Best Practices in Disinfection of Noncritical Surfaces in the Healthcare Setting: A Bundle Approach and New Strategies

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

DISCLOSURES

2020-2021

- **Consultations**
  - PDI (Professional Disposable International)
- **Honoraria**
  - PDI
- Other
  - Kinnos

Best Practices in Disinfection of Noncritical Surfaces in the Healthcare Setting: A Bundle Approach and New Strategies

- Disinfection of noncritical surfaces in healthcare: A bundle approach
  - Overview of how environment contributes to HAIs
  - Policy, products, educate/train, compliance, “no touch”
- New Strategies in cleaning and disinfection
  - Colorized disinfectant, new sporicide, sporicide at discharge cleaning, emerging pathogens, electrostatic sprayer, continuously active disinfectant

Sources of Healthcare-Associated Pathogens

Weinstein RA. Am J Med 1991:91 (suppl 3B):179S

- Endogenous flora (SSI, UTI, CLABSI): 40-60%
- Exogenous: 20-40% (e.g., cross-infection via contaminated hands [staff, visitors])
- Other (environment): 20%
  - Medical devices
  - Contact with environmental surfaces (direct and indirect contact)

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 pathogen by 39-353%
- For example, increased risk for *C. difficile* is 235% (11.0% vs 4.6%; Shaughnessy et al. ICHE 2011;32:201)
- 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)

Acquisition of EIP on Hands of Healthcare Providers after Contact with Contaminated Environmental Sites or Patients 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



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

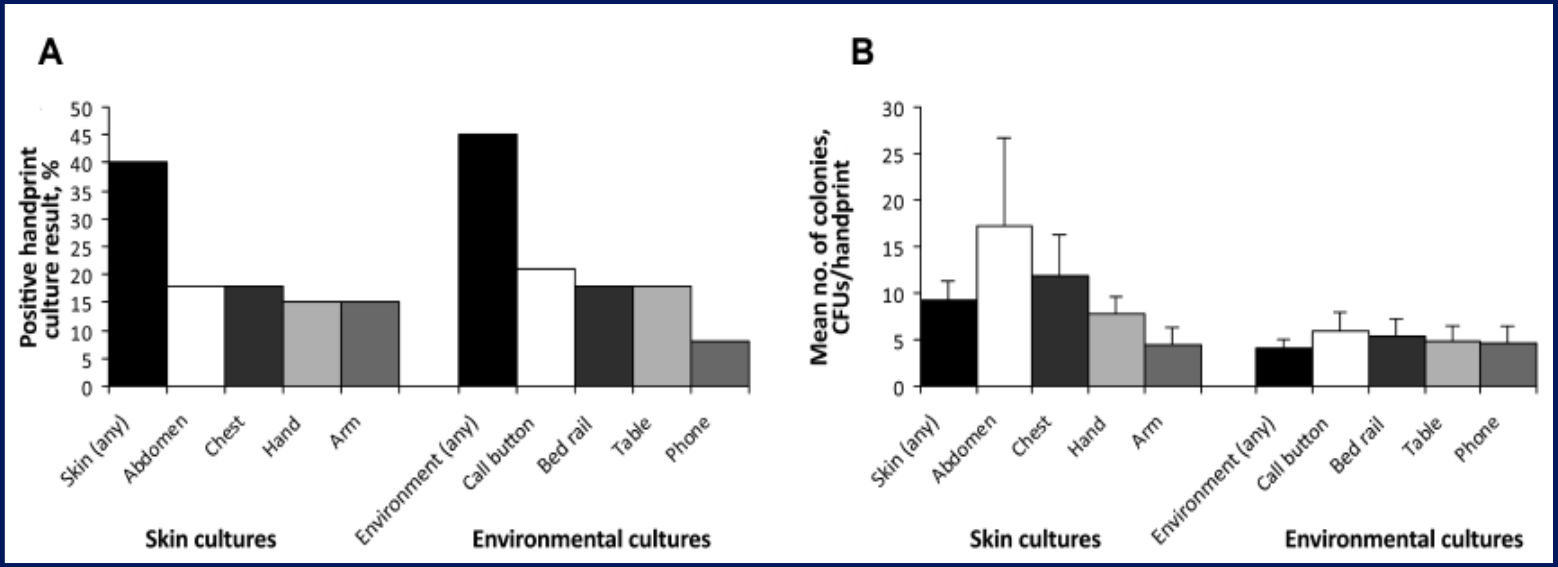
ENVIRONMENTAL SURVIVAL OF KEY PATHOGENS ON HOSPITAL SURFACES

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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[b] Case Western Reserve University School of Medicine, Cleveland, OH

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.

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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.[7-12] 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

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

Best Practices in Disinfection of Noncritical Surfaces in the Healthcare Setting: A Bundle Approach

A set of evidence-based practices, generally 3-5, that when performed collectively and reliably have been proven to improve patient outcomes

Best Practices in Disinfection of Noncritical Surfaces in the Healthcare Setting: A Bundle Approach

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

A Bundle Approach to Surface Disinfection

- 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 (and new strategies)

Disinfection of Noncritical Surfaces Bundle

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

- Develop policies and procedures
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Disinfection of Noncritical Surfaces Bundle

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

- Develop policies and procedures
  - Standardize C/D patient rooms and pieces of equipment throughout the hospital
  - All touchable hand contact surfaces wiped with disinfection daily, when spills occur and when the surfaces are visibly soiled.
  - All noncritical medical devices should be disinfected daily and when soiled
  - Clean and disinfectant sink and toilet
  - Damp mop floor with disinfectant-detergent
  - If disinfectant prepared on-site, document correct concentration
  - Address treatment time/contact time for wipes and liquid disinfectants (e.g., treatment time for wipes is the kill time and includes a wet time via wiping as well as the undisturbed time).

Clean/disinfect at least daily (one-step cleaning and disinfection)



REVIEW 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.

Blood Pressure Cuff
Non-Critical Patient Care Item





Surface Disinfection

Noncritical Patient Care

Rutala, Weber, HICPAC. CDC 2008. www.cdc.gov

- Disinfecting Noncritical Patient-Care Items
  - Process noncritical patient-care equipment with a EPA-registered disinfectant at the proper use dilution and a contact time of at least 1 min. *Category IB*
  - Ensure that the frequency for disinfecting noncritical patient-care surfaces be done minimally when visibly soiled and on a regular basis (such as after each patient use or once daily or once weekly). *Category IB*

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

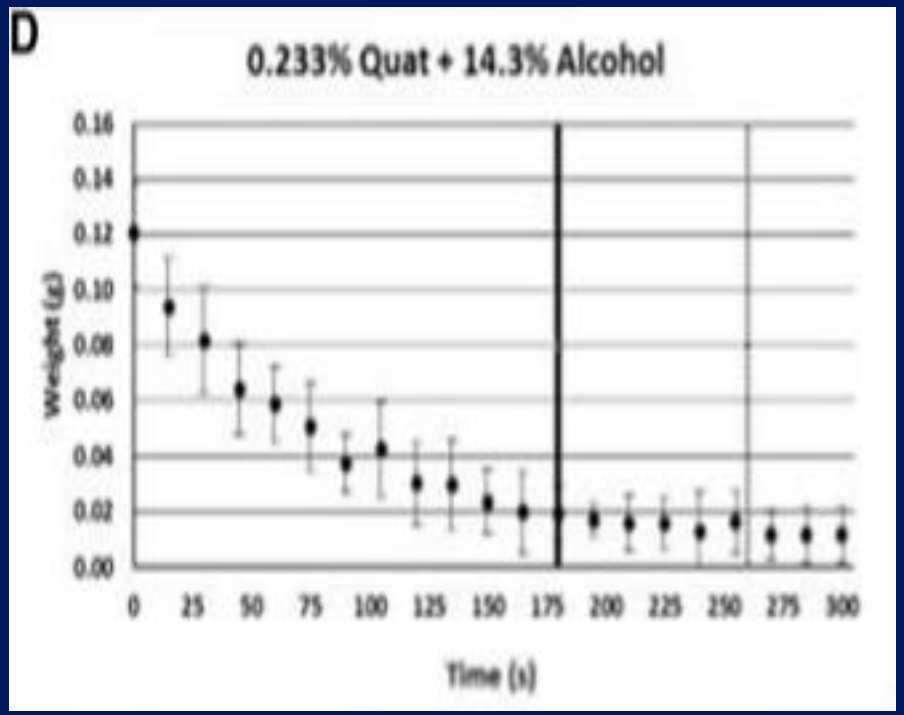
	Log_{10} Reductions							
	VSE		VRE		MSSA		MRSA	
Product	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min	0.5 min	5 min
Vesphene IIse	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Clorox	>5.4	>5.4	>4.9	>4.9	>5.0	>5.0	>4.6	>4.6
Lysol Disinfectant	>4.3	>4.3	>4.8	>4.8	>5.1	>5.1	>4.6	>4.6
Lysol Antibacterial	>5.5	>5.5	>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.

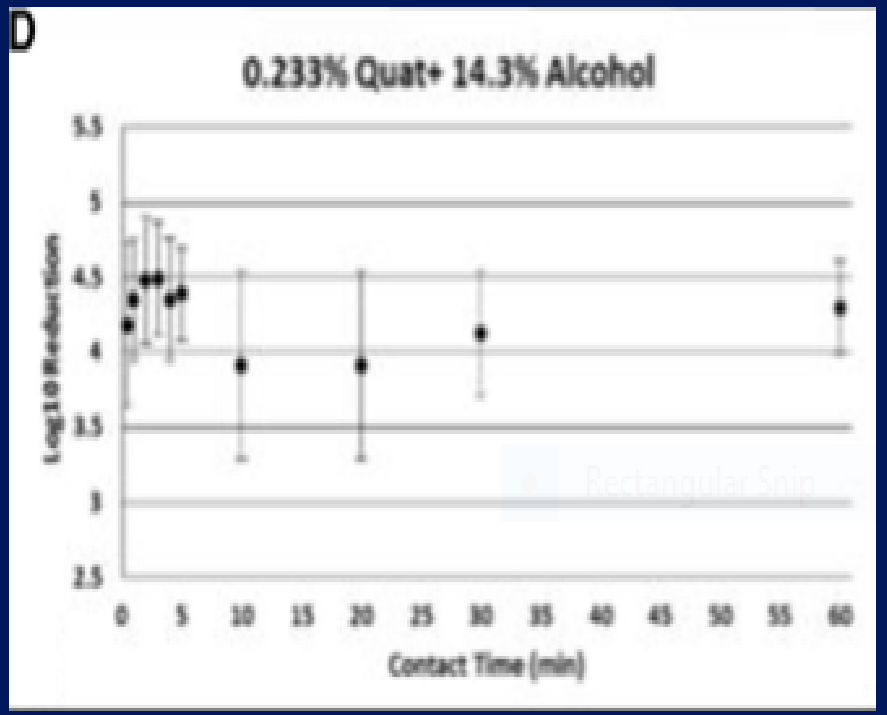
Bactericidal (*S. aureus*) Efficacy of EPA-Registered Towelettes

West, Teska, Oliver, AJIC, 2018

- Drying time curve based on surface wetness; bold-contact time (180s); dashed-dry (~260s)



- Wet time Is not crucial for complete disinfection (wet or dry ~4.5 $\log_{10}$ reduction); 30s for $\log_{10}$ reduction





Surface Disinfection

Environmental Surfaces

Rutala, Weber, HICPAC. CDC 2008. www.cdc.gov

- Disinfecting Environmental Surfaces in HCF
  - Disinfect (or clean) housekeeping surfaces (e.g., floors, tabletops) on a regular basis (e.g., daily, three times per week), when spills occur, and when these surfaces are visibly soiled. *Category IB*
  - Use disinfectant for housekeeping purposes where: uncertainty exists as to the nature of the soil on the surfaces (blood vs dirt); or where uncertainty exists regarding the presence of multi-drug resistant organisms on such surfaces. *Category II*

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. Daily disinfection less hand contamination.

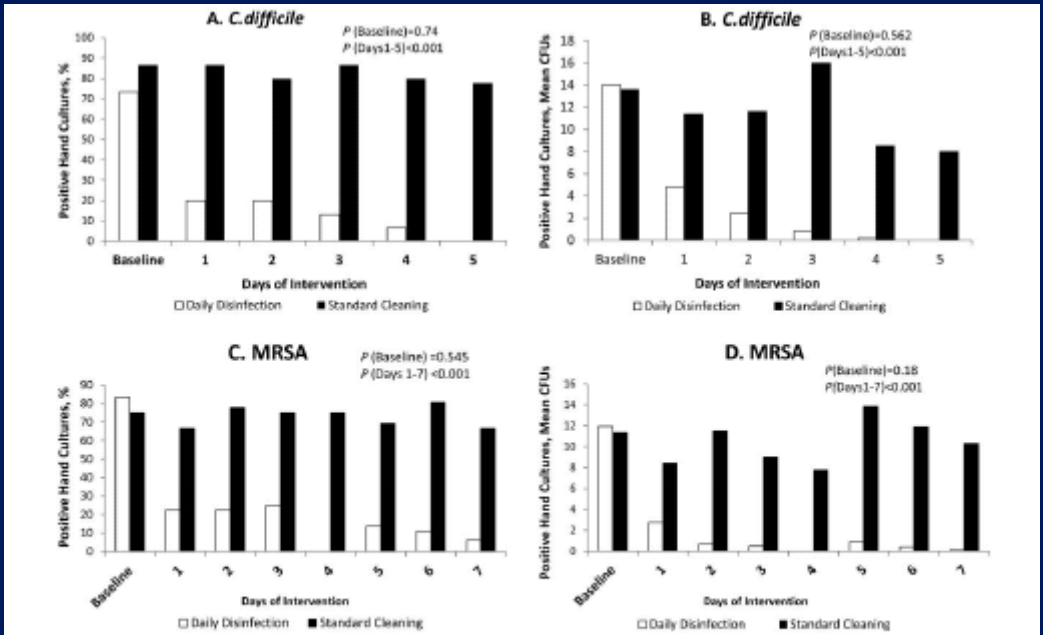


FIGURE 1. Effect of daily disinfection of high-touch environmental surfaces on acquisition of *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus* (MRSA) on gloved hands of investigators after contact with the surfaces. *A*, Percentage of positive *C. difficile* cultures; *B*, mean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

Use of a Daily Disinfectant Cleaner Instead of a Daily Cleaner Reduced HAI Rates

Alfa et al. AJIC 2015.43:141-146

- Method: Improved hydrogen peroxide disposable wipe was used once per day for all high-touch surfaces to replace cleaner
- Result: When cleaning compliance was ≥ 80%, there was a significant reduction in cases/10,000 patient days for MRSA, VRE and *C. difficile*
- Conclusion: Daily use of disinfectant applied to environmental surfaces with a 80% compliance was superior to a cleaner because it resulted in significantly reduced rates of HAIs caused by *C. difficile*, MRSA, VRE

EVIDENCE THAT ALL TOUCHABLE ROOM SURFACES ARE EQUALLY CONTAMINATED

TABLE 1. Precleaning and Postcleaning Bacterial Load Measurements for High-, Medium-, and Low-Touch Surfaces

Surface (no. of samples)	Mean CFUs/RODAC (95% CI)	
	Precleaning	Postcleaning
High (n = 40)	71.9 (46.5–97.3)	9.6 (3.8–15.4)
Medium (n = 42)	44.2 (28.1–60.2)	9.3 (1.2–17.5)
Low (n = 37)	56.7 (34.2–79.2)	5.7 (2.01–9.4)

NOTE. CFU, colony-forming unit; CI, confidence interval.

Huslage K, Rutala W, Gergen M, Sickbert-Bennett S, Weber D ICHE 2013;34:211-2

Number of culture sites and prevalence of contamination with nosocomial pathogens in intensive care units (N=523)

Ward	Culture sites[a]			
	HCWs' hands	Surfaces distant from patients	Surfaces close to patients	Prevalence of contamination
A	3/10 (30%)	0/22 (0%)	6/25 (24.0%)	9/57 (15.8%)
B	2/9 (22.2%)	4/19 (21.1%)	5/48 (10.4%)	11/76 (14.5%)
C	2/10 (20%)	2/26 (7.7%)	7/49 (14.3%)	11/85 (12.9%)
D	1/9 (11.1%)	2/24 (18.2%)	7/45 (15.6%)	10/78 (12.8%)
E	0/5 (0%)	4/22 (18.2%)	3/30 (10%)	7/57 (12.3%)
F	1/10 (10%)	0/11 (0%)	4/31 (12.9%)	5/52 (9.6%)
G	0/3 (0%)	2/14 (14.3%)	0/20 (0%)	2/37 (5.4%)
H	1/10 (10%)	0/16 (0%)	1/55 (1.8%)	2/81 (2.5%)
Total	10/66 (15.2%)	14/154 (9.1%)	33/303 (10.9%)	57/523 (10.9%)

HCW, healthcare worker.
[a] Number of contaminated samples/number of samples obtained.

Willi I, Mayre A, Kreidl P, et al. JHI 2018;98:90-95

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. Cleaning and disinfecting is one-step with disinfectant-detergent. No pre-cleaning necessary unless spill or gross contamination.

Evaluation of Hospital Floors as a Potential Source of Pathogen Dissemination Using a Nonpathogenic Virus

Koganti et al. ICHE 2016. 37:1374



FIGURE 1. Illustration of high-touch surfaces sampled. Star, surfaces less than or equal to 3 feet from the center of the bed; square, surfaces more than 3 feet from the center of the bed; circle, personal items.

Recovery of Nonpathogenic Viruses from Surfaces and Patients on Days 1, 2, and 3 After Inoculation of Floor Near Bed

Koganti et al. ICHE 2016. 37:1374

Variable	Day 1 (% Positive)	Day 2 (% Positive)	Day 3 (% Positive)
Patient Hands	40	63	43
Patient Footwear	100	100	86
High-touch surface <3ft	58	62	77
High-touch surface >3ft	40	68	34
Personal items	50	44	50
Adjacent room floor	NA	100	80
Adjacent room environment	NA	40	11
Nursing station	53	47	63
Portable equipment	33	23	100

Surfaces <3ft included bedrail, call button, telephone, tray table, etc; surfaces >3ft included side table, chair, IV pole, etc; personal-cell phones, books, clothing, wheelchairs; nurses station included computer keyboard, mouse, etc

Recovery of Nonpathogenic Viruses from Surfaces and Patients on Days 1, 2, and 3 After Inoculation of Floor Near Bed

Koganti et al. ICHE 2016. 37:1374

- Found that a nonpathogenic virus inoculated onto floors in hospital rooms disseminated rapidly to the footwear and hands of patients and to high-touch surfaces in the room
- The virus was also frequently found on high-touch surfaces in adjacent rooms and nursing stations
- Contamination in adjacent rooms in the nursing station suggest HCP contributed to dissemination after acquiring the virus during contact with surfaces or patients
- Studies needed to determine if floors are source of transmission

Evaluation of Hospital Floors as a Potential Source of Pathogen Dissemination

Deshpande et al. AJIC 2017. 45:336.

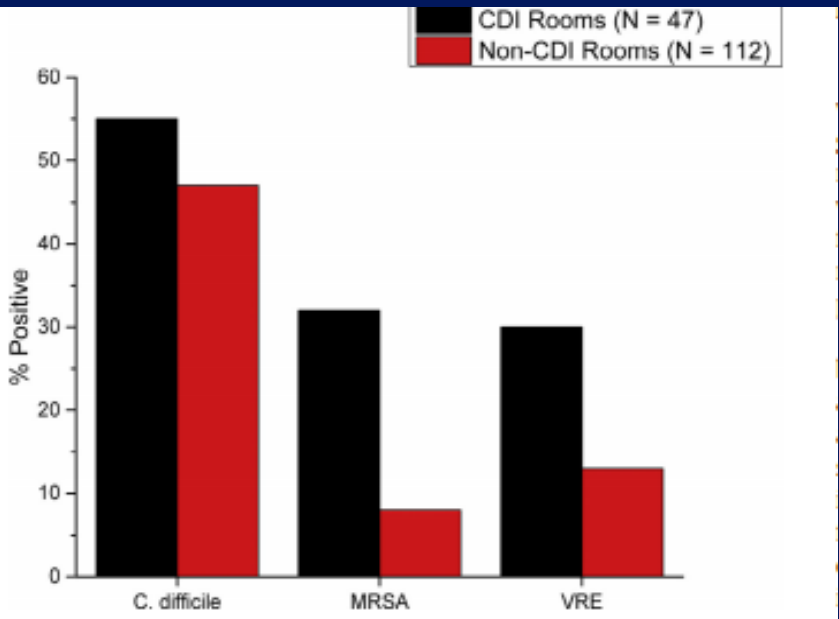


Fig 1. Recovery of *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant enterococci from floors in patient rooms from 5 hospitals in northeast Ohio.

- 318 floors sites sampled in 159 rooms
- *C. difficile* most frequently isolated
- MRSA and VRE isolated more frequently from CDI rooms
- 41% (100) had objects (personal-clothing, phone charges; medical-BP cuff, call button) in contact with floor
- Of 31 objects on floor, 18% MRSA, 6% VRE, 3% Cd bare/glove cultures positive
- Demonstrates potential for indirect transfer of pathogens to hands from fomites on floor

Evaluation of Hospital Floors as a Potential Source of Pathogen Dissemination

Koganti et al. ICHE 2016. 37:1374; Deshpande et al. AJIC 2017. 45:336.

- Effective disinfection of contaminated surfaces is essential to prevent transmission of epidemiologically-important pathogens
- Efforts to improve disinfection focuses on touched surfaces
- Although floors contaminated, limited attention because not frequently touched
- Floors are a potential source of transmission because often contacted by objects that are then touched by hands (e.g., shoes, socks)
- Non-slip socks contaminated with MRSA, VRE (Mahida, J Hosp Infect. 2016;94:273

Disinfection of Noncritical Surfaces Bundle

NL Havill AJIC 2013;41:S26-30

- 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

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 many cases “best” practices not scientifically determined.

Science of Cleaning and Disinfection

Rutala, Weber, HICPAC. November 2008. www.cdc.gov

- Cleaning-removes organisms/organic matter
- Disinfection-inactivates organisms

Effectiveness of Different Methods of Surface Disinfection for MRSA

Rutala, Gergen, Weber. Unpublished data.

Technique (with cotton)	MRSA Log_{10} Reduction (QUAT)
Saturated cloth	4.41
Spray (10s) and wipe	4.41
Spray, wipe, spray (1m), wipe	4.41
Spray	4.41
Spray, wipe, spray (until dry)	4.41
Disposable wipe with QUAT	4.55
Control: detergent (no disinfectant activity will transfer pathogens)	2.88

Effective Surface Decontamination

Product and Practice = Perfection

Effective Surface Decontamination

Product and Practice = Perfection

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

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

MOST PREVALENT PATHOGENS CAUSING HAI

Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865; Weiner et al ICHE 2016;37:1288

- **Most prevent pathogens causing HAI (easy to kill)**
  - *E. coli* (15.4%)
  - *S. aureus* (11.8%)
  - *Klebsiella* (7.7%)
  - Coag neg Staph (7.7%)
  - *E. faecalis* (7.4%)
  - *P. aeruginosa* (7.3%)
  - *C. albicans* (6.7%)
  - *Enterobacter* sp. (4.2%)
  - *E. faecium* (3.7%)
- **Common causes of outbreaks and ward closures (relatively hard to kill)**
  - *C. difficile* spores
  - Norovirus
  - Rotavirus
  - Adenovirus

Microbiological Disinfectant Hierarchy

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

Most Resistant

Spores (*C. difficile*)

Mycobacteria (*M. tuberculosis*)

Non-Enveloped Viruses (norovirus, HAV, polio)

Fungi (Candida, *Trichophyton*)

Bacteria (MRSA, VRE, *Acinetobacter*)

Enveloped Viruses (HIV, HSV, Flu)

Most Susceptible

LLD

LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865; Rutala, Weber, AJIC 2019;47:A96-A105

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, 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)

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, one 4% HP

Novel Hydrogen Peroxide Sporicide

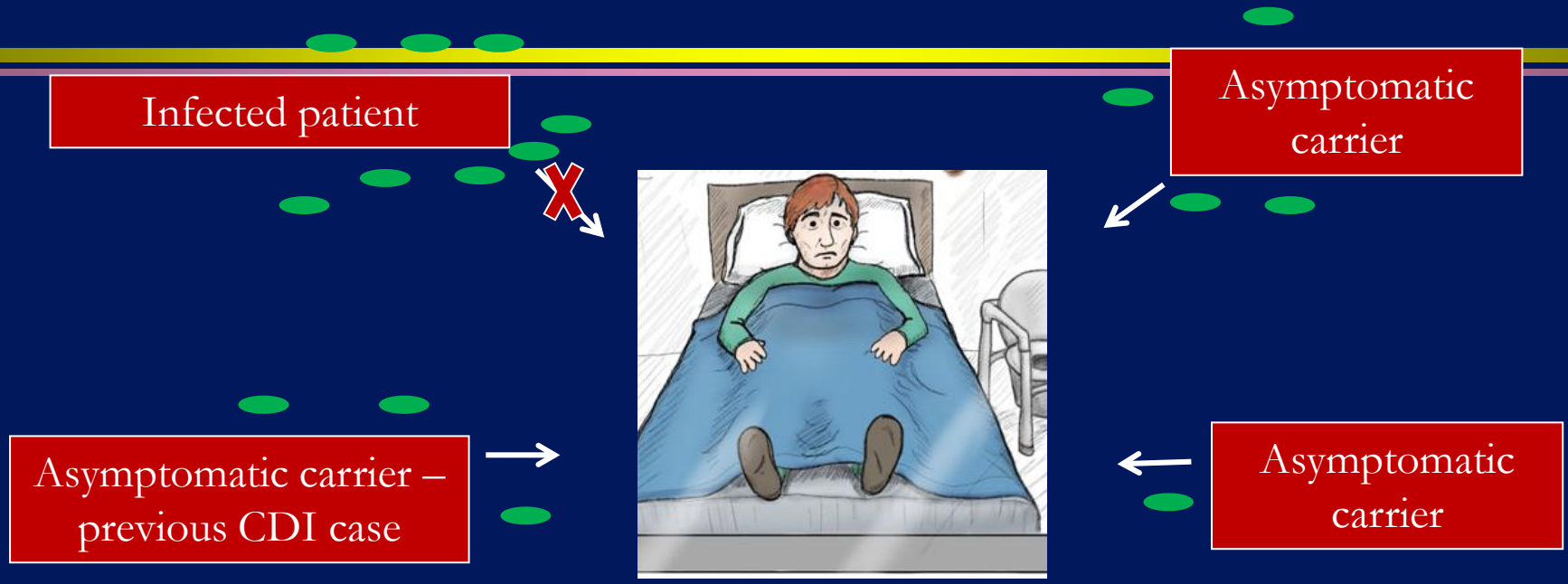
Cadnum et al. AJIC 2021

A novel 4% HP was effective against MRSA, CRE, *C. difficile* spores and *C. auris.* HP may be a useful addition to the sporicidal products available in healthcare.

Table. Mean (Standard error) $\log_{10}$ reductions in healthcare-associated pathogens using a quantitative carrier test with a 1-minute exposure time

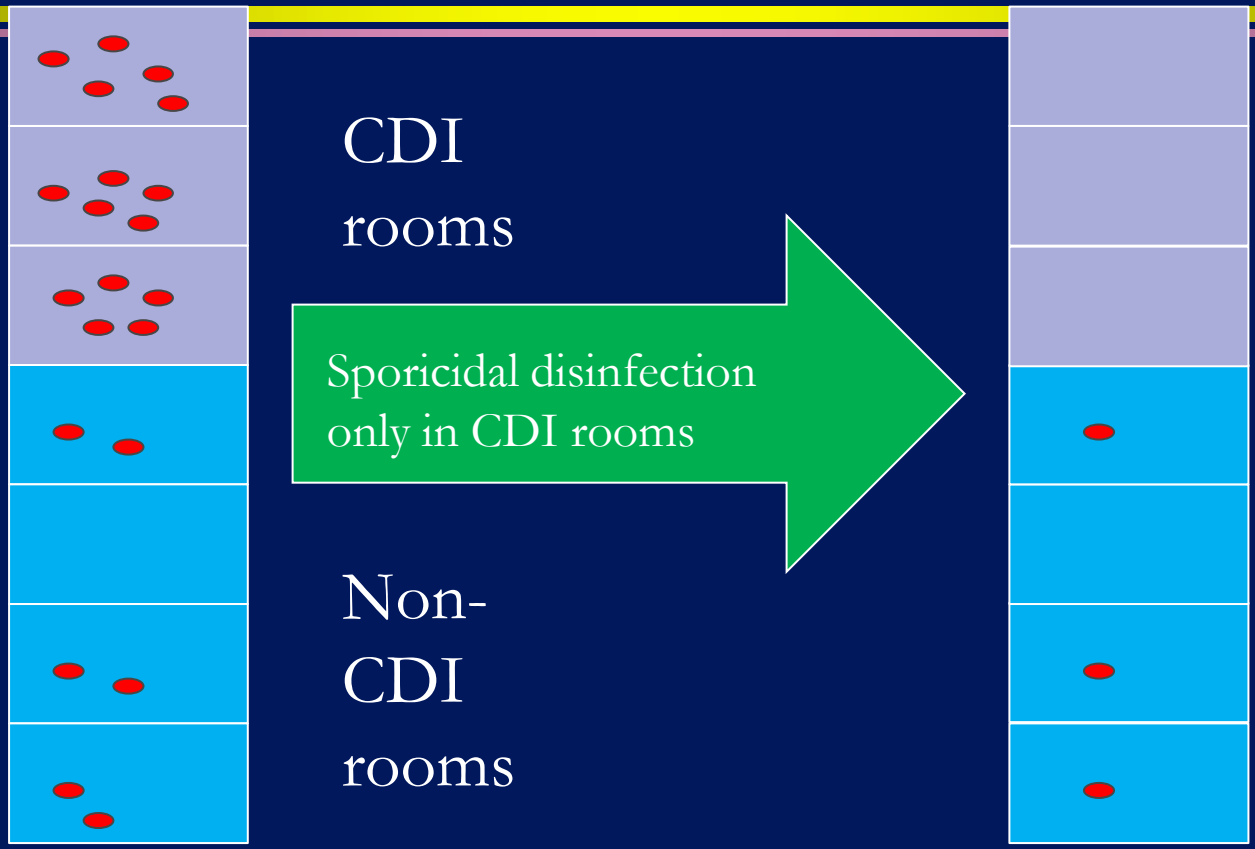
Disinfectant	*C. difficile*	MRSA	CRE (*E. coli*)	*Candida auris* (N=2)
Sani-HyPerCide	4.7 (0.08)	≥6.4 (0)	≥5.6 (0)	>5.1 (0)
Clorox germicidal bleach	≥6.7 (0)	≥6.4 (0)	≥5.6 (0)	≥6.1 (0)
OxyCide	≥5.0 (0)	≥5.48 (0)	≥5.6 (0)	≥5.1 (0)
Oxivir 1	2.6 (0.3)	≥6.5 (0)	6.2 (0.3)	≥5.1 (0)

Asymptomatic carriers contribute to *C. difficile* transmission



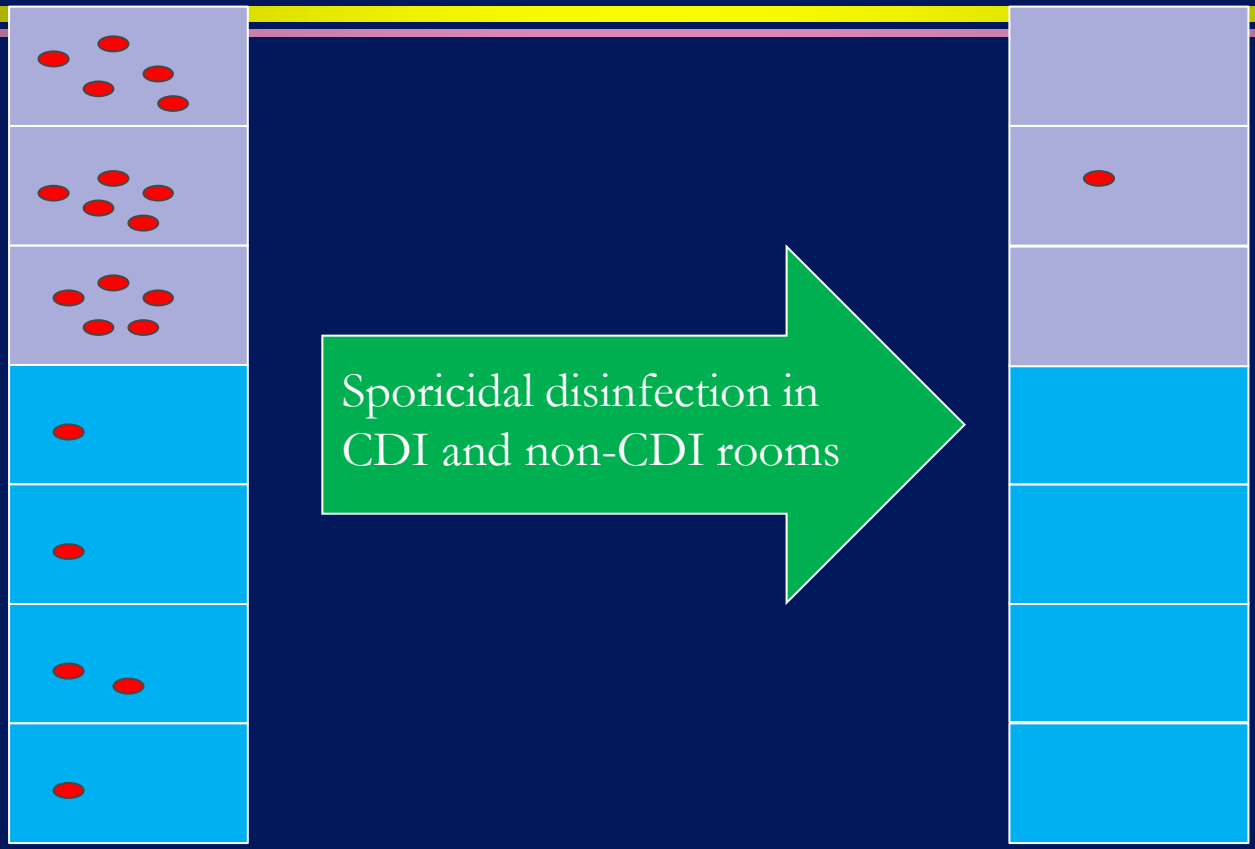
1. Curry SR. Clin Infect Dis 2013 (29% of hospital-associated CDI cases linked to carriers by MLVA); 2. Blixt T. Gastroenterol 2017;152:1031 (exposure to carriers increased CDI risk); 3. Longtin Y. JAMA Int Med 2016 (screening for and isolating carriers reduced CDI by 63%); 4. Samore MH. Am J Med 1996;100:32 (only 1% of cases linked to asymptomatic carriers - roommates and adjacent rooms - by PFGE/REA); 5. Eyre DW. PLOS One 2013;8:e78445 (18 carriers: no links to subsequent CDI cases); 6. Lisenmyer K. Clin Infect Dis 2018 (screening and isolation of carriers associated with control of a ward outbreak); 7. Paquet-Bolduc B. Clin Infect Dis 2018 (unit-wide screening and isolation of carriers not associated with shorter outbreak durations vs historical controls); 8. Donskey CJ. Infect Control Hosp Epidemiol 2018 (14% of healthcare-associated CDI cases linked to LTCF asymptomatic carriers); 9. Kong LY. Clin Infect Dis 2018 (23% of healthcare-associated CDI linked to carriers vs 42% to CDI cases and 35% to carriers or cases)

Interventions focused on CDI rooms



Curry SR, et al. Clin Infect Dis 2013;57:1094-102; Kong LY, et al. Clin Infect Dis 2018; Longtin Y, et al. JAMA Intern Med 2016;

Interventions addressing CDI cases and asymptomatic carriers

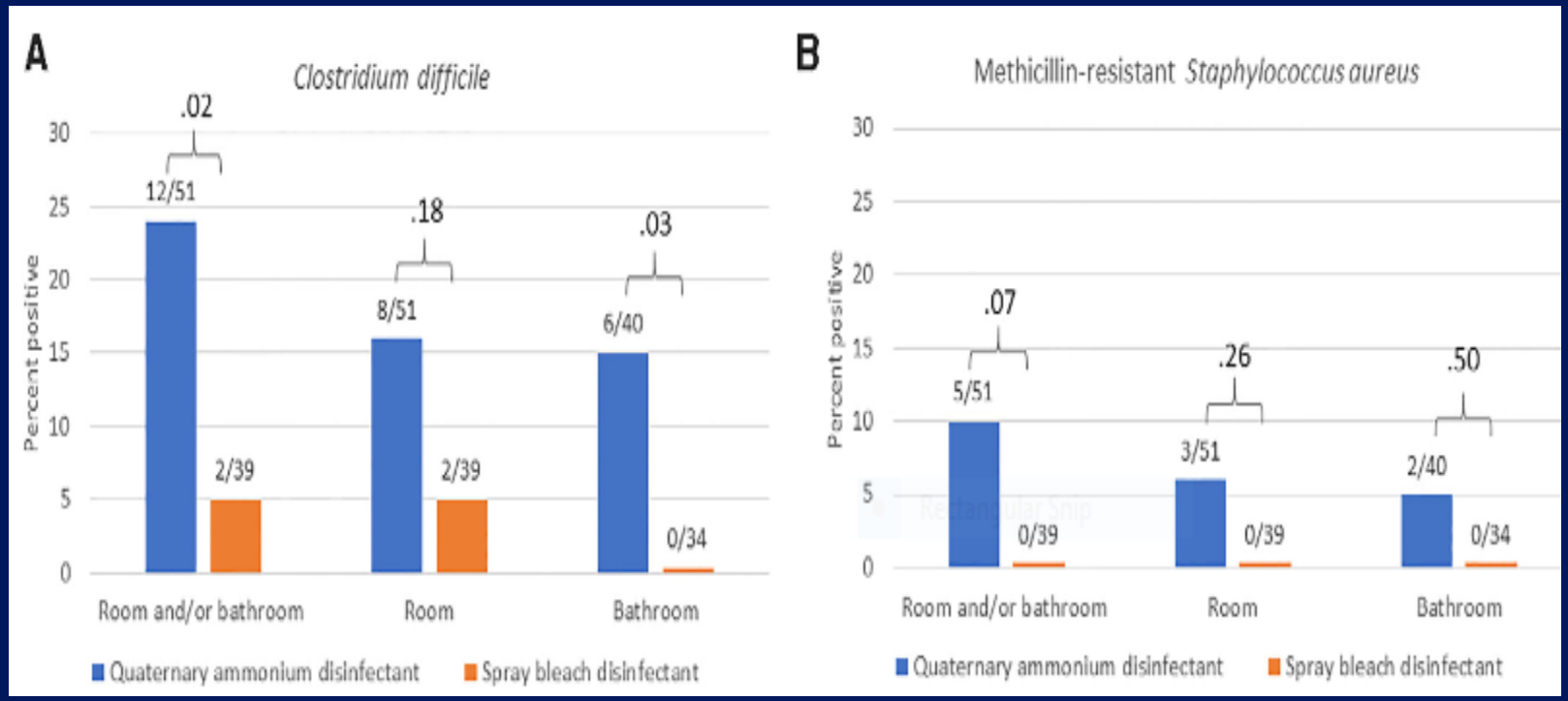


C. difficile slides courtesy Dr. Donskey

Use of Sporicidal Disinfectant on *C. difficile* spore Contamination in non-*C. difficile* Infection Rooms

Wong et al. AJIC. 2019:47:843-845

The percentage of rooms contaminated with *C. difficile* was significantly reduced during the period with a sporicidal product was used 5% vs 24%. Results suggest sporicidal disinfectant in all postdischarge rooms could potentially be beneficial in reducing the risk *for C. difficile* transmission from contaminated surfaces



Disinfection of Noncritical Surfaces Bundle

NL Havill AJIC 2013;41:S26-30

- 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

Disinfection of Noncritical Surfaces Bundle

- Develop policies and procedures
  - Standardize C/D patient rooms and pieces of equipment throughout the hospital
  - All touchable hand contact surfaces wiped with disinfection daily, when spills occur and when the surfaces are visibly soiled.
  - All noncritical medical devices should be disinfected daily and when soiled
  - Clean and disinfectant sink and toilet
  - Damp mop floor with disinfectant-detergent
  - If disinfectant prepared on-site, document correct concentration
  - Address treatment time/contact time for wipes and liquid disinfectants (e.g., treatment time for wipes is the kill time and includes a wet time via wiping as well as the undisturbed time).

Disinfection of Noncritical Surfaces Bundle

- Develop policies and procedures
  - Environmental cleaning and disinfection is an integral part of preventing transmission of pathogens
  - In addition to identifying products and procedures, ensure standardization of cleaning throughout the hospital
    - **Some units utilize ES to clean pieces of equipment (e.g., vital sign machines, IV pumps); some units use patient equipment, and some units utilize nursing staff.**
    - **Multidisciplinary group (ES, Nursing, IP, Pt Equip) to create a standardized plan for cleaning patient rooms and pieces of patient equipment throughout the hospital**

Disinfection of Noncritical Surfaces Bundle

NL Havill AJIC 2013;41:S26-30

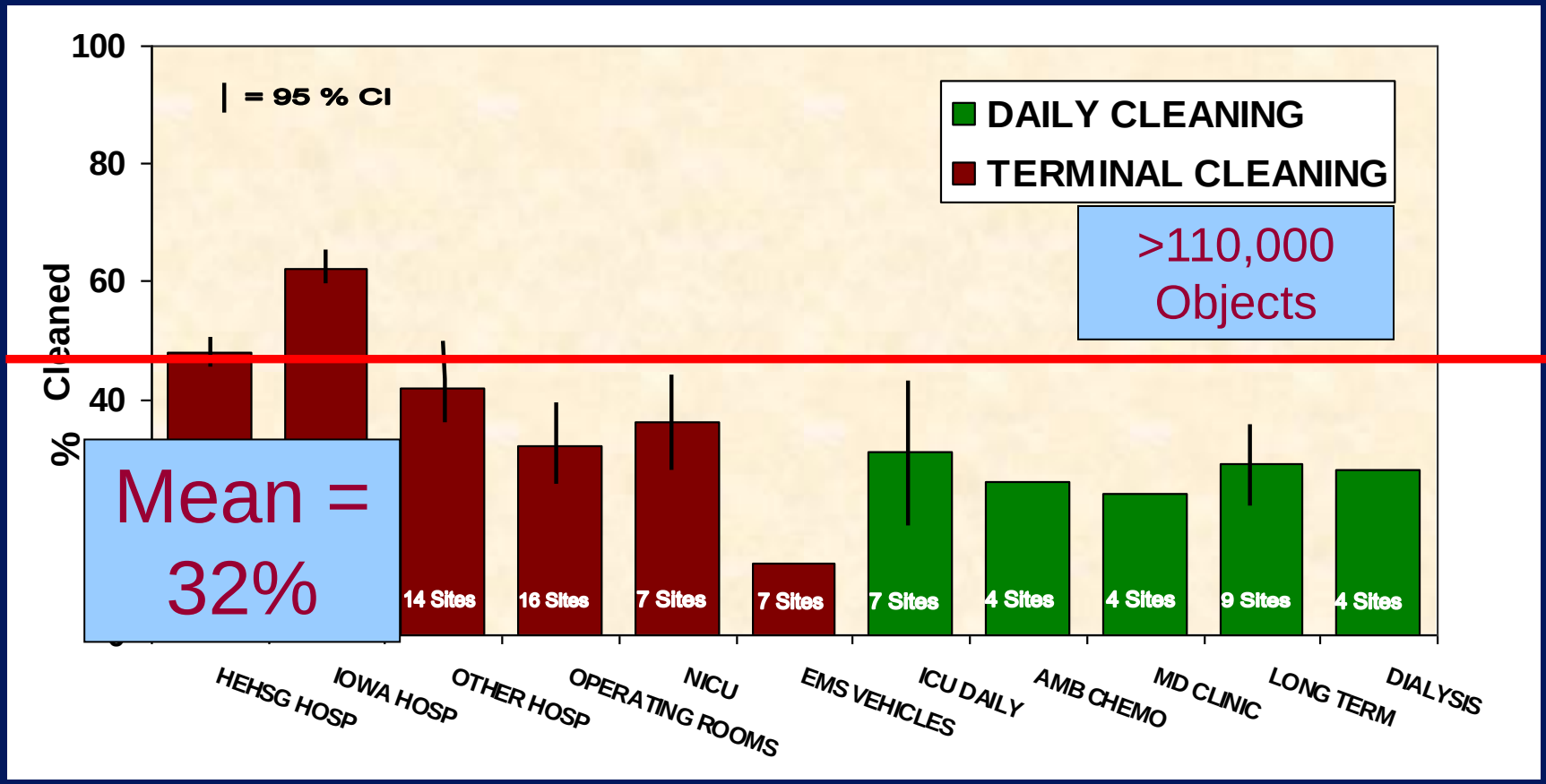
- Develop policies and procedures
- Select cleaning and disinfecting products
- Educate staff-environmental services and nursing
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- Implement “no touch” room decontamination technology and monitor compliance

Effective Surface Decontamination

Product and Practice = Perfection

Thoroughness of Environmental Cleaning

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



Practice* NOT Product

*surfaces not wiped

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)

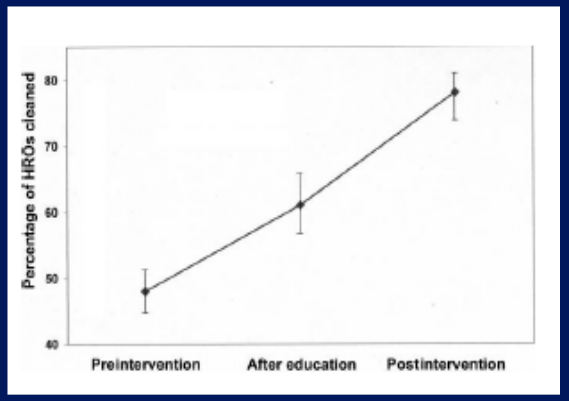
TARGET ENHANCED

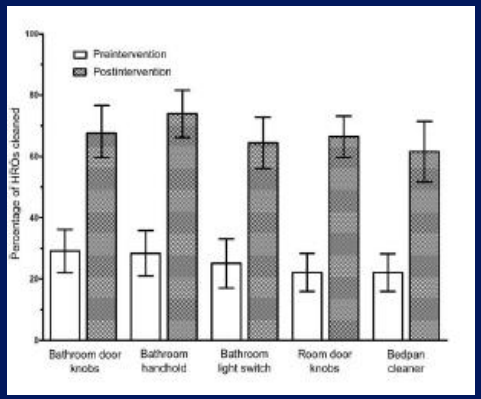


TERMINAL ROOM CLEANING: DEMONSTRATION OF IMPROVED CLEANING

- 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



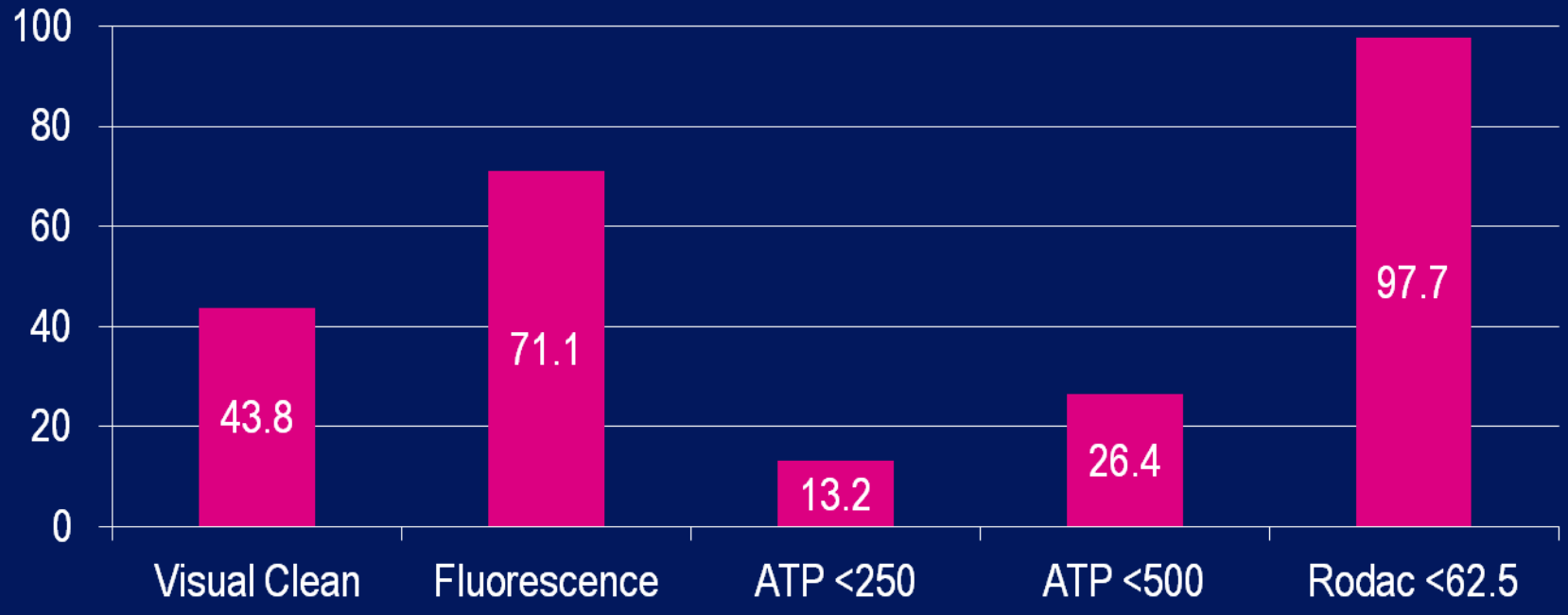


Carling PC, et al. ICHE 2008;29:1035-41

Percentage of Surfaces Clean by Different Measurement Methods

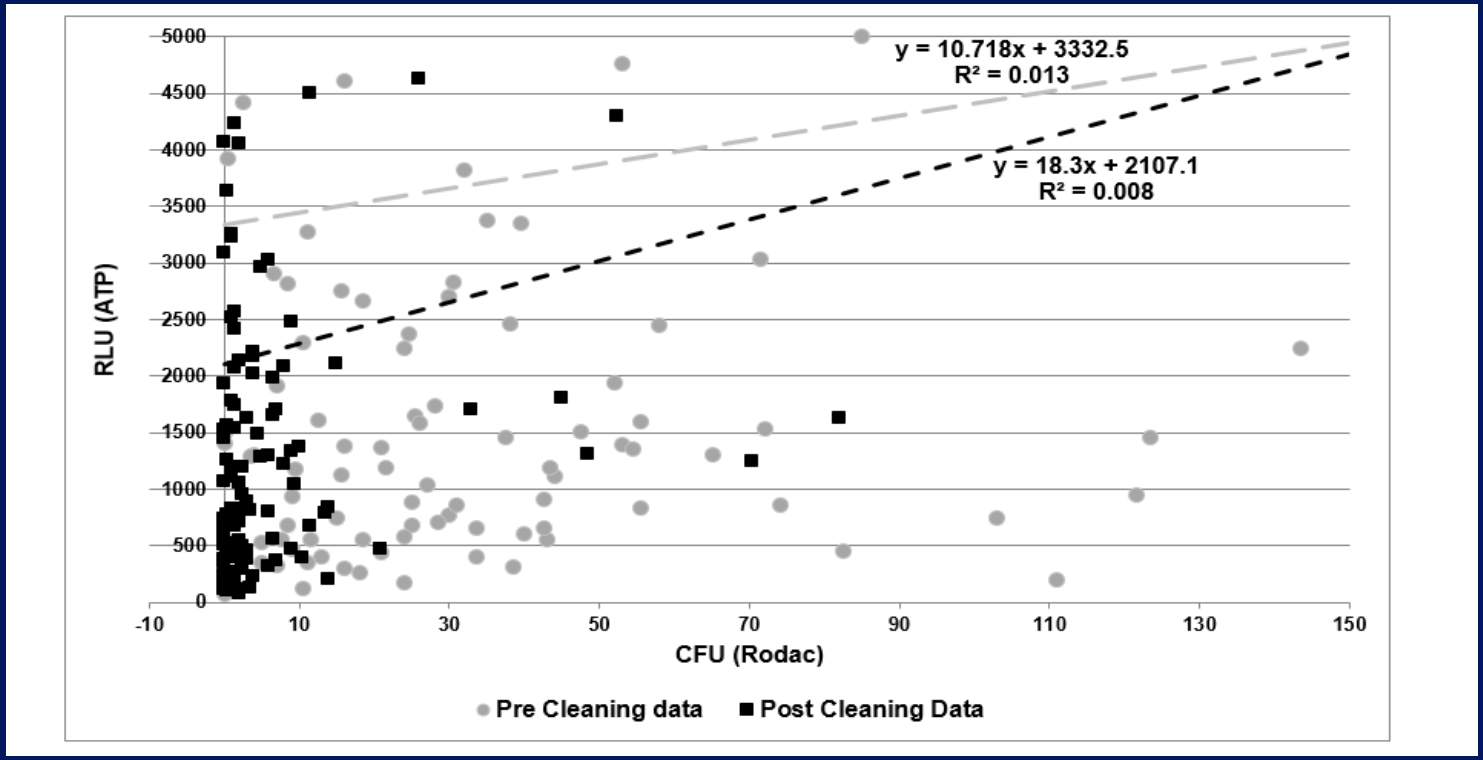
Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC Poster 2017.

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.

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.

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

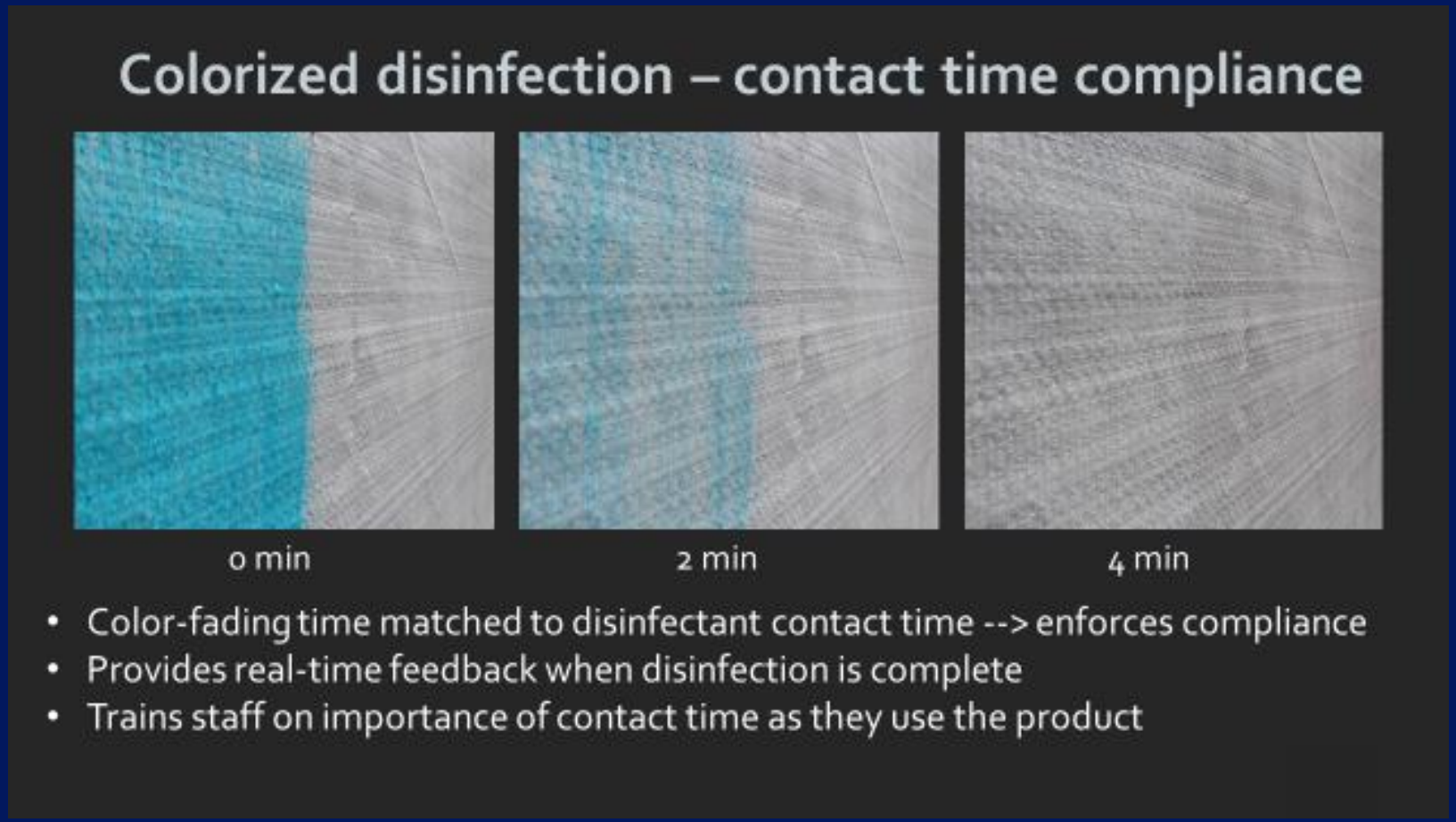
Surface	Prior to Cleaning Mean CFU/RODAC (95% CI)	Post Cleaning (mean) Mean CFU/RODAC (95% CI)
High	71.9 (46.5-97.3)	9.6
Medium	44.2 (28.1-60.2)	9.3
Low	56.7 (34.2-79.2)	5.7

- **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**

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

Future May Have Methods to Ensure Thoroughness Such as Colorized Disinfectant

Kang et al. J Hosp Infect 2017



Colorized disinfectant slides courtesy of Kevin Tyan and Rachael Sparks

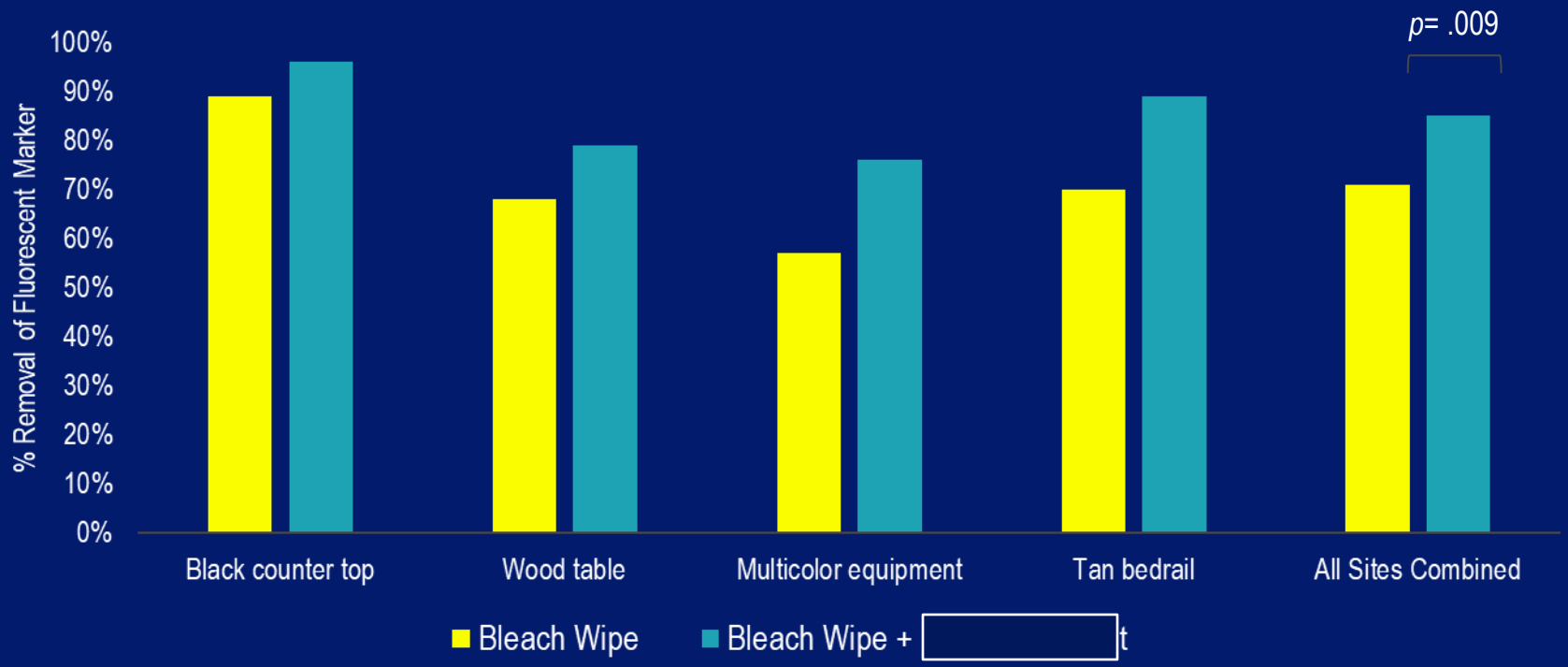
Colorized disinfection – empowers behavior change to improve coverage



- Increased visibility when disinfecting surfaces, fewer missed spots
- Real-time quality control that allows staff to monitor thoroughness of cleaning

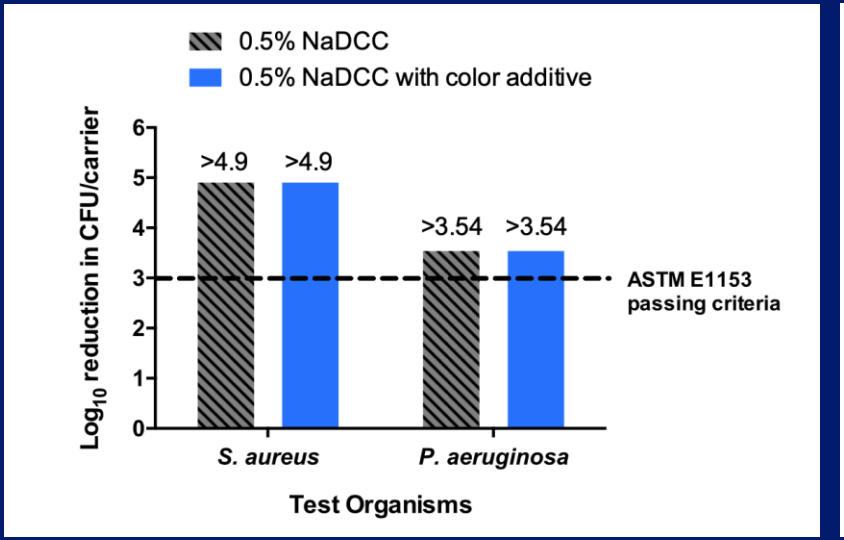
Colorized disinfectant increases cleaning efficacy by 29%

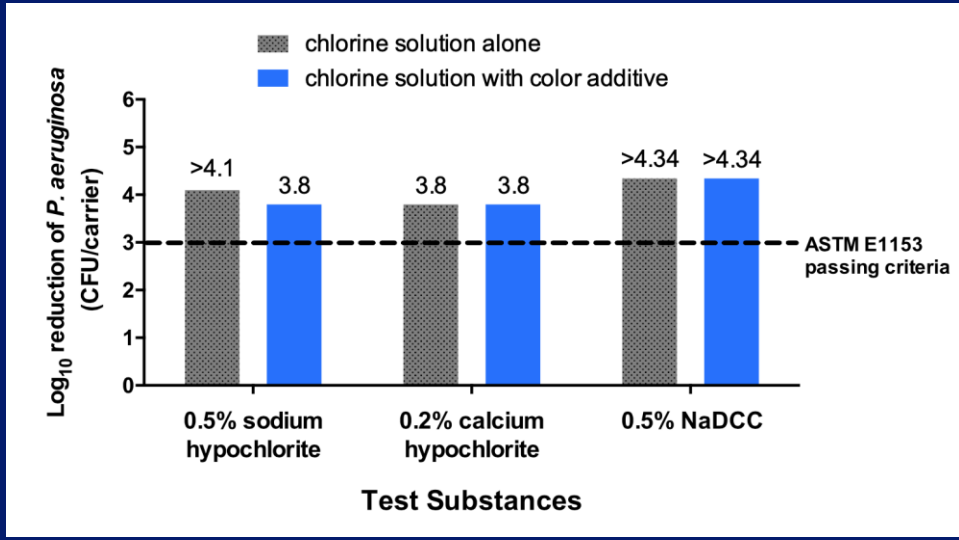
Cleveland VA Medical Center found the colorized disinfectant to quantifiably improve thoroughness of cleaning



Manuscript in preparation.

Efficacy and skin toxicity testing of colorized disinfectant®

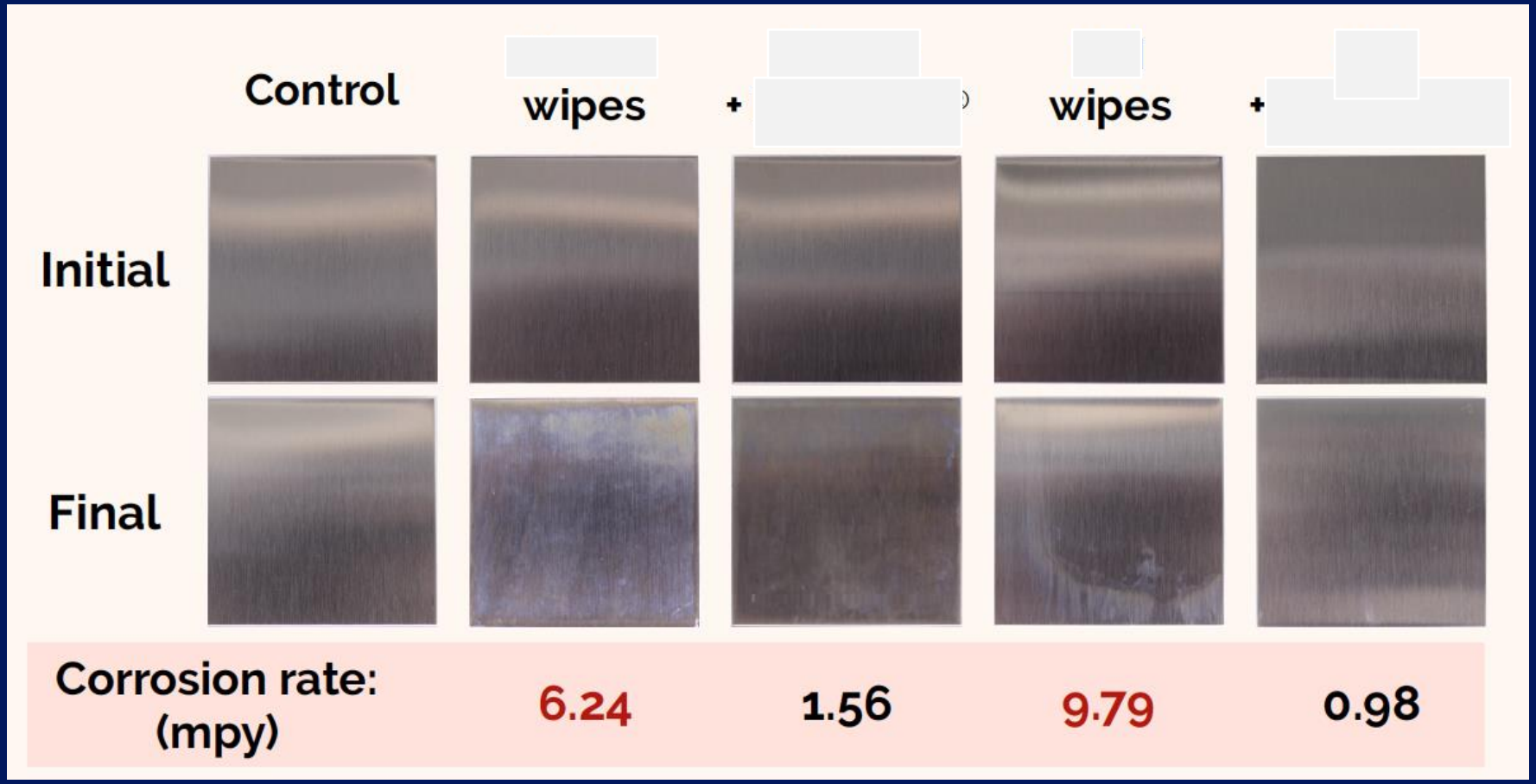




- 3rd party testing: the colorized disinfectant is a non-irritant and does not reduce efficacy of disinfectant

Tyan KS, Kang J, Jin K, Kyle AM. *Am J Infect Control*. 2018;46:1254-61.

Colorized disinfectant reduces bleach corrosiveness



Bleach wipes alone caused severe corrosion (> 5 mils per year [mpy], 1 normal) while the addition of colorized disinfectant both significantly reduced corrosion rate (< 2 mpy) and prevented discoloration of the metal.

Tyan K, Jin K, Kang J. *J Hosp Infect*. 2018;S0195-6701(18)30491-2.

Disinfection of Noncritical Surfaces Bundle

NL Havill AJIC 2013;41:S26-30

- 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 (and new strategies)

RATIONALE FOR ENHANCED TERMINAL DISINFECTION OF ROOMS OF PATIENTS WITH CDI

RELATIVE RISK OF PATHOGEN ACQUISITION IF PRIOR ROOM OCCUPANT INFECTED



*** Prior room occupant infected; ^Any room occupant in prior 2 weeks infected**

Adapted from Otter JA, et al. Am J Infect Control 2013;84(suppl 5):S6-S11

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)

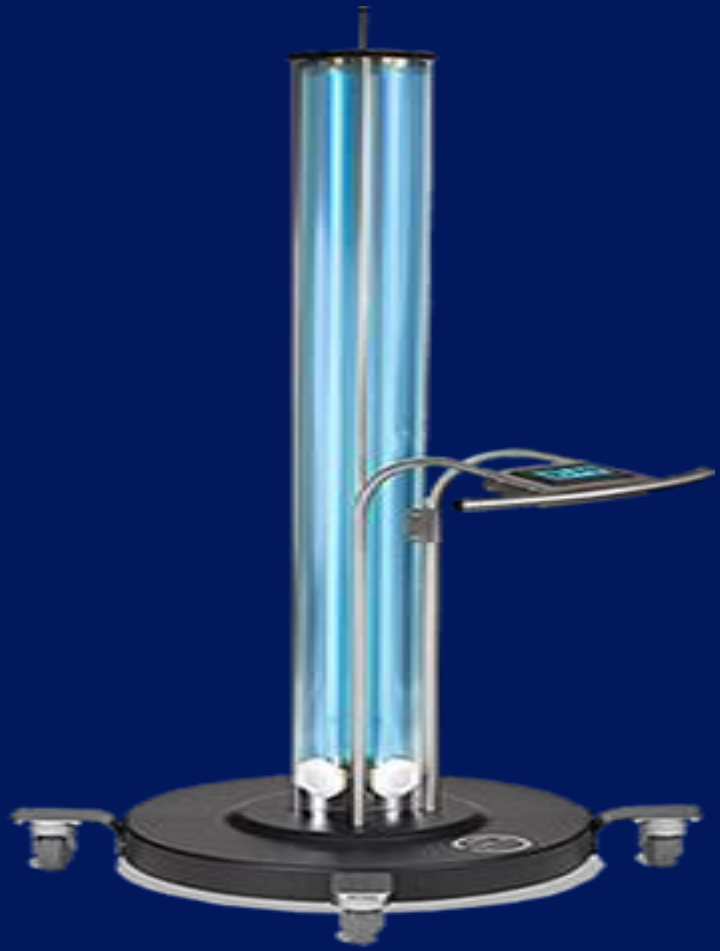
"NO TOUCH" APPROACHES TO ROOM DECONTAMINATION

(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.







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 In press.

	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

All enhanced disinfection technologies were significantly superior to Quat alone in reducing EIPs. 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. First study which quantitatively described the entire pathway whereby improved disinfection decreases microbial contamination which in-turn reduced patient colonization/infection.

This technology (“no touch”-e.g., UV/HP) should be used (capital equipment budget) for terminal room disinfection (e.g., after discharge of patients on Contact Precautions).

New Strategies in Cleaning and Disinfection

www.disinfectionandsterilization.org

- New Strategies in Cleaning and Disinfection
  - New sporicide-4% HP
  - Sporicide in all discharge patient rooms
  - Colorized disinfectant
  - Inactivation of *C. auris*, CRE, SARS-CoV-2
  - Electrostatic sprayer
  - Continuous room decontamination

AMERICAN SOCIETY FOR MICROBIOLOGY | Antimicrobial Agents and Chemotherapy®

EXPERIMENTAL THERAPEUTICS

Germicidal Activity against Carbapenem/Colistin-Resistant *Enterobacteriaceae* Using a Quantitative Carrier Test Method

Hajime Kanamori,[a,b] William A. Rutala,[a,b] Maria F. Gergen,[a] Emily E. Sickbert-Bennett,[a,b] David J. Weber[a,b]

[a]Department of Hospital Epidemiology, University of North Carolina Health Care, Chapel Hill, North Carolina, USA

[b]Division of Infectious Diseases, University of North Carolina School of Medicine, Chapel Hill, North Carolina, USA

ABSTRACT Susceptibility to germicides for carbapenem/colistin-resistant *Enterobacteriaceae* is poorly described. We investigated the efficacy of multiple germicides against these emerging antibiotic-resistant pathogens using the disc-based quantitative carrier test method that can produce results more similar to those encountered in health care settings than a suspension test. Our study results demonstrated that germicides commonly used in health care facilities likely will be effective against carbapenem/colistin-resistant *Enterobacteriaceae* when used appropriately in health care facilities.

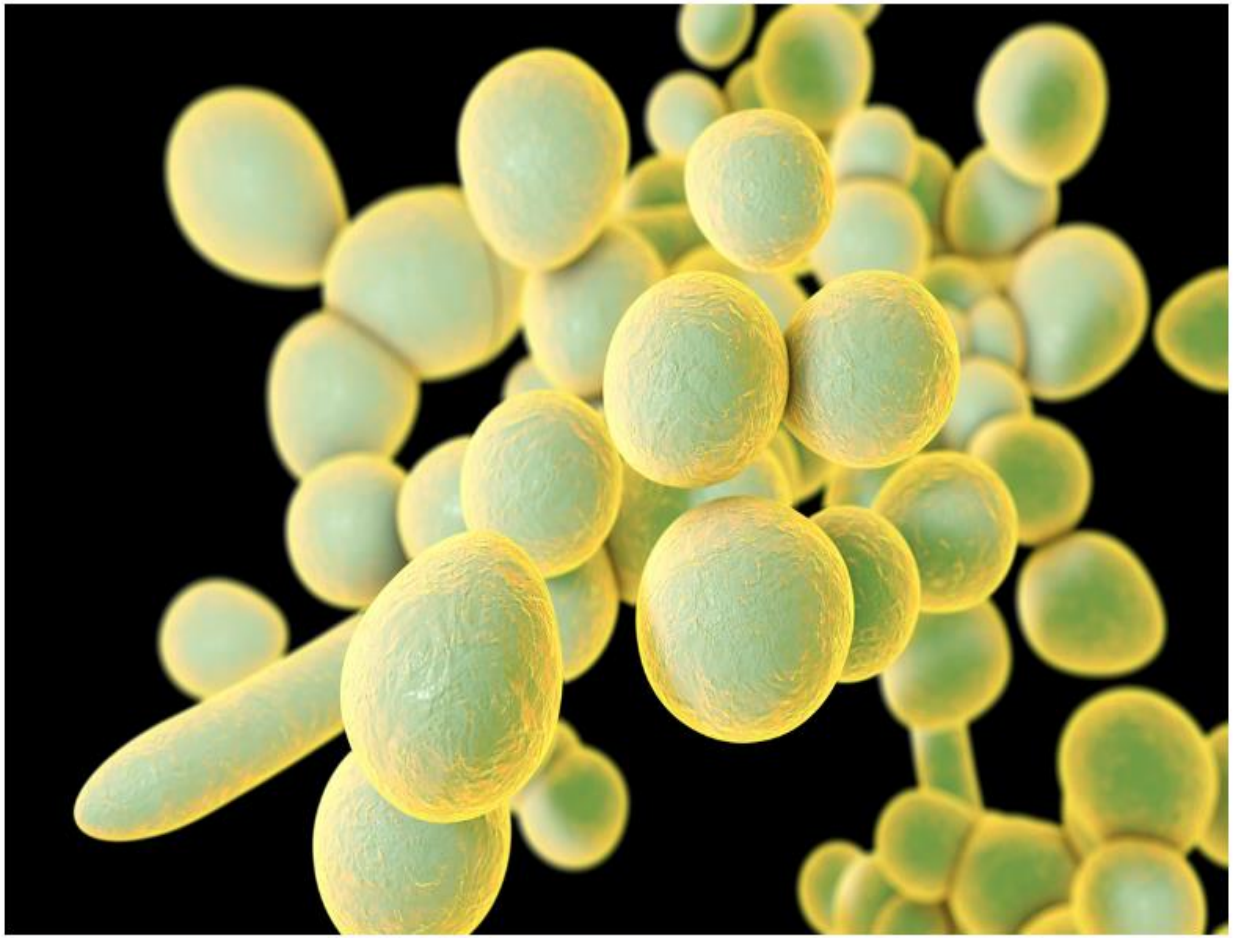
KEYWORDS carbapenem-resistant *Enterobacteriaceae*, *Klebsiella pneumoniae* carbapenemase, colistin-resistant *Enterobacteriaceae*, *mcr-1*, germicides, disinfectants, antiseptics, efficacy

Efficacy of Disinfectants and Antiseptics against Carbapenem-Resistant *Enterobacteriaceae*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017 ID Week;
Kanamori et al Antimicrob. Agents Chemother 2018.

- ≥3 $\log_{10}$ reduction (CRE, 1m, 5% FCS, QCT)
  - 0.20% peracetic acid
  - 2.4% glutaraldehyde
  - 0.5% Quat, 55% isopropyl alcohol
  - 58% ethanol, 0.1% QUAT
  - 28.7% isopropyl alcohol, 27.3% ethyl alcohol, 0.61% QAC
  - 0.07% o-phenylphenol, 0.06% p-tertiary amylphenol
  - ~5,250 ppm chlorine
  - 70% isopropyl alcohol
  - Ethanol hand rub (70% ethanol)
  - 0.65% hydrogen peroxide, 0.15% peroxyacetic acid
  - Accelerated hydrogen peroxide, 1.4% and 2.0%
  - Quat, (0.085% QACs; not *K. pneumoniae*)

Deadly, drug-resistant Candida yeast infection spreads in the US



Candida auris causes multidrug-resistant infections that can result in organ failure

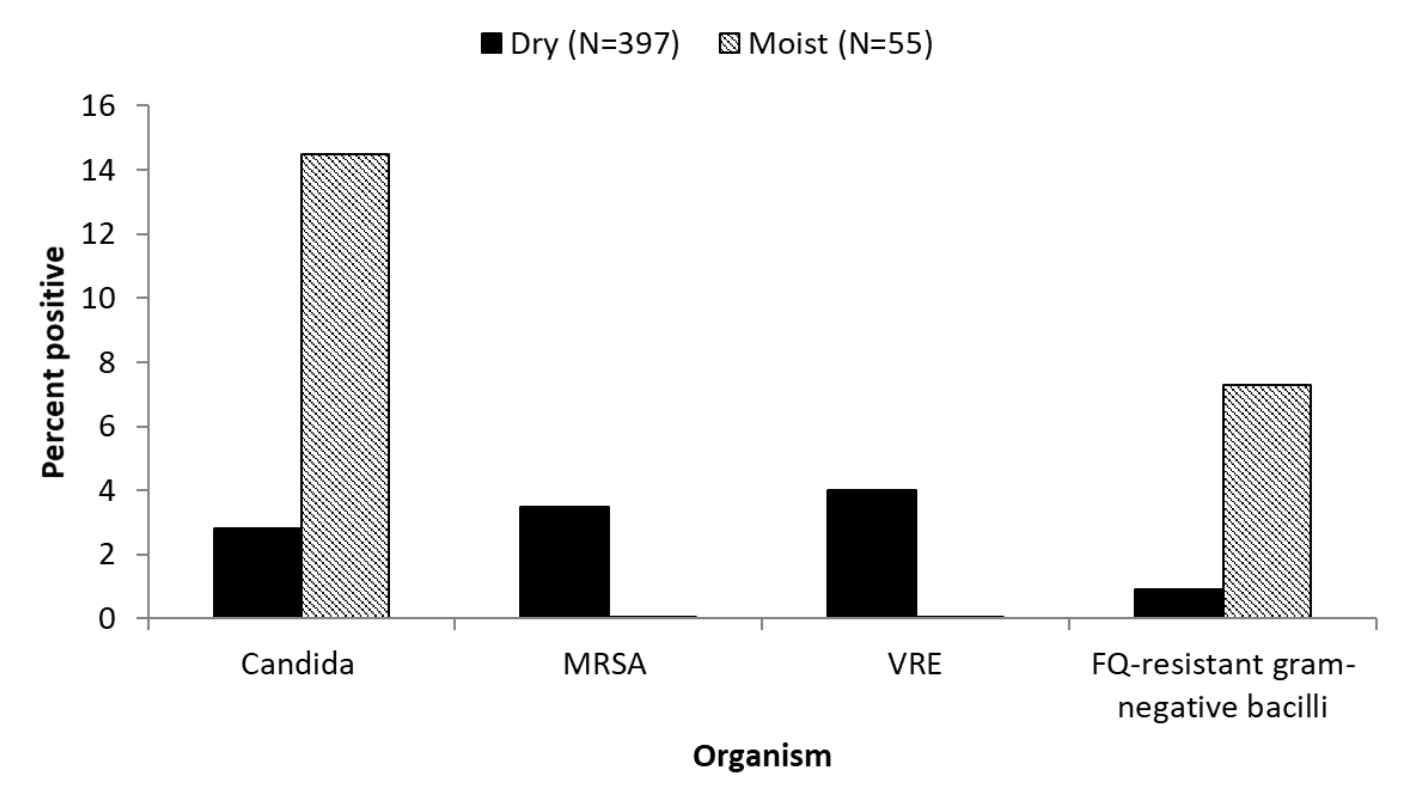
Kateryna Kon/Science Photo Library

Candida auris

Cadnum et al . ICHE 2017;38:1240-1243

- *Candida auris* is a globally emerging pathogen that is often resistant to multiple antifungal agents
- In several reports, *C. auris* has been recovered from the hospital environment
- CDC has recommended daily and post-discharge disinfection of surfaces in rooms of patients with *C. auris* infection.
- Several disinfectants (~30) are registered with the EPA for claims against C*. auris*, and its susceptibility to germicides is in the scientific literature

Recovery of *Candida* species on moist versus dry surfaces



Piedrahita C. Environmental surfaces in healthcare facilities are a potential source for transmission of *C. auris* and other *Candida s*species. ICHE 2017;38:1107-9.

Efficacy of Disinfectants and Antiseptics against *Candida auris*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, ICHE 2019

- ≥3 $\log_{10}$ reduction (*C. auris*, 1m, 5% FCS, QCT)
  - 0.20% peracetic acid
  - 2.4% glutaraldehyde
  - 0.65% hydrogen peroxide, 0.14% peroxyacetic acid
  - 0.5% Quat, 55% isopropyl alcohol
  - Disinfecting spray (58% ethanol, 0.1% QUAT)
  - 28.7% isopropyl alcohol, 27.3% ethyl alcohol, 0.61% QAC
  - 0.07% o-phenylphenol, 0.06% p-tertiary amylphenol
  - 70% isopropyl alcohol
  - ~5,250 ppm chlorine
  - Ethanol hand rub (70% ethanol)
  - Accelerated hydrogen peroxide, 1.4%
  - Accelerated hydrogen peroxide, 2%

Efficacy of Disinfectants and Antiseptics against *Candida auris*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, ICHE 2019

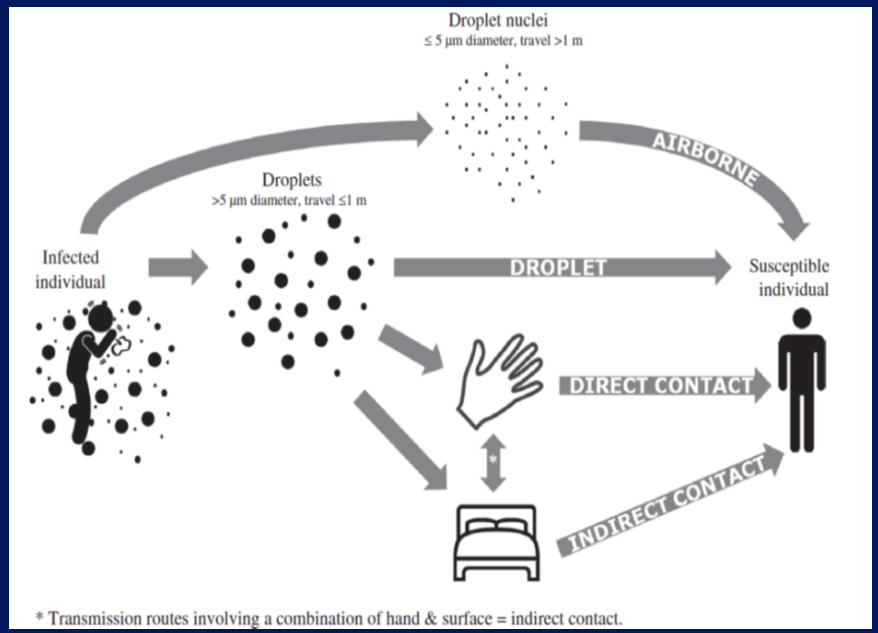
- ≤3 $\log_{10}$ (most <2 $\log_{10}$) reduction (*C. auris*, 1m, 5% FCS, QCT)
  - 0.55% OPA
  - 3% hydrogen peroxide
  - Quat, (0.085% QACs)
  - 10% povidone-iodine
  - ~1,050 ppm chlorine
  - 2% Chlorhexidine gluconate-CHG
  - 4% CHG
  - 0.5% triclosan
  - 1% CHG, 61% ethyl alcohol
  - 1% chloroxylenol

Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

Kanamori, Weber, Rutala, Clin Infect Dis, https://doi.org/10.1093/cid/ciaa1467, 28 September 2020

- Centers for Disease Control & Prevention says the virus spreads from person to person mainly through respiratory droplets from coughing, sneezing or talking in close proximity to each other, but the CDC has also said it may be possible for a person to get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose or possibly their eyes. CDC clarified while it is still possible that a person can catch it from touching a contaminated surface, it's "not thought to be the main way the virus spreads."

Transmission of SARS-CoV-2



- Droplet (< 6 feet)
- Direct-person-to-person via respiratory aerosols
- Indirect (via the contaminated environment); not main route
- Asymptomatic (infection transmission demonstrated)
- Pre-symptomatic-highly likely

Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

Kanamori, Weber, Rutala, Clin Infect Dis, https://doi.org/10.1093/cid/ciaa1467, 28 September 2020

Contamination of SARS-CoV-2 RNA by PCR on environmental surfaces and medical devices have been documented. Rate varies from 0-75% (median 12.1%).

Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

Kanamori, Weber, Rutala, Clin Infect Dis, https://doi.org/10.1093/cid/ciaa1467, 28 September 2020

SARS-CoV-2 RNA				
Bed rail	Sink	BP monitor	Infusion pump	Keyboard
Bedside table	Floor	ECG monitor	Fluid stand	Phone
Chair	Toilet seat	Oxygen regulator	Hand sanitizer	Computer mouse
Doorknob	Toilet bowl	Oxygen mask	Trash can	Door
Light switches	Stethoscope	CT scanner	Self-service printer	Glass window
Call button	Pulse oximetry	Ventilator	Desktop	PPE storage area
Centrifuge	Biosafety cabinet	Infant bed	Air outlet	Ambu bag
TV remote	Bed sheet	Urinary catheters	TV	Beepers
Elevator buttons	Ventilator tubing	Glove boxes	Touch screen	All surfaces in nurse's station

Do established infection prevention measures prevent spread of SARS-CoV-2 to the hospital environment beyond the patient room?

Jerry et al. J Hosp Infection 2020

Contamination rate: patient room-42% (11/26); nurse's station-3%; post terminal clean-4% (1/25)

Sites of swabs/air samples and results

Sample location	Grand total	Detected	Not detected
COVID-19 patient's room			
Bed rail	6	4	2
Bedside table	6	3	3
Call bell	4	1	3
Patient chair-arm	4	1	3
Remote for bed	2	2	0
Toilet door handle	4	0	4
Total	26	11	15
Nurses' station COVID-19 cohort ward			
Desk	10	0	10
Keyboard	10	0	10
Telephone	10	1	9
Total	30	1	29
Patient room post-terminal clean			
Bed rail	5	0	5
Bedside table	5	0	5
Call bell	5	1	4
Patient chair-arm	5	0	5
Toilet door handle	5	0	5
Total	25	1	24

Environmental Contamination in COVID-19 Rooms with Severe Pneumonia

Ahn et al. J Hospi Infect 2020;106:570

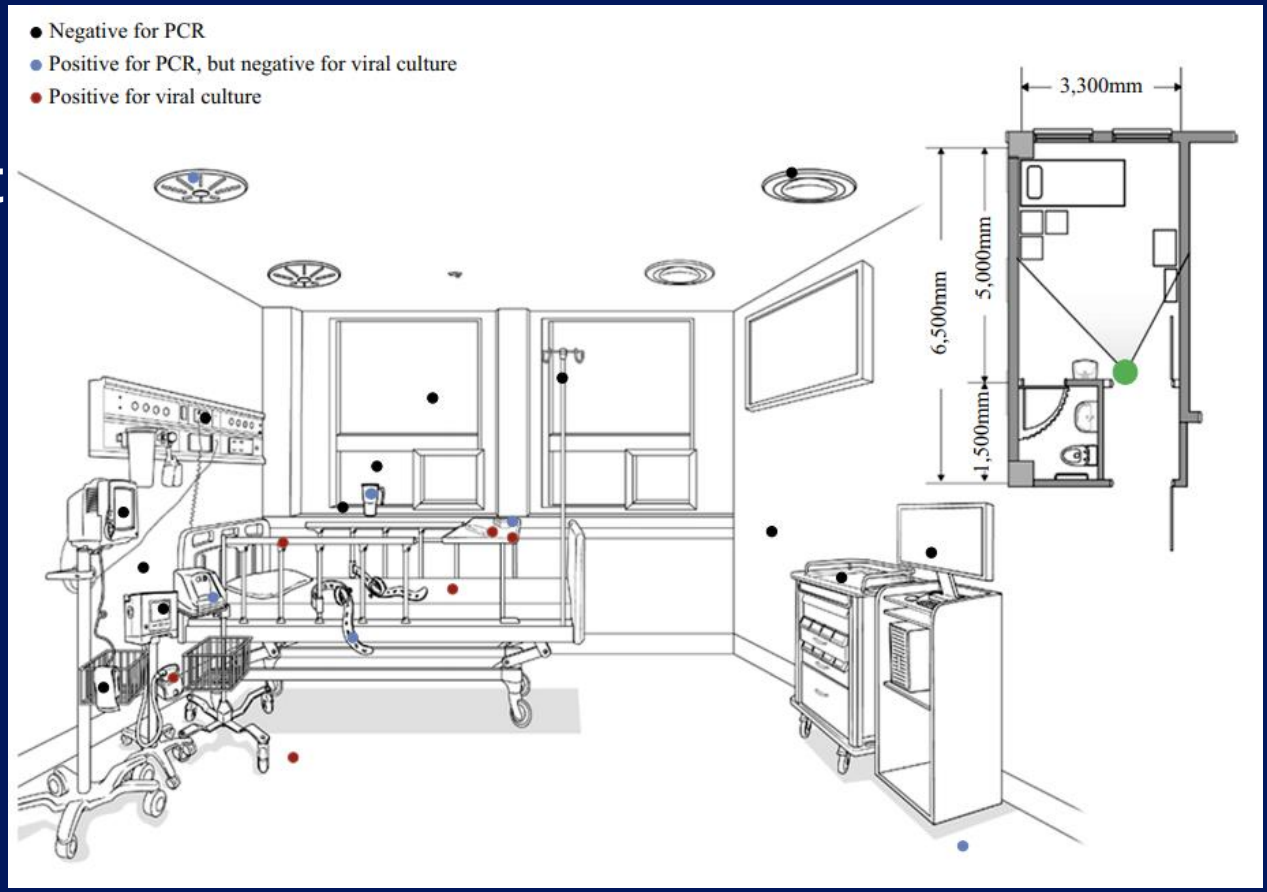
Pt 1 and 2-2/48-4% (closed suction to ventilator) pt 3-13/28-46% (high-flow oxygen therapy via nasal cannula, non-invasive ventilation). Found viable virus (7/28-25%) only on surfaces within droplet distance. All air samples negative.

Sample	Patient 1				Patient 2				Patient 3			
	PCR	C_T value		Culture	PCR	C_T value		Culture	PCR	C_T value		Culture
		E gene	RdRp			E gene	RdRp			E gene	RdRp	
Air	−			ND	−			ND	−			ND
Air outlet fan	−			ND	−			ND	+	33.93	34.99	−
Air inlet fan	−			ND	−			ND	−			ND
Nasal prong/endotracheal tube	+	30.95	31.36	+	+	32.33	33.02	−	+	31.78	34.28	+
Intravenous pole	−			ND	−			ND	−			ND
Computer	−			ND	−			ND	−			ND
Medication cart	−			ND	−			ND	−			ND
Window	−			ND	−			ND	U	U	U	−
Window frame	−			ND	−			ND	−	34.23	36.04	−
Blind curtain	−			ND	−			ND	−			ND
Wall 1	−			ND	−			ND	−			ND
Wall 2	−			ND	−			ND	−			ND
Floor near the patient[a]	−			ND	−			ND	+	30.38	33.07	+
Floor far from the patient[b]	−			ND	−			ND	+	31.97	34.28	−
Bed rails	−			ND	−			ND	+	30.22	30.13	+
Bedsheet	−			ND	−			ND	+	31.54	31.99	+
Pillows	−			ND	−			ND	ND			ND
Faucet handle	−			ND	−			ND	ND			ND
Door knob	−			ND	−			ND	−			ND
Call button	−			ND	−			ND	−			ND
Restraint	−			ND	−			ND	+	34.08	35.18	−
Blood pressure cuff	−			ND	−			ND	−			ND
Ambu mask/NIV mask	−			ND	−			ND	+	28.85	28.94	+
Ventilator	−			ND	−			ND	−			ND
Patient monitor	−			ND	−			ND	−			ND
Bedside table	ND			ND	ND			ND	U	33.09	U	+
High-flow oxygen generator	ND			ND	ND			ND	+	30.56	33.12	−
Telephone	ND			ND	ND			ND	+	31.39	33.42	−
Remote controller	ND			ND	ND			ND	+	29.48	29.66	+
Thermometer	ND			ND	ND			ND	+	31.56	32.13	−
Cup	ND			ND	ND			ND	+	32.32	33.55	−

Environmental Contamination in COVID-19 Rooms with Severe Pneumonia

Ahn et al. J Hospi Infect 2020;106:570

Found viable virus only on surface within droplet distance.



Inactivation of Coronavirus

Kampf G. J Hosp Infect 2020

Table II. Inactivation of coronaviruses by different types of biocidal agents in suspension tests.

Biocidal agent	Concentration	Virus	Strain / isolate	Exposure time	Reduction of viral infectivity (log_{10})	Reference
Ethanol	95%	SARS-CoV	Isolate FFM-1	30 s	≥ 5.5	[29]
	85%	SARS-CoV	Isolate FFM-1	30 s	≥ 5.5	[29]
	80%	SARS-CoV	Isolate FFM-1	30 s	≥ 4.3	[29]
	80%	MERS-CoV	Strain EMC	30 s	> 4.0	[14]
	78%	SARS-CoV	Isolate FFM-1	30 s	≥ 5.0	[28]
	70%	MHV	Strains MHV-2 and MHV-N	10 min	> 3.9	[30]
	70%	CCV	Strain I-71	10 min	> 3.3	[30]
2-Propanol	100%	SARS-CoV	Isolate FFM-1	30 s	≥ 3.3	[28]
	75%	SARS-CoV	Isolate FFM-1	30 s	≥ 4.0	[14]
	75%	MERS-CoV	Strain EMC	30 s	≥ 4.0	[14]
	70%	SARS-CoV	Isolate FFM-1	30 s	≥ 3.3	[28]
	50%	MHV	Strains MHV-2 and MHV-N	10 min	> 3.7	[30]
	50%	CCV	Strain I-71	10 min	> 3.7	[30]
2-Propanol and 1-propanol	45% and 30%	SARS-CoV	Isolate FFM-1	30 s	≥ 4.3	[29]
		SARS-CoV	Isolate FFM-1	30 s	≥ 2.8	[28]
Benzalkonium chloride	0.2%	HCoV	ATCC VR-759 (strain OC43)	10 min	0.0	[31]
	0.05%	MHV	Strains MHV-2 and MHV-N	10 min	> 3.7	[30]
	0.05%	CCV	Strain I-71	10 min	> 3.7	[30]
	0.00175%	CCV	Strain S378	3 d	3.0	[32]
Didecyldimethyl ammonium chloride	0.0025%	CCV	Strain S378	3 d	> 4.0	[32]
Chlorhexidine digluconate	0.02%	MHV	Strains MHV-2 and MHV-N	10 min	0.7 – 0.8	[30]
	0.02%	CCV	Strain I-71	10 min	0.3	[30]
Sodium hypochlorite	0.21%	MHV	Strain MHV-1	30 s	≥ 4.0	[33]
	0.01%	MHV	Strains MHV-2 and MHV-N	10 min	2.3 – 2.8	[30]
	0.01%	CCV	Strain I-71	10 min	1.1	[30]
	0.001%	MHV	Strains MHV-2 and MHV-N	10 min	0.3 – 0.6	[30]
	0.001%	CCV	Strain I-71	10 min	0.9	[30]
Hydrogen peroxide	0.5%	HCoV	Strain 229E	1 min	> 4.0	[34]
Formaldehyde	1%	SARS-CoV	Isolate FFM-1	2 min	> 3.0	[28]

Journal Pre-proof

Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

Kanamori, Weber, Rutala, Clin Infect Dis, 2020. https://doi.org/10.1093/cid/ciaa1467, 28 September 2020

- CDC recommends that an EPA-registered disinfectant on the EPA's List N that has qualified under the emerging pathogen program for use against SARS-CoV-2 be chosen for the COVID-19 patient care.
- List N has >500 entries and 32 different active ingredients (Quats, chlorine, etc)

Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants

Rutala, Weber, CDC DS Guideline 2008. www.cdc.gov

Most Resistant



Most Susceptible

Prions

Spores (*C. difficile*)

Mycobacteria

Non-Enveloped Viruses (norovirus, adeno)

Fungi

Bacteria (MRSA, VRE, *Acinetobacter*)

Enveloped Viruses (SARS-CoV-2)

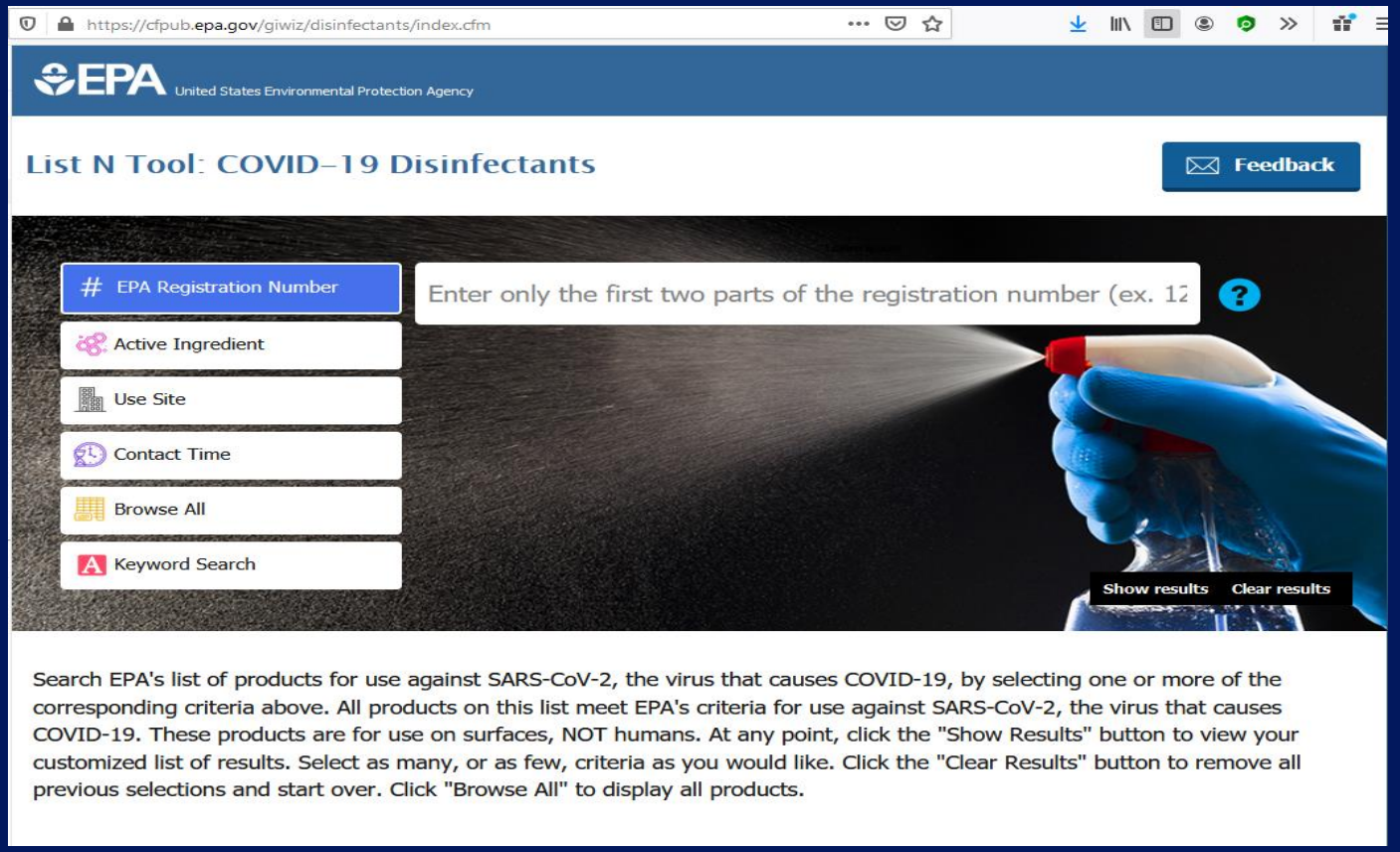
List N Tool: COVID-19 Disinfectants

32 Active Ingredients

- Ethyl alcohol
- Hydrogen peroxide
- Hypochlorous acid
- Isopropyl alcohol
- Peracetic acid
- Phenolic
- Quaternary ammonium

List N Tool: COVID-19 Disinfectants

https://cfpub.epa.gov/giwiz/disinfectants/index.cfm



Am J Infect Control. 2020 Aug; 48(8): 951–954.
Published online 2020 Jun 6. doi: 10.1016/j.ajic.2020.06.002
PMCID: PMC7275188
PMID: 32522608

Evaluation of an electrostatic spray disinfectant technology for rapid decontamination of portable equipment and large open areas in the era of SARS-CoV-2

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Abstract

Go to:

In the setting of the coronavirus disease 2019 pandemic, efficient methods are needed to decontaminate shared portable devices and large open areas such as waiting rooms. We found that wheelchairs, portable equipment, and waiting room chairs were frequently contaminated with potential pathogens. After minimal manual precleaning of areas with visible soiling, application of a dilute sodium hypochlorite disinfectant using an electrostatic sprayer provided rapid and effective decontamination and eliminated the benign virus bacteriophage MS2 from inoculated surfaces.

Efficacy of Disinfectant Electrostatic Spray (positive charged droplets attracted to negatively charged surfaces or microbes) in Reducing Pathogen Contamination

Cadnum et al. AJIC 2020

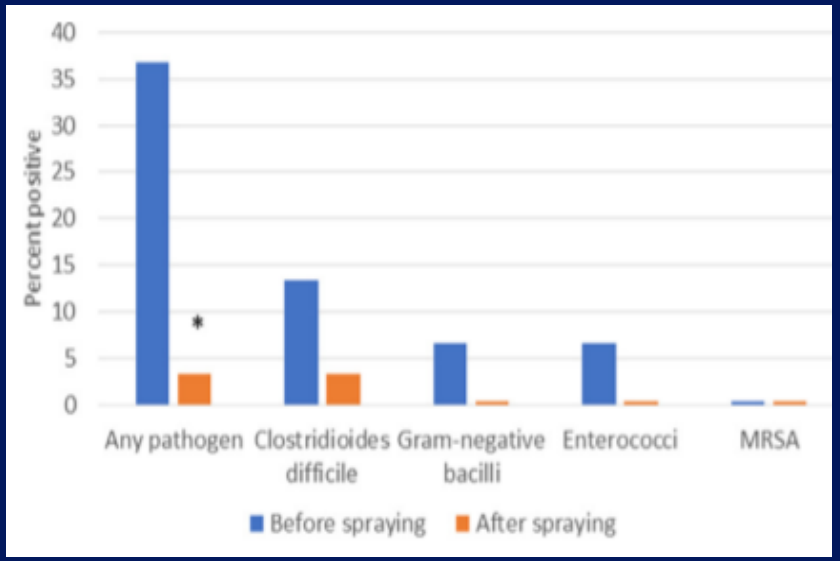
Picture of electrostatic sprayer

(0.25% sodium hypochlorite)



Efficacy of disinfectant spray

(waiting room chairs)



Summary of Electrostatic Sprayer Issues

- Optimal droplet size is between 40-70u; what is the droplet size of the proposed unit
- Spray patterns vary tremendously across vendors and even across products from a single vendor
- EPA demands that all surfaces being disinfected be thoroughly wetted for the contact time of the specific disinfectant
- Person applying the disinfectant may need to wear full PPE because of inhalation concerns
- Electrostatic sprayer does not replace the initial cleaning and disinfecting that EVS performs
- Cadnum/Donskey study used sporicidal disinfectant alone with no pre-cleaning or wiping
- Electrostatic sprayers might be most useful for items and areas that are not amenable to standard cleaning and disinfection (Cadnum/Donskey)
- Effectiveness on soft surfaces?
- Considerations for purchase include: coverage requirements, weight of loaded device; ease of handling; effective distance; particulate size; and disinfectant safety
- Electrostatic sprayers are promoted as a “get in” and “get out” time saving technology
- How many seconds per square foot with a sprayer to properly treat the surface
- Equipment can be easily misused (must prevent misuse and consider sprayer, time allotted to perform, disinfectant, surface [soft v hard], space/area to disinfect, level of cleaning prior to application, user training)

Continuous Room Decontamination Technologies fo Disinfection of the Healthcare Environment

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

- 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 and may eliminate the problem of recontamination
  - Patients, staff and visitors can remain in the room

Microbial Assessment of Recontamination with *Acinetobacter* in Patient Room Environment in Burn Units

Rutala et al. AJIC. 2020; 48 Suppl;S20

- Purpose: assess how much environmental sites (e.g., chair, bedrail, overbed table, stock cabinet, IV pump, etc.) become recontaminated with *Acinetobacter* over time after cleaning/disinfection.
- Results:
- At baseline all environmental sites sampled except overbed table were contaminated with *Acinetobacter*.
- No *Acinetobacter* were detected except bed rail just after cleaning/disinfection.
- First time to recontamination with *Acinetobacter* was 3 hours at chair, 2 hours at overbed table, 3 hours at stock cabinet, and 2 hours at IV pump. No recontamination was observed at the monitor.
- The level of *Acinetobacter* contamination on surfaces was occasionally high (e.g., when a stock cabinet was sampled at 5 hours, 75 of 96 CFU were *Acinetobacter*).
- The amount of recontamination with aerobes and *Acinetobacter* on some surfaces tended to increase over time.

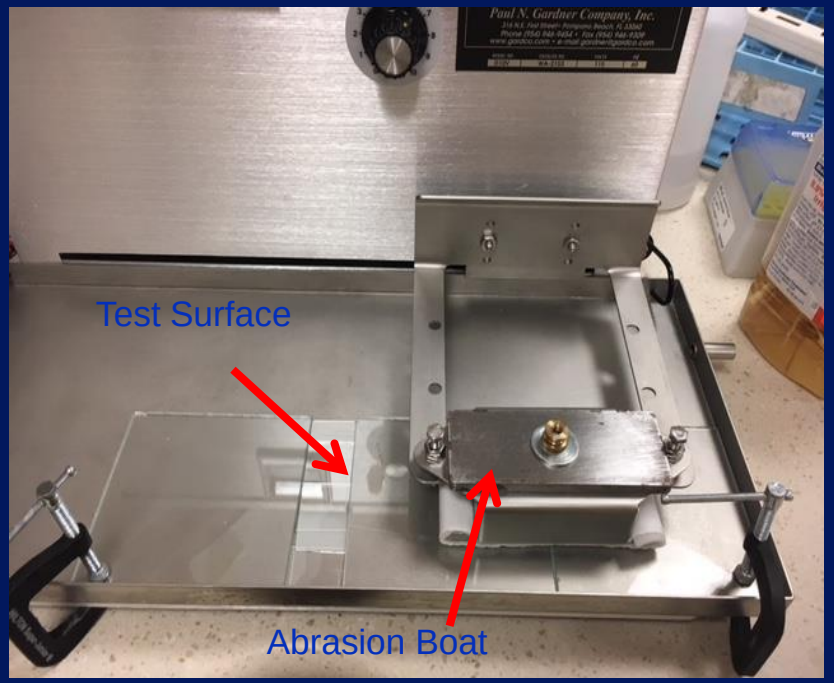
Surfaces should be hygienically clean (not sterile)-free of pathogens in sufficient numbers to prevent human disease

Evaluation of a Continuously Active Disinfectant

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

Rutala et al. ICHE, In press, 2021; Rutala et al. ICHE 2019;40:1284

- 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 ($10^{\geq 3.75}$, 30min dry) over 48hr
- At the end of the study and at least 48 hours later, the ability of the test surface to kill microbes (99.9%) within 1 min is measured using the last inoculation (10^6)



Efficacy of a Continuously Active Disinfectant Against Healthcare Pathogens

Rutala WA et al. ICHE 2019;40:1284; Redmond et al. ICHE 2021, https://doi.org/10.1017/ice.2021.66

4-5 log_{10} reduction in 5 min over 24hr for most pathogens; ~99% reduction with *Klebsiella* and CRE *Enterobacter*. Redmond et al. found 5 log_{10} reduction for CRE *Enterobacter, K. pneumoniae*, MRSA, VRE, and *C. auris*

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)

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

Rutala WA, Gergen M, Sickbert-Bennett E, Anderson D, Weber D. ICHE 2019;40:1284

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

Will the continuously active disinfectant kill viruses like coronaviruses?

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

Rutala WA et al. ICHE, In press

A novel disinfectant studied using an EPA protocol (wears/re-inoculations) demonstrated excellent 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

Best Practices in Disinfection of Noncritical Surfaces in the Healthcare Setting: A Bundle Approach and New Strategies

- Disinfection of noncritical surfaces in healthcare: A bundle approach
  - Overview of how environment contributes to HAIs
  - Policy, products, educate/train, compliance, “no touch”
- New Strategies in cleaning and disinfection
  - Colorized disinfectant, new sporicide, sporicide at discharge cleaning, emerging pathogens, electrostatic sprayer, continuously active disinfectant

THANK YOU!

www.disinfectionandsterilization.org

