

Effectiveness of Ultraviolet Devices and Fogging Systems for Room Decontamination

I. Executive Summary

Maintaining cleanliness within a healthcare facility is a top priority for patients, staff, and healthcare systems. The need to address Healthcare-Associated Infections (HAI) remains a top industry priority¹, as they are an important source of patient morbidity and mortality².

The attention paid to HAIs has resulted in some exciting advancements which deserve careful assessment. Most of the systems developed in recent years to address terminal cleaning are referred to as “No-Touch” decontamination (NTD), as they are conducted by “robots” without human application of the selected disinfectant. No NTD system is intended to substitute for proper hygiene and cleaning practices, but are designed to supplement these practices with the aim of reducing HAIs to near zero³.

It is important to maintain awareness of the leading best practices available to combat HAIs; reliance upon dated studies, or failure to compare newer or evolving technologies to those already evaluated, can expose a potential blind spot to healthcare systems. Most studies involve comparison of Ultraviolet light technologies (generally in the UV-C wavelengths (200nm-280nm⁴)), and Vaporized Hydrogen Peroxide (VHP). A more recent entry into this burgeoning field includes vaporized Chlorine Dioxide. All have proven germicidal capabilities.

While NTD device manufacturers will make claims regarding the efficacy of their systems versus listed pathogens, it is important to determine the level of efficacy. While “hospital-grade disinfectants” are required to achieve a 4 log reduction (10⁴, or 99.99%), the EPA requires a 6 log (10⁶, or 99.9999%) reduction in order to claim elimination^{5,6} for pathogen such as *C. diff* spores.

II. Background

This is not a scientific paper, but relies upon the work of credentialed scientists. As such, it is neither exhaustive nor authoritative, but rather seeks to raise certain issues for clinical consideration. Due to the fact that Chlorine Dioxide (ClO₂)-based decontamination systems are relatively new, the author selected only studies and references which were recent (e.g., 2011-present)- with a few exceptions (e.g., CDC). “No touch” decontamination is a rapidly evolving field, with many vendors vying for market share; this paper does not attempt to address every vendor of each type of system, rather a few prominent examples.

Hospital System A evaluated both misting and UV disinfection technologies at the health system level as part of the *C. diff* task force in December of 2016. While four Ultraviolet (UV) technologies were considered (Tru-D, Surfacide, Steris and Xenex)⁷, the author is unaware of which misting technologies were considered, although he suspects it was Vaporized Hydrogen Peroxide (VHP). The discussion regarding the efficacy of ClO₂-based decontamination systems is pertinent, as:

¹ <https://www.beckershospitalreview.com/quality/infection-prevention-in-2016-10-key-areas-of-focus.html>

² <http://www.aafp.org/afp/2014/0915/p377.html>

³ Otter, Jon & Yezli, Saber & Perl, Trish & Barbut, Frédéric & L French, G. (2012). The role of 'no-touch' automated room disinfection systems in infection prevention and control. The Journal of Hospital Infection. 83. . 10.1016/j.jhin.2012.10.002.

⁴ <https://ntp.niehs.nih.gov/pubhealth/roc/listings/uv/summary/index.html>

⁵ EPA Guidance for *Clostridium difficile* Testing. EPA Office of Pesticide Programs, Microbiology Laboratory Branch. February 18, 2014

⁶ <http://www.hpnonline.com/inside/2015-09/1509-OR-RoomDecontam.html>

⁷ Doline, Krista M. “RE: AeroClave Demo.” Message to David Bittner. October 10, 2017 5:53 PM. Email.

1. They are approved by both the FAA and DoD⁸
2. They use EPA-registered decontaminants
3. They have been approved by multiple states (including Georgia) for use in the Infectious Disease Transportation Network (IDTN)^{9,10}
4. As a member of the GA IDTN, System EMS is currently in possession of a CIO2-based decontamination system (received at no cost)

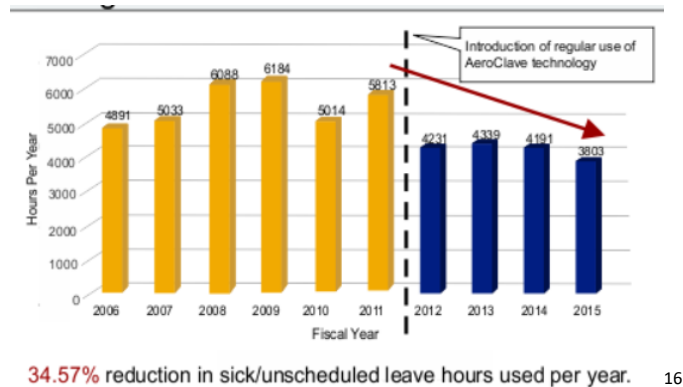
While Hospital 1 has worked hard to reduce the number of *C. diff* cases (FY17: 4; FY16: 11¹¹), *C. diff* is not the only HAI for which we should be concerned. It is clear that environmental terminal cleaning and disinfection with germicides is not always efficacious, as it has been estimated that 5%-30% of environmental surfaces remain contaminated with nosocomial pathogens¹².

Care should be taken in reviewing vendor claims, as some vendors have been ordered to end their practices of false and misleading statements regarding product efficacy.

Tru-D falsely claims its device is capable of disinfecting an entire room from a single position, specifically including shadowed areas, ignoring peer-reviewed studies that show that its device does not remove all pathogens from these areas as claimed¹³.

Xenex was required by the Better Business Bureau's National Advertisers Division to discontinue misleading advertising claims^{14,15}.

The Hospital 1 Emergency Department (ED) Director has expressed interest in using adjunct disinfection technologies in a number of ways, including within the ED Waiting Area during peak Flu season. Such implementation holds promise, as demonstrated by the Winter Park, FL EMS System, which has incorporated a touchless decontamination technology within their ambulances once/week and their EMS stations once/quarter and has reduced their sick days by 34%.



⁸ http://ogc.osd.mil/defense_ethics/resource_library/contractor_list.pdf

⁹ Prince, Margaret F. "RE: IDTN." Message to Mark Austin. October 12, 2017 12:46 PM. Email.

¹⁰ <http://www.aeroclave.net/mt-content/uploads/2017/02/fidtn.pdf>

¹¹ Doline, Krista M. "RE: AeroClave Demo." Message to David Bittner. October 10, 2017 5:53 PM. Email.

¹² Weber DJ, Rutala WA, Anderson DJ, Chen LF, Sickbert-Bennett EE, Boyce JM. Effectiveness of ultraviolet devices and hydrogen peroxide systems for terminal room decontamination: Focus on clinical trials. *Am J Infect Control* 2016;44(5 Suppl):e77-84.

¹³ <http://www.businesswire.com/news/home/20151005006780/en/Court-Order-Requires-Tru-D-Cease-False-Misleading>

¹⁴ <https://www.beckershospitalreview.com/quality/uv-robots-go-to-court-clorox-xenex-feuding.html>

¹⁵ <http://www.ascreviews.org/xenex-discontinues-claims-for-germ-zapping-robots-following-nad-inquiry-claims-at-issue-including-ebola-disinfectant-claims-challenged-by-clorox/>

¹⁶ <http://www.aeroclave.net/first-responders/>

III. NTD Assessment

A. CDC Guidance

While the Centers for Disease Control and Prevention (CDC) is an esteemed organization which often provides invaluable guidance, some of the guidance provided relies upon dated information and studies- as they themselves point out. From the “CDC Infection Control” website¹⁷, edited Feb 15, 2017- (emphasis in the original (except for highlights); numbering is in the original):

6. Disinfectant Fogging

a. Do not perform disinfectant fogging for routine purposes in patient-care areas. Category II. 23, 228*

Environmental Fogging Clarification Statement [December 2009]: CDC and HICPAC have recommendations in the 2008 Guideline for Disinfection and Sterilization in Healthcare Facilities that state that the CDC does not support disinfectant fogging.

These recommendations refer to the spraying or fogging of chemicals (e.g., formaldehyde, phenol-based agents, or quaternary ammonium compounds) as a way to decontaminate environmental surfaces or disinfect the air in patient rooms. The recommendation against fogging was based on studies in the 1970's that reported a lack of microbicidal efficacy (e.g., use of quaternary ammonium compounds in mist applications) but also adverse effects on healthcare workers and others in facilities where these methods were utilized. Furthermore, some of these chemicals are not EPA-registered for use in fogging-type applications.

These recommendations do not apply to newer technologies involving fogging for room decontamination (e.g., ozone mists, vaporized hydrogen peroxide) that have become available since the 2008 recommendations were made. These newer technologies were assessed by CDC and HICPAC in the 2011 Guideline for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings, which makes the recommendation:

“More research is required to clarify the effectiveness and reliability of fogging, UV irradiation, and ozone mists to reduce norovirus environmental contamination. (No recommendation/unresolved issue)”

The 2008 recommendations still apply; however, CDC does not yet make a recommendation regarding these newer technologies. This issue will be revisited as additional evidence becomes available.

23. Centers for Disease Control. Guidelines for Environmental Infection Control in Health-Care Facilities, 2003. MMWR 2003;52 (No. RR-10):1-44.

228. Centers for Disease Control. Recommendations for prevention of HIV transmission in health-care settings. MMWR 1987;36:S3-S18.

***Note:** “Category II”- Those recommendations suggested for implementation and supported by suggestive clinical or epidemiologic studies or by a theoretical rationale.

¹⁷ <https://www.cdc.gov/infectioncontrol/guidelines/disinfection/index.html>

The following is from reference 23, listed above (MMWR 2203;52):

MMWR

June 6, 2003 / 52(RR10);1-42

Guidelines for Environmental Infection Control in Health-Care Facilities

Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)

Do not perform disinfectant fogging in patient-care areas (270, 285). Category IB

270. Garner JS, Favero MS. CDC guideline for handwashing and hospital environmental control. *Infect Control* 1986;7:231--43.

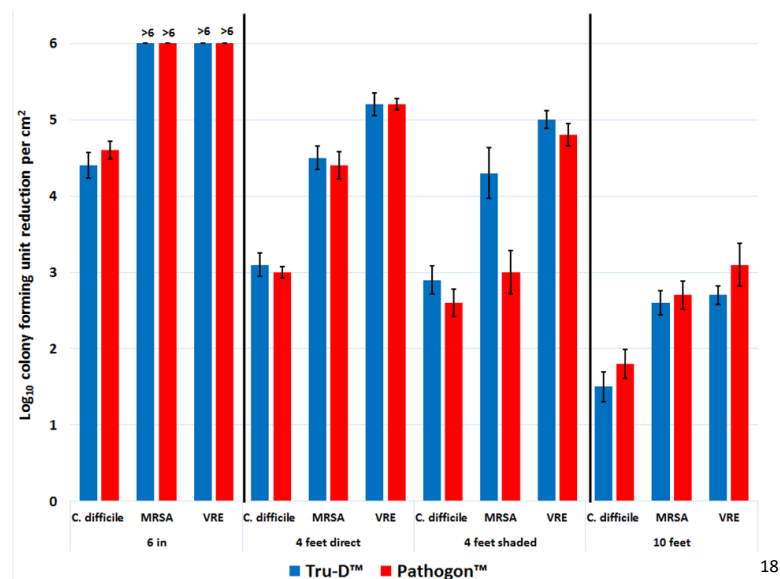
285. Mallison GF. Decontamination, disinfection, and sterilization. *Nurs Clin North Am* 1980;15:757--67.

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Thus, it is evident that the current available CDC guidance regarding NTD systems is dated and therefore not necessarily definitive.

B. UV Systems

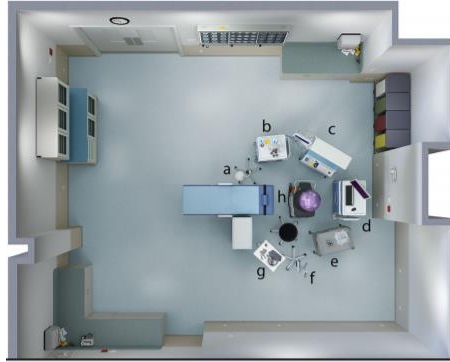
UV systems generally offer a faster room-turn time than fogging systems. Most UV systems lose effectiveness based upon distance and shading. A study showing the comparison of two leading UV systems in regard to pathogen reduction efficacy is shown in the graph below.



Some systems have attempted to address these challenges by utilizing multiple emitters, while most recent UV systems employ a “mapping” function with sensors to detect distance

¹⁸ Nerandzic, M. M., Fisher, C. W., & Donskey, C. J. (2014). Sorting through the Wealth of Options: Comparative Evaluation of Two Ultraviolet Disinfection Systems. *PLoS ONE*, 9(9). doi:10.1371/journal.pone.0107444

and reflection, adjusting both emission and duration to compensate, resulting in a more consistent efficacy rate¹⁹. The problems of distance and shadowing are inherent in all UV-C systems and cannot be completely overcome²⁰. Another shortcoming which cannot be overcome with enhancements is the fact that UV-C does not penetrate surfaces such as sheets, upholstery and curtains²¹. Most evaluations recommend repositioning equipment within the room in order to maximize the effectiveness of UV-C systems^{22,23}.



The long-term impact of UV-C on hospital materials has not been described²⁴, but UV light is known to cause deterioration of plastics²⁵.

UV-C bulbs can reach temperatures in excess of 200 degrees²⁶, requiring caution following operation. In addition, care should be taken to avoid touching the bulbs, as skin oils can affect operation²⁷; care should be taken in general to prevent damaging the bulbs. Finally, all UV-C systems come with either a remote or tablet for operation, requiring charging and tracking.

Since UV-C systems cannot be operated with humans in the room, all such systems are equipped with motion sensors to ensure automatic shut off should a door open²⁸; some are equipped with infrared sensors.

Most UV-C systems require 15 amps, and should not be plugged into an outlet with any other device²⁹.

¹⁹ Otter, Jon & Yezli, Saber & Perl, Trish & Barbut, Frédéric & L French, G. (2012). The role of 'no-touch' automated room disinfection systems in infection prevention and control. *The Journal of Hospital Infection*. 83. . 10.1016/j.jhin.2012.10.002.

²⁰ <https://infectioncontrol.tips/2016/08/18/considerations-choosing-enhanced-disinfection-system-652/>

²¹ Nerandzic, M. M., Fisher, C. W., & Donskey, C. J. (2014). Sorting through the Wealth of Options: Comparative Evaluation of Two Ultraviolet Disinfection Systems. *PLoS ONE*, 9(9). doi:10.1371/journal.pone.0107444

²² Spencer, M., Vignari, M., Bryce, E., Johnson, H. B., Fauerbach, L., & Graham, D. (2017). A model for choosing an automated ultraviolet-C disinfection system and building a case for the C-suite: Two case reports. *American Journal of Infection Control*, 45(3), 288-292. doi:10.1016/j.ajic.2016.11.016

²³ Haddad, L. E., Ghantaji, S. S., Stibich, M., Fleming, J. B., Segal, C., Ware, K. M., & Chemaly, R. F. (2017). Evaluation of a pulsed xenon ultraviolet disinfection system to decrease bacterial contamination in operating rooms. *BMC Infectious Diseases*, 17(1). doi:10.1186/s12879-017-2792-z

²⁴ Otter, Jon & Yezli, Saber & Perl, Trish & Barbut, Frédéric & L French, G. (2012). The role of 'no-touch' automated room disinfection systems in infection prevention and control. *The Journal of Hospital Infection*. 83. . 10.1016/j.jhin.2012.10.002.

²⁵ <https://www.coleparmer.com/tech-article/uv-properties-of-plastics>

²⁶ https://www.light-sources.com/wp-content/uploads/2015/05/Germicidal_Lamp_Basics_-_2013.pdf

²⁷ <https://www.spadepot.com/docs/ultraray-UV-bulb-replacement-instructions.pdf>

²⁸ <http://www.infectionpreventiontechnologies.com/next-gen-uv-validated-by-science/uv-c-safety.html>

²⁹ <http://5980c1917cb02508ad8a-145c0cd6e0bc8080df9d3865f16d59d7.r67.cf1.rackcdn.com/APIC/pdf/154128.pdf>

UV-C Continuous vs. Pulse (PU-UX)

A study funded by the U.S. Department of Veterans Affairs (VA) determined that pulsed Xenon light UV devices were less effective than continuous UV light systems³⁰.

Sodexo announced plans to Xenex as part of its standard hospital-cleaning service³¹.

Xenon bulbs last 4-6 months. Mercury bulbs last 4,000-16,000 hours (depending upon type), but require maintenance, and effectiveness degrades over time. Lower dosages from degraded bulbs can result in reduced efficacy and a false sense of security³².

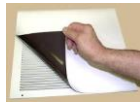
Note: Houston Medical Center in Warner Robins, GA, adopted the Clorox Optimum System in June 2014

C. VHP Systems

VHP systems generally offer a higher efficacy result than UV systems^{33,34}.

May discolor fabrics; difficult to remove from fabrics³⁵. Other materials which may be affected by VHP include: nylon, anodized aluminum, copper, galvanized steel, titanium dioxide, latex, freshly painted/improperly cured surfaces³⁶.

HVAC systems and smoke detectors must either be disabled or covered during system use. A variety of readily available, easy to use, reusable and inexpensive products are available to assist in this process. Magnetic vent covers are available from Home Depot, WalMart and Amazon, and are available to fit standard-size floor and wall vents. For smoke detectors and



Magnetic Vent Cover



Smoke Detector Cover



Haloshield HVAC Vent Cover



ceiling vents, HaloShield reusable vent and smoke detector covers help make room preparation for fogging treatment faster and easier. They install quickly, using an extendable pole to provide secure cover installation from the floor without the use of a ladder.

D. CIO2 Systems

CIO2 systems seem to offer the fast turn-around times of UV systems with the ability to ensure whole room decontamination utilizing a safe, EPA-approved disinfectant, coupled with

³⁰ Michelle M. Nerandzic, Priyaleela Thota, Thriveen Sankar C., Annette Jencson, Jennifer L. Cadnum, Amy J. Ray, Robert A. Salata, Richard R. Watkins and Curtis J. Donskey (2015). Evaluation of a Pulsed Xenon Ultraviolet Disinfection System for Reduction of Healthcare-Associated Pathogens in Hospital Rooms. *Infection Control & Hospital Epidemiology*, 36, pp 192-197. doi:10.1017/ice.2014.36.

³¹ <https://www.forbes.com/sites/christopherhelman/2011/11/02/bug-zapper-how-a-new-machine-snuffs-killer-bacteria-with-ultraviolet-blasts/#755e5c91237c>

³² <http://5980c1917cb02508ad8a-145c0cd6e0bc8080df9d3865f16d59d7.r67.cf1.rackcdn.com/APIC/pdf/154128.pdf>

³³ Nerandzic, M. M., Fisher, C. W., & Donskey, C. J. (2014). Sorting through the Wealth of Options: Comparative Evaluation of Two Ultraviolet Disinfection Systems. *PLoS ONE*, 9(9). doi:10.1371/journal.pone.0107444

³⁴ Cobb, T. C. (2017). Methicillin-resistant *Staphylococcus aureus* decontamination. *Reviews in Medical Microbiology*, 28(2), 69-74. doi:10.1097/mrm.0000000000000097

³⁵ <http://5980c1917cb02508ad8a-145c0cd6e0bc8080df9d3865f16d59d7.r67.cf1.rackcdn.com/APIC/pdf/154128.pdf>

³⁶ https://www.bandvtesting.com/uploads/news/id49/B&V_Archive_decon_item2_VHP%20decon%20Life%20sciences.pdf

ease-of-use- but potentially at the cost of greater efficacy. While no modern case studies were found which employed ClO₂ fogging in a hospital environment for the purpose of adjunctive terminal cleaning, >6 log reductions have been observed in ambulance environments³⁷.

AeroClave has the added feature of a handheld wand, making it suitable for spot treatment, or for use in areas where a single-point emitter (e.g., UV) isn't feasible, such as: hallways; vertical treatment areas; areas which cannot be vacated for a decontamination cycle.

While a minor consideration, the portable AeroClave unit can be placed on a shelf and doesn't require floor space for storage (unlike the larger AeroClave or all of the UV devices).

Like VHP systems, HVAC systems and smoke detectors must either be disabled or covered during system use. There are no documented hazards with the AeroClave system; it is considered safe for use with all major material classes (metal, wood, vinyl, plastic, paper, etc.).

IV. Other Factors

A. Training and Compliance

Most environmental failures are likely due to personnel themselves, not products or practices³⁸. Assessment of the cleaning process can be introduced by using educational strategies, direct and indirect cleaning inspections, observation, scientific monitoring, and feedback to staff. Any form of environmental monitoring is quickly noticed by housekeeping staff, although the effect can wear off without continued feedback or education³⁹.

B. Air Quality

While high-touch areas are a key area for IPC efforts, HAIs are not just transmitted through cross-contamination via hard surfaces and floors. Attention should also be paid to airborne germs. Patients and staff are exposed through sneezing, and by round-the-clock movement of visitors, as germs are drawn into and distributed by heating, ventilation and air-conditioning (HVAC) systems.

Ultra Violet Germicidal Irradiation (UVGI) technology is commonly used in hospital and commercial buildings. This simple technology retrofits into existing heating, ventilation and air-conditioning systems, significantly improving indoor air quality and reducing HAIs for patients and healthcare professionals⁴⁰.

V. Selection criteria

There are a number of variables and cautions which should be considered when evaluating adjunct terminal cleaning systems, only a few of which will be discussed here.

³⁷ Lowe, J. J., Hewlett, A. L., Iwen, P. C., Smith, P. W., & Gibbs, S. G. (2013). Evaluation of Ambulance Decontamination Using Gaseous Chlorine Dioxide. *Prehospital Emergency Care*, 17(3), 401-408. doi:10.3109/10903127.2013.792889

³⁸ Hota B, Blom DW, Lyle EA, Weinstein RA, Hayden MK. 2009. Interventional evaluation of environmental contamination by vancomycin-resistant enterococci: failure of personnel, product, or procedure? *J. Hosp. Infect.* 71:123–131. 10.1016/j.jhin.2008.10.030

³⁹ Dancer SJ. 2011. Hospital Cleaning in the 21st Century. *Euro. J. Clin. Microbiol. Infect. Dis.* 30:1473–1481. 10.1007/s10096-011-1250-x

⁴⁰ https://www.cleanroomtechnology.com/technical/article_page/COMMENT_UVC_lights_the_way_to_improved_healthcare_and_reduced_cots/88249

One issue which hampers comparison of NTD systems is the lack of standardized testing methods for UV-C systems⁴¹. This, coupled with evolving technology and up-front system costs, have resulted in a dearth of scientific case studies.

An independent study performed at Yale compared the two most commonly used no-touch disinfection systems, VHP and UV systems. "VHP systems are associated with elimination of pathogens from surfaces, a 6-log sporicidal reduction and homogeneous distribution. UV systems are associated with a reduction, but not elimination of pathogens from surfaces, a 1-3 log sporicidal reduction and are significantly less effective out of direct line of sight of the device,"⁴².

The chart below compares the major NTD systems against a simple set of selection criteria.

Selection Criteria	UV-C					VHP	CIO2	
	Xenex ¹	Steris	Surfacide	Tru-D	Optimum	Bioquell	RDS 3110	RDS 6110
Up Front Cost	\$104,000	\$50,000	\$125,000	\$125,000	\$47,250	\$47,000	\$14,000	\$27,499
Infection Rate Impact ⁶	10 ⁵	10 ⁴	10 ^{2.5}	10 ^{2.4}	10 ^{2.78}	10 ⁶	10 ^{2.5}	10 ^{2.5}
Maintenance Cost	\$60	\$3,780	\$3,645	\$560	\$4,200	\$180	\$35	\$35
Cycle Time ⁷	15 min	20-30 min	30-45 min	15-25 min	15-20 min	45 min (+)	35 min	25 min
Cycle Cost	\$3.50	\$15	\$15	\$15	\$15	\$175	\$1.75	\$1.75
Operators	Trained	EVS	EVS	EVS	EVS	EVS	EVS	EVS
Access to Rooms	No ³	No ³	No ³	No ³	No ³	No	Yes ⁴	Yes ⁴
Safety ⁵								
Environmental Friendliness ²								
	1- Pulse Xenon							
	2- Green: No negative impact; Yellow: glass bulbs with mercury (disposal); Red: hazardous							
	3- Human hazard; motion detector automatic shut-off. Remote activation. Barriers required.							
	4- Rated HIMMS-0, no danger to humans							
	5- Green: no hazard to humans; Yellow: danger to retina and skin; Red: Vapor dangerous							
	6- Rate is for C.diff; most systems obtain higher rates for other pathogens.							
	7- Cycle time for C. diff could be longer- open source data is incomplete							
	Surfacide system has three emitters, so maintenance is 3x							

VI. ROI

A. General

A detailed Return on Investment (ROI) discussion will require a more detailed analysis of specific NTD systems. For this discussion, ROI is presented in gross terms.

A recent study from the Journal of the American Medical Association *Internal Medicine* demonstrated the average 'per case' cost of the top five HAIs in the U.S. (in 2012 dollars)⁴³:

1. Central-line associated bloodstream infection: \$45,814
2. Ventilator-associated pneumonia: \$40,144
3. Surgical Site Infections: \$20,785

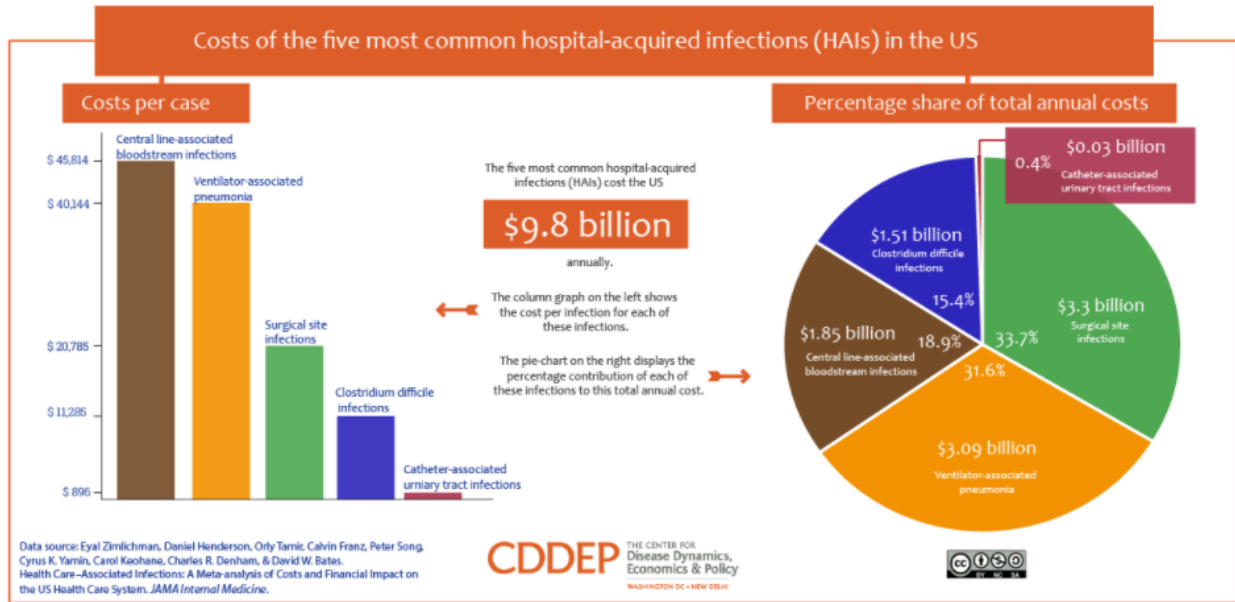
⁴¹ Cadnum, J. L., Tomas, M. E., Sankar, T., Jencson, A., Mathew, J. I., Kundrapu, S., & Donskey, C. J. (2016). Effect of Variation in Test Methods on Performance of Ultraviolet-C Radiation Room Decontamination. *Infection Control & Hospital Epidemiology*, 37(05), 555-560. doi:10.1017/ice.2015.349

⁴² Otter JA, Yezli S, Perl TM, Barbut F, French GL. Is there a role for "no-touch" automated room disinfection systems in infection prevention and control? *J Hosp Infect* 2013; 83: 1-13.

⁴³ https://www.cddep.org/tool/overall_and_unit_costs_five_most_common_hospital_acquired_infections_hais_us/

- 4. *C. diff* infections: \$11,285
- 5. Catheter-associated UTIs: \$896

Most healthcare system reports and industry studies show that, when properly implemented, NTDs provide a rapid and positive ROI. It is reasonable to assume that Hospital 1 and Hospital 2 could also enjoy positive ROI if the correct NTD were adopted and properly implemented as an effective part of the overall infection prevention and control strategy.



The following chart indicates the cost to Hospital 1 for HAIs during FY 2017, based upon industry averages for cost per case.

HAI	HAI Count	Est. Avg \$/case	Est. Total HAI Cost
		\$896	\$6,272
		\$45,814	\$183,256
		\$11,285	\$45,140
		Total:	\$234,668

While actual case studies were reviewed in order to ascertain potential ROI, each healthcare facility experience will be different. This is due to a wide range of factors, from patient population, facility design, staff training, IPC systems, PPE, soiling rates, pathogen testing methods, etc. Certain case studies further found differing efficacy rates in different areas of the facility⁴⁴. Other factors which impact overall ROI include: service contract costs; lifecycle ranges; increased power cost; potential for increased staff cost, etc. One factor which is not readily available through open sources are monthly licensing or service fees⁴⁵.

⁴⁴ Vianna, P. G., Dale, C. R., Simmons, S., Stibich, M., & Licitra, C. M. (2016). Impact of pulsed xenon ultraviolet light on hospital-acquired infection rates in a community hospital. *American Journal of Infection Control*, 44(3), 299-303. doi:10.1016/j.ajic.2015.10.009

⁴⁵ http://www.mrsa-uv.com/uploads/8/9/7/2/8972491/selecting_and_using_no-touch_room_disinfection.pdf

Efficacy is reflected as a published reduction in rates of pathogen infections in a healthcare setting, not the appearance (or kill rate) of pathogens during testing.																		
HAI	HAI Count	Est. Avg \$/case	Est. Total HAI Cost	UV-C												RS6112		
				Xenex		Steris ⁴		Surfactide		Tru-D		Optimum ³		VHP ¹			CIO2*	
		\$896	\$6,272	0.56	\$3,512.32	0.53	\$3,324.16	0.43	\$2,696.96	0.35	\$2,195.20	0	\$0.00	0.64	\$4,014.08	0.54	\$3,386.88	
		\$45,814	\$183,256		\$102,623.36		\$97,125.68		\$78,800.08		\$64,139.60		\$0.00		\$117,283.84		\$98,958.24	
		\$11,285	\$45,140	0.56	\$25,278.40	0.53	\$23,924.20	0.41	\$18,507.40	0.35	\$15,799.00	0.25	\$11,285.00	0.66	\$29,792.40	0.56	\$25,278.40	
		Total	\$234,668	Savings:	\$131,414.08		\$124,374.04		\$100,004.44		\$82,133.80		\$11,285.00		\$151,090.32		\$127,623.52	
			ROI ² (Years)		0.792		0.432		1.286		1.529		4.559		0.312		0.110	0.216

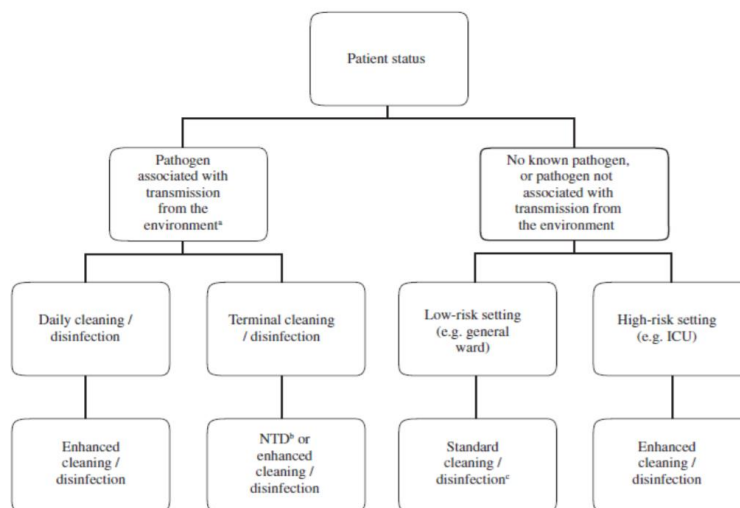
¹ One hospital study showed a complete elimination of HAIs from *C. diff*, MRSA and other antibiotic resistant organisms.
² Only costs considered are purchase and maintenance costs for the NTD system.
³ One Journal study (pub Jan 2017) noted "no apparent effect... on rates of other HAIs, including ClaBSI and MRSA"
⁴ No published case studies could be found showing reduced HAI incidents. Since Steris has a log reduction close to Xenex (and higher than Surfactide), an adjusted case reduction rate was assigned.

The ROI analysis presented here relies on published reduction rates of pathogen infections in a healthcare setting, not on the published “kill rate”; while there is a relation between a pathogen kill rate and lower rates of incidence, it is not linear.

B. Implementation Plan

ROI will, of course, be affected by how often, and where, the NTD system is used. An integrated team should consider a) if a NTD adjunct terminal disinfecting system is viable; b) which system is suitable; and c) how best to employ the system. Options include:

1. All contact isolation rooms
2. *C. diff* rooms only/MRSA rooms only
3. ICU + Isolation rooms
4. All rooms + Operating rooms at night (between surgeries...)
5. ED
6. Waiting areas.
7. Staff break rooms
8. Rest rooms
9. Biomed + Cardia Cath + Equipment Rooms
10. Cafeteria



Adapted from J.A. Otter et al. / Journal of Hospital Infection 83 (2013) 1-13

There is limited equivocal evidence that enhanced cleaning/disinfection in a low-risk general ward setting can reduce the spread of pathogens⁴⁶.

From a strictly “dollars and cents” perspective, it seems reasonable to adopt an appropriate NTD system to aid in terminal cleaning. Most hospitals report a positive ROI in 4-5 months⁴⁷. While leasing is an option to consider, ROI projections generally support purchase.

VII. Summary/Conclusion

Existing studies (including the one conducted by Health System A) have not compared the efficacy, cost analysis, or benefit analysis of Chlorine Dioxide (ClO₂) based fogging decontamination systems (e.g., AeroClave) vs. UV technologies. Existing studies have compared UV systems against Hydrogen Peroxide-based fogging systems^{48,49,50}, which have benefits and limitations not posed by ClO₂-based systems. In the interest of serving the best needs of our patients, staff, and our healthcare system, it is advisable to complete a rigorous scientific inquiry into the best decontamination methods and systems available.

Due consideration should be given to the intended purpose of the NTD system. Which pathogens are of the greatest concern? How and where should the system be employed to augment existing IPC protocols? When a “high-level kill” (e.g., 10⁶, or “six log”) is required, there is no substitute for an effective fogging system^{51,52}.

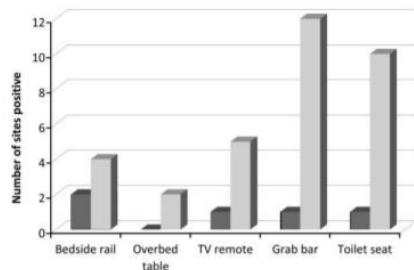


FIGURE 1. Number of samples positive for bacterial growth after decontamination with hydrogen peroxide vapor (HPV) and ultraviolet radiation (UVC) for each of the 5 sites.

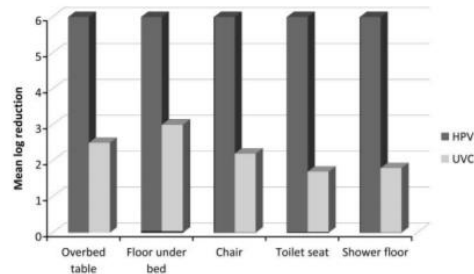


FIGURE 2. Mean *Clostridium difficile* log reductions for each of the 5 sites after decontamination with hydrogen peroxide vapor (HPV) and ultraviolet radiation (UVC).

53

Since Hospital 1 already possesses a ClO₂-based system (at no cost), due consideration should be given as to how to best use it to meet our decontamination/disinfection needs.

⁴⁶ Wilcox MH, Fawley WN, Wigglesworth N, Parnell P, Verity P, Freeman J. Comparison of the effect of detergent versus hypochlorite cleaning on environmental contamination and incidence of *Clostridium difficile* infection. *J Hosp Infect* 2003;54:109e114.

⁴⁷ <https://www.bizjournals.com/louisville/news/2016/05/19/this-hospital-spent-300-000-on-giant-superbug.html>

⁴⁸ Boyce, John M. “Modern technologies for improving cleaning and disinfection of environmental surfaces in hospitals.” *Antimicrobial Resistance & Infection Control*, vol. 5, no. 10, Nov. 2016, doi:10.1186/s13756-016-0111-x.

⁴⁹ Weber, David J., et al. “Effectiveness of ultraviolet devices and hydrogen peroxide systems for terminal room decontamination: Focus on clinical trials.” *American Journal of Infection Control*, vol. 44, no. 5, 2016, doi:10.1016/j.ajic.2015.11.015.

⁵⁰ Non-Manual Techniques for Room Disinfection in Healthcare Facilities: A Review of Clinical Effectiveness and Guidelines [Internet]. Ottawa (ON): Canadian Agency for Drugs and Technologies in Health; 2014 Apr 30. CONTEXT AND POLICY ISSUES. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK264204/>

⁵¹ <https://www.cloroxprofessional.com/assets/products/Optimum-UV/HPN-article-UV-Mauzey-Velez-Sept-2015.pdf>

⁵² Havill, N. L., Moore, B. A., & Boyce, J. M. (2012). Comparison of the Microbiological Efficacy of Hydrogen Peroxide Vapor and Ultraviolet Light Processes for Room Decontamination. *Infection Control & Hospital Epidemiology*, 33(05), 507-512. doi:10.1086/665326

⁵³ *ibid*