Role of Hospital Surfaces in Disease Transmission: Will Use of a Continuously Active Disinfectant Reduce Microbial Contamination?

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DISCLOSURES

2018-2019

- **Consultations**
  - ASP (Advanced Sterilization Products), PDI
- **Honoraria**
  - PDI, ASP , 3M
- **Scientific Advisory Board**
  - Kinnos
- **Grants**
  - CDC

THANK YOU!

www.disinfectionandsterilization.org

Objective

Institute Practices that Prevent All Infectious Disease Transmission via Environment

Learning Objectives

- Describe the role of the environment in HAI transmission
- Outline best practices for environmental cleaning/disinfection
- Identify options for evaluating environmental cleaning/disinfection
- Highlight options of “no touch” technology for room decontamination
- Describe the role of a continuously active disinfectant for surface disinfection

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- Review the role of environmental surfaces
- Review the use of low-level disinfectants and the selection of the ideal disinfectant
- Review “best” practices for environmental cleaning and disinfection
- Discuss options for evaluating environmental cleaning and disinfection
- Discuss “no touch” technologies for room decontamination and reduction of HAIs
- Will use of a continuously active disinfectant (CAD) reduce microbial contamination

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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)

EVALUATION OF HOSPITAL ROOM ASSIGNMENT AND ACQUISITION OF CDI

- Study design: Retrospective cohort analysis, 2005-2006
- Setting: Medical ICU at a tertiary care hospital
- Methods: All patients evaluated for diagnosis of CDI 48 hours after ICU admission and within 30 days after ICU discharge
- Results (acquisition of CDI)
  - Admission to room previously occupied by CDI = 11.0%
  - Admission to room not previously occupied by CDI = 4.6% (p=0.002)

TABLE 3. Multivariate Analysis of Risk Factors for Acquisition of *Clostridium difficile* Infection (CDI)

Risk factor	HR (95% CI)	*P*
Prior room occupant with CDI	2.35 (1.21–4.54)	.01
Greater age	1.00 (0.99–1.01)	.71
Higher APACHE III score	1.00 (1.00–1.01)	.06
Proton pump inhibitor use	1.11 (0.44–2.78)	.83
Antibiotic exposure		
Norfloxacin	0.38 (0.05–2.72)	.33
Levofloxacin	1.08 (0.67–1.73)	.75
Ciprofloxacin	0.49 (0.15–1.67)	.23
Fluoroquinolones	1.17 (0.72–1.91)	.53
Clindamycin	0.45 (0.14–1.42)	.17
Third- or fourth-generation cephalosporins	1.17 (0.76–1.79)	.48
Carbapenems	1.05 (0.63–1.75)	.84
Piperacillin-tazobactam	1.31 (0.82–2.10)	.27
Other penicillin	0.47 (0.23–0.98)	.04
Metronidazole	1.31 (0.83–2.07)	.24
Vancomycin		
Oral	1.38 (0.32–5.89)	.67
Intravenous	1.55 (0.88–2.73)	.13
Aminoglycosides	1.27 (0.78–2.06)	.35
Multiple (≥3 antibiotic classes)	1.28 (0.75–2.21)	.37

NOTE. APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; HR, hazard ratio.

Shaughnessy MK, et al. ICHE 2011;32:201-206

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

ENVIRONMENTAL CONTAMINATION LEADS TO HAIs

- There is increasing evidence to support the contribution of the environment to disease transmission
- This supports comprehensive disinfecting regimens (goal is not sterilization) to reduce the risk of acquiring a pathogen from the healthcare environment/equipment

KEY PATHOGENS WHERE ENVIRONMENTIAL SURFACES PLAY A ROLE IN TRANSMISSION

- MRSA
- VRE
- *Acinetobacter* spp.
- *Clostridium difficile*
- Norovirus
- Rotavirus
- SARS

ENVIRONMENTAL CONTAMINATION ENDEMIC AND EPIDEMIC MRSA

	Outbreak	Endemic				Site estimated mean§
	Rampling et al[27]*	Boyce et al[48]*	Sexton et al[51]†	Lemmen et al[50]*‡	French et al[64]*	
Floor	9%	50–55%	44–60%	24%	..	34·5%
Bed linen	..	38–54%	44%	34%	..	41%
Patient gown	..	40–53%	..	34%	..	40·5%
Overbed table	..	18–42%	64–67%	24%	..	40%
Blood pressure cuff	13%	25–33%	..	..	..	21%
Bed or siderails	5%	1–30%	44–60%	21%	43%	27%
Bathroom door handle	..	8–24%	..	12%¶	..	14%
Infusion pump button	13%	7–18%	..	30%	..	19%
Room door handle	11%	4–8%	..	23%	59%	21·5%‖
Furniture	11%	..	44–59%	19%	..	27%
Flat surfaces	7%	..	32–38%	..	..	21·5%
Sink taps or basin fitting	..	..	..	14%	33%	23·5%
Average quoted**	11%	27%	49%	25%	74%	37%

Dancer SJ et al. Lancet ID 2008;8(2):101-13

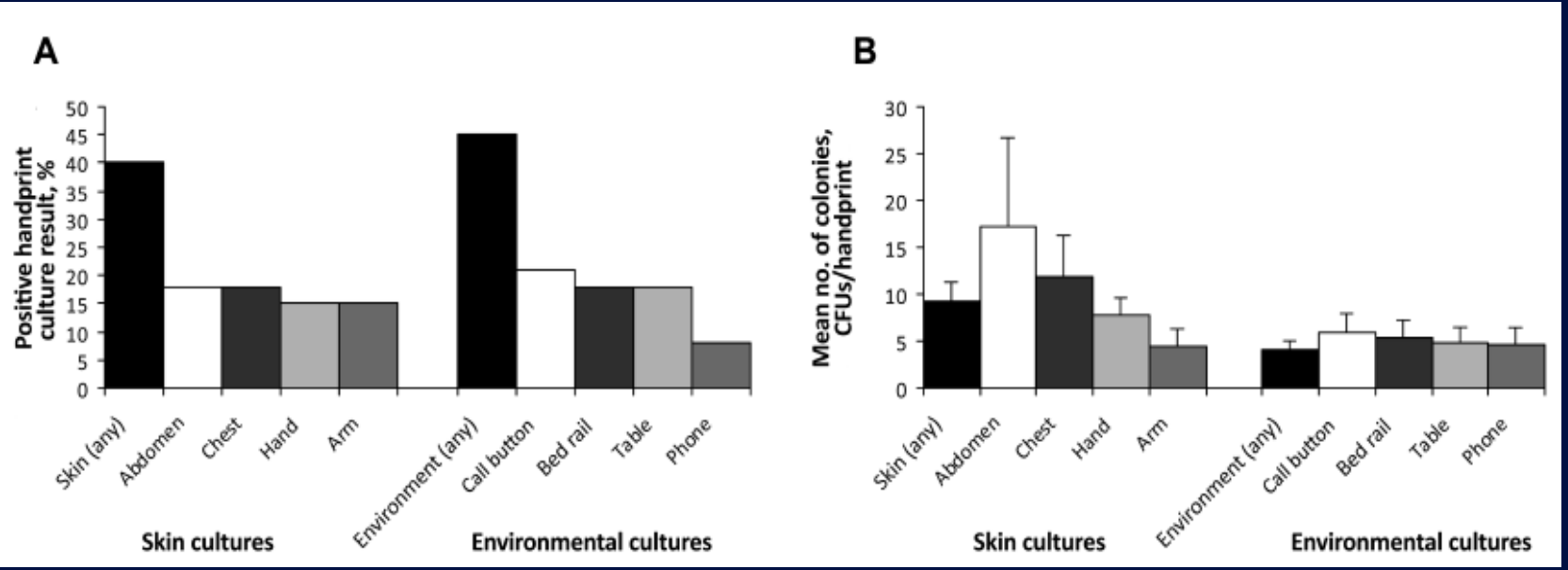
ENVIRONMENTAL SURVIVAL OF KEY PATHOGENS ON HOSPITAL SURFACES

Pathogen	Survival Time
S. aureus (including MRSA)	7 days to >12 months
Enterococcus spp. (including VRE)	5 days to >46 months
Acinetobacter spp.	3 days to 11 months
Clostridium difficile (spores)	>5 months
Norovirus (and feline calicivirus)	8 hours to >2 weeks
Pseudomonas aeruginosa	6 hours to 16 months
Klebsiella spp.	2 hours to >30 months

Adapted from Hota B, et al. Clin Infect Dis 2004;39:1182-9 and Kramer A, et al. BMC Infectious Diseases 2006;6:130

FREQUENCY OF ACQUISITION OF MRSA ON GLOVED HANDS AFTER CONTACT WITH SKIN AND ENVIRONMENTAL SITES

No significant difference on contamination rates of gloved hands after contact with skin or environmental surfaces (40% vs 45%; p=0.59)



Stiefel U, et al. ICHE 2011;32:185-187

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Major article

Does improving surface cleaning and disinfection reduce health care-associated infections?

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Key Words:
Environment
Cleaning
Transmission

Contaminated environmental surfaces provide an important potential source for transmission of health care-associated pathogens. In recent years, a variety of interventions have been shown to be effective in improving cleaning and disinfection of surfaces. This review examines the evidence that improving environmental disinfection can reduce health care-associated infections.

Contaminated environmental surfaces provide an important potential source for transmission of many health care associated pathogens.[1-6] These include *Clostridium difficile*, methicillin resistant

infected with health care associated pathogens shed organisms onto their skin, clothing, bedding, and nearby environmental surfaces.[12] In addition to surfaces in rooms, portable equipment

Environmental Disinfection Interventions

Donskey CJ. Am J Infect Control 2013;41:S12

- Cleaning product substitutions
- Improvements in the effectiveness of cleaning and disinfection practices
  - Education
  - Audit and feedback
  - Addition of housekeeping personnel or specialized cleaning staff
- Automated technologies
- Conclusion: Improvements in environmental disinfection may prevent transmission of pathogens and reduce HAIs

It appears that not only is disinfectant use important but how often is important

Daily disinfection vs clean when soiled

Daily Disinfection of High-Touch Surfaces

Kundrapu et al. ICHE 2012;33:1039

Daily disinfection of high-touch surfaces (vs cleaned when soiled) with sporicidal disinfectant (PA) in rooms of patients with CDI and MRSA **reduced acquisition of pathogens on hands after contact with surfaces and of hands caring for the patient**

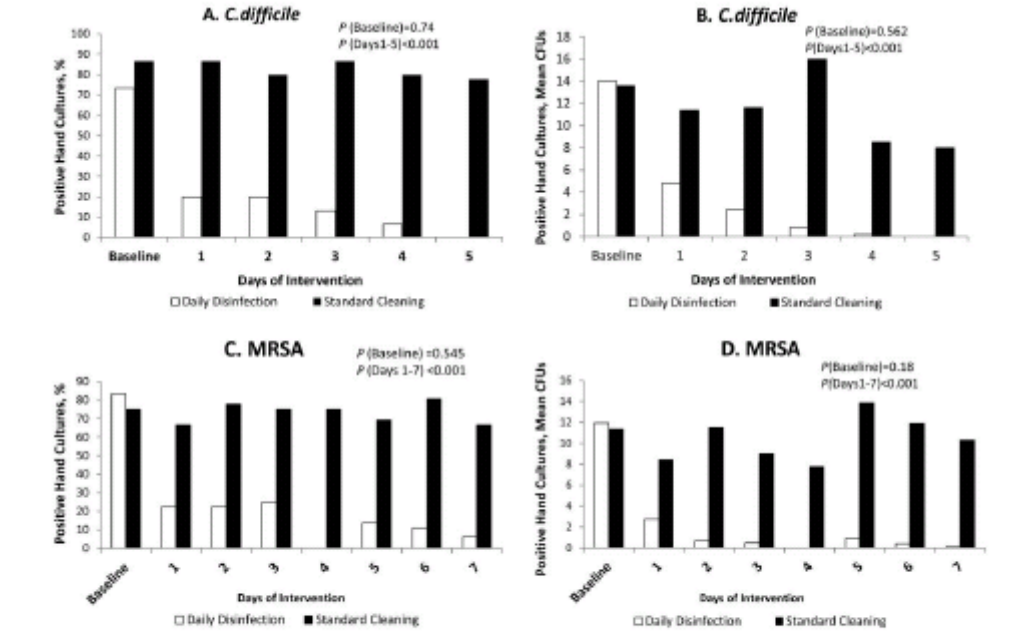

FIGURE 1. Effect of daily disinfection of high-touch environmental surfaces on acquisition of *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus* (MRSA) on gloved hands of investigators after contact with the surfaces. *A*, Percentage of positive *C. difficile* cultures; *B*, mean number of *C. difficile* colony-forming units acquired; *C*, percentage of positive MRSA cultures; *D*, mean number of MRSA colony-forming units acquired.

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DISINFECTION AND STERLIZATION

- EH Spaulding believed that how an object will be disinfected depended on the object's intended use
  - **CRITICAL - objects which enter normally sterile tissue or the vascular system or through which blood flows should be sterile**
  - **SEMICRITICAL - objects that touch mucous membranes or skin that is not intact require a disinfection process (high-level disinfection[HLD]) that kills all microorganisms; however, small numbers of bacterial spores are permissible.**
  - **NONCRITICAL - objects that touch only intact skin require low-level disinfection**

Effective Surface Decontamination

Product and Practice = Perfection

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

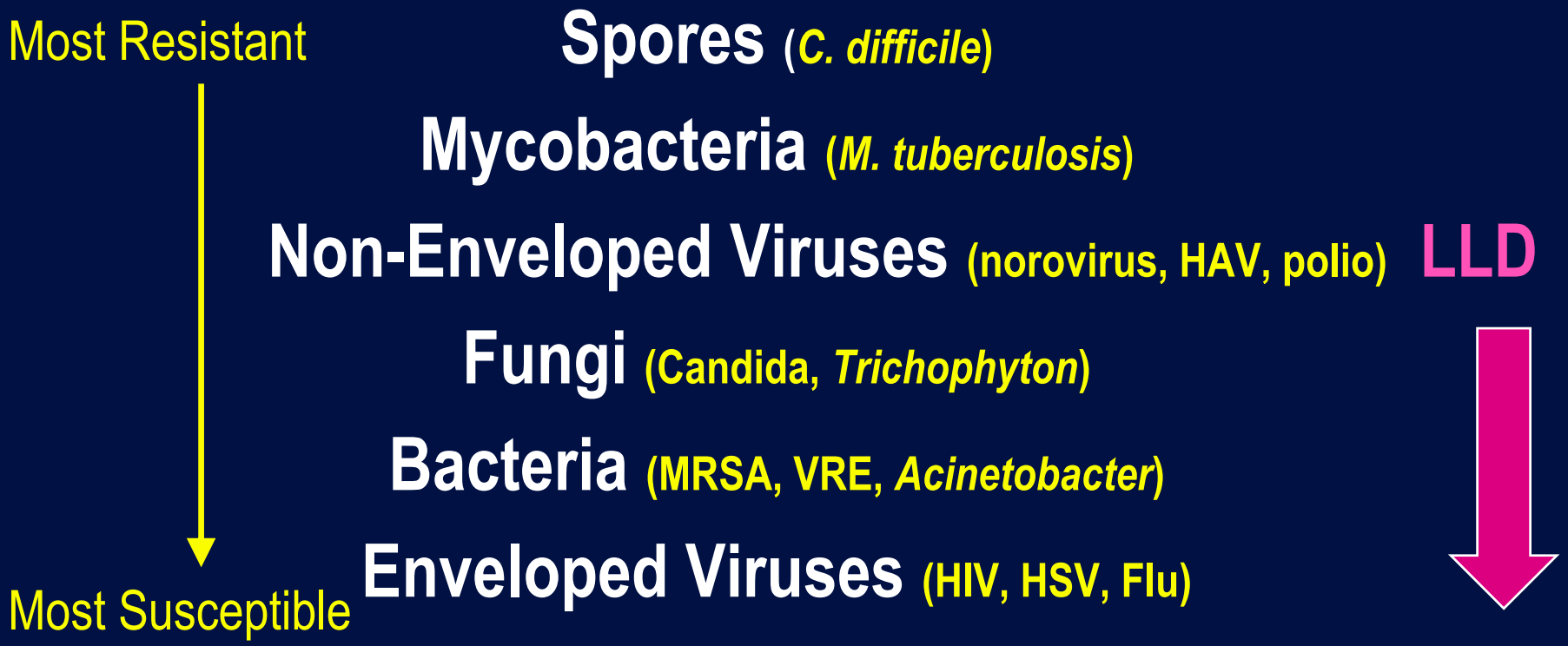
Exposure time ≥ 1 min

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)

Microbiological Disinfectant Hierarchy

Rutala WA, Weber DJ, HICPAC. www.cdc.gov



THE "BEST" PRACTICES FOR CLEANING AND DISINFECTING

Cleaning and disinfecting is one-step with disinfectant-detergent. No pre-cleaning necessary unless spill or gross contamination. In some cases "best" practices not scientifically determined.

PROPERTIES OF AN IDEAL DISINFECTANT

Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865

- **Broad spectrum**-wide antimicrobial spectrum
- **Fast acting**-should produce a rapid kill
- **Remains Wet**-meet listed kill/contact times with a single application
- **Not affected by environmental factors**-active in the presence of organic matter
- **Nontoxic**-not irritating to user
- **Surface compatibility**-should not corrode instruments and metallic surfaces
- **Persistence**-should have sustained antimicrobial activity
- **Easy to use**
- Acceptable odor
- Economical-cost should not be prohibitively high
- Soluble (in water) and stable (in concentrate and use dilution)
- Cleaner (good cleaning properties) and nonflammable

Key Considerations for Selecting the Ideal Disinfectant for Your Facility

Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865

Consideration	Question to Ask	Score (1-10)
Kill Claims	Does the product kill the most prevalent healthcare pathogens	
Kill Times and Wet-Contact Times	How quickly does the product kill the prevalent healthcare pathogens. Ideally, contact time greater than or equal to the kill claim.	
Safety	Does the product have an acceptable toxicity rating, flammability rating	
Ease-of-Use	Odor acceptable, shelf-life, in convenient forms (wipes, spray), water soluble, works in organic matter, one-step (cleans/disinfects)	
Other factors	Supplier offer comprehensive training/education, 24-7 customer support, overall cost acceptable (product capabilities, cost per compliant use, help standardize disinfectants in facility	

Note: Consider the 5 components shown, give each product a score (1 is worst and 10 is best) in each of the 5 categories, and select the product with the highest score as the optimal choice (maximum score is 50).

MOST PREVALENT PATHOGENS CAUSING HAI

Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865

- Most prevent pathogens causing HAI (~75% easy to kill)
  - *S. aureus* (15.6%)
  - *E. coli* (11.5%)
  - Coag neg Staph (11.4%)
  - *Klebsiella* (8.0%)
  - *P. aeruginosa* (8.0%)
  - *E. faecalis* (6.8%)
  - *C. albicans* (5.3%)
  - *Enterobacter* sp. (4.7%)
  - Other *Candida* sp (4.2%)
  - *C. difficile* in top 2-3 past 5 years
- Common causes of outbreaks and ward closures (relatively hard to kill)
  - *C. difficile* spores
  - Norovirus
  - Rotavirus
  - Adenovirus

EFFECTIVENESS OF DISINFECTANTS AGAINST MRSA AND VRE

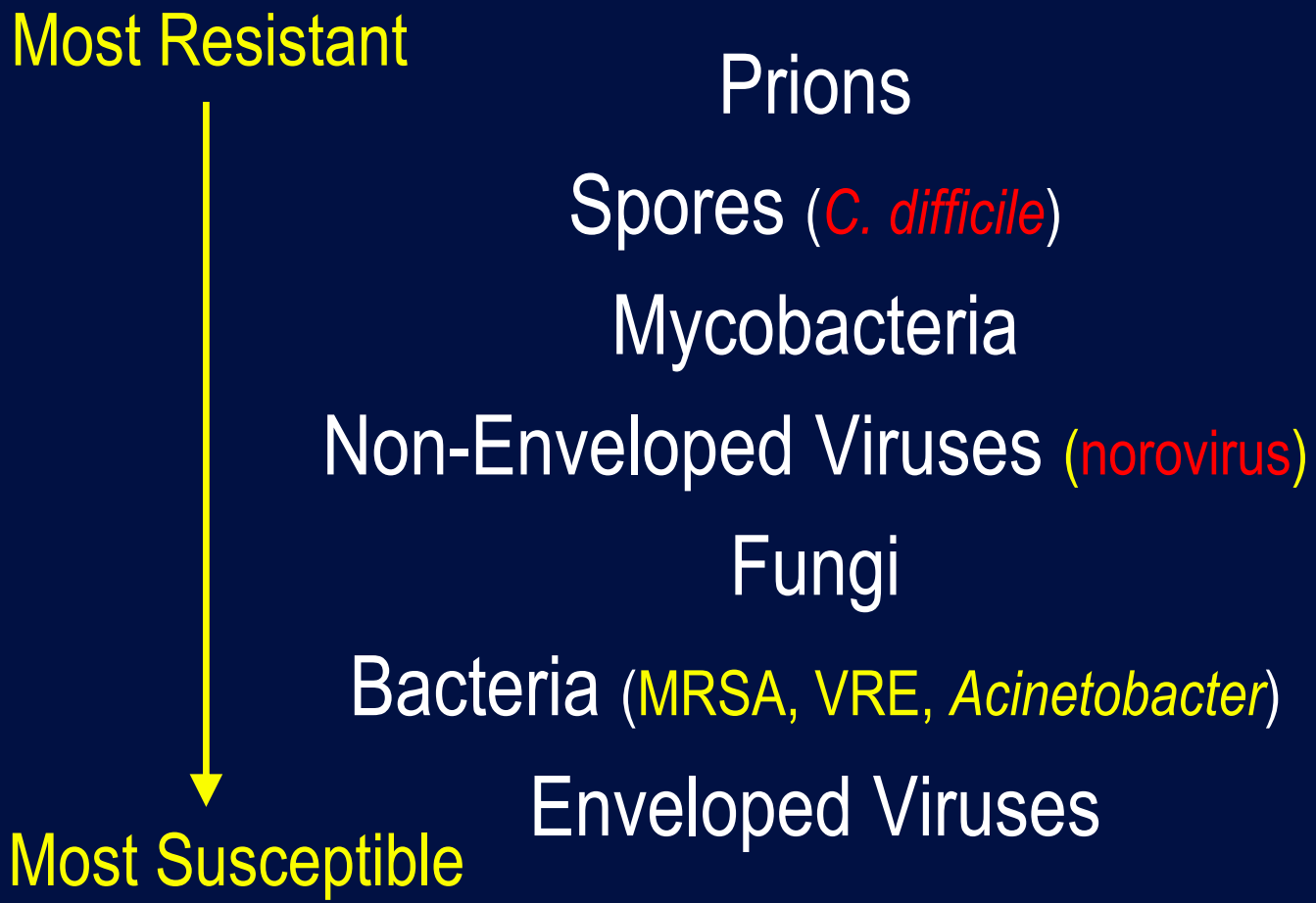
Rutala WA, et al. *Infect Control Hosp Epidemiol* 2000;21:33-38

TABLE 2
DISINFECTANT ACTIVITY AGAINST ANTIBIOTIC-SUSCEPTIBLE AND ANTIBIOTIC-RESISTANT BACTERIA

	Log_{10} Reductions							
	VSE		VRE		MSSA		MRSA	
Product	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min
Vesphene IIse	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Clorox	>5.4	>5.4	>4.9	>4.9	>5.0	>5.0	>4.6	>4.6
Lysol Disinfectant	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Lysol Antibacterial	>5.5	>5.5	>5.5	>5.5	>5.1	>5.1	>4.6	>4.6
Vinegar	0.1	5.3	1.0	3.7	+1.1	+0.9	+0.6	2.3

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus;* MSSA, methicillin-susceptible *S aureus;* VRE, vancomycin-resistant *Enterococcus;* VSE, vancomycin-susceptible *Enterococcus.* Data represent mean of two trials (n=2). Values preceded by ">" represent the limit of detection of the assay. Assays were conducted at a temperature of 20°C and a relative humidity of 45%. Results were calculated as the log of Nd/No, where Nd is the titer of bacteria surviving after exposure and No is the titer of the control.

Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants



C. difficile
EPA-Registered Products

- List K: EPA's Registered Antimicrobials Products Effective Against *C. difficile* spores, April 2014
- http://www.epa.gov/oppad001/list_k_clostridium.pdf
- Most registered products are chlorine-based, some HP/PA-based, new 4% HP

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Effective Surface Decontamination

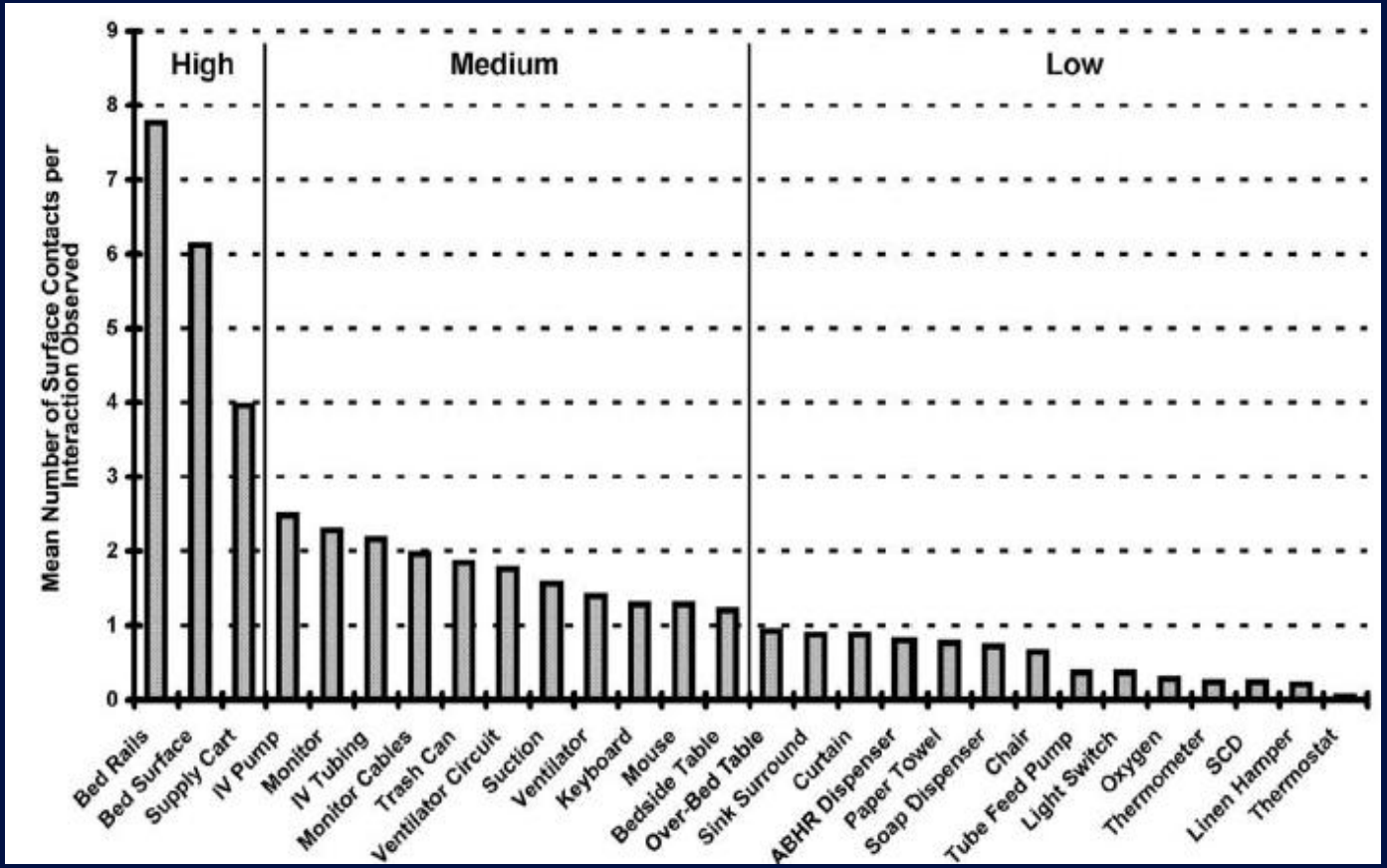
Product and Practice = Perfection

SHOULD WE CONCENTRATE ON "HIGH TOUCH" OR "HIGH RISK" OBJECTS

No, not only "high risk" (all surfaces).
"High touch" objects only recently defined and "high risk" objects not scientifically defined.

DEFINING HIGH TOUCH SURFACES

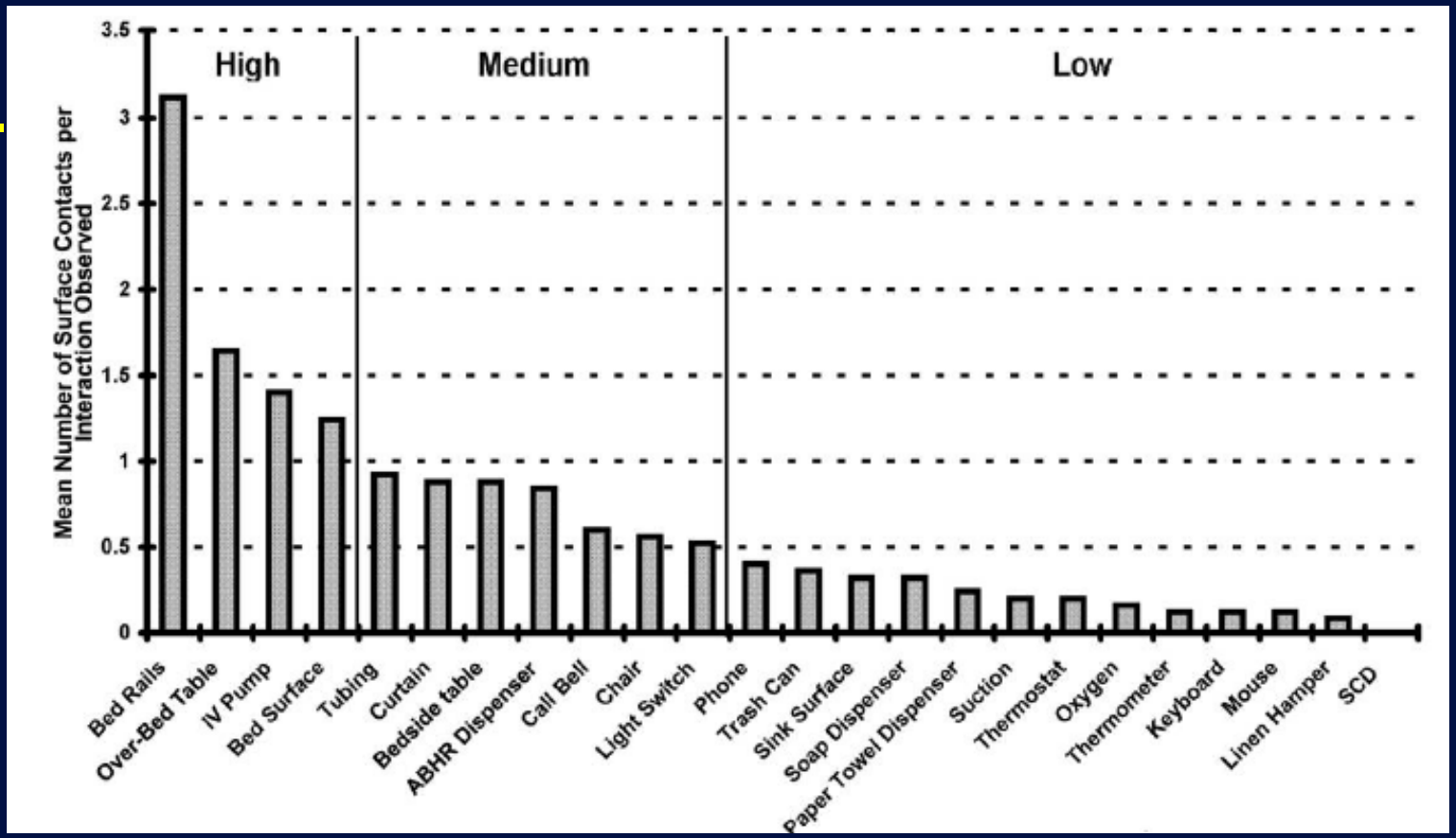
ICU



Huslage K, Rutala WA, Sickbert-Bennett E, Weber DJ. ICHE 2010;31:850-853

DEFINING HIGH TOUCH SURFACES

Non-ICU



Huslage K, Rutala WA, Sickbert-Bennett E, Weber DJ. ICHE 2010;31:850-853

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

Huslage K, Rutala WA, Weber DJ. ICHE. 2013;34:211-212

Surface	Prior to Cleaning Mean CFU/RODAC (95% CI)	Post Cleaning (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**

TABLE. Rates of Cleaning for 14 Types of High-Risk Objects

Object	Percentage cleaned		95% CI
	Mean ± SD	Range	
Sink	82 ± 12	57-97	77-88
Toilet seat	76 ± 18	40-98	68-84
Tray table	77 ± 15	53-100	71-84
Bedside table	64 ± 22	23-100	54-73
Toilet handle	60 ± 22	23-89	50-69
Side rail	60 ± 21	25-96	51-69
Call box	50 ± 19	9-90	42-58
Telephone	49 ± 16	18-86	42-56
Chair	48 ± 28	11-100	35-61
Toilet door knobs	28 ± 22	0-82	18-37
Toilet hand hold	28 ± 23	0-90	18-38
Bedpan cleaner	25 ± 18	0-79	17-33
Room door knobs	23 ± 19	2-73	15-31
Bathroom light switch	20 ± 21	0-81	11-30

NOTE. CI, confidence interval.

ALL “TOUCHABLE” (HAND CONTACT) SURFACES SHOULD BE WIPED WITH DISINFECTANT

“High touch” objects only recently defined (no significant differences in microbial contamination of different surfaces) and “high risk” objects not epidemiologically defined.

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

BEST PRACTICES FOR ROOM DISINFECTION

- Follow the CDC Guideline for Disinfection and Sterilization with regard to choosing an appropriate germicide and best practices for environmental disinfection (at least daily for surfaces and non-critical patient care items)
- Appropriately train environmental service workers on proper use of PPE and cleaning/disinfection of the environment
- Have environmental service workers use checklists to ensure all room surfaces are cleaned/disinfected
- Assure that nursing and environmental service have agreed what items (e.g., sensitive equipment) are to be cleaned/disinfected by nursing and what items (e.g., environmental surfaces) are to be cleaned/disinfected by environmental service workers. Staff must have sufficient time. Increasing workload compromising infection control activities.
- Use a method (e.g., fluorescent dye, ATP) to ensure proper cleaning

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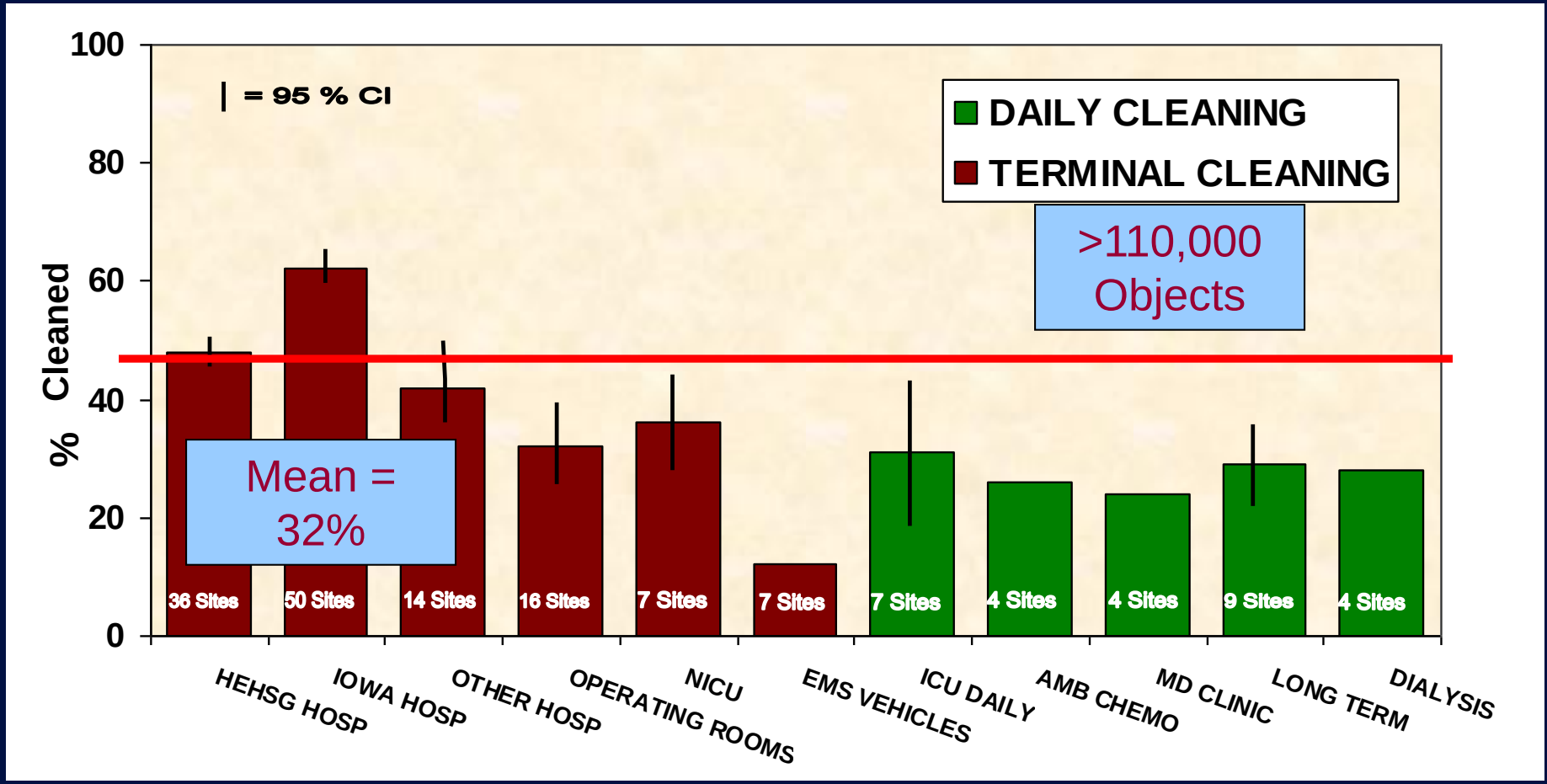
Thoroughness of Environmental Cleaning

Carling P. AJIC 2013;41:S20-S25



MONITORING THE EFFECTIVENESS OF CLEANING

Cooper et al. AJIC 2007;35:338

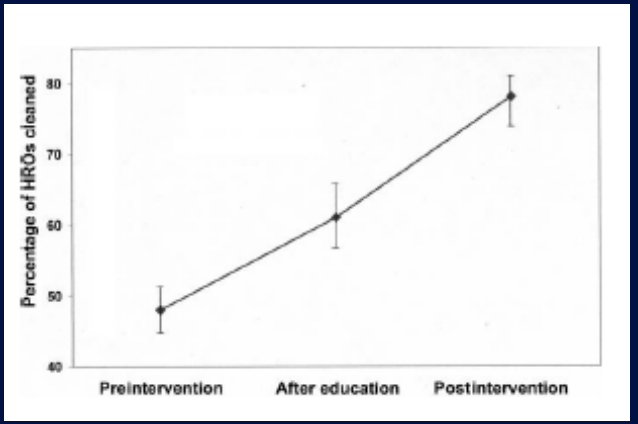
- Visual assessment-not a reliable indicator of surface cleanliness
- ATP bioluminescence-measures organic debris (each unit has own reading scale, <250-500 RLU)
- Microbiological methods-<2.5CFUs/cm^2-pass; can be costly and pathogen specific
- Fluorescent marker-transparent, easily cleaned, environmentally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

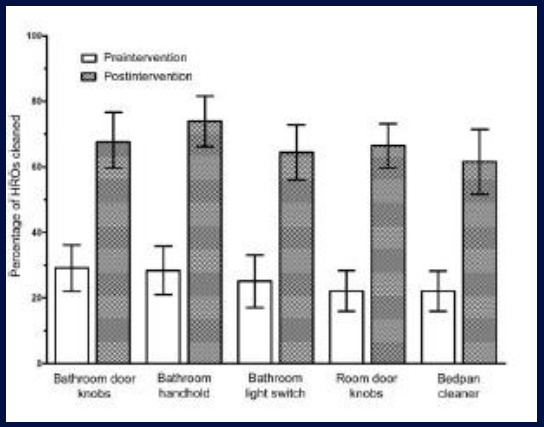
TARGET ENHANCED

TERMINAL ROOM CLEANING: DEMONSTRATION OF IMPROVED CLEANING

- 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





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

SURFACE EVALUATION USING ATP BIOLUMINESCENCE

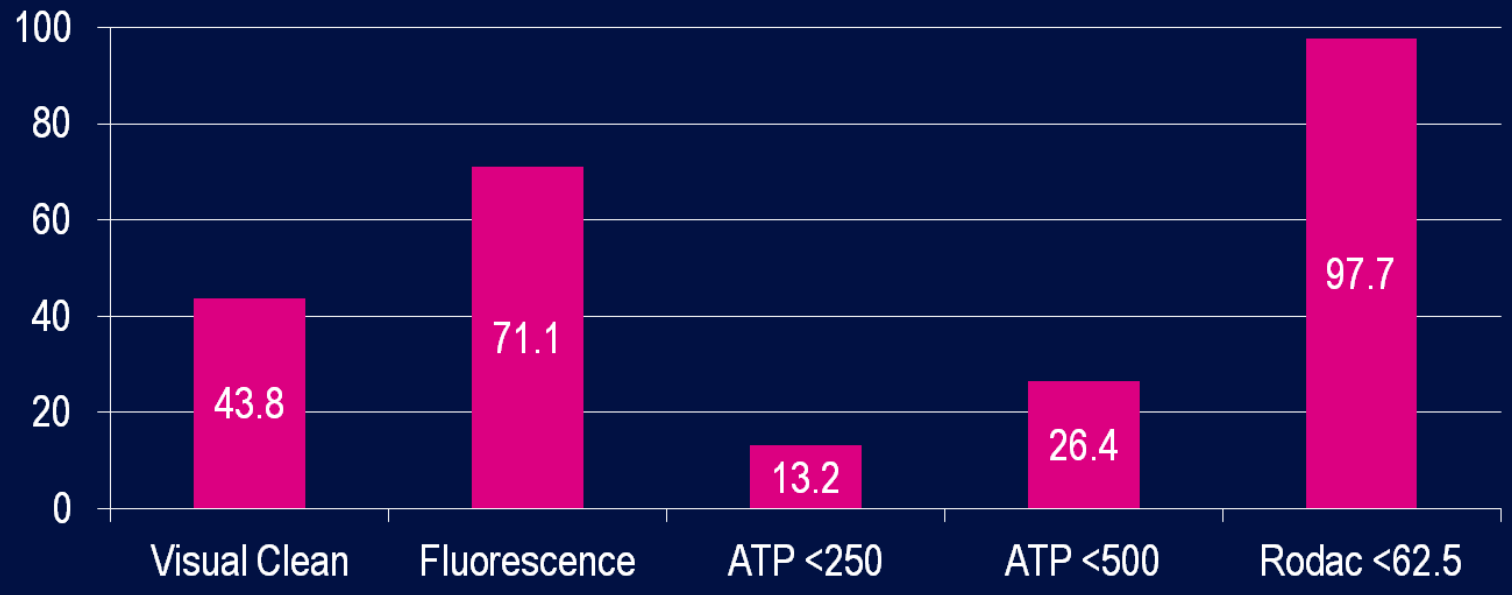
Swab surface → luciferace tagging of ATP → Hand held luminometer

Used in the commercial food preparation industry to evaluate surface cleaning before reuse and as an educational tool for more than 30 years.

Percentage of Surfaces Clean by Different Measurement Methods

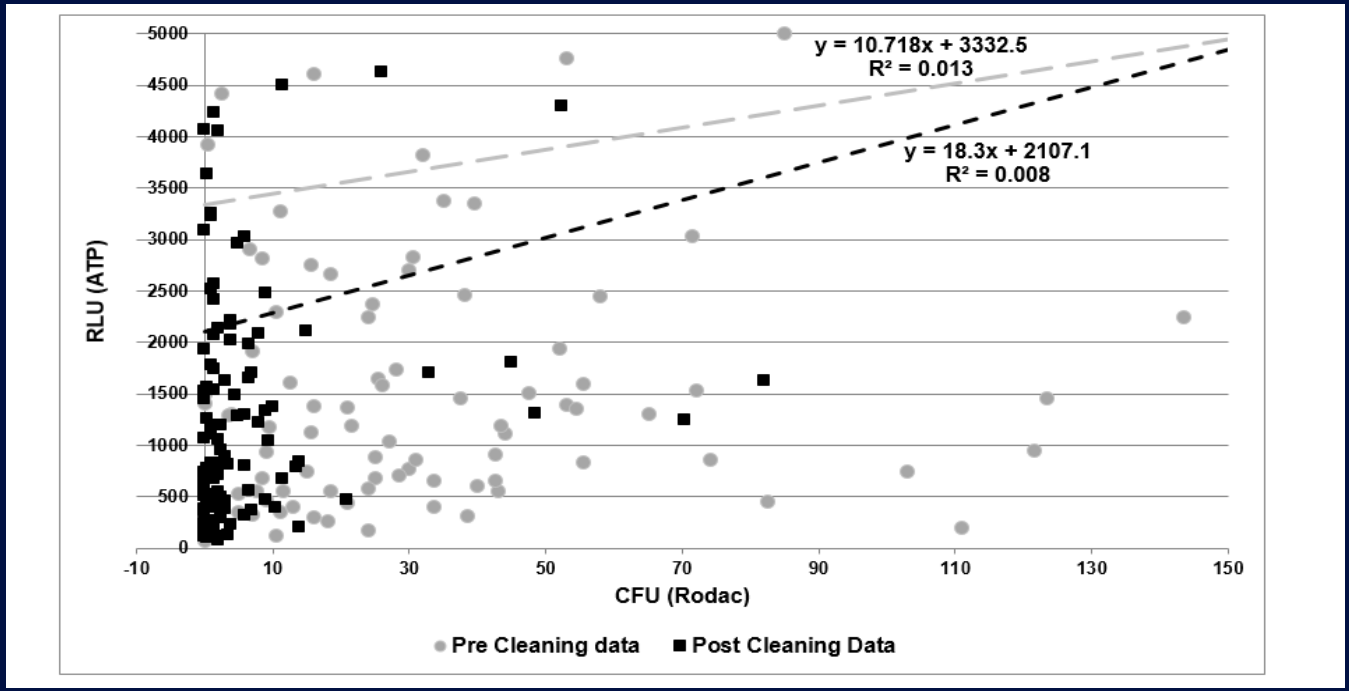
Rutala, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017

Fluorescent marker is a useful tool in determining how thoroughly a surface is wiped and mimics the microbiological data better than ATP



Scatterplot of ATP Levels (less than 5000 RLUs) and Standard Aerobic Counts (CFU/Rodac)

Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017



There was no statistical correlation between ATP levels and standard aerobic plate counts.

These interventions 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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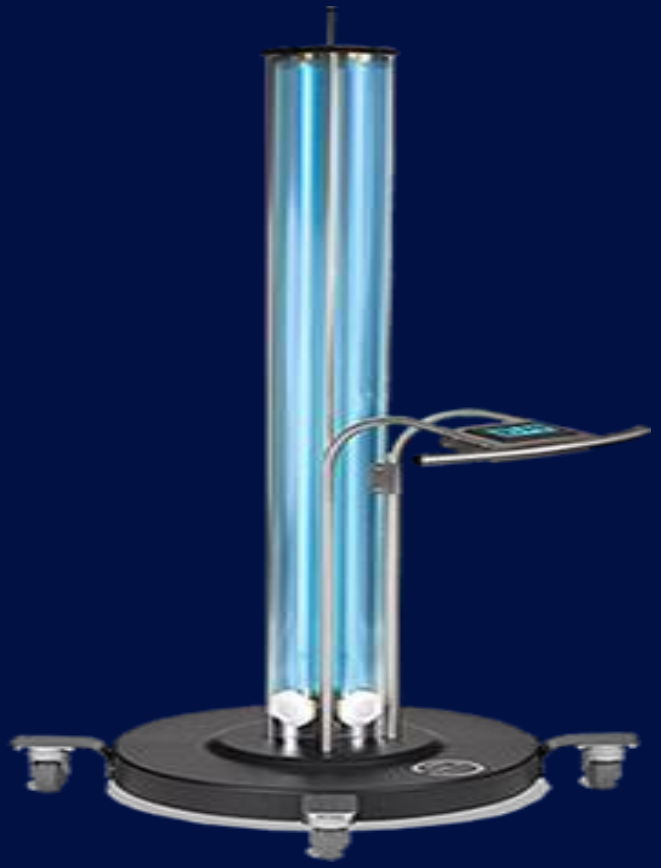
- Review “best” practices for environmental cleaning and disinfection
- Discuss options for evaluating environmental cleaning and disinfection
- Discuss “no touch” technologies for room decontamination and reduction of HAIs
- Will use of a continuously active disinfectant (CAD) reduce microbial contamination

"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.



Touch (Wiping) vs No-Touch (Mechanical)

No Touch

(supplements but do not replace surface cleaning/disinfection)

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

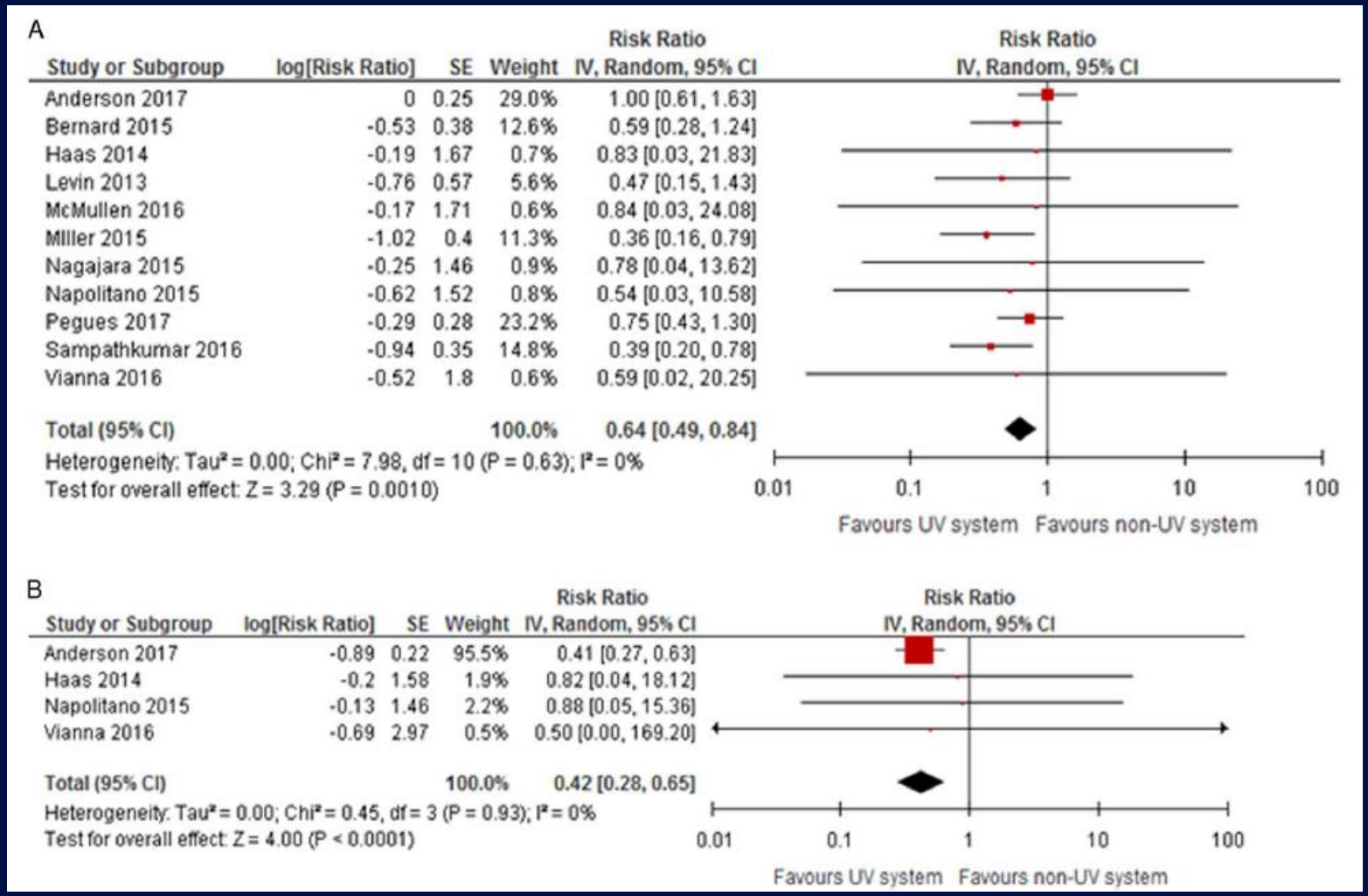
	Standard Method		Enhanced method	
	Quat	Quat/UV	Bleach	Bleach/UV
EIP (mean CFU per room)[a]	60.8	3.4	11.7	6.3
Reduction (%)		94	81	90
Colonization/Infection (rate)[a]	2.3	1.5	1.9	2.2
Reduction (%)		35	17	4

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%). Our data demonstrated that a decrease in room contamination was associated with a decrease in patient colonization/infection.

Efficacy of UVC at Terminal Disinfection to Reduce HAIs

(A = *C. difficile*, B = VRE; UV effective in preventing VRE and *C. difficile*)

Marra AR, et al. ICHE 2018;39:20-31



This technology (“no touch” with microbicidal data in literature) should be used (capital equipment budget) for terminal room disinfection (e.g., after discharge of patients on Contact Precautions).

Role of Hospital Surfaces in Disease Transmission: Will Use of a Continuously Active Disinfectant Reduce Microbial Contamination?

- Review the role of environmental surfaces
- Review the use of low-level disinfectants and the selection of the ideal disinfectant
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- Discuss options for evaluating environmental cleaning and disinfection
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- Will use of a continuously active disinfectant (CAD) reduce microbial contamination

Environmental Contamination Leads to HAIs

- By contaminating hands/gloves via contact with the environment and transfer to patient, or patient self inoculation
- Surface should be hygienically clean (not sterile)-free of pathogens in sufficient numbers to prevent human disease
- Two environmental surface concerns
  - Discharge/terminal-new patient in room
  - Daily room recontamination/decontamination

Recontamination with MRSA after Decontamination with HP Vapor

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

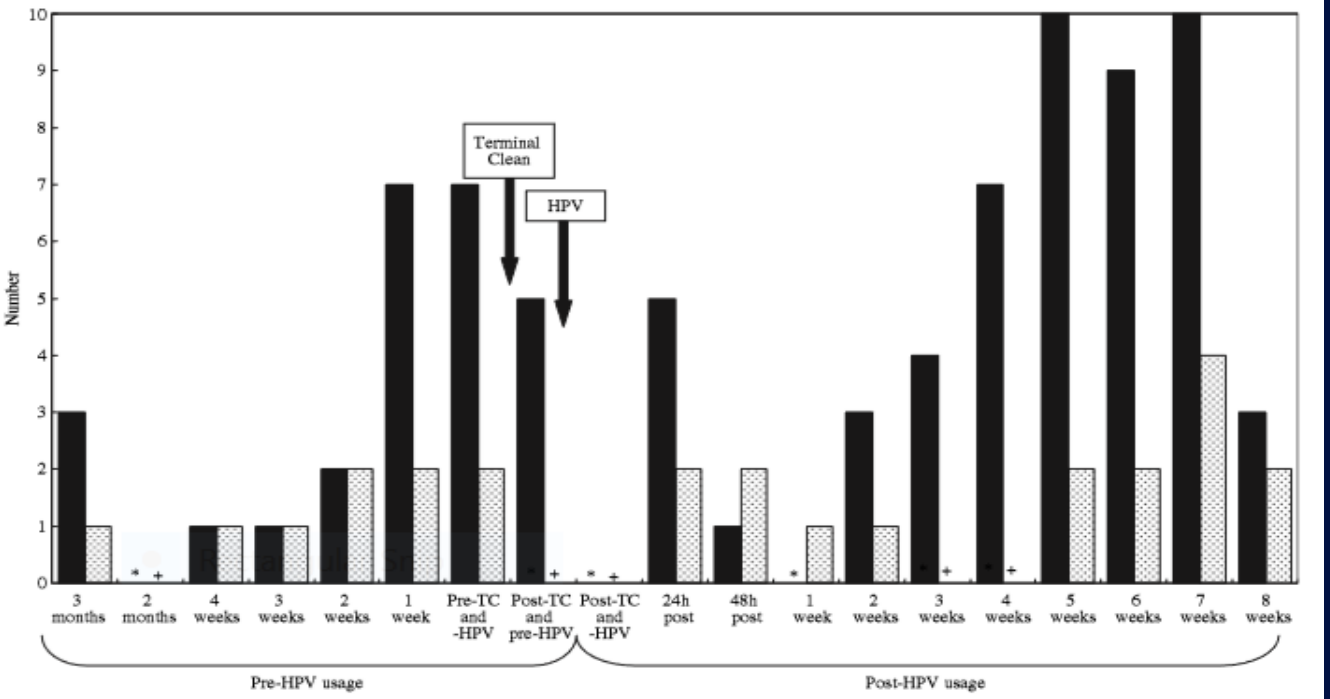

Figure 1 Number of environmental sites (■) contaminated with MRSA, and number of patients (□) colonized with MRSA on intensive care units on each screen. *MRSA environmental samples all negative; †no patients colonized with MRSA. HPV, hydrogen peroxide vapour; TC, terminal clean.

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
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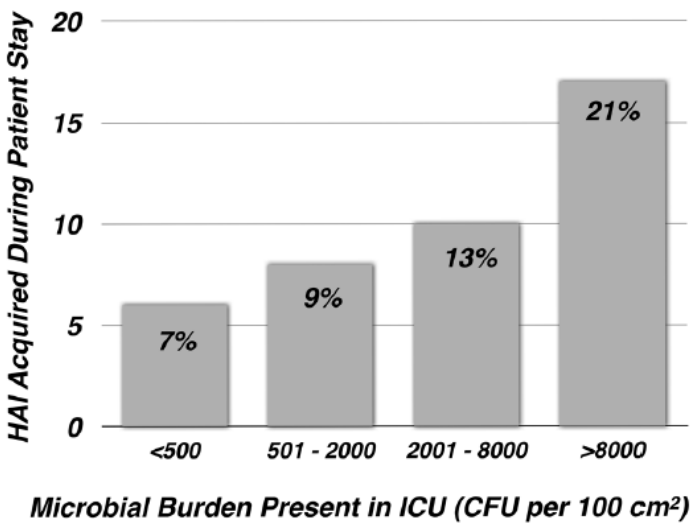


FIGURE 2. Quartile distribution of healthcare-acquired infections (HAIs) stratified by microbial burden measured in the intensive care unit (ICU) room during the patient's stay. There was a significant association between burden and HAI risk ($P = .038$), with 89% of HAIs occurring among patients cared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

To reduce microbial contamination

Continuous Room Decontamination Technology

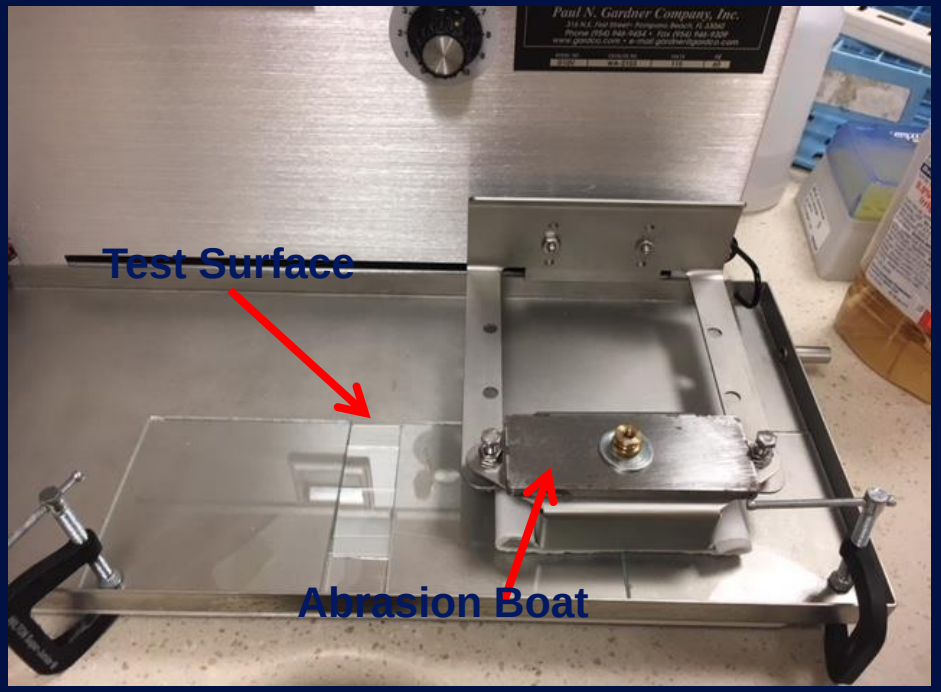
Continuous Room Decontamination Technologies for Disinfection of the Healthcare Environment

- Visible light disinfection through LEDs
- Low concentration hydrogen peroxide
- Self-disinfecting surfaces
- **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

Evaluation of a Continuously Active Disinfectant

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

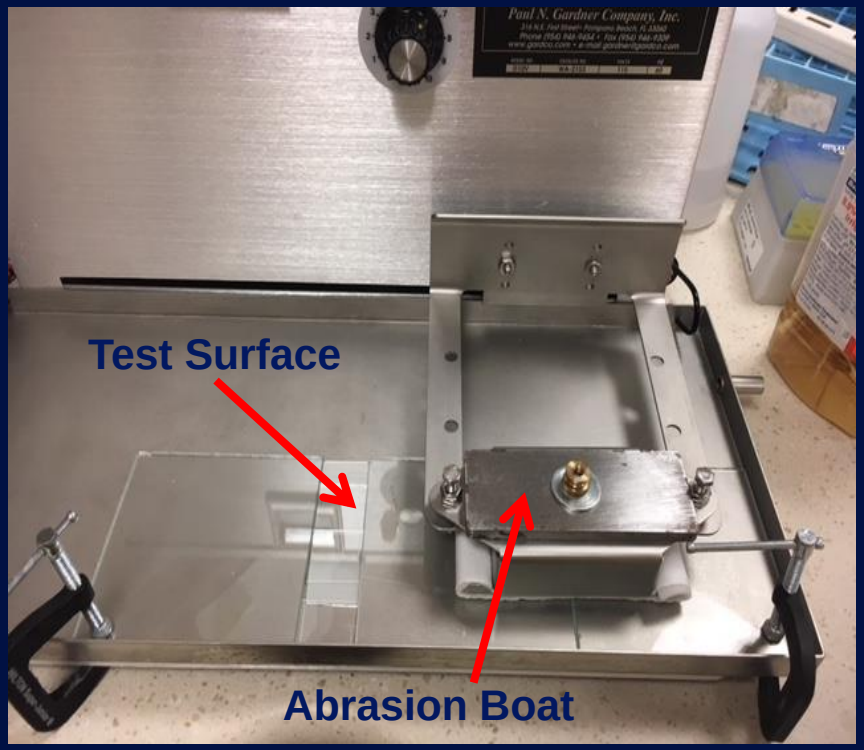
Abrasion Tester



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. ICHE, In press

4-5 log_{10} reduction in 5min over 24hr for most pathogens; ~99% reduction with *Klebsiella* and CR *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)
CR *E.coli*	3.0 (2.6, 3.4)
CR *Enterobacter*	2.0 (1.6, 2.4)
CR *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. ICHE In press

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

Efficacy of a Continuously Active Disinfectant

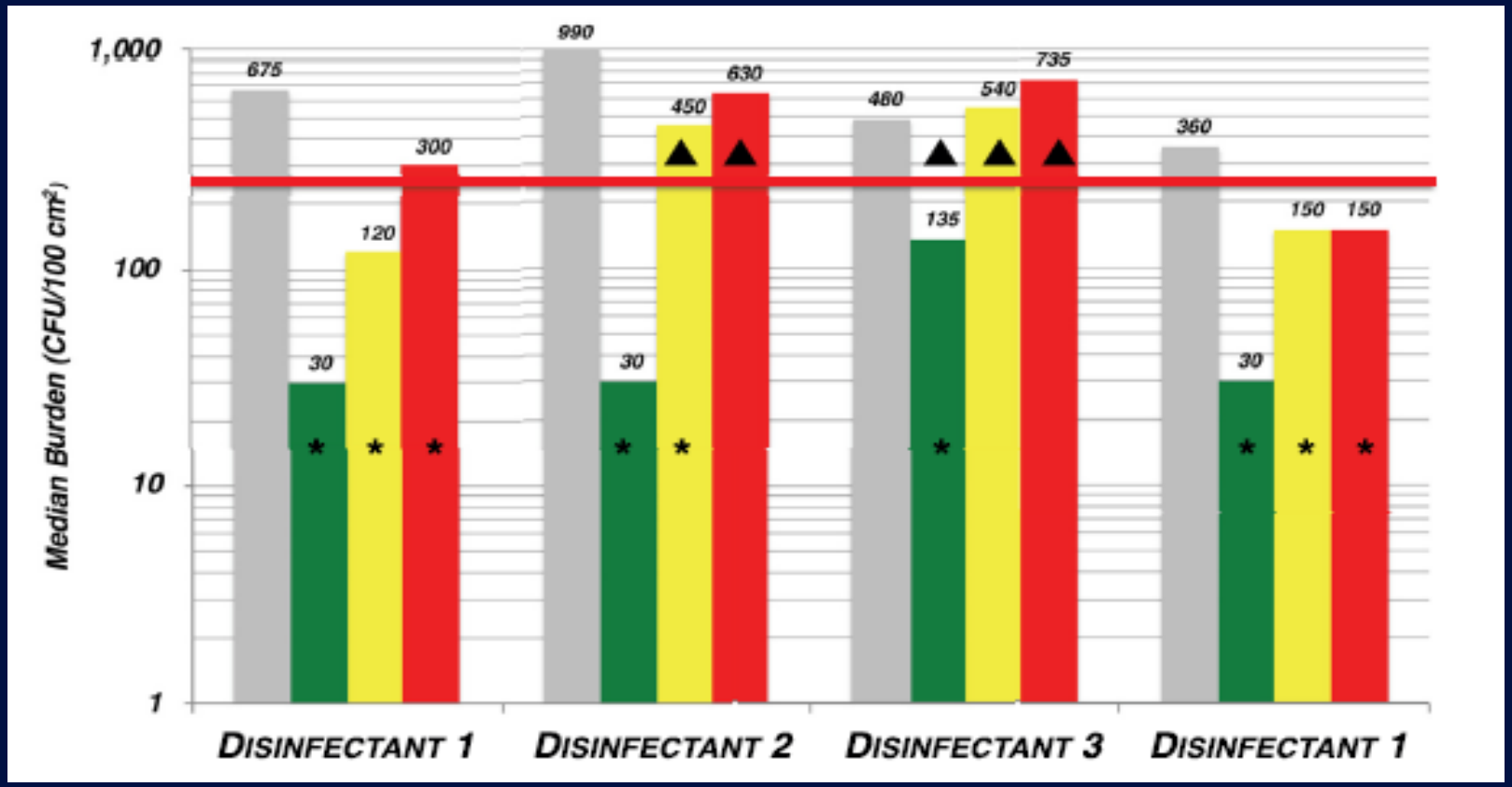
Summary

- Preliminary studies with a new continuously active disinfectant are promising (e.g., 4-5 $\log_{10}$ reduction in 5min over 24hr)
- Unclear why 99% reduction with *Klebsiella* and CR *Enterobacter* (another researcher [Donskey] found a 4 $\log_{10}$ reduction; most surfaces have <100 CFU/Rodac
- Continuously active disinfectants may reduce or eliminate the problem of recontamination.

Evaluation of Three Disinfectants for Ability to Limit Establishment of Bioburden After Disinfection

Schmidt et al. Am J Infect Control 2019;47:732-4

The CAD (disinfectant 1, red-24h sample) was able to significantly control bioburden on bed rails, a critical touch surface



Why do we need to consider continuous room decontamination technology?

To reduce microbial contamination

(associated with **suboptimal CD practices and recontamination**)

Evaluation of Three Disinfectants for Ability to Limit Establishment of Bioburden After Disinfection

Schmidt et al. Am J Infect Control 2019;47:732

- The use of a continuously active disinfectant (CAD) offers the infection prevention community a new opportunity to limit the re-establishment of bacteria on touch surfaces in the hospital environment
- Several studies (Salgado et al., Anderson et al, Rutala et al) were able to demonstrate that when the microbial bioburden of a patient room was kept low, the risk of acquisition of HAIs was reduced

Relationship Between Microbial Burden and HAIs

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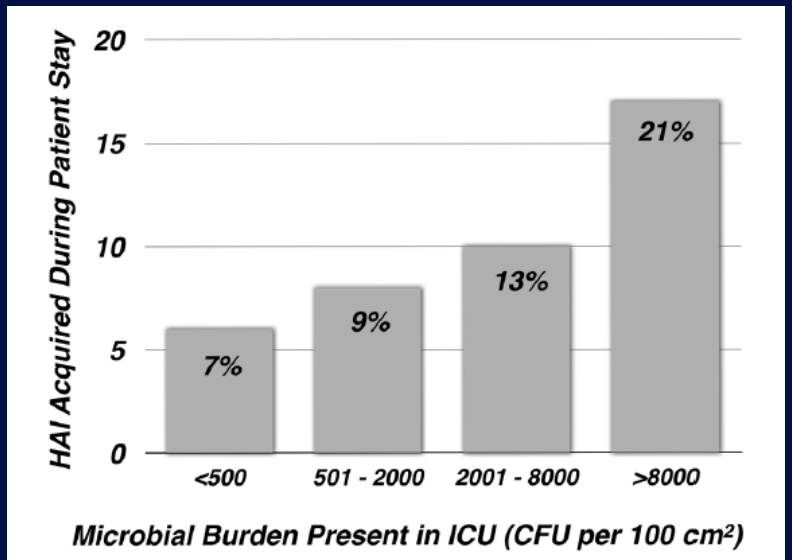

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Environmental Disinfection in Health Care Facilities

Recommendations

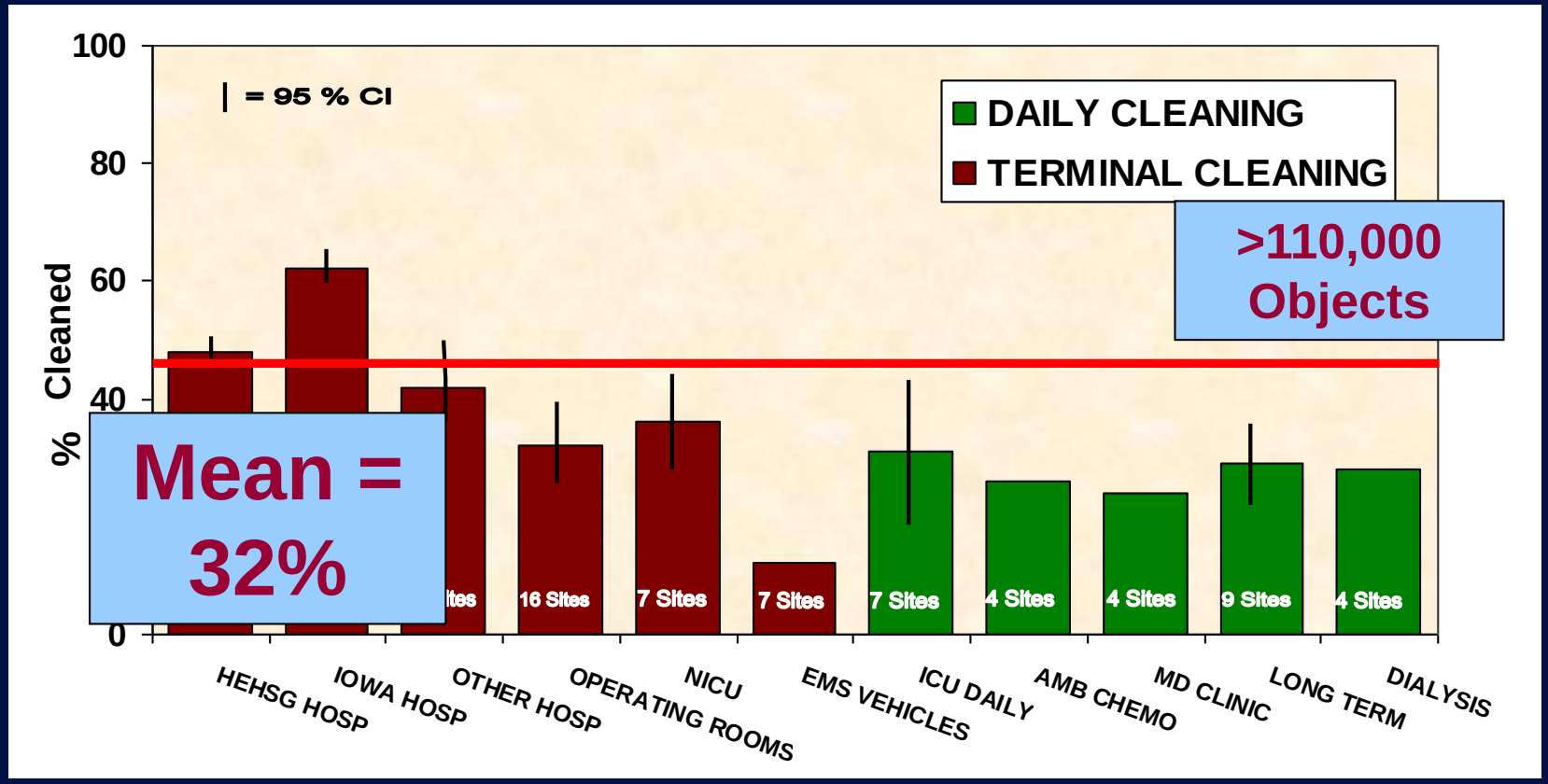
- Decontaminate **surfaces in patient room** that are touched by health care workers and patients (**daily, terminal**)
- **Decontaminate portable equipment** that is shared among patients such as medication carts, wheelchairs, portable x-ray machines, etc. **after each patient use**

Environmental Disinfection in Health Care Facilities

- Environmental disinfection is suboptimal
  - Patient rooms are contaminated due to suboptimal cleaning/disinfection and recontamination
  - Portable equipment not decontaminated per policy
  - Outbreaks and environmental-mediated infections occur

Thoroughness of Environmental Cleaning

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

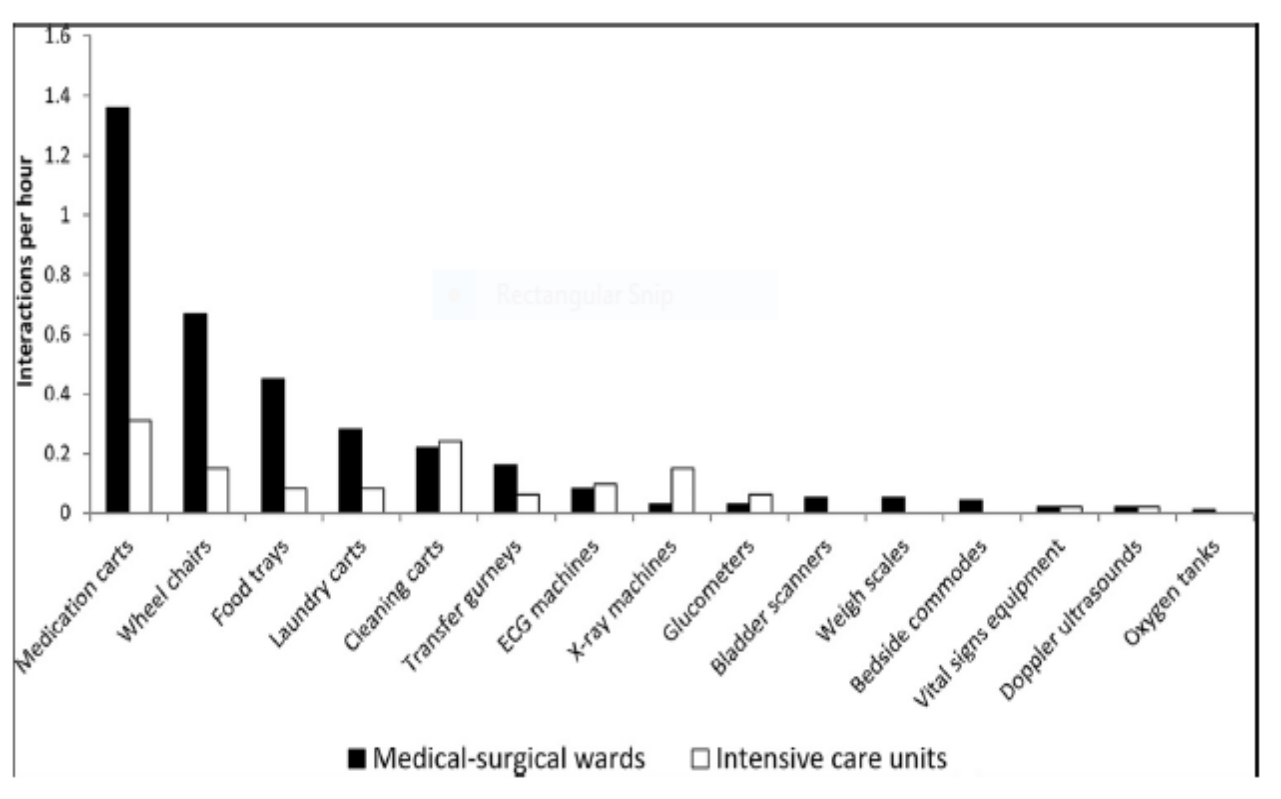


Portable Equipment
(decontaminate after each patient use)

Interactions Between Patients and Shared Portable Equipment

Suwantarat N, et al. AJIC 2017;45:1276

Of 360 interactions between portable equipment and patients, 42% involved equipment or fomites that made direct contact with the patient or surfaces in the room



Frequency of Recovery of Healthcare Pathogens from Portable Equipment

Suwantarat N, et al. AJIC 2017;45:1276

Of 80 items cultured, 12 (15%) were contaminated with ≥ 1 healthcare pathogen

Frequency of recovery of health care–associated pathogens from portable equipment and fomites on medical-surgical wards and in intensive care units

Portable equipment and fomites	MRSA	VRE	*Clostridium difficile*
Medication carts	2/31 (7)	1/31 (3)	1/31 (3)
Wheelchairs	1/12 (8)	0/12 (0)	0/12 (0)
ECG machines	1/8 (13)	1/8 (13)	0/8 (0)
Food trays	0/7 (0)	0/7 (0)	0/7 (0)
Laundry carts	3/5 (60)	2/5 (40)	1/5 (20)
Bladder scanners	0/3 (0)	2/3 (67)	0/3(0)
Portable x-ray machines	1/3 (33)	0/3 (0)	0/3 (0)
Weight scales	0/3 (0)	0/3 (0)	0/3 (0)
Doppler ultrasound machines	0/2 (0)	0/2 (0)	0/2 (0)
Glucometers	0/2 (0)	0/2 (0)	0/2 (0)
Transfer gurneys	0/2 (0)	0/2 (0)	0/2 (0)
Vital sign machines	0/2 (0)	0/2 (0)	0/2 (0)
Total	8/80 (10)	6/80 (8)	2/80 (3)

NOTE. Values are the no. of positive samples/no. sampled (%).
ECG, electrocardiogram; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *VRE*, vancomycin-resistant enterococci.

Environmental Disinfection in Healthcare Facilities

- Continuously active disinfectants reduces bioburden
- Whether a CAD translates in a reduction of HAIs remains to be determined
- Continuously active disinfectants should not alter the frequency of cleaning and disinfection as one of the purposes of routine cleaning and disinfection is to remove dirt and debris in addition to the reduction of microbial contamination

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Role of Hospital Surfaces in Disease Transmission

- 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
- When determining the optimal disinfecting product, consider the 5 components (kill claims/time, safety, ease of use, others).
- Implement a method to improve the thoroughness of cleaning
- Goal: Product + Practice = Perfection
- An enhanced method of room decontamination is superior to a standard method
- "No touch" technology should be used at discharge for CP patients
- When microbial bioburden on surfaces is low, risk of acquisition of HAIs was reduced. CAD reduces microbial contamination over 24 hours.

THANK YOU!

www.disinfectionandsterilization.org