The Role of the Environment in Disease Transmission: Will Use of "No Touch" Technologies Reduce HAIs

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Former Director, Hospital Epidemiology, Occupational Health and Safety, UNC Health Care, Chapel Hill, NC (1979-2017)

DISCLOSURES

2020

- **Consultations/honoraria**
  - PDI
- **Grants**
  - CDC

The Role of the Environment in Disease Transmission: Will "No Touch" Room Decontamination Technologies Reduce HAIs

Lecture Objectives

- Role of the environment
- "No touch" room decontamination technologies
  - UV/HP
- New continuous room decontamination technologies
  - Continuously active disinfectants (or persistent disinfectant that provides continuous disinfection rates)

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Environmental Contamination Leads to HAIs

Weber, Kanamori, Rutala. Curr Op Infect Dis 2016:29:424-431

- Evidence environment contributes
- Role-MRSA, VRE, *C. difficile*
- Surfaces are contaminated-~25%
- EIP survive days, weeks, months
- Contact with surfaces results in hand contamination
- Disinfection reduces contamination
- Disinfection (daily) reduces HAIs
- Rooms not adequately cleaned

Admission to Room Previously Occupied by Patient C/I with Epidemiologically Important Pathogen

- Results in the newly admitted patient having an increased risk of acquiring that previous patient's pathogen by 39-353%
- For example, increased risk for *C. difficile* is 235% (11.0% vs 4.6%)
- Exposure to contaminated rooms confers a 5-6 fold increase in odds of infection, hospitals must adopt proven methods for reducing environmental contamination (Cohen et al. ICHE. 2018;39:541-546)

Association between HAI Exposure to Previous Bed Occupants with the Same Pathogen

Cohen et al. ICHE 2019;39:541

- Quantify the association between having a prior bed occupant or roommate with HAI and subsequent infection
- 761,426 inpatients discharged from 2006-2012 eligible
- 10,289 HAIs were identified
- Odds of cases exposed to a prior bed occupant with the same organism were 5.83 times that of controls and the odds od cases exposed to a roommate with the same organism were 4.82 times
- I/C roommates and prior occupants do pose a risk, which may warrant enhanced terminal and intermittent cleaning measures

Acquisition of EIP on Hands of Healthcare Providers after Contact with Contaminated Environmental Sites and Transfer to Other Patients

Acquisition of EIP on Hands of Patient after Contact with Contaminated Environmental Sites and Transfers EIP to Eyes/Nose/Mouth

Relationship Between Microbial Burden and HAIs

Rutala WA et al. ICHE 2018;38:1118-1121; Salgado CD, et al. ICHE 2013;34:479-86

Table 2. Relationship between microbial reduction of epidemiologically-important pathogens (EIP) and colonization/infection in a patient subsequently admitted to a room of a patient colonized/infected with an EIP by decontamination method.

	Standard Method		Enhanced method	
	Quat	Quat/UV	Bleach	Bleach/UV
EIP (mean CFU per room)[a]	60.8	3.4	11.7	6.3
Reduction (%)		94	81	90
Colonization/Infection (rate)[a]	2.3	1.5	1.9	2.2
Reduction (%)		35	17	4

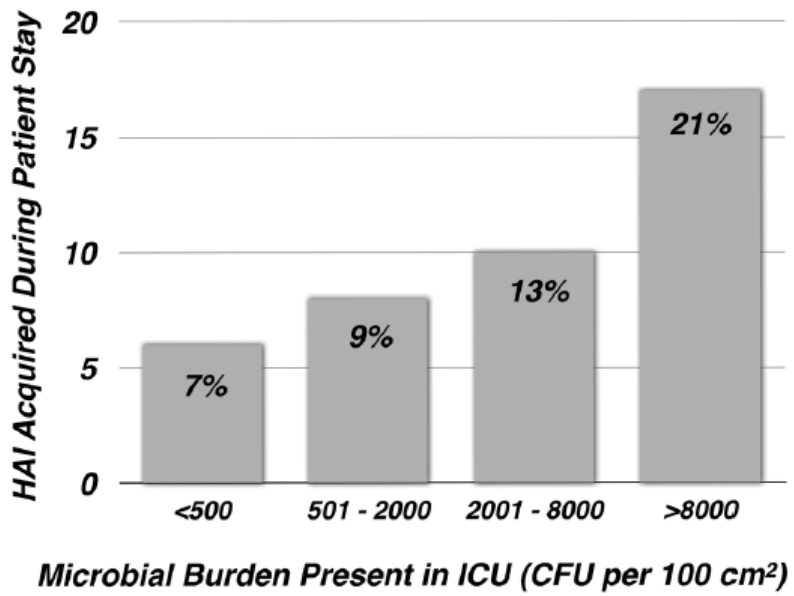


FIGURE 2. Quartile distribution of healthcare-acquired infections (HAIs) stratified by microbial burden measured in the intensive care unit (ICU) room during the patient's stay. There was a significant association between burden and HAI risk ($P = .038$), with 89% of HAIs occurring among patients cared for in a room with a burden of more than 500 colony-forming units (CFUs)/100 cm².

MICROBIAL BURDEN ON ROOM SURFACES AS A FUNCTION OF FREQUENCY OF TOUCHING

Huslage K, Rutala WA, Weber DJ. ICHE

Surface	Prior to Cleaning/Disinfection Mean CFU/RODAC (95% CI)	Post Cleaning/Disinfection (mean) Mean CFU/RODAC (95% CI)
High	71.9 (46.5-97.3)	9.6
Medium	44.2 (28.1-60.2)	9.3
Low	56.7 (34.2-79.2)	5.7

- **The level of microbial contamination of room surfaces is similar regardless of how often they are touched both before and after cleaning**
- **Therefore, all surfaces that are touched must be cleaned and disinfected**

Disinfection of Noncritical Surfaces Bundle

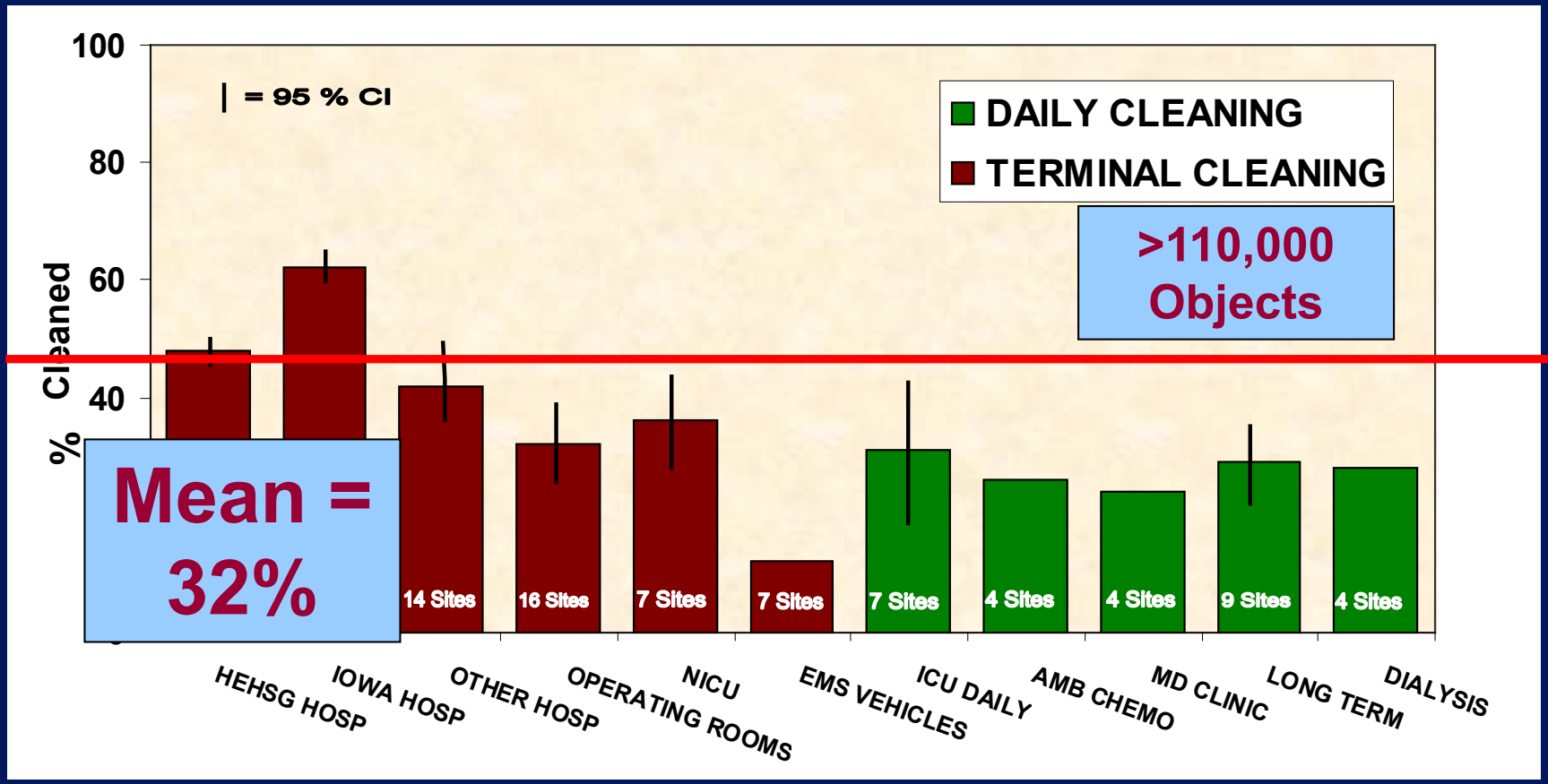
NL Havill AJIC 2013;41:S26-30; Rutala, Weber AJIC 2019;47:A96-A105

- Develop policies and procedures
- Select cleaning and disinfecting products
- Educate staff-environmental services and nursing
- Monitor compliance (thoroughness of cleaning, product use) and feedback
- Implement “no touch” room decontamination technology and monitor compliance

Why consider “no touch” room decontamination technology

Thoroughness of Environmental Cleaning

Carling et al. ECCMID, Milan, Italy, May 2011



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- Results in the newly admitted patient having an increased risk of acquiring that previous patient's pathogen by 39-353%
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Effective Surface Decontamination

Product and Practice = Perfection

LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865; Rutala, Weber. AJIC 2019;47:A3-A9

Exposure time ≥ 1 min

Germicide	Use Concentration
Ethyl or isopropyl alcohol	70-90%
Chlorine	100ppm (1:500 dilution)
Phenolic	UD
Iodophor	UD
Quaternary ammonium (QUAT)	UD
QUAT with alcohol	RTU
Improved hydrogen peroxide (HP)	0.5%, 1.4%
PA with HP, 4% HP, chlorine (*C. difficile*)	UD

UD=Manufacturer's recommended use dilution; others in development/testing-electrolyzed water; polymeric guanidine; cold-air atmospheric pressure plasma (Boyce Antimicrob Res IC 2016. 5:10)

Thoroughly clean/disinfect at least daily

MONITORING THE EFFECTIVENESS OF CLEANING

Cooper et al. AJIC 2007;35:338

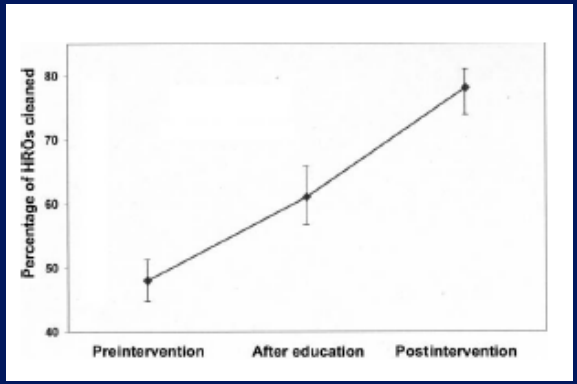
- Visual assessment-not a reliable indicator of surface cleanliness
- ATP bioluminescence-measures organic debris (each unit has own reading scale, <250-500 RLU)
- Microbiological methods-<2.5 CFUs/cm^2-pass; can be costly and pathogen specific
- Fluorescent marker-transparent, easily cleaned, environmentally stable marking solution that fluoresces when exposed to an ultraviolet light (applied by IP unbeknown to ES, after ES cleaning, markings are reassessed)

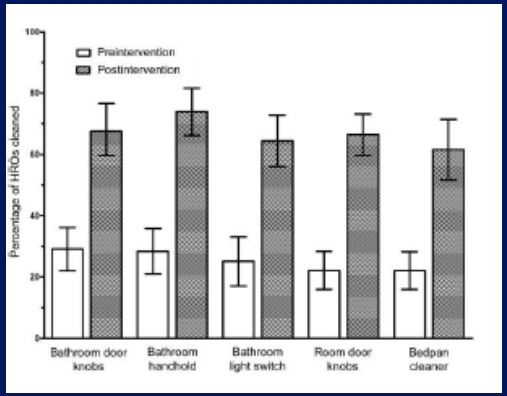
TERMINAL ROOM CLEANING: DEMONSTRATION OF IMPROVED CLEANING

Carling PC, et al. ICHE 2008;29:1035-41

- Evaluated cleaning before and after an intervention to improve cleaning
- 36 US acute care hospitals
- Assessed cleaning using a fluorescent dye
- Interventions
  - Increased education of environmental service workers
  - Feedback to environmental service workers

†Regularly change "dotted" items to prevent targeting objects





These interventions (effective surface disinfection, thoroughness indicators) not enough to achieve consistent and high rates of cleaning/disinfection

No Touch

(supplements but do not replace surface cleaning/disinfection)

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Touch (Wiping) vs No-Touch (Mechanical)

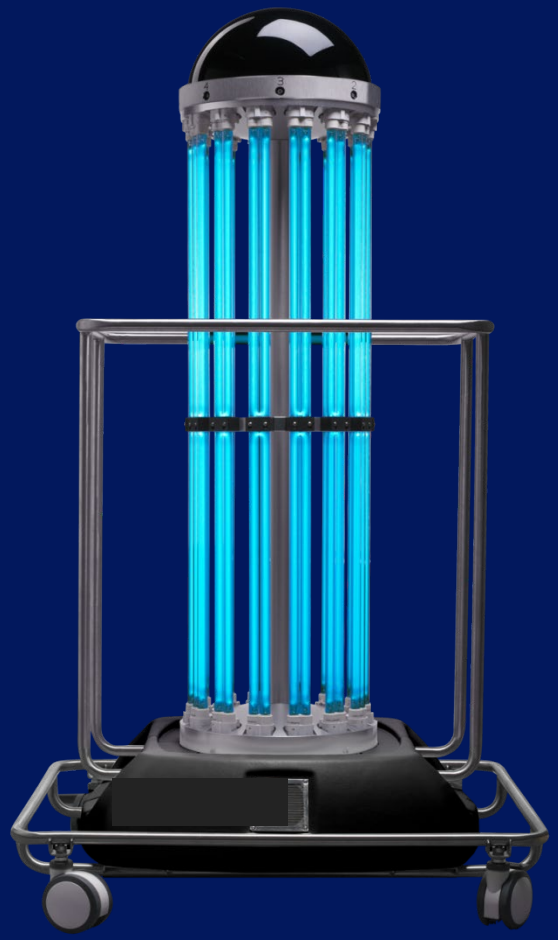
No Touch

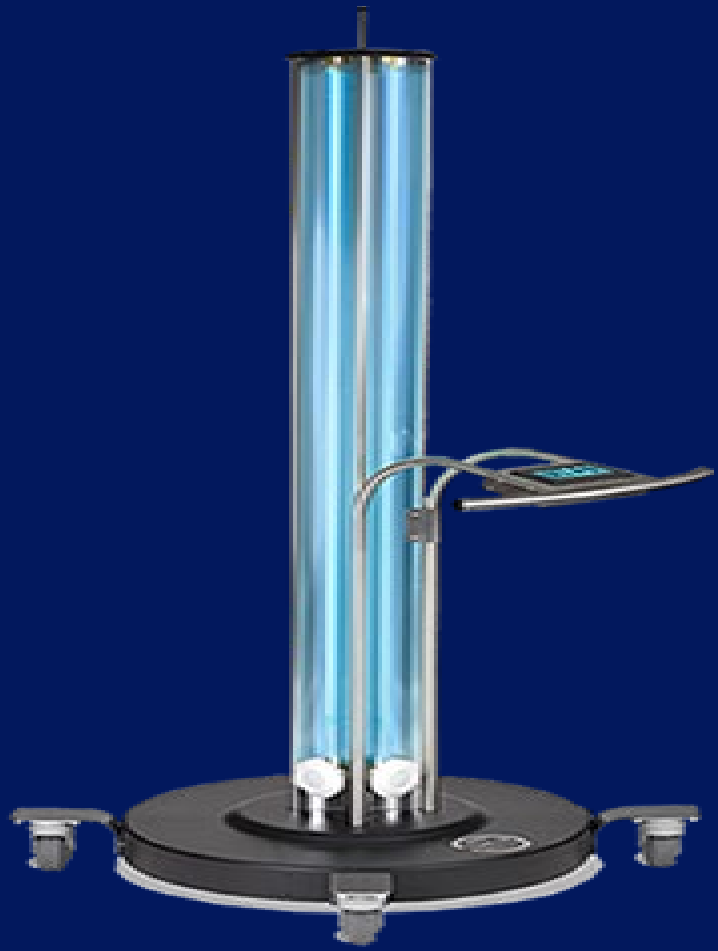
(supplements but do not replace surface cleaning/disinfection)

“No Touch” Approaches To Room Decontamination

(UV/VHP~20 microbicidal studies, 12 HAI reduction studies; will not discuss technology with limited data)

Weber, Kanamori, Rutala. Curr Op Infect Dis 2016;29:424-431; Weber, Rutala et al. AJIC; 2016:44: e77-e84; Anderson et al. Lancet 2017;389:805-14; Anderson et al. Lancet Infect Dis 2018;June 2018.





UV Room Decontamination

Rutala, Gergen, Weber, ICHE. 2010:31:1025-1029

- Fully automated, self calibrates, activated by hand-held remote
- Room ventilation does not need to be modified
- Uses UV-C (254 nm range) to decontaminate surfaces
- Measures UV reflected from walls, ceilings, floors or other treated areas and calculates the operation total dosing/time to deliver the programmed lethal dose for pathogens.
- UV sensors determines and targets highly-shadowed areas to deliver measured dose of UV energy
- After UV dose delivered (36,000µWs/cm^2 for spore, 12,000µWs/cm^2 for bacteria), will power-down and audibly notify the operator
- Reduces colony counts of pathogens by >99.9% within 20 minutes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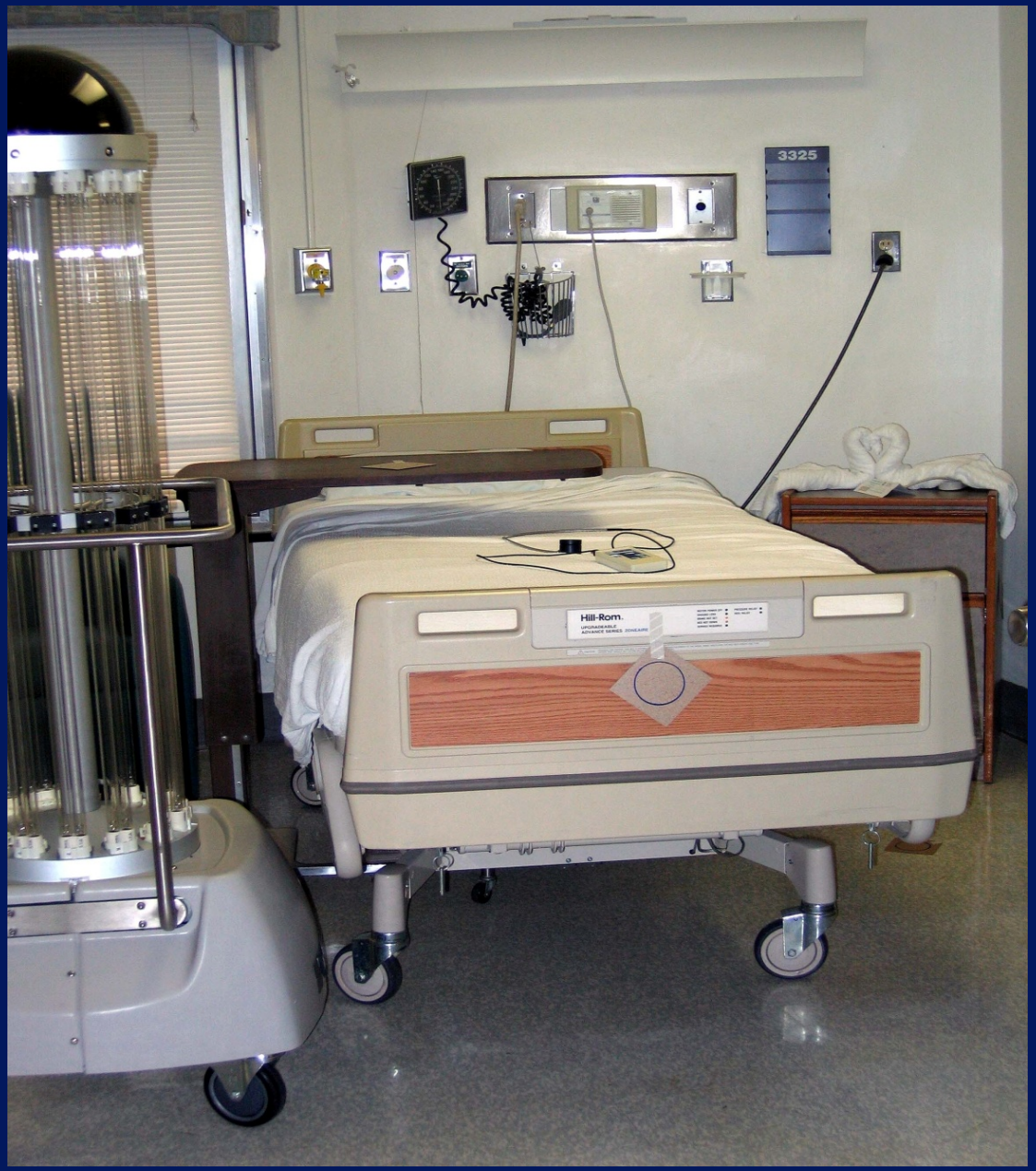
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Hill-Rom

Effectiveness of UV Room Decontamination

Rutala WA, Gergen MF, Weber DJ. Infect Control Hosp Epidemiol 2010;31:1025-9

TABLE 1. UV-C Decontamination of Formica Surfaces in Patient Rooms Experimentally Contaminated with Methicillin-Resistant *Staphylococcus aureus* (MRSA), Vancomycin-Resistant *Enterococcus* (VRE), Multidrug-Resistant (MDR) *Acinetobacter baumannii*, and *Clostridium difficile* Spores

		UV-C line of sight						
		Total		Direct		Indirect		
Organism	Inoculum	No. of samples	Decontamination, $\log_{10}$ reduction, mean (95% CI)	No. of samples	Decontamination, $\log_{10}$ reduction, mean (95% CI)	No. of samples	Decontamination, $\log_{10}$ reduction, mean (95% CI)	*P*
MRSA	4.88 $\log_{10}$	50	3.94 (2.54–5.34)	10	4.31 (3.13–5.50)	40	3.85 (2.44–5.25)	.06
VRE	4.40 $\log_{10}$	47	3.46 (2.16–4.81)	15	3.90 (2.99–4.81)	32	3.25 (1.97–4.62)	.003
MDR *A. baumannii*	4.64 $\log_{10}$	47	3.88 (2.59–5.16)	10	4.21 (3.27–5.15)	37	3.79 (2.47–5.10)	.07
C. difficile spores	4.12 $\log_{10}$	45	2.79 (1.20–4.37)	10	4.04 (3.71–4.37)	35	2.43 (1.46–3.40)	<.001

EFFECTIVENESS OF UV ROOM DECONTAMINATION

Nerandzic et al. BMC Infect Dis 2010;8:197

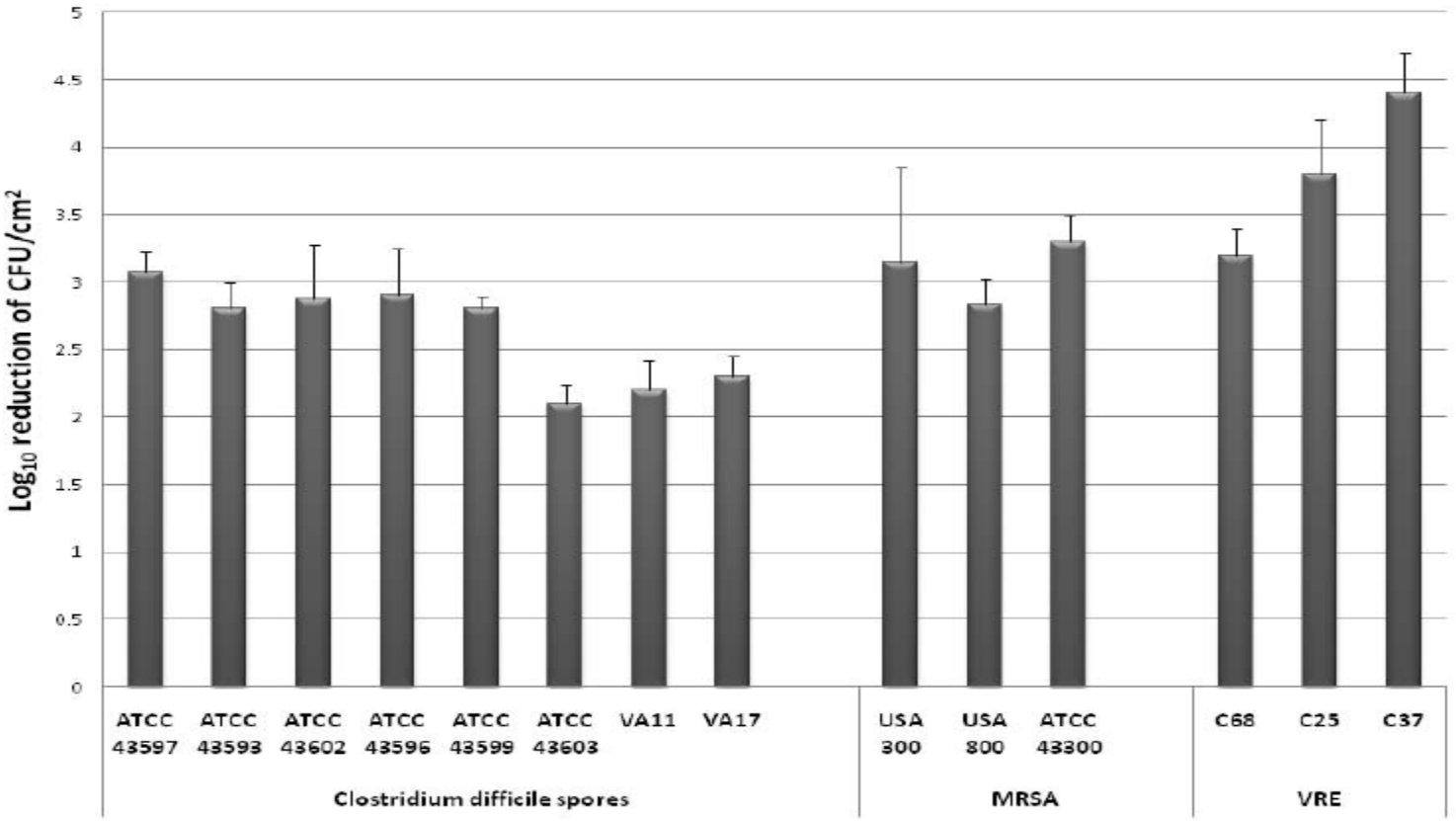


Figure 2 Mean reduction (log_{10}colony-forming units [CFU]/cm^2) in recovery of multiple strains of *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus* (MRSA), and vancomycin-resistant *Enterococcus* (VRE) from laboratory bench top surfaces after the use of the Tru-D device. For each pathogen, the inoculum applied to the bench top was adjusted such that 10^3 to 10^5 CFU were recovered from the positive control specimens. The Tru-D device was operated at a reflected dose of 22,000 μWs/cm^2 for ~45 minutes.

EFFECTIVENESS OF UV DEVICES ON REDUCING MDROs ON CARRIERS

Weber DJ, Rutala WA et al. Am J Infect Control 2016;44:e77-e84

Author, year	UV system	MDROs	Time (min)	Energy ($\mu W/cm^2$)	Log_{10} reduction direct (indirect)
Rutala, 2010[27]	UV-C, Tru-D	MRSA, VRE, A	~15	12,000	4.31 (3.85), 3.90 (3.25), 4.21 (3.79)
Rutala, 2010[27]	UV-C, Tru-D	Cd	~50	36,000	4.04 (2.43)
Boyce, 2011[28]	UV-C, Tru-D	Cd	67.8 (1 stage)	22,000	1.7-2.9
Havill, 2012[29]	UV-C, Tru-D	Cd	73 (mean)	22,000	2.2
Rutala, 2013[30]	UV-C, Tru-D	MRSA	25	12,000	4.71 (4.27)
Rutala, 2013[30]	UV-C, Tru-D	Cd	43	22,000	3.41 (2.01)
Mahida, 2013[31]	UV-C, Tru-D	OR: MRSA, VRE	49	12,000	≥4.0 (≥4.0), 3.5 (2.4)
Mahida, 2013[31]	UV-C, Tru-D	Single patient room: VRE, A, As	23-93	12,000	≥4.0 (>2.3), ≥4.0 (1.7), ≥4.0 (2.0)
Rutala, 2014[32]	UV-C, Optimum	MRSA	5	NS	4.10 (2.74)
Rutala, 2014[32]	UV-C, Optimum	Cd	10	NS	3.35 (1.80)
Nerandzic, 2015[33]	UV, PX, Xenon	Cd, MRSA, VRE	10 at 4 ft (2 cycles)	NS	0.55, 1.85, 0.6

A, *Acinetobacter* spp; *As*, *Aspergillus*; *Cd*, *Clostridium difficile*; *MDRO*, multidrug-resistant organism; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *NS*, not stated; *OR*, operating room; *PX*, pulsed xenon; *UV*, ultraviolet light; *VRE*, vancomycin-resistant enterococci.

EFFECTIVENESS OF UV DEVICES ON REDUCING MDROs IN CONTAMINATED PATIENT ROOMS

Weber DJ, Rutala WA, et al. Am J Infect Control 2016;44:e77-e84

Author, year	UV system	MDROs	Time (min); energy ($\mu W/cm^2$)	Positive sites (before and after) (%)	Log_{10} reduction
Rutala, 2010[27]	UV-C, Tru-D	MRSA	~15; 12,000	20.2, 0.5	1.30
Nerandzic, 2010[34]	UV-C, Tru-D	MRSA, VRE	20; 12,000	10.7, 0.8; 2.7, 0.38	0.68; 2.52
Nerandzic, 2010[34]	UV-C, Tru-D	Cd	45; 22,000	3.4, 0.38	1.39;
Stibich, 2011[35]	UV, PX, Xenex	VRE	12; NS	8.2, 0	1.36
Anderson, 2013[36]	UV-C, Tru-D	All, VRE, A	25; 12,000	NS; 11, 1; 13, 3	1.35; 1.68; 1.71
Anderson, 2013[36]	UV-C, Tru-D	Cd	45; 22,000	10, 5	1.16
Jinadatha, 2015[37]	UV, PX, Xenex	MRSA	15 (3 cycles of 5 min), NS	70, 8	2.0
Nerandzic, 2015[33]	UV, PX, Xenex	MRSA, VRE, Cd	10 (2 cycles of 5 min); NS	10, 2; 4, 0.9; 19, 8	0.90, 1.08, NS
Jinadatha, 2015[37]	UV-PX, Xenex	MRSA	15 (3 cycles of 5 min); NS	NS, NS	0.63

A, *Acinetobacter* spp; *All*, all target organisms; *Cd*, *Clostridium difficile*; *MDRO*, multidrug-resistant organism; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *NS*, not stated; *PX*, pulsed xenon; *UV*, ultraviolet light; *VRE*, vancomycin-resistant enterococci.

Clinical Trials Using UV for Terminal Room Decontamination to Reduce HAIs

Weber, Rutala et al. Am J Infect Control. 2016;44:e77-e84.

Author, Year	Design	Pathogens	Reduction in HAIs
Levin, 2013	Before-After, Pulsed Xenon	CDI	Yes
Hass, 2014	Before-After, Pulsed Xenon	CDI, MRSA, VRE, MDRO-GNR	Yes
Miller, 2015	Before-After, Pulsed Xenon	CDI	Yes
Nagaraja, 2015	Before-After, Pulsed Xenon	CDI	Yes (p=0.06)
Pegues, 2015	Before-After, Optimum	CDI	Yes
Anderson, 2017	Randomized-controlled trial, Tru-D	MRSA, VRE, CDI	Yes
Vianna, 2016	Before-After, Pulsed Xenon	CDI, MRSA, VRE	Yes

Enhanced terminal room disinfection and acquisition and infection caused by multidrug-resistant organisms and *Clostridium difficile* (the Benefits of Enhanced Terminal Room Disinfection study): a cluster-randomised, multicentre, crossover study

Deverick J Anderson, Luke F Chen, David J Weber, Rebekah W Moehring, Sarah S Lewis, Patricia F Triplett, Michael Blocker, Paul Becherer, J Conrad Schwab, Lauren P Knelson, Yuliya Lokhnygina, William A Rutala, Hajime Kanamori, Maria F Gergen, Daniel J Sexton; for the CDC Prevention Epicenters Program

Anderson et al. Lancet 2017;289:805

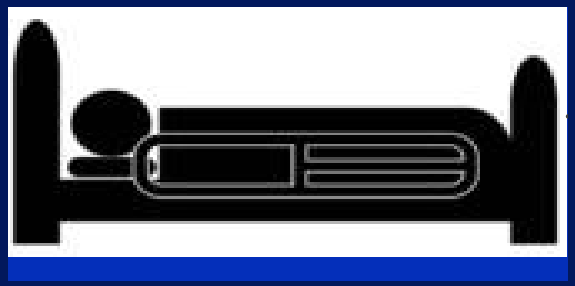
2x2 Factorial Design

	No UV Light	UV Light
Quat*	A	B
Bleach	C	D

NOTE: Bleach always used in rooms of patients with suspected or confirmed *C. difficile

Key Definitions – Patient-Level Analyses

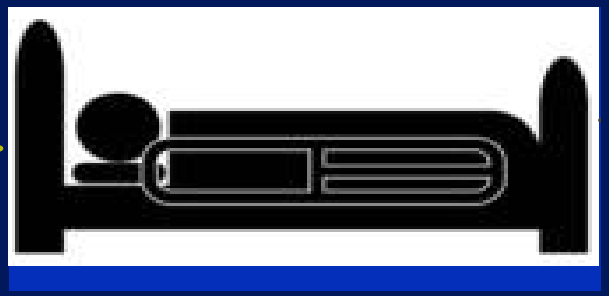
Patient in "Seed Room"



Documented infection or colonization with
MRSA
VRE
C. difficile
MDR-Acinetobacter

Terminal Clean

"Exposed Patient"

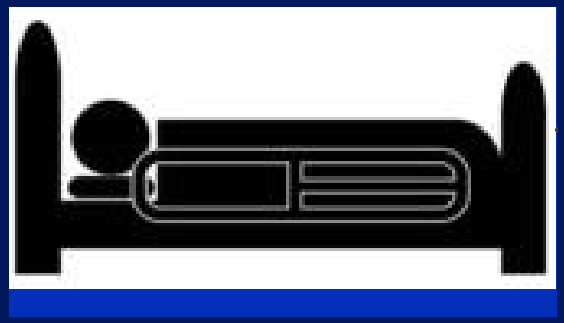


In room ≥ 24 hours

Exposure days = Time spent in "seed room"

Key Definitions – Inclusion Criteria

"Exposed Patient" → Potential "Incident Case"



In room ≥ 24 hours

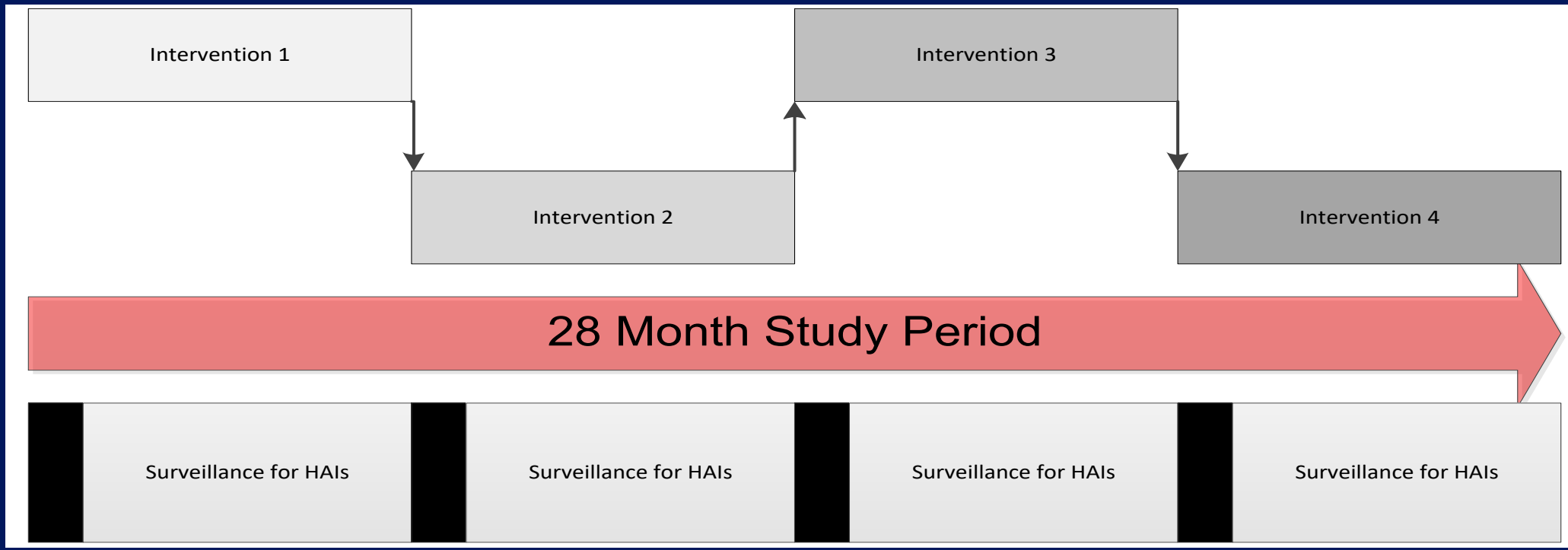
1. Same organism as the patient in the "seed room" *AND*

2a. Positive culture while in room *OR*

2b. Positive culture after stay in room

- 90 days (MRSA, VRE, MDRAB)
- 28 days (*C. difficile*)

DUKE/UNC BETR-D STUDY: DESIGN



Anderson et al. Lancet 2017;289:805

Enhanced Disinfection Leading to Reduction of Microbial Contamination and a Decrease in Patient Col/Infection

Anderson et al. Lancet 2017;289:805; Rutala et al. ICHE 2018;38:1118-1121

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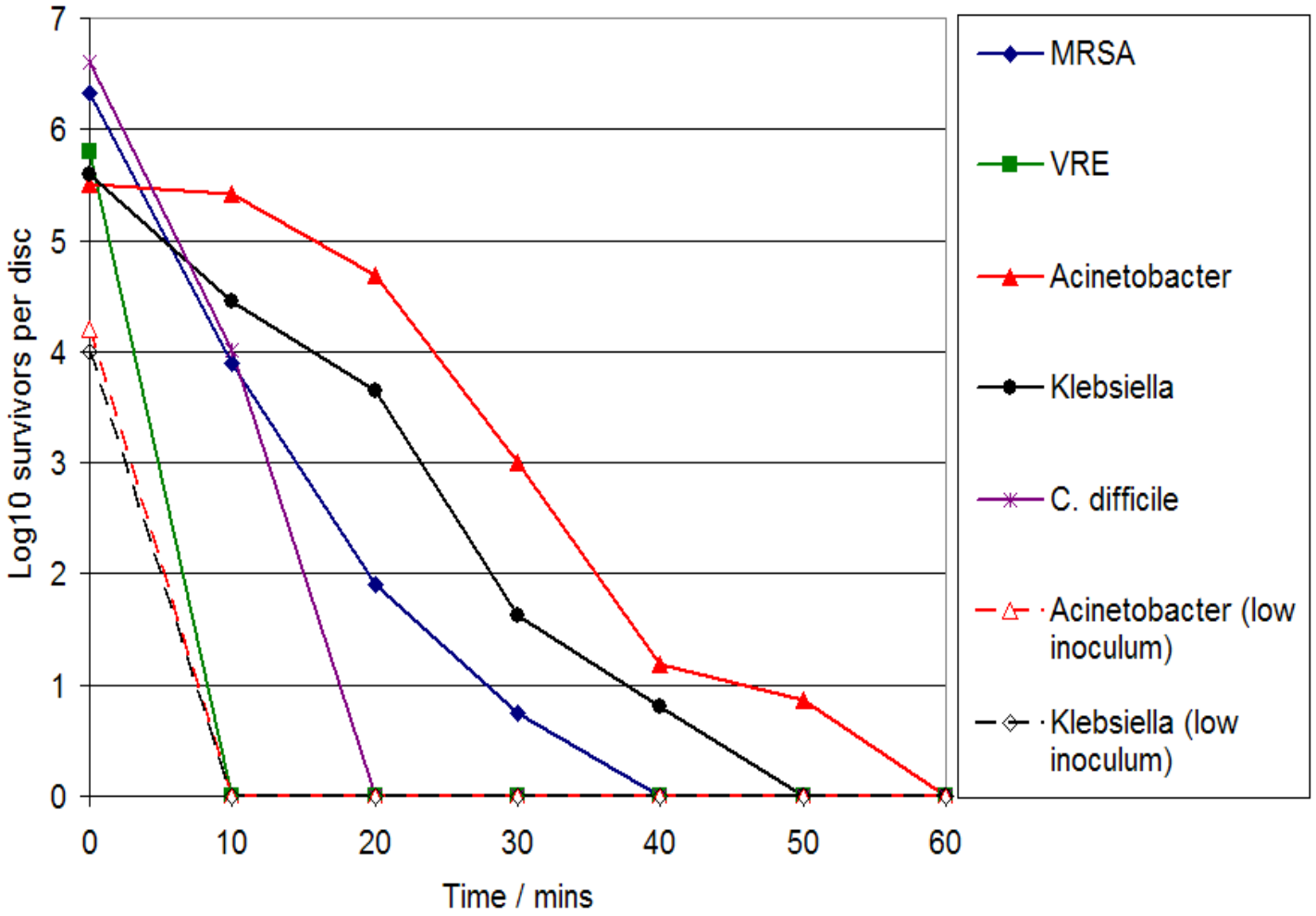
Reduction (%)		94	81	90
Colonization/Infection (rate)[a]	2.3	1.5	1.9	2.2
Reduction (%)		35	17	4

Comparing the best strategy with the worst strategy (i.e., Quat vs Quat/UV) revealed that a reduction of 94% in EIP (60.8 vs 3.4) led to a 35% decrease in colonization/infection (2.3% vs 1.5%). Data demonstrated that a decrease in room contamination was associated with a decrease in patient colonization/infection.

Hydrogen Peroxide Vapor/Aerosol Decontamination

HPV *in vitro* Efficacy



Otter and French. *J Clin Microbiol* 2009;47:205-207.

HYDROGEN PEROXIDE FOR DECONTAMINATION OF THE HOSPITAL ENVIRONMENT

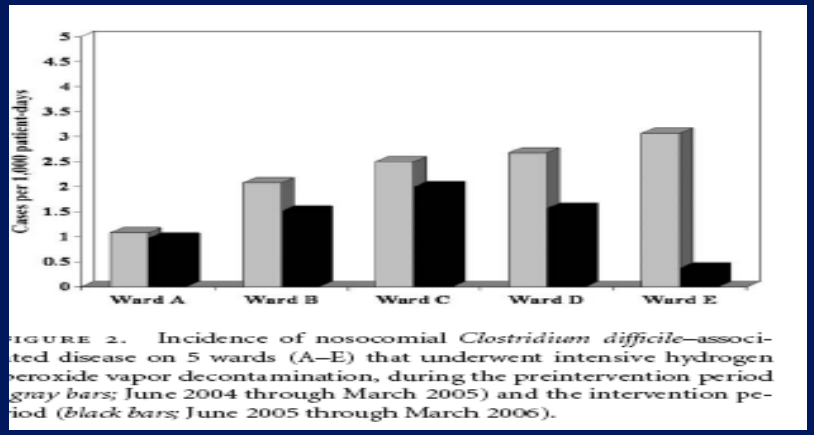
Falagas, et al. J Hosp Infect. 2011;78:171.

Author, Year	HP System	Pathogen	Before HP	After HP	% Reduction
French, 2004	VHP	MRSA	61/85-72%	1/85-1%	98
Bates, 2005	VHP	*Serratia*	2/42-5%	0/24-0%	100
Jeanes, 2005	VHP	MRSA	10/28-36%	0/50-0%	100
Hardy, 2007	VHP	MRSA	7/29-24%	0/29-0%	100
Dryden, 2007	VHP	MRSA	8/29-28%	1/29-3%	88
Otter, 2007	VHP	MRSA	18/30-60%	1/30-3%	95
Boyce, 2008	VHP	*C. difficile*	11/43-26%	0/37-0%	100
Bartels, 2008	HP dry mist	MRSA	4/14-29%	0/14-0%	100
Shapey, 2008	HP dry mist	*C. difficile*	48/203-24%	7/203-3%	88
Barbut, 2009	HP dry mist	*C. difficile*	34/180-19%	4/180-2%	88
Otter, 2010	VHP	GNR	10/21-48%	0/63-0%	100

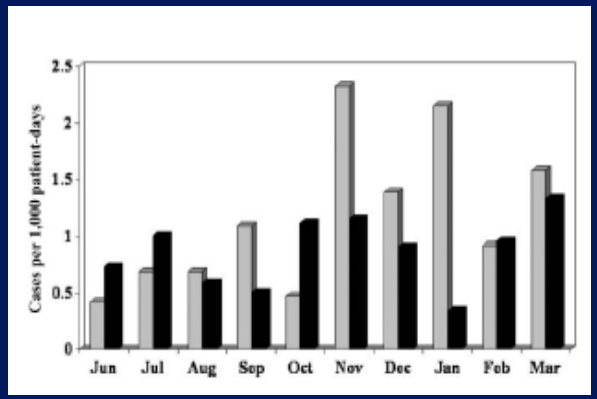
Room Decontamination With VHP

Boyce JM, et al. ICHE 2008;29:723-729

- Study design
  - **Before and after study of VHP**
- Outcome
  - ***C. difficile* incidence**
- Results
  - **VHP decreased environmental contamination with *C. difficile* (p<0.001), rates on high incidence floors from 2.28 to 1.28 cases per 1,000 pt-days (p=0.047), and throughout the hospital from 1.36 to 0.84 cases per 1,000 pt days (p=0.26)**



IGURE 2. Incidence of nosocomial *Clostridium difficile*–associated disease on 5 wards (A–E) that underwent intensive hydrogen peroxide vapor decontamination, during the preintervention period (*gray bars*; June 2004 through March 2005) and the intervention period (*black bars*; June 2005 through March 2006).



Clinical Trials Using HP for Terminal Room Disinfection to Reduce HAIs

Weber, Rutala et al. Am J Infect Control 2016;44:e77-e84

Author, Year	Design	Pathogen	Reduction in HAIs
Boyce, 2008	Before-After	CDI	Yes
Cooper, 2011	Before-After	CDI	Decrease cases (incidence not stated)
Passaretti, 2013	Prospective cohort	MRSA, VRE, CDI	Yes, in all MDROs
Manian, 2013	Before-After	CDI	Yes
Mitchell, 2014	Before-After	MRSA	Yes
Horn, 2015	Before-After	CDI, VRE, ESBL GNR	Yes

This technology should be used (capital equipment budget) for terminal room disinfection (e.g., after discharge of patients under Contact Precautions, during outbreaks).

UV ROOM DECONTAMINATION: ADVANTAGES AND DISADVANTAGES

Rutala WA, Weber DJ. Am J Infect Control 2013;41:S36

- Advantages
  - Reliable biocidal activity against a wide range of pathogens
  - Surfaces and equipment decontaminated
  - Room decontamination is rapid (5-25 min) for vegetative bacteria (*C. difficile* spores 10-50m)
  - HVAC system does not need to be disabled and room does not need to be sealed
  - UV is residual free and does not give rise to health and safety concerns
  - No consumable products so operating costs are low (key cost = acquisition)
  - Studies show use of UV reduces HAIs
- Disadvantages
  - Can only be done for terminal disinfection (i.e., not daily cleaning)
  - All patients and staff must be removed from room
  - Substantial capital equipment costs
  - Does not remove dust and stains which are important to patients/visitors
  - Sensitive use parameters (e.g., UV dose delivered)

HP ROOM DECONTAMINATION: ADVANTAGES AND DISADVANTAGES

Rutala WA, Weber DJ. Am J Infect Control 2013;41:S36

- Advantages
  - Reliable biocidal activity against a wide range of pathogens
  - Surfaces and equipment decontaminated
  - Demonstrated to decrease disease incidence (e.g., *C. difficile,* VRE)
  - Residual free and does not give rise to health and safety concerns (aeration units convert HPV into oxygen and water)
  - Useful for disinfecting complex equipment and furniture
  - Does not require direct or indirect line of sight
- Disadvantages
  - Can only be done for terminal disinfection (i.e., not daily cleaning)
  - All patients and staff must be removed from room
  - Decontamination takes approximately 1.5-5 hours
  - HVAC system must be disabled and the room sealed with tape
  - Substantial capital equipment costs
  - Does not remove dust and stains which are important to patients/visitors
  - Sensitive use parameters (e.g., HP concentration)

Selection of "No Touch" Room Decontamination Device

Weber, Rutala et al. Am J Infect Control. 2016;44:e77-e84.

- Since different "no touch" systems (e.g., UV and hydrogen peroxide) vary substantially, infection preventionists should review the peer-reviewed literature and choose only devices with demonstrated bactericidal capability as assessed by carrier tests and/or the ability to disinfect actual patient rooms
- Ideally, one would select a device that has demonstrated bactericidal capability and the ability to reduce HAIs

New Technologies for Room/Surface Decontamination

Assessment Parameters

- Safe
- Microbicidal
- Reduction of HAIs
- Cost-effective

Cost-Effectiveness of UVC

Rutala WA, Brewer A. Healthcare Facilities Today. January 20, 2020

- Cost savings-The following example illustrates how UVC can be a smart investment.
  - If UVC usage reduced HAIs for approximately 20% of patients (e.g., patients on Contact Precautions) by 10-30% as demonstrated in a randomized trial (Anderson et al, Lancet 2017) the number of infections prevented in a 900-bed hospital with an infection rate of ~4 per 1,000 patient days would be approximately 18-55 per year
  - If each HAI cost $24,000 on average, the hospital would need to prevent only 23 HAIs in the first two years to cover the acquisition and operational costs of the UVC program for a 24-month period
  - If the hospital prevented 30% of infections per year (55 per year) for two years, the cost savings would be $2,085,000

“No touch” technology should be used (capital equipment budget) for terminal room disinfection (e.g., after discharge of patients under Contact Precautions, during outbreaks).

Why do we need to consider continuous room decontamination technology?

To reduce microbial contamination

(associated with suboptimal CD practices and recontamination)

Recontamination with MRSA After Decontamination with HP Vapor

Hardy et al. J Hosp Infect 2007;66:360-368

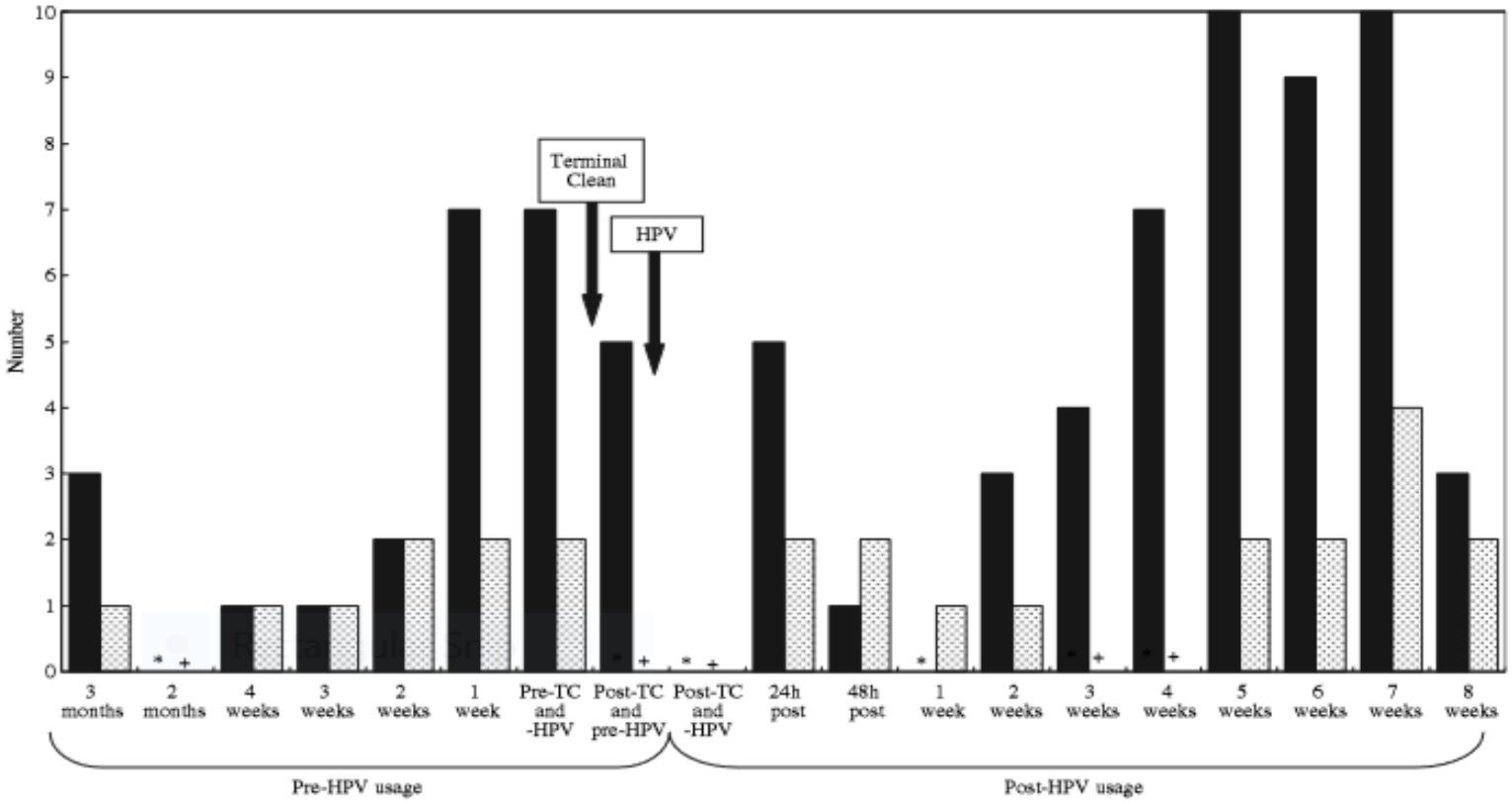


Figure 1 Number of environmental sites (■) contaminated with MRSA, and number of patients (□) colonized with MRSA on intensive care units on each screen. *MRSA environmental samples all negative; †no patients colonized with MRSA. HPV, hydrogen peroxide vapour; TC, terminal clean.

Continuous Room Decontamination Technologies for Disinfection of the Healthcare Environment

Weber, Rutala et al. AJIC. 2019;47:A72

- Visible light disinfection through LEDs
- Dry/dilute hydrogen peroxide
- Self-disinfecting surfaces (e.g., copper)
- Far UV 222 nm
- Bipolar ionization
- Multijet cold air plasma
- Continuously active disinfectant (CAD) or persistent disinfectant that provides continuous disinfection action
  - Allows continued disinfection (may eliminate the problem of recontamination)
  - Patients, staff and visitors can remain in the room

Hygienically clean (not sterile)-free of pathogens in sufficient numbers to prevent human disease

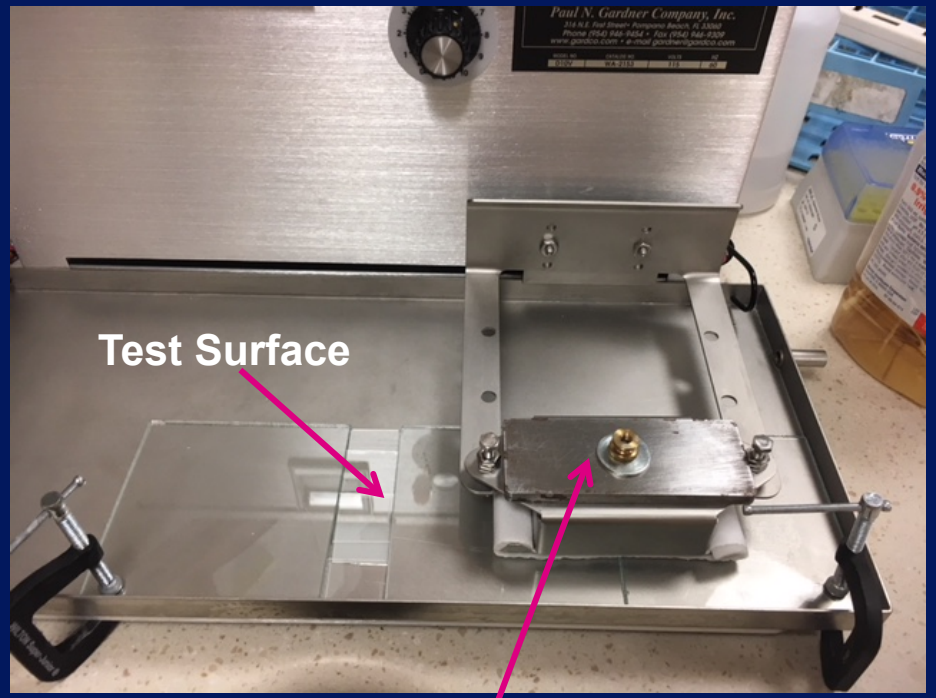
SURFACE DISINFECTANTS: PERSISTENCE

Surface disinfectant	Persistence
Phenolic	No
Quaternary ammonium compound	Yes (undisturbed)
Alcohol	No
Hypochlorite	No
Hydrogen peroxide	No

Evaluation of a Continuously Active Disinfectant

"EPA Protocol for Residual Self-Sanitizing Activity of Dried Chemical Residuals on Hard, Non-Porous Surfaces"

- Test surface inoculated (10^5), treated with test disinfectant, allowed to dry.
- Surface will undergo "wears" (abraded under alternating wet and dry conditions [24 passes, 12 cycles]) and 6 re-inoculations (10^3, 30min dry) over 24hr
- At the end of the study and at least 24 hours later, the ability of the test surface to kill microbes (99.9%) within 5 min is measured using the last inoculation (10^6)



Efficacy of a Continuously Active Surface Disinfectant

Rutala WA, Gergen M, Sickbert-Bennett E, Anderson D, Weber D. Infect Control Hosp Epidemiol. 2019. 40:1284-1286.

4-5 $\log_{10}$ reduction in 5min over 24hr for most pathogens; ~99% reduction with *Klebsiella* and CRE *Enterobacter*.

Test Pathogen	Mean Log_{10} Reduction , 95% CI n=4
*S.aureus**	4.4 (3.9, 5.0)
S.aureus (formica)	4.1 (3.8, 4.4)
S.aureus (stainless steel)	5.5 (5.2, 5.9)
VRE	≥4.5
E.coli	4.8 (4.6, 5.0)
Enterobacter sp.	4.1 (3.5, 4.6)
Candida auris	≥5.0
K pneumoniae	1.5 (1.4, 1.6)
CRE *E.coli*	3.0 (2.6, 3.4)
CRE *Enterobacter*	2.0 (1.6, 2.4)
CRE *K pneumoniae*	2.1 (1.8, 2.4)

*Test surface glass unless otherwise specified

Comparison of CAD with Three Disinfectants Using EPA Method and *S. aureus*

Rutala WA, Gergen M, Sickbert-Bennett E, Anderson D, Weber D. Infect Control Hosp Epidemiol. 2019. 40:1284-1286.

Test Disinfectant	Mean Log_{10} Reduction
Continuously Active Disinfectant (CAD)	4.4
Quat-Alcohol	0.9
Improved hydrogen peroxide	0.2
Chlorine	0.1

Efficacy of a Continuously Active Disinfectant Against a Human Coronavirus, 229E, Evaluated after 48 hours

Rutala WA et al. Unpublished data, September 2020

A novel disinfectant studied using an EPA protocol (wears/re-inoculations) demonstrated continuous antiviral activity (i.e., >4.5 log_{10} reduction) in 1 minute after **48** hours for a human coronavirus, 229E

Carrier Treatment with Wears and Re-inoculations	Contact Time	Mean Viral Recovery Titer per Carrier (log_{10})	Log_{10} Reduction
Control (sterile water, n=3)	1 minute	6.00 ± 0.25	N.A.
Test disinfectant (n=3)	1 minute	≤ 1.50 ± 0.00	>4.50

The Role of the Environment in Disease Transmission: Will "No Touch" Room Decontamination Technologies Reduce HAIs

Lecture Objectives

- Role of the environment
- "No touch" room decontamination technologies
  - UV/HP
- New continuous room decontamination technologies
  - Continuously active disinfectants (or persistent disinfectant that provides continuous disinfection rates)

Will "No Touch" Room Decontamination Technologies Reduce HAIs? Yes

Summary

- Disinfection of noncritical environmental surfaces/equipment is an essential component of infection prevention
- Disinfection should render surfaces and equipment free of pathogens in sufficient numbers to cause human disease
- Implement a method to improve the thoroughness of cleaning
- Goal of effective surface disinfection: Product + Practice = Perfection
- An enhanced method of room decontamination ("no touch") is superior to a standard method
- "No touch" technology should be used at discharge for Contact Precaution patients
- Continuously active disinfectants may reduce or eliminate the problem of recontamination (e.g., 4-5 $\log_{10}$ reduction in 5m over 24h)

THANK YOU!

www.disinfectionandsterilization.org

FACTORS AFFECTING UV ROOM DISINFECTION DEVICE EFFECTIVENESS

Cadnum JL, et al. ICHE 2016;37:555-560; Boyce JM, Donskey CJ. ICHE 2019;40:1030-1035

- Intensity of UV delivered (i.e., energy)
- Wavelength(s) of UV
- Duration of exposure
- Distance (energy delivered falls off as a square of distance)
- Orientation of the surface being disinfected to the UV source
  - For non-shadowed surfaces, direct line of sight to UV so
  - For shadowed surfaces, UV reflectivity of walls/surfaces
- Intrinsic susceptibility of microbes (e.g., spore formers such as *C. difficile* more difficult to inactivate than vegetative bacteria such as MRSA and VRE)
- Study variables: 1) microbial strain (there may be strain variability to UV); 2) spreading the inoculum over a greater surface area enhances killing; 3) organic load (e.g., 10% fetal calf serum) significantly decreases killing; 4) test surface, in general does not affect killing (e.g., Formica, glass, steel); 5) humidity