
Gizmos and Gadgets

A Review of New Technologies for Environmental Services

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DISCLOSURES

2017-2018

- Consultations
 - ASP (Advanced Sterilization Products), PDI
- Honoraria
 - PDI, Kennall
- Scientific Advisory Board
 - Kinnos
- Grants
 - CDC, CMS

Gizmos and Gadgets

- New Technologies
 - UV, VHP, ATP, colorize disinfectant, light disinfection, persistent disinfectant, impregnated fabrics and surfaces
 - Describe integration of new technologies into environmental infection prevention; business case
 - Review strategies for education and changing the culture of HCPs and assessing competence of HCPs

Medical/Surgical Devices

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

EH Spaulding believed that how an object will be disinfected depended on the object's intended use (developed 1968).

CRITICAL-medical/surgical devices which enter normally sterile tissue or the vascular system or through which blood flows should be sterile.

SEMICRITICAL-medical devices that touch mucous membranes or skin that is not intact require a disinfection process (high-level disinfection [HLD]) that kills all microorganisms but high numbers of bacterial spores.

NONCRITICAL-surfaces/medical devices that touch **only intact skin** require **low-level disinfection**.

Noncritical Medical Devices

Rutala et al. AJIC 2016;44:e1; Rutala, Weber. Env Issues NI, Farber 1987



- Noncritical medical devices
- Transmission: secondary transmission by contaminating hands/gloves via contact with the environment and transfer to patient
- Control measures: hand hygiene and low-level disinfection
- Noncritical devices (stethoscopes, blood pressure cuffs, wound vacuum), rare outbreaks

How Gizmos/Gadgets Will Help Prevent Infections Associated with the Environment?

- Implement evidence-based practices for surface disinfection
 - Ensure use of safe and effective (against emerging pathogens such as *C. auris* and CRE) low-level disinfectants
 - Ensure thoroughness of cleaning (new thoroughness technology)
- Use “no touch” room decontamination technology proven to reduce microbial contamination on surfaces and reduction of HAIs at terminal/discharge cleaning
- Use new continuous room decontamination technology that continuously reduces microbial contamination

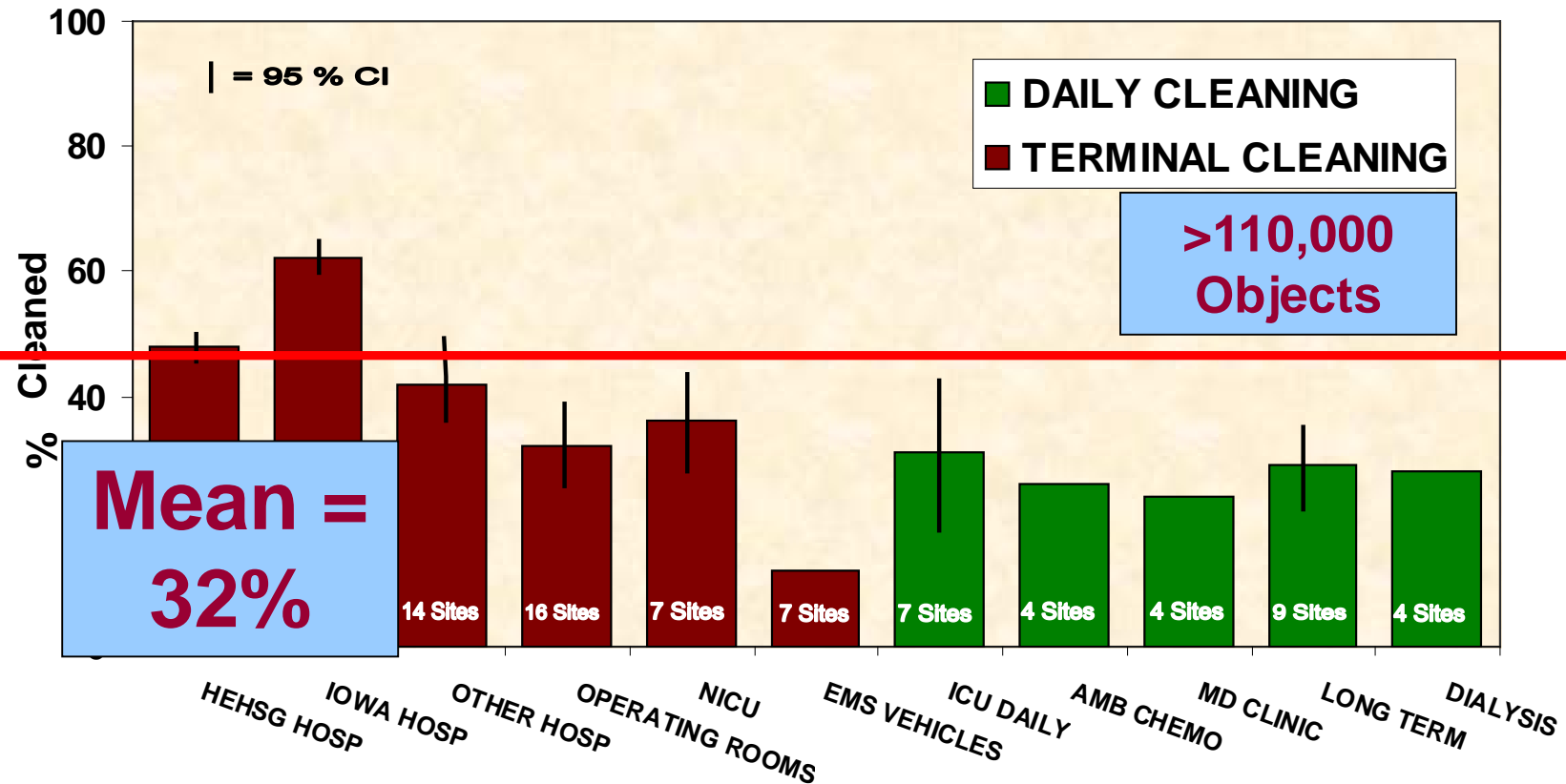
New Technologies for Room/Surface Decontamination

Assessment Parameters

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

Thoroughness of Environmental Cleaning

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



Thoroughness of Environmental Cleaning

Carling and Herwaldt. Infect Control Hosp Epidemiol 2017;38:960–965

Hospitals can improve their thoroughness of terminal room disinfection through fluorescent monitoring

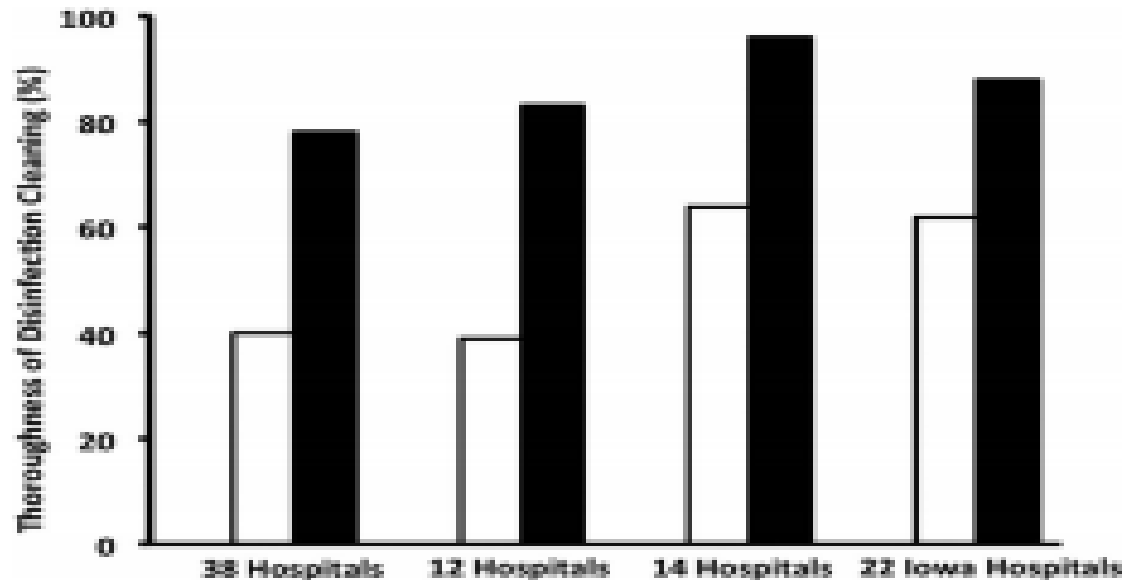


FIGURE 4. A comparison of the results of the 3 previously published multisite studies compared with results from the Iowa project. White bars represent the average baseline TDCs and black bars represent the average final TDCs for sites that completed each study.

MONITORING THE EFFECTIVENESS OF CLEANING

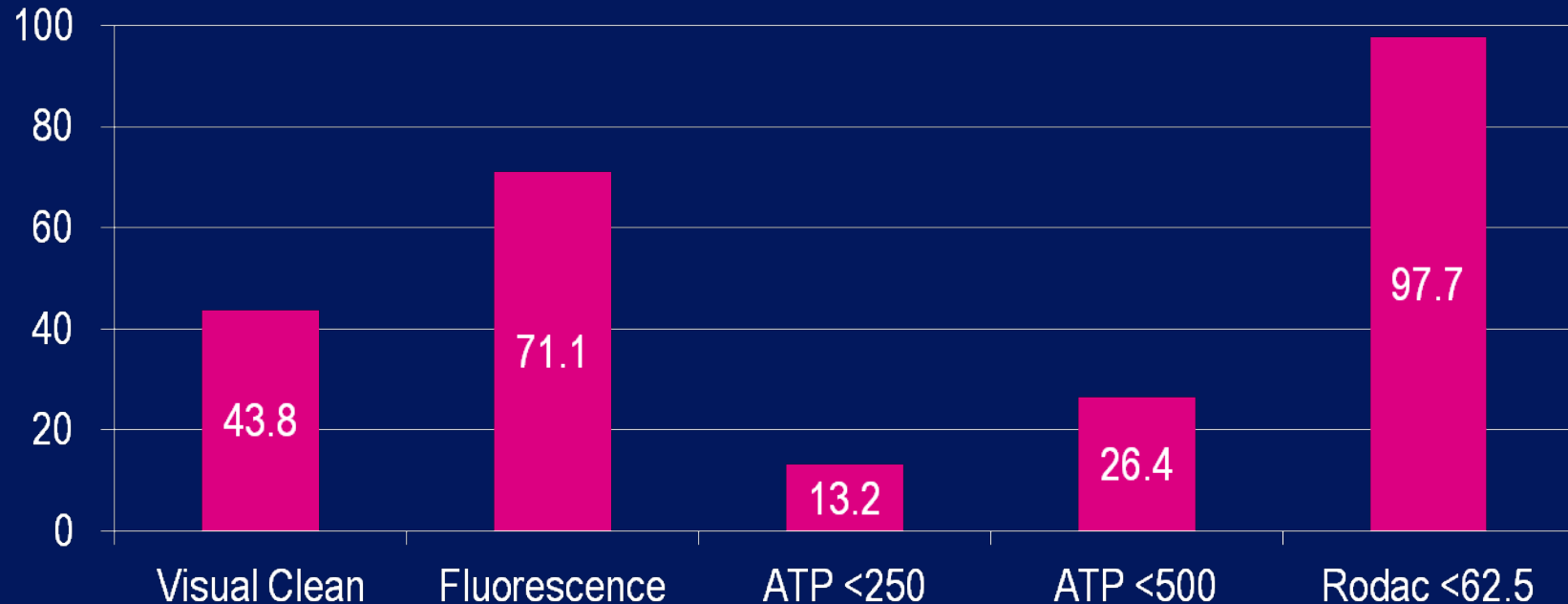
Cooper et al. AJIC 2007;35:338

- 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/cm²-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)

Percentage of Surfaces Clean by Different Measurement Methods

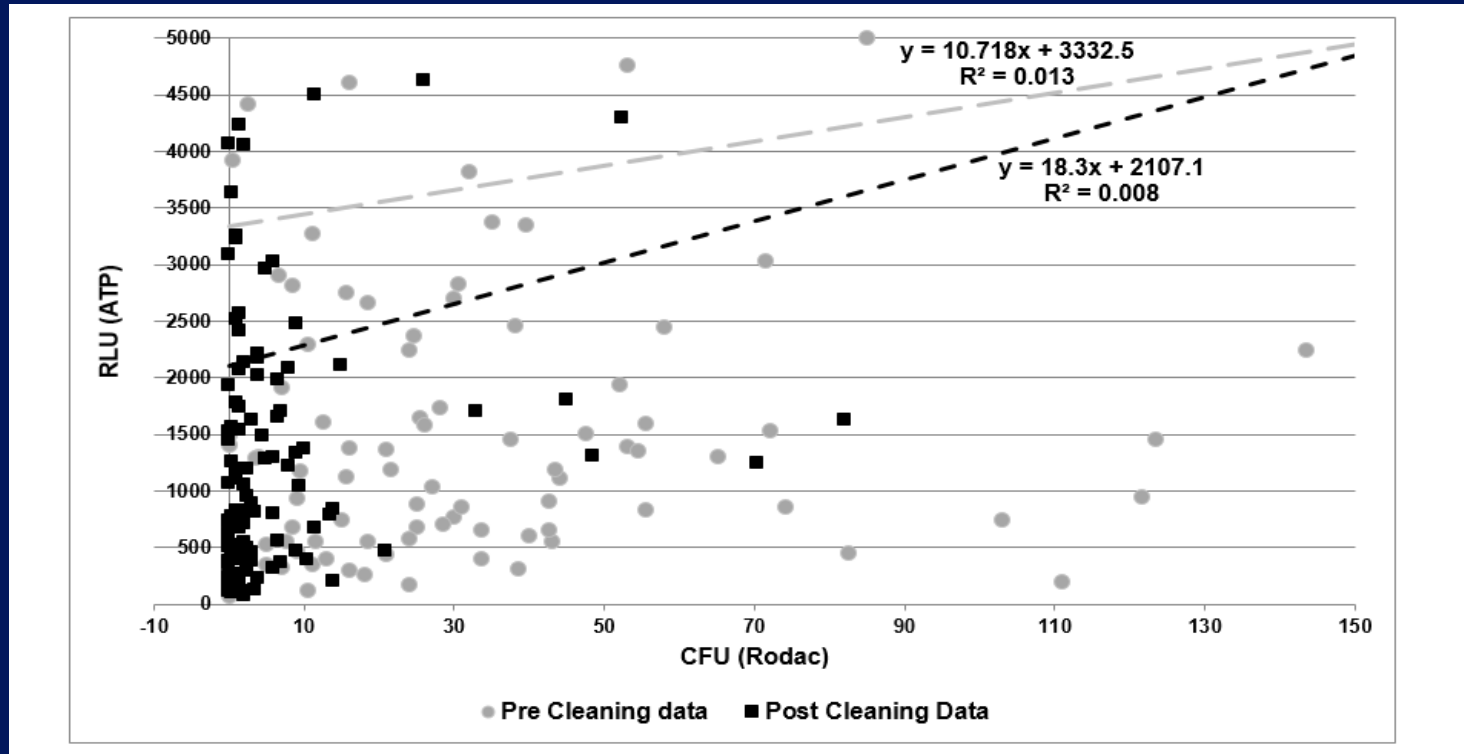
Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017.

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 RLU) and Standard Aerobic Counts (CFU/Rodac)

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

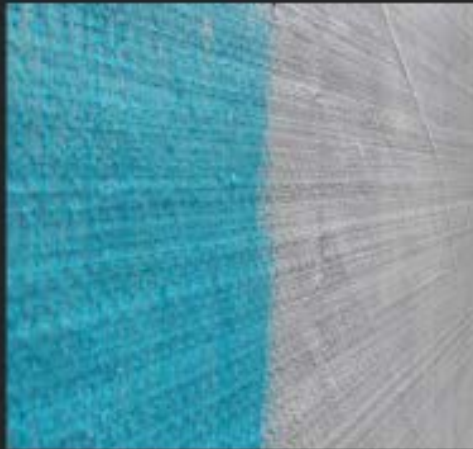


There was no statistical correlation between ATP levels and standard aerobic plate counts.

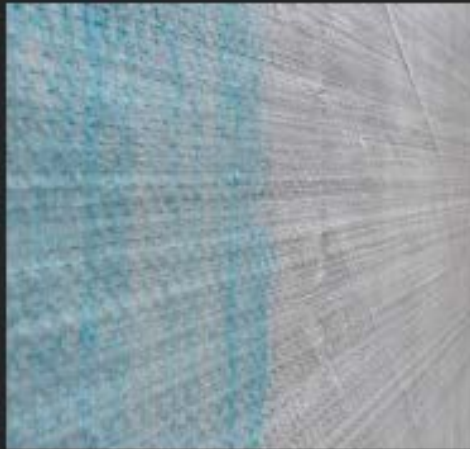
Future Methods to Ensure Thoroughness

Future May Have Methods to Ensure Thoroughness Such as Colorized Disinfectant

Colorized disinfection – contact time compliance



0 min



2 min

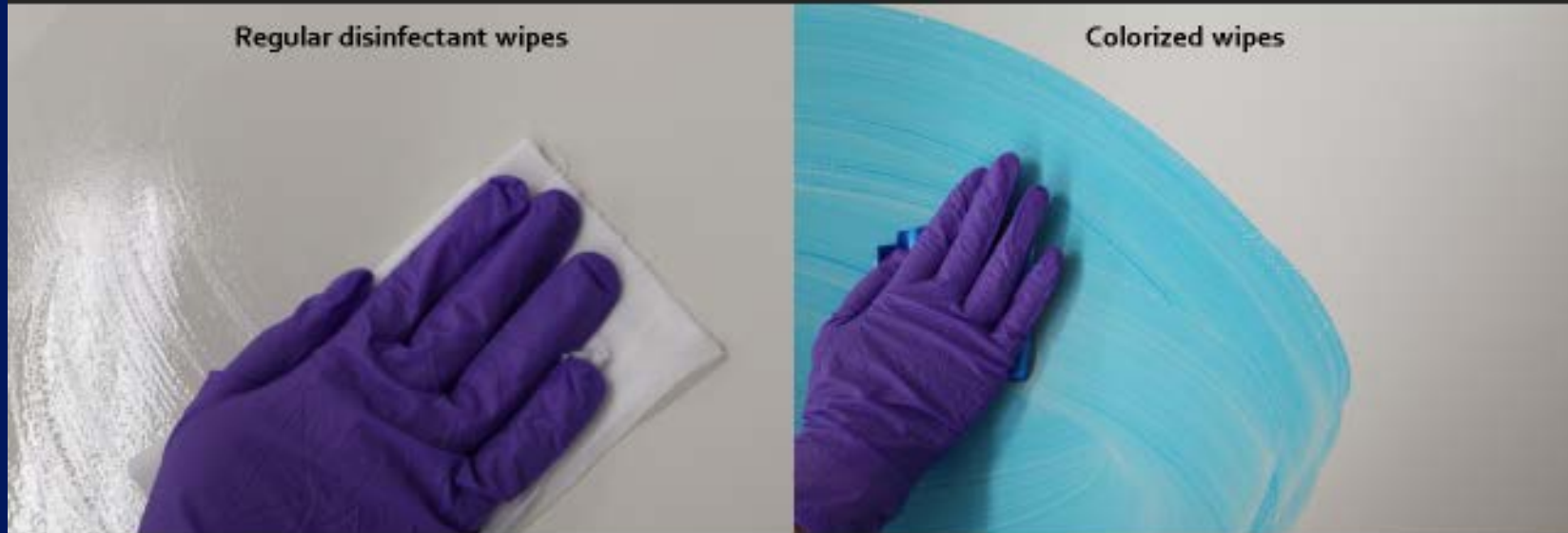


4 min

- Color-fading time matched to disinfectant contact time --> enforces compliance
- Provides real-time feedback when disinfection is complete
- Trains staff on importance of contact time as they use the product

Future May Have Methods to Ensure Thoroughness Such as Colorized Disinfectant

Colorized disinfection – improved coverage



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

Novel Chemical Additive That Colorizes Disinfectant to Improve Visualization of Surface Coverage

Mustapha et al . AJIC; 2018:48:191-121

By improving thoroughness will it reduce microbial contamination and reduce transmission?

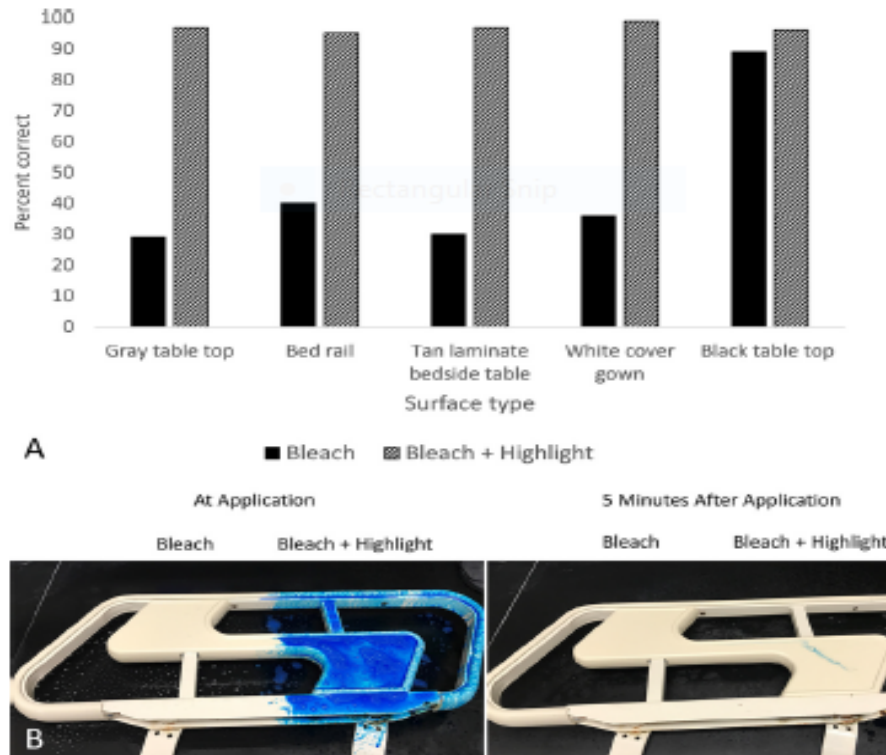


Fig 1. (A) Percentage of sites correctly identified by personnel as having or not having bleach application when testing occurred within 30 seconds of application, stratified based on whether [redacted] was added to colorize the bleach solution. (B) Image of a bed rail with application of bleach versus bleach-plus-Highlight.

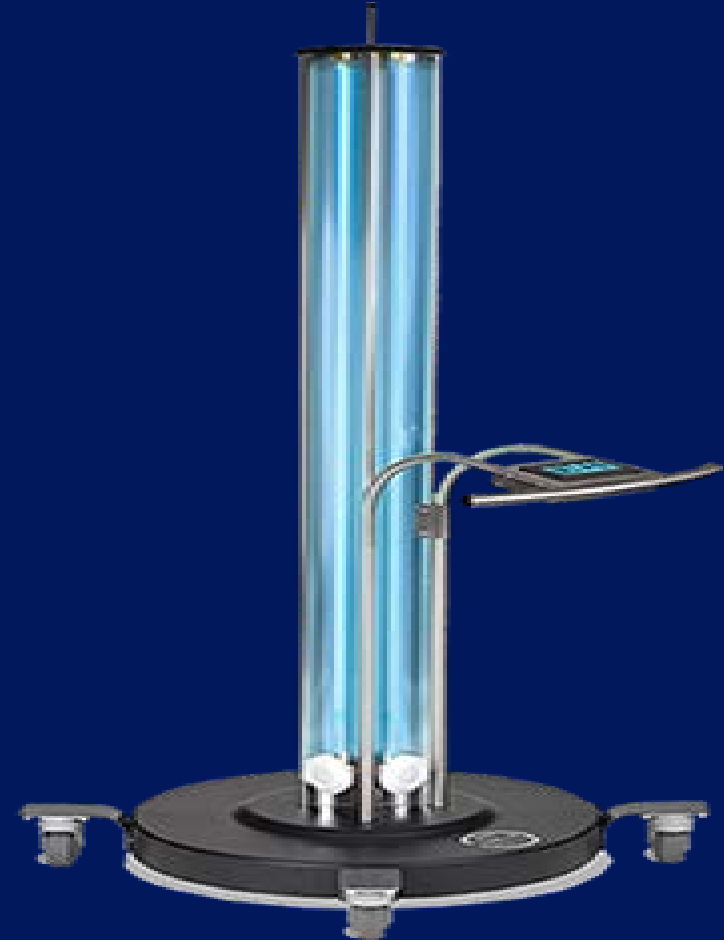
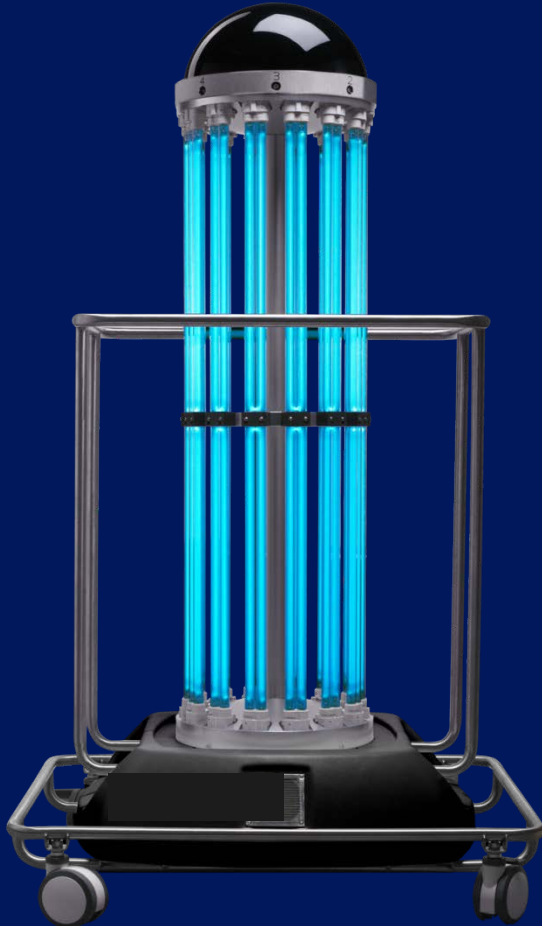
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"NO TOUCH" APPROACHES TO ROOM DECONTAMINATION

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

Rutala, Weber. Infect Control Hosp Epidemiol. 2013;41:S36-S41



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

Anderson et al. Lancet 2017;289:805

	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).

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Integration of New Technology

Anderson et al. Infect Control Hosp Epidemiol 2018;39:157

- Implementation lessons from BETR Disinfection Study (enhanced terminal room disinfection study with four strategies- Quat [except *C. difficile*], Quat-UV, chlorine, chlorine-UV and ~20,000 exposed patients), three key barriers
 - Timely and accurate identification of rooms that would benefit such as Contact Precaution rooms
 - Overcoming time constraints to allow EVS cleaning staff sufficient time to properly employ new technology
 - Purchase of capital equipment-compete for CE dollars

Implementation Lessons from BETR Disinfection Study

Anderson et al. Infect Control Hosp Epidemiol 2018;39:157

Timely and accurate identification of rooms that would benefit, that is, Contact Precaution patient rooms

- During BETR disinfection study, used “Swiss cheese” model of multiple redundant strategies to increase ability to identify Contact Precaution rooms for enhanced terminal disinfection
 - ◆ Bed control and EVS staff had daily monitoring (morning) discussion about patients expected to be discharged
 - ◆ EVS staff were instructed to use Contact Precaution signs to determine the need for enhanced or standard disinfection
 - ◆ IPs made regular rounds to ensure Contact Precaution signage was accurate

Implementation Lessons from BETR Disinfection Study

Anderson et al. Infect Control Hosp Epidemiol 2018;39:157

- 88% of eligible Contact Precaution rooms were treated
- Cycle completed 97%
- Median room cleaning time was ~4m longer in the UV and UV and bleach groups
- Total wait time in the ED and days on diversion were unchanged across disinfection strategies
- Time from admit decision to departure from ED was ~10 longer in enhanced groups
- Reasons for cycle aborted or blocked
 - Room needed immediately for patient
 - Device malfunction
- Device and personnel availability and perception of difficulty moving the machine were infrequent causes of missed or aborted opportunities

Integration of New Technologies into Environmental Infection Prevention

- Review scientific data and how technology adds a level of disinfection above routine cleaning and disinfection (EVS staff, BOD, Leadership, Dept Heads)
 - Surfaces are contaminated
 - EIP survive for days, weeks, months
 - Contact with surfaces results in hand contamination
 - Disinfection reduces contamination and HAIs
 - Rooms not adequately cleaned
 - Results in newly admitted patient with increased risk of infection
 - “No touch” technology microbicidal (>20 studies)
- Business case (CFO, VP-ES) -12 clinical studies demonstrating reduction of HAIs. Average cost of HAI (2007\$) is \$25,903

Strategies for Education and Changing the Culture and Assessing Compliance

- Education customized to meet the needs of the group for which it is given (EVS, BOD, Leadership, Nursing, Dept Heads)
- Communicate regularly and clearly the importance of the initiative and the results that are being achieved
- Through communication, change beliefs (C/D suboptimal nationwide, new technologies improve C/D, reduce HAIs, reduce patient harm)

Continuous Room Decontamination

Rutala, Gergen, Kanamori, Sickbert-Bennett, Weber, 2015-2018

- Visible light disinfection system-effective
- Dilute hydrogen peroxide system-not effective (potential)
- Self-disinfecting surface coating-some data
- Others-copper-some data

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

Continuous Room Decontamination Technology

- Advantages
 - Allows continued disinfection (may eliminate the problem of recontamination)
 - Patients, staff and visitors can remain in the room
 - Does not require an ongoing behavior change or education of personnel
 - Self-sustaining once in place
 - Once purchased might have low maintenance cost
 - Technology does not give rise to health or safety concerns
 - No (limited) consumable products

Continuous Room Decontamination Technology

Weber, Rutala. Am J Infect Control 2013. 41:S31-S35

- Disadvantages
 - Room decontamination/biocidal activity is slow (10-24h) and low
 - Capital equipment costs are substantial
 - Does not remove dust, dirt, stains that are important to patients and visitors
 - Studies have not shown whether their use will decrease HAIs
 - Some technology (light) may cause patient dissatisfaction (e.g., lights on 24/7)

Visible Light Disinfection in a Patient Room

(automatic switching between modes performed by wall-mounted controls)



White light



Blue light-increase irradiance, increase

Antimicrobial Activity of a Continuous Visible Light Disinfection System

- Visible Light Disinfection uses the blue-violet range of visible light in the 400-450nm region generated through light-emitting diodes (LEDs)
- Initiates a photoreaction with endogenous porphyrin found in microorganisms which yield production of reactive oxygen species inside microorganisms, leading to microbial death
- Overhead illumination systems can be replaced with Visible Light Disinfection counterparts

Time to Specified Percent Reduction of Epidemiologically-Important Pathogens with “Blue” and “White” Light

Rutala et al. APIC Poster 2017

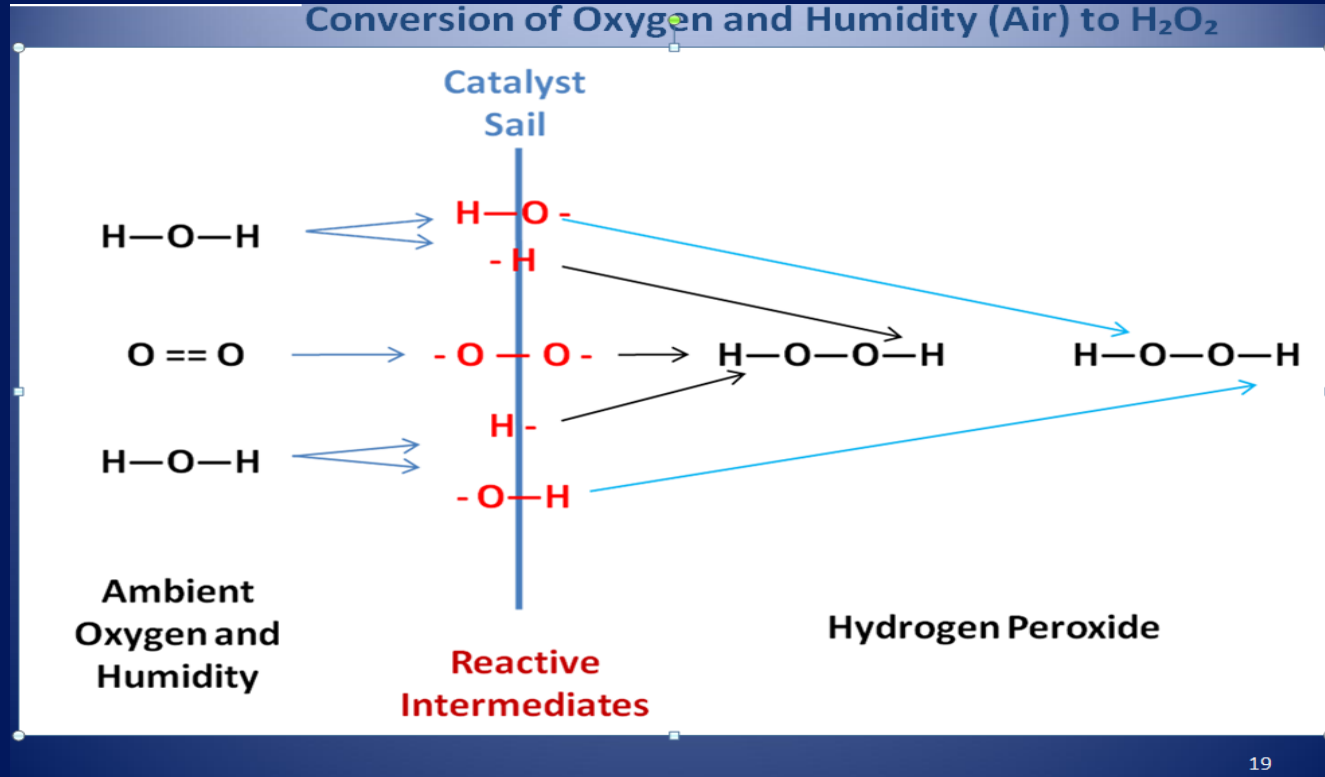
1 log₁₀ reduction in 10-24 hours

Time to specified percent reductions of epidemiologically-important pathogens with “blue” light and “white” light.

Pathogen	Treatment (light)	Time (least number of hours) to achieve sustained microbial reduction of listed percentage			
		25%	50%	75%	90%
MRSA	White	5	10	17	24
	Blue	2	3	6	10
VRE	White	13	29	51	NA
	Blue	2	5	9	15
MDR-Acinetobacter	White	2	5	9	14
	Blue	2	4	9	15
C. difficile	White	NA	NA	NA	NA
	Blue	56	68	NA	NA

Dilute Hydrogen Peroxide Technology

UV activates the catalyst which creates H ion and hydroxyl radical and free electron, hydroxyl radicals removed from catalyst and combine to form HP; also H_2 and O_2 and electron make HP



Application of Dilute Hydrogen Peroxide Gas Technology for Continuous Room Decontamination

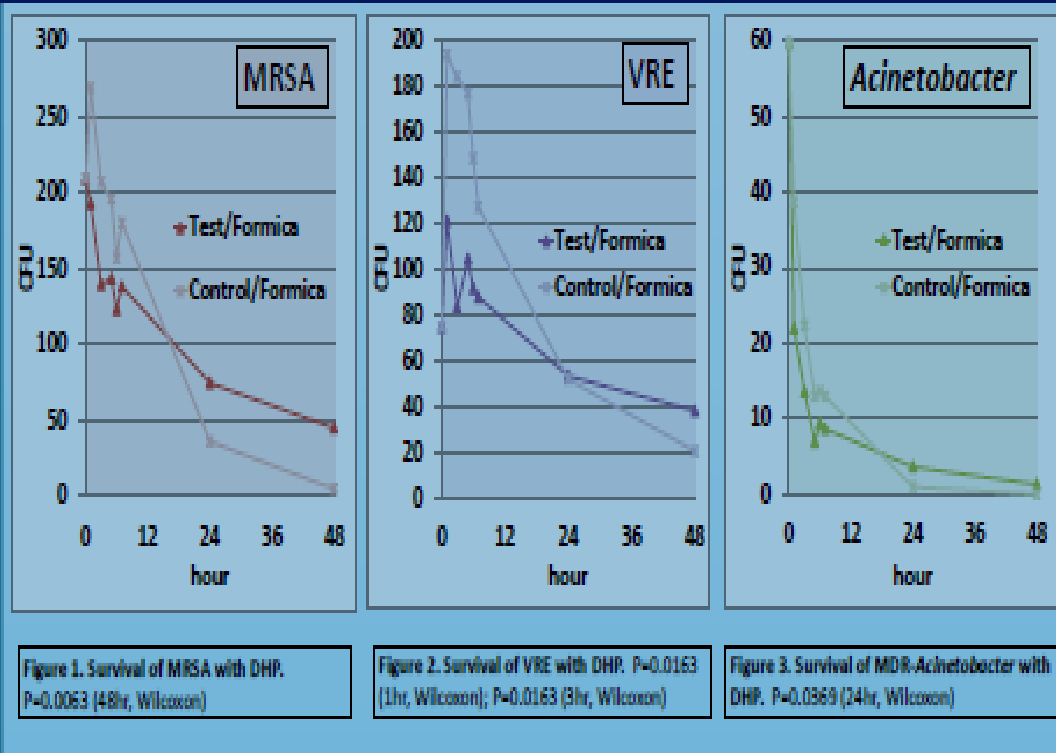
Rutala et al. ID Week 2017



- DHP units were installed in the ceilings of a model room and the hallway in front of the room per manufacturer's installation specifications, and the door closed
- We tested three test bacteria: MRSA, VRE and MDR *Acinetobacter*
- An estimated 100-500 CFU for each test organisms was inoculated and spread separately on each formica sheet then exposed to DHP gas released into

Application of Dilute Hydrogen Peroxide Gas Technology for Continuous Room Decontamination

Rutala et al. ID Week 2017



- There was no statistical differences in survival between DHP and control groups except very few time points
- The DHP units did not generate a germicidal concentration of hydrogen peroxide gas
- Modifications will be required to maintain effective DHP levels for continuous room decontamination

SURFACE DISINFECTANTS: PERSISTENCE

Rutala WA et al. ICHE 2006;27:372-77

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

Evaluation of A Persistent Surface Disinfectant

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



- Test method involves "wear" and re-inoculation of the test and control surfaces; over 48h
- Tester set to 5s for one pass
- Surface will undergo wear and re-inoculations over 24h
- Initial inoculation (10^5), apply disinfectant (dry overnight); 6 re-inoculations (10^3 , 30m dry), last inoculation (10^6)
- 24 passes (6 dry, 6 wet cycles)

Evaluation of a Persistent Surface Disinfectant

Rutala, Gergen, Sickbert-Bennett, Weber, 2018

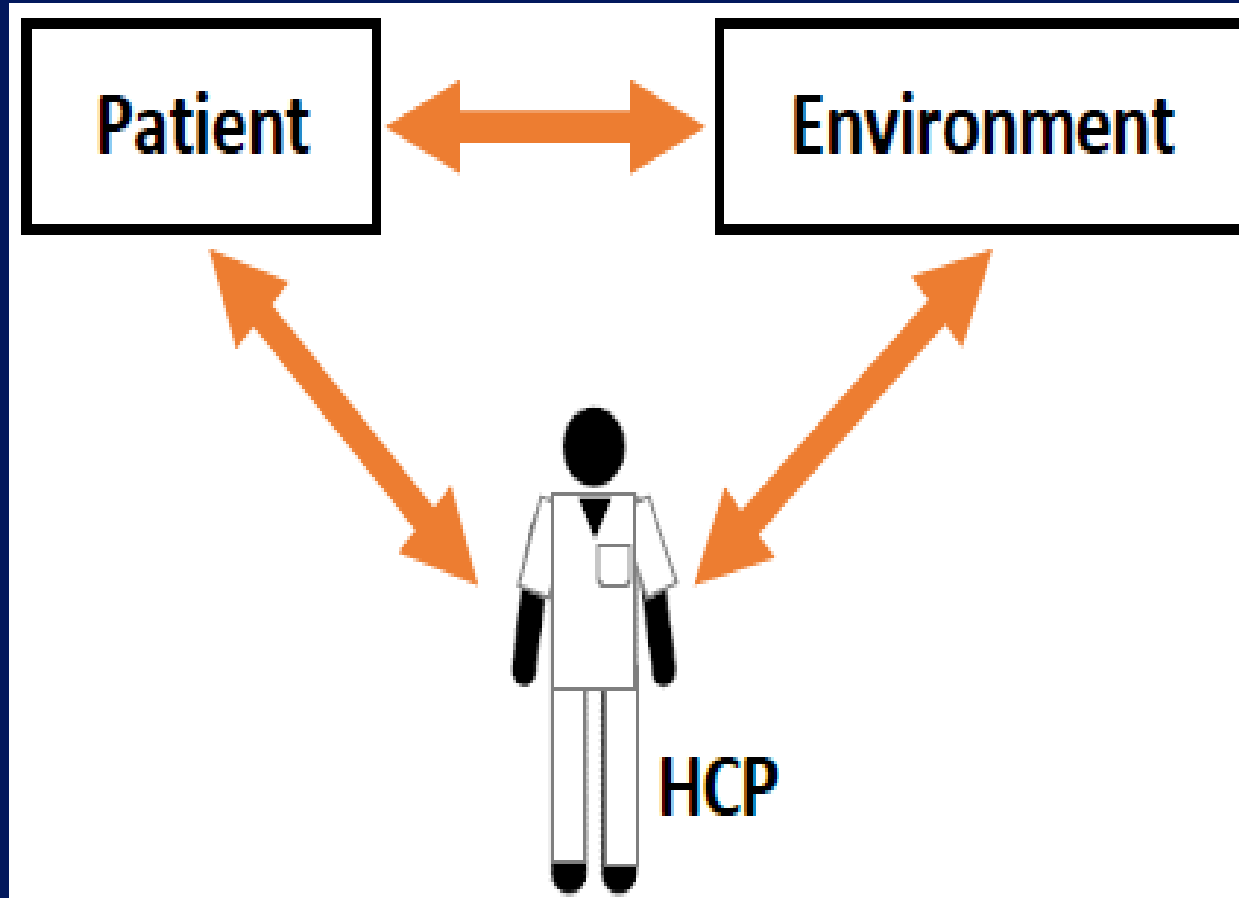
Test (<i>S. aureus</i>)	Log ₁₀ Reduction after 24h regardless of wears/touches and re-inoculations
1	5.25
2	4.14
3	4.05
4	4.17

Evaluation of a Persistent Surface Disinfectant

Persistent disinfectants may reduce or eliminate the problem of recontamination. Preliminary studies with a new persistent disinfectant are promising (4- 5 log₁₀ reduction in 5m over 24h)

"Transmission Triangle"

Slide from Dev Anderson, MD, Duke UMC



Antimicrobial Scrub Contamination and Transmission (ASCOT) Trial

Anderson et al. Infect Control Hosp Epidemiol 2017;38:1147-1154

- A prospective, blinded, 3-arm RCT with a crossover design
 - Objective - to determine if antimicrobial-impregnated surgical scrubs (silver-alloy, organosilane-based Quat) decrease the burden of HCP clothing contamination compared to standard, control surgical scrubs
- SA1 – Determine if antimicrobial-impregnated surgical scrubs are less contaminated than standard surgical scrubs after being worn by nurses in intensive care units (ICU)
- SA2 – Characterize the type, extent, similarity and direction of transmission of bacterial contamination among ICU nurses, their patients, and the hospital environment

ASCOT Trial

Summary

Anderson et al. Infect Control Hosp Epidemiol 2017;38:1147-1154

- Antimicrobial-impregnated scrubs do not decrease the risk of pathogen contamination for nurses in the ICU
- Nurse clothing will become contaminated with epidemiologically important organisms >10% of shifts
 - MSSA, *Acinetobacter*, and MRSA most common
 - 30-40% of contaminations from environment
 - Pathogen movement is complex

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Gizmos and Gadgets

A Review of New Technologies for Environmental Services Summary

- New gizmos/gadgets such as disinfection technologies (“no touch”, colorized disinfectant) could reduce risk of infection associated with devices and surfaces.
- Some of these potential methods of reducing transmission of pathogens from the environment have been studied to include: continuous light disinfection, dilute hydrogen peroxide and persistent disinfectants . Studies of continuous light system demonstrated 1-2 \log_{10} reduction over 10-24 hours, whereas, the hydrogen peroxide unit studied failed to produce sufficient levels of hydrogen peroxide to kill test bacteria.
- Persistent disinfectants may reduce the problem of recontamination. Preliminary studies with a persistent disinfectant are promising (4- 5 \log_{10} reduction in 5m over 24h)

THANK YOU!
www.disinfectionandsterilization.org

