## DISCUSSION

The purpose of this study is to measure the performance of Nimbus automated fogging technology in a real-world clinical setting. While baseline bioburden (pre-disinfection), bioburden after manual cleaning, and post-disinfection were measured, the results reflect the bioburden after manual cleaning compared to post-disinfection with Nimbus.

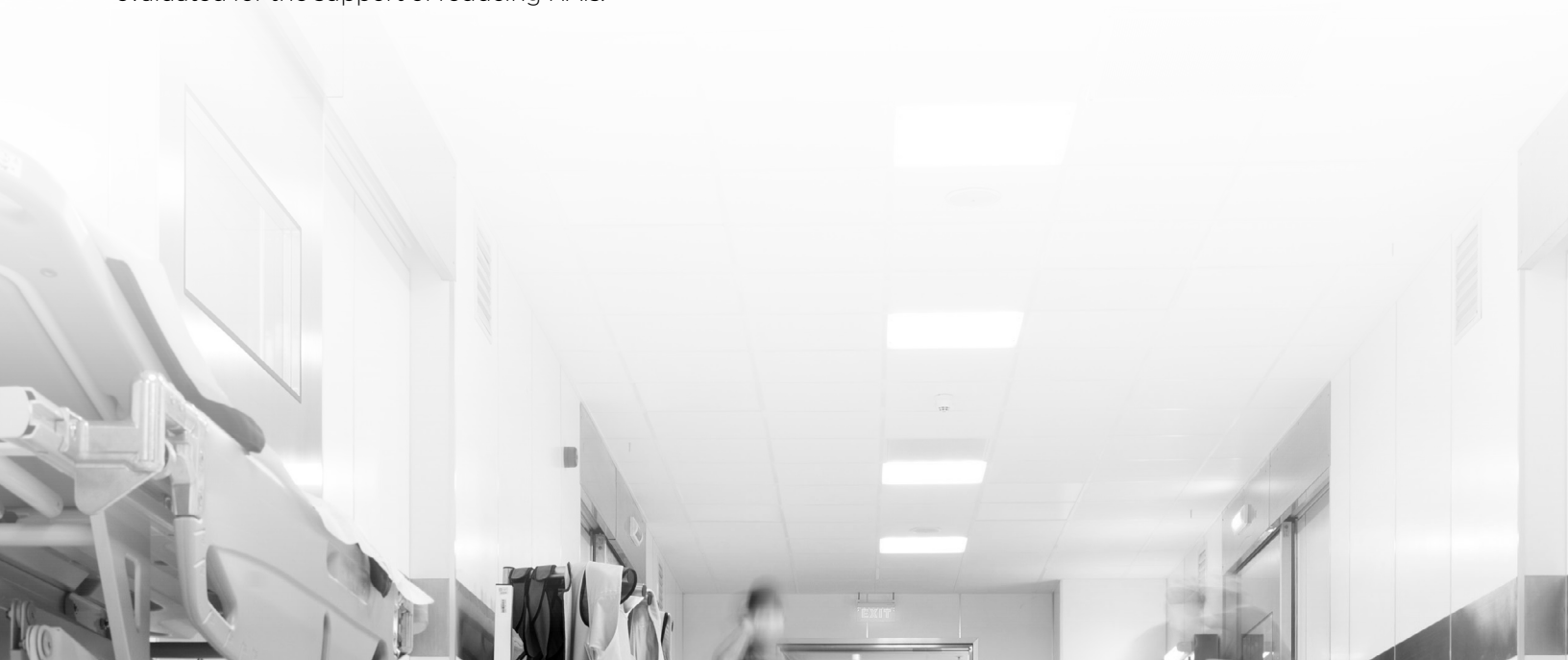
Future studies will omit the manual cleaning step as the purpose of the study is to measure the efficacy of the device, not manual cleaning. The Nimbus is designed to be used post-manual cleaning; however, we can most appropriately measure the log reduction when skipping the manual cleaning step. If manual cleaning is too efficacious, it is a confounding variable in the study that prevents us from demonstrating the true performance of the Nimbus.

Despite the hospital's EVS personnel strictly adhering to in-house guidelines for the manual cleaning of patient discharge rooms, high-touch surfaces were still found to have significant numbers of aerobic colonies creating the opportunity for potential pathogen transfer to the next admitted patient.

Notably, surfaces tested closer to the patient bed area had higher baseline colony counts than the patient monitor located farther from the patient core area. However, post manual cleaning cultures of the same sites indicated that the monitor received less attention than the bedrail and bedside table.

Manual cleaning protocols provide an opportunity for human error in disinfection practices resulting in the potential for residual pathogens. ***Documented evidence suggests that 20%-40% of HAIs originate from contaminated environmental surfaces via direct and indirect pathogen transfer.***[10] Elimination of pathogens from patient room surfaces is essential for the prevention of HAIs. Conventional, manual cleaning practices for surface disinfection are limited as they rely on personnel to ensure appropriate selection, formulation, distribution, and contact time of an effective agent.[11]

Enhanced disinfection protocols that employ automated technology such as the Nimbus fogging of Microburst™ in conjunction with standard disinfection practices deliver improved pathogen reduction and should continue to be evaluated for the support of reducing HAIs.



## CONCLUSION

Automated room disinfection systems reduce the reliance on personnel, limit the opportunity for human error, and have the potential to improve the efficacy and efficiency of terminal room disinfection. This study suggests that incorporating the fogging technology of Nimbus with Microburst™ hypochlorous acid into discharge cleaning practices delivers consistent pathogen reduction, eliminates the potential for human error and variability, and provides an efficient, repeatable disinfection process.

The automated system significantly reduces environmental surface bioburden when compared to manual cleaning alone and should be a requirement of a hospital's comprehensive cleaning protocol for the enhancement of infection prevention.

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