
Gizmos and Gadgets

A Review of New Technologies for Infection Control

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DISCLOSURES

2017-2018

- Consultations
 - ASP (Advanced Sterilization Products), PDI
- Honoraria
 - PDI, ASP
- 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, impregnated urinary catheters, CHG patch
- 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

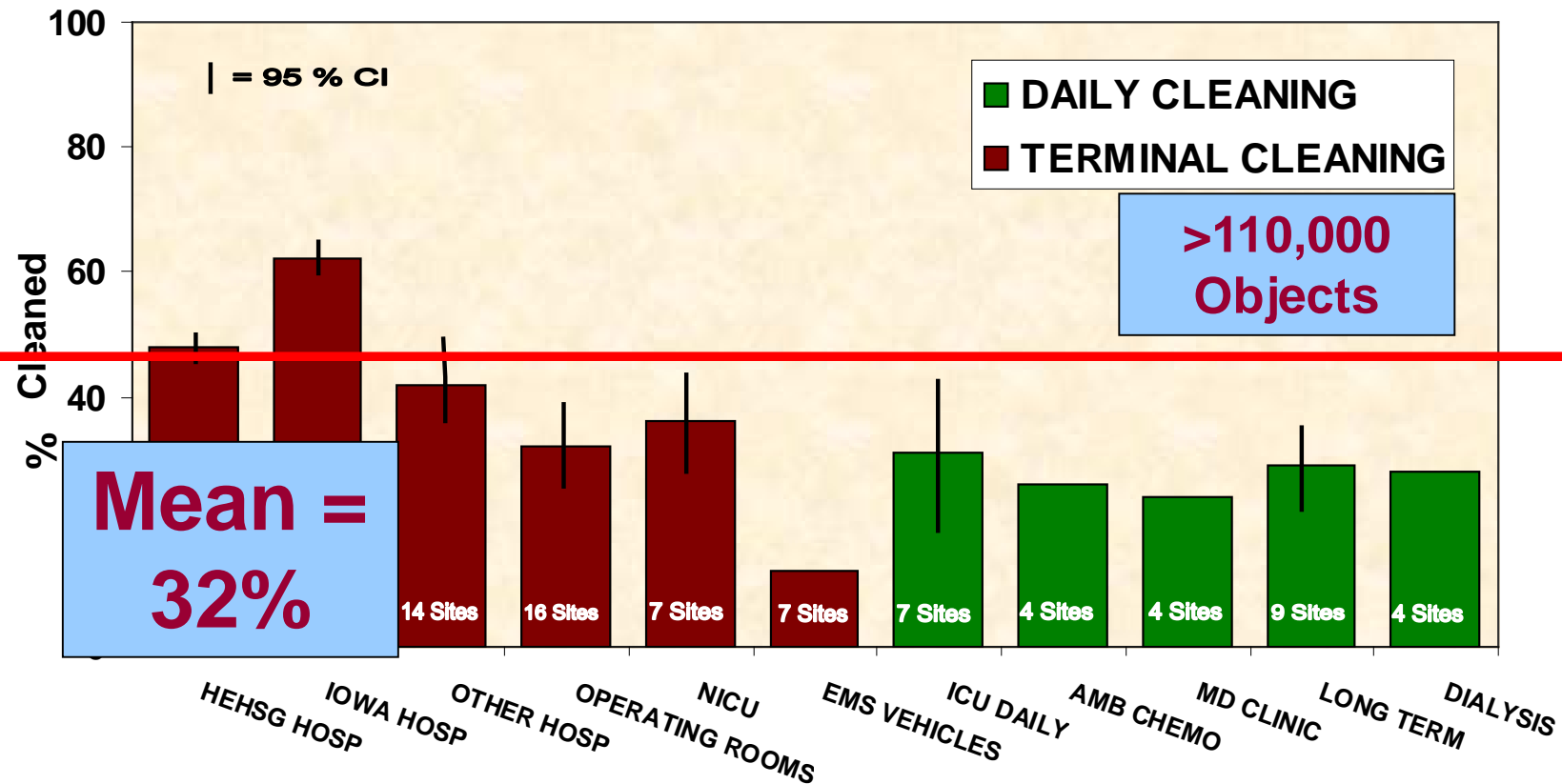
- Safe
- Microbicidal
- Reduction of HAIs
- Cost-effective

Colorized Disinfectant



Thoroughness of Environmental Cleaning

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



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)

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

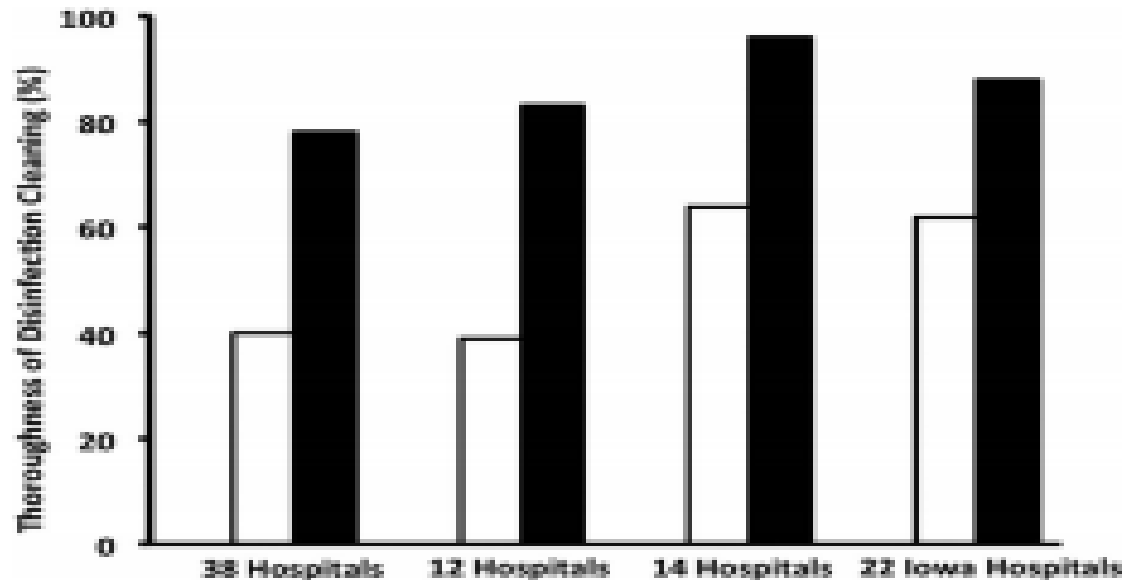
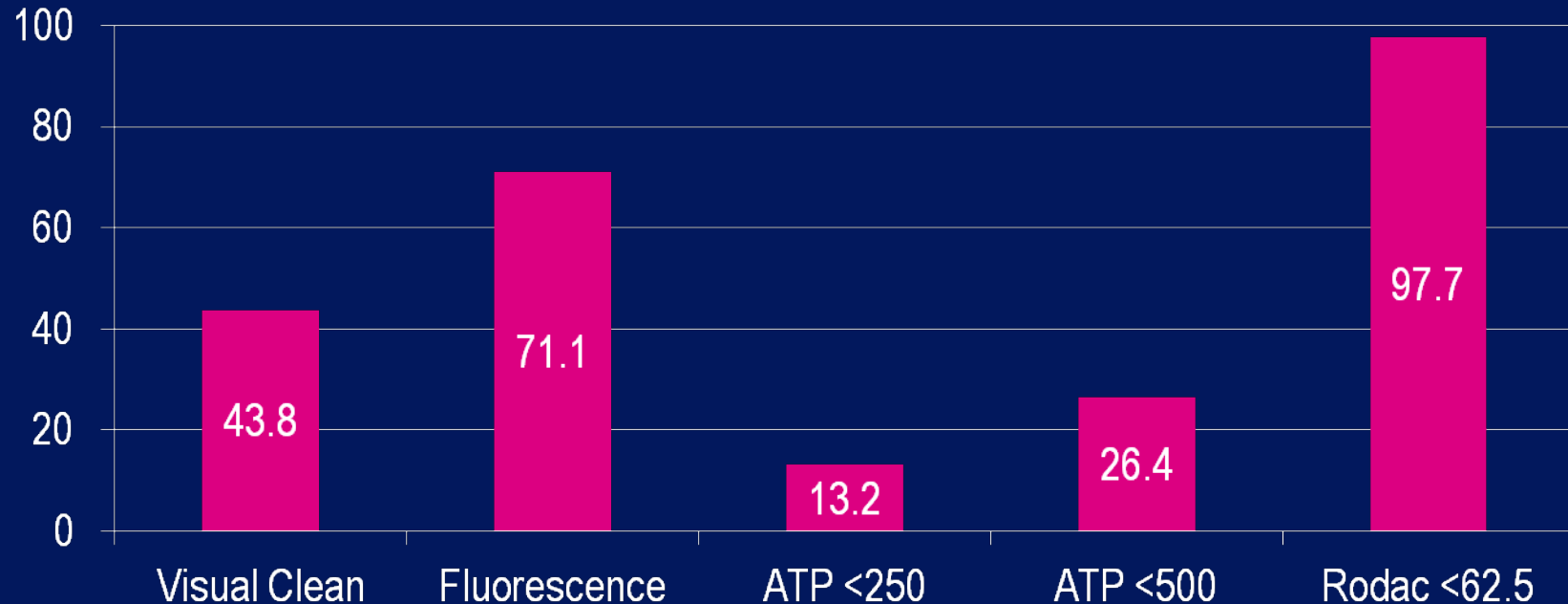


FIGURE 4. A comparison of the results of the 3 previously published multisite studies compared with results from the Iowa project. White bars represent the average baseline TDCs and black bars represent the average final TDCs for sites that completed each study.

Percentage of Surfaces Clean by Different Measurement Methods

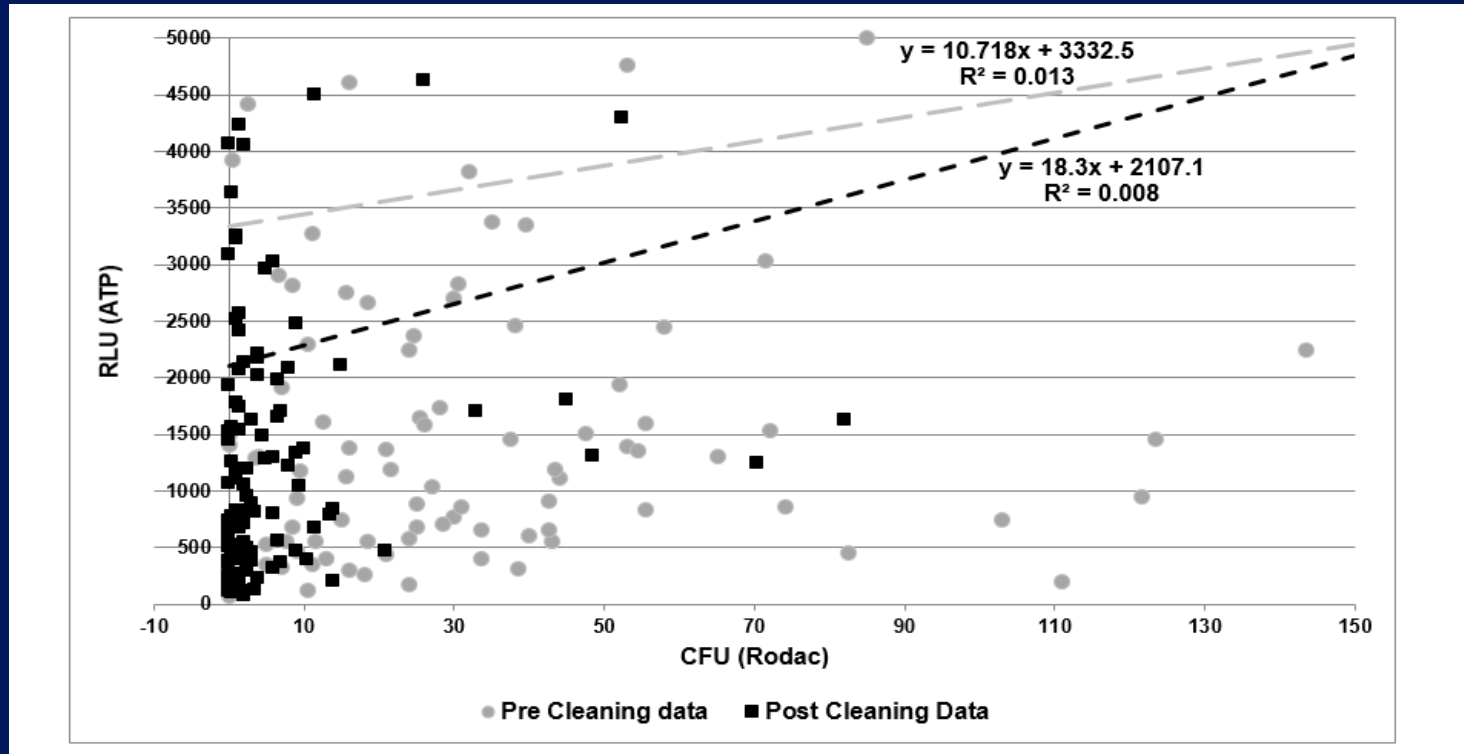
Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017.

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

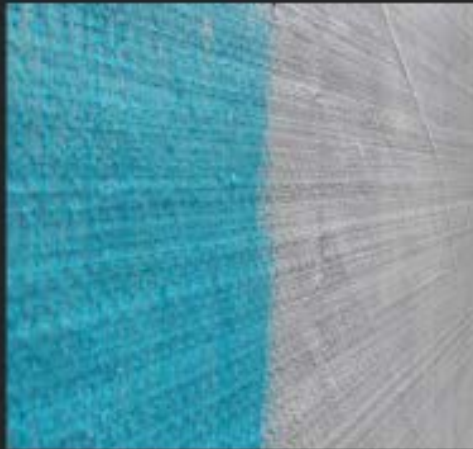


There was no statistical correlation between ATP levels and standard aerobic plate counts.

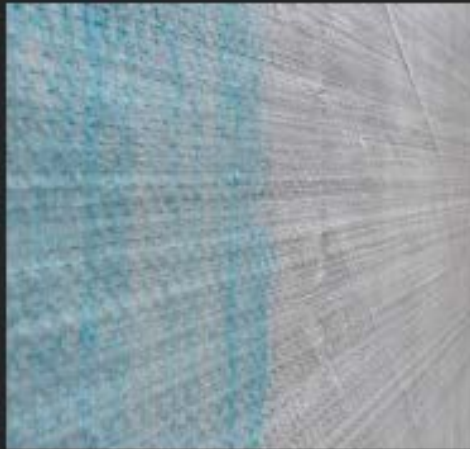
Future Methods to Ensure Thoroughness

Future May Have Methods to Ensure Thoroughness Such as Colorized Disinfectant

Colorized disinfection – contact time compliance



0 min



2 min

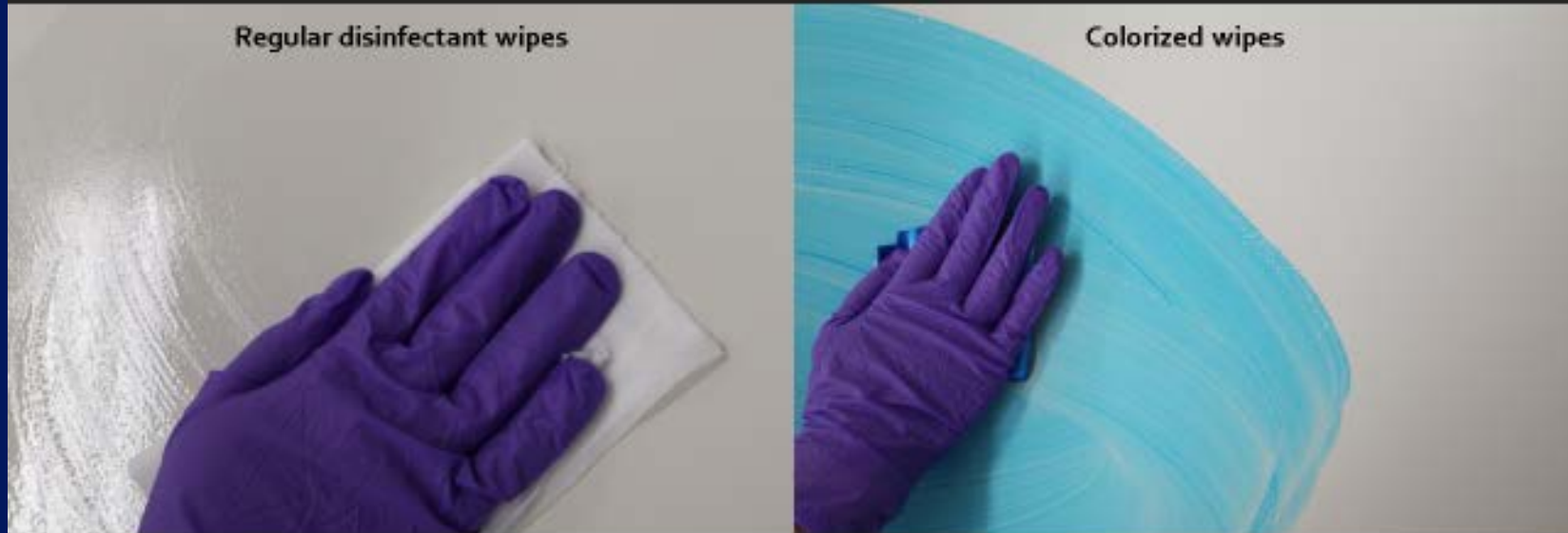


4 min

- 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?

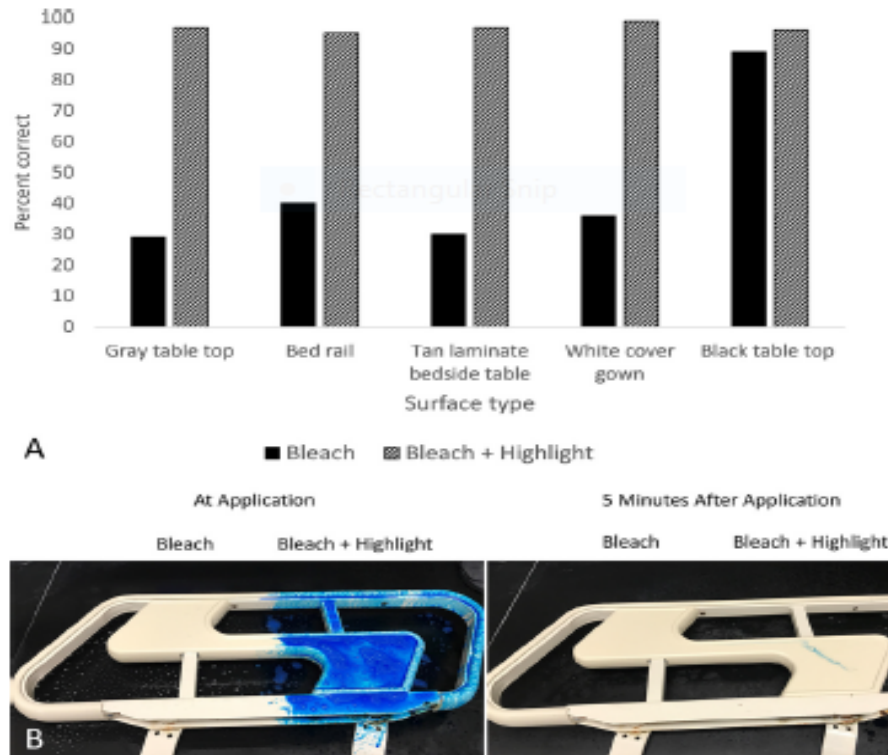


Fig 1. (A) Percentage of sites correctly identified by personnel as having or not having bleach application when testing occurred within 30 seconds of application, stratified based on whether [redacted] was added to colorize the bleach solution. (B) Image of a bed rail with application of bleach versus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

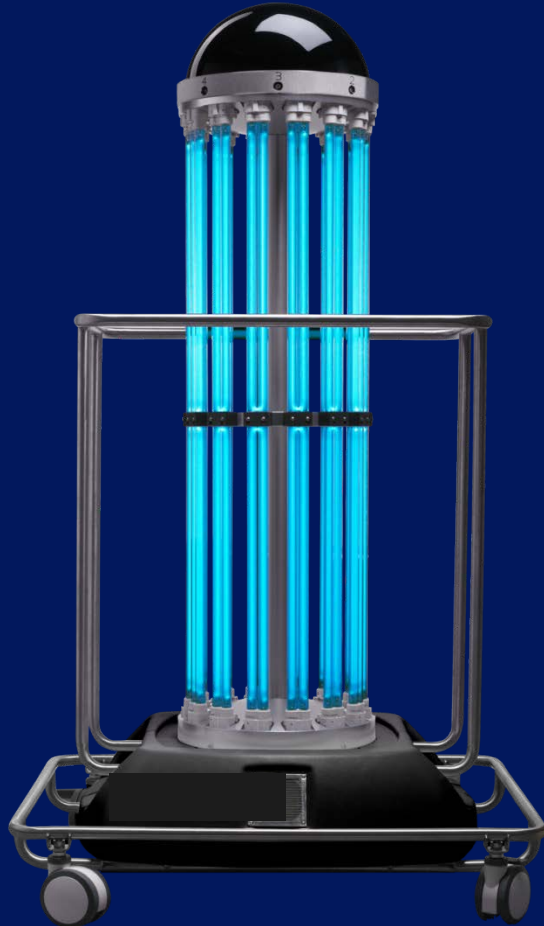
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"NO TOUCH" APPROACHES TO ROOM DECONTAMINATION

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

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.

	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)

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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



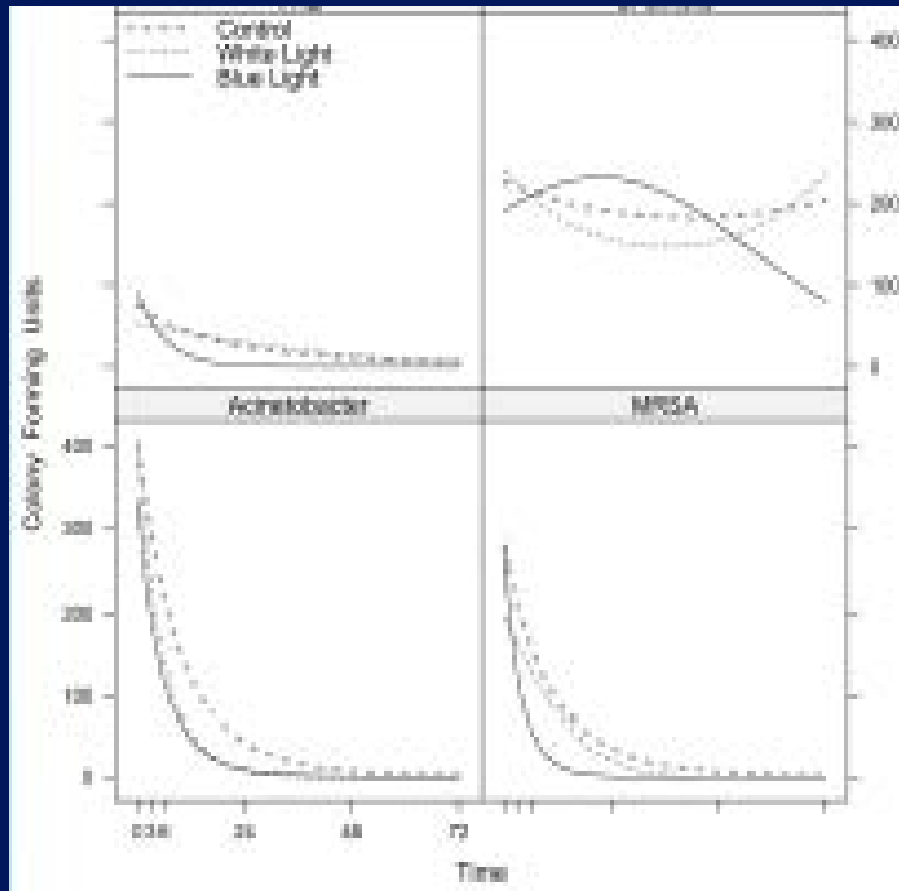
Blue light-increase irradiance, increase kill

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

Inactivation of Health Pathogens by Continuous Visible Light Disinfection

Rutala et al. APIC 2017; ICHE. In press



- The treatment (i.e. both “blue” and “white” light) had significantly different rates over time for all four organisms
- Both light treatments were associated with more rapid decreases in observed bacterial counts over time with all four organism
- Overall, the model demonstrated improved inactivation of pathogens with the “blue” and “white” light

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

Rutala et al. APIC Poster 2017; ICHE In press

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

Efficacy of UV-A Light System

Livingston, et al, SHEA Poster 2018

Figure 1. Reduction of organisms exposed to 3 W/m² of UV-A

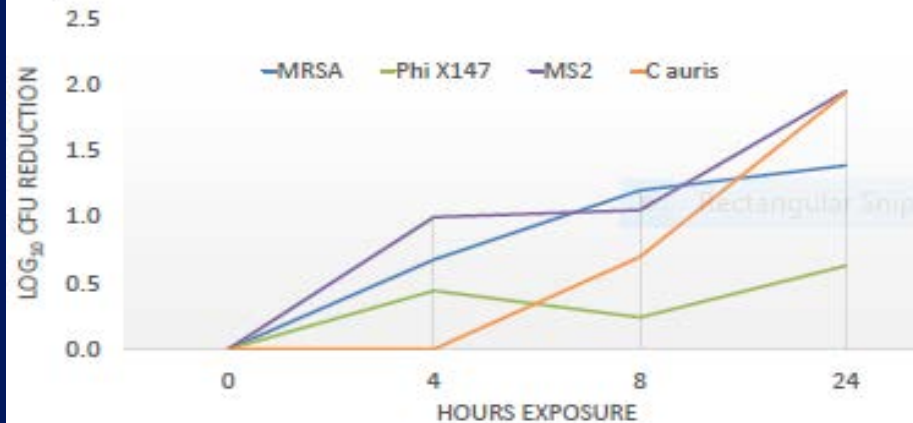
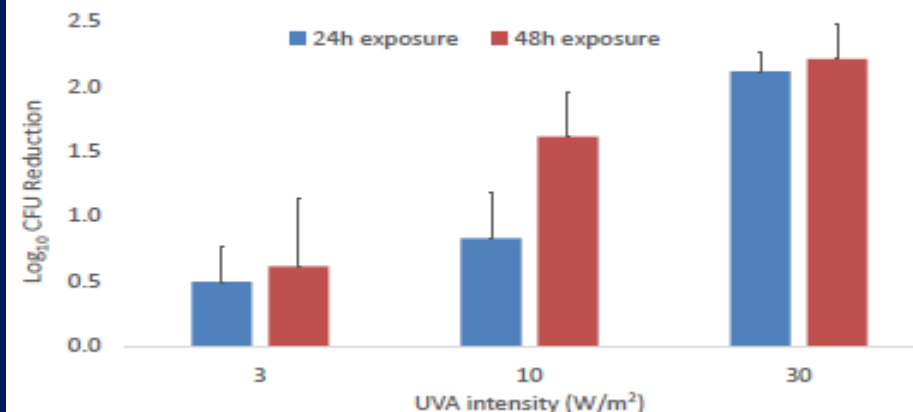


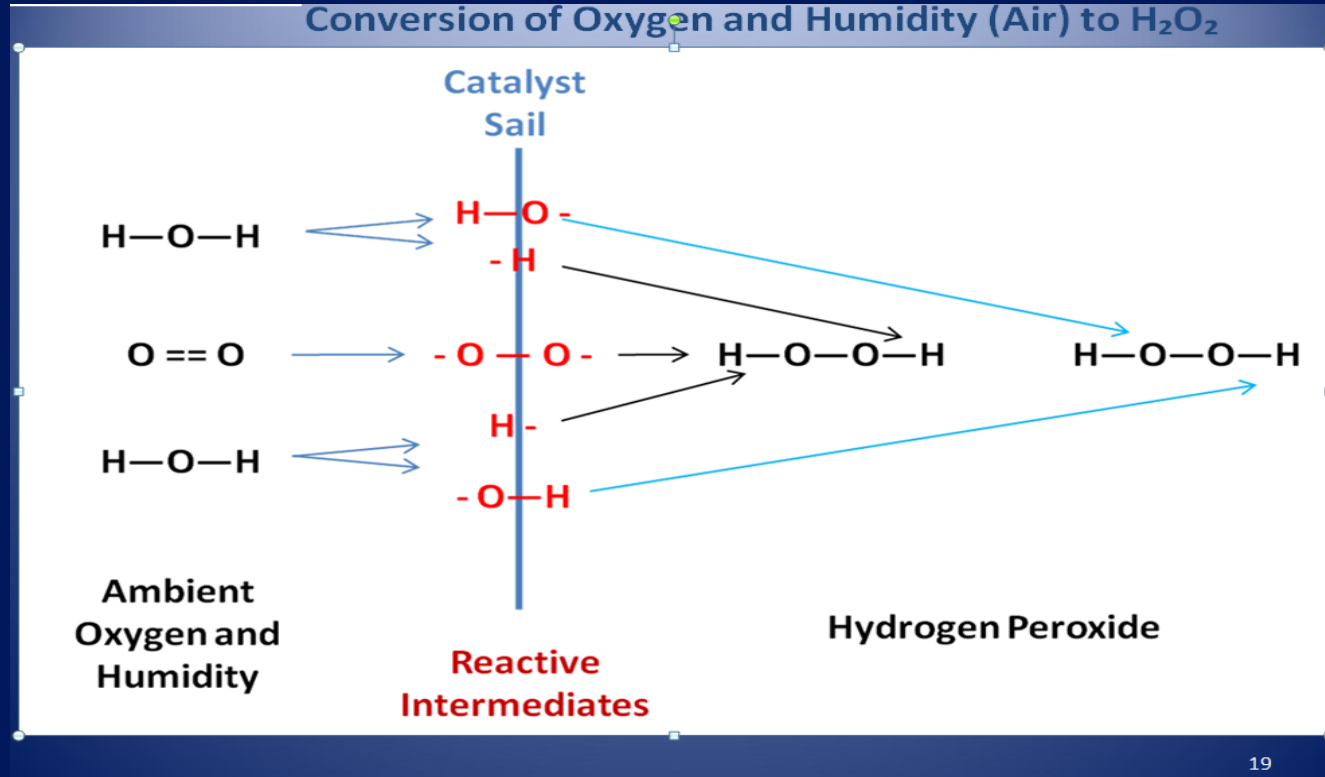
Figure 2. Reduction of *C. difficile* spores exposed to variable intensities of UV-A



- UV-A (315-400nm) proposed as a safe method to provide continuous disinfection of surfaces while patients and staff are in the room
- At 3W/m² of UV-A light was effective in reducing MRSA, *E. coli* and MS2 (1-2 log₁₀ reduction in 24h)
- At higher intensities (10, 30 W/m²), UV-A also effective against *C. difficile* spores

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

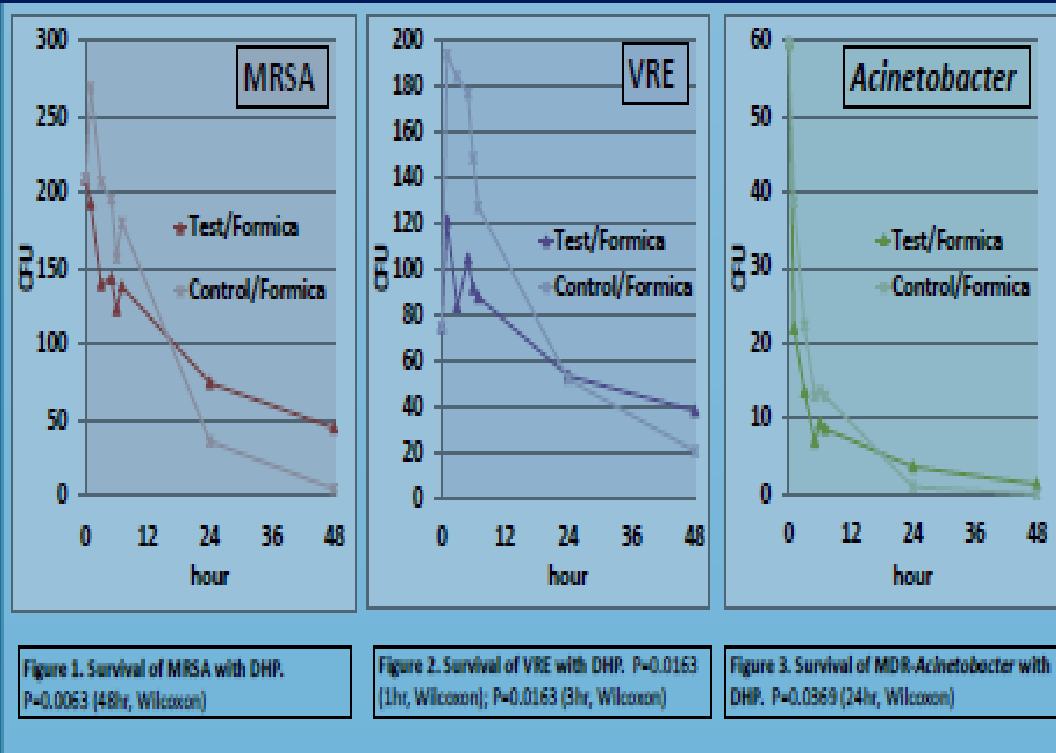
Rutala et al. ID Week 2017



- 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



- The displayed curves revealed no clinically relevant differences in die-off of the test organisms comparing interventions and control groups especially in the time periods ≥ 24 hours.
- The DHP units did not generate a concentration of hydrogen peroxide gas >0.1 ppm
- 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

- Evaluation use the EPA "Protocol for Residual Self-Sanitizing Activity of Dried Chemical Residuals on Hard, Non-Porous Surfaces"
- Surfaces-glass, formica and SS
- Organisms- *S. aureus*, CRE and *C. auris*

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)

EFFICACY OF A PERSISTENT CHEMICAL DISINFECTANT

Rutala WA, Gergen M, Sickbert-Bennett E, Anderson D, Weber D. ID Week 2018

- Methods: Surfaces were inoculated , treated with the novel disinfectant, allowed to dry, and then abraded using a standardized abrasion machine under multiple alternating wet and dry wipe conditions (N=12) interspersed with 6 re-inoculations. After 24 hours, the surface was re-inoculated a final time and ability of the disinfectant to kill >99.9% of 9 test microbes within 5min was measured on test surfaces (glass).
- **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).** When the novel disinfectant was compared to three other commonly used disinfectants using the same methodology with *S. aureus*, the mean log₁₀ reductions were: 4.4 (novel disinfectant); 0.9 (quat-alcohol); 0.2 (improved hydrogen peroxide); and 0.1 (chlorine).

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

Test surface glass unless otherwise specified

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)

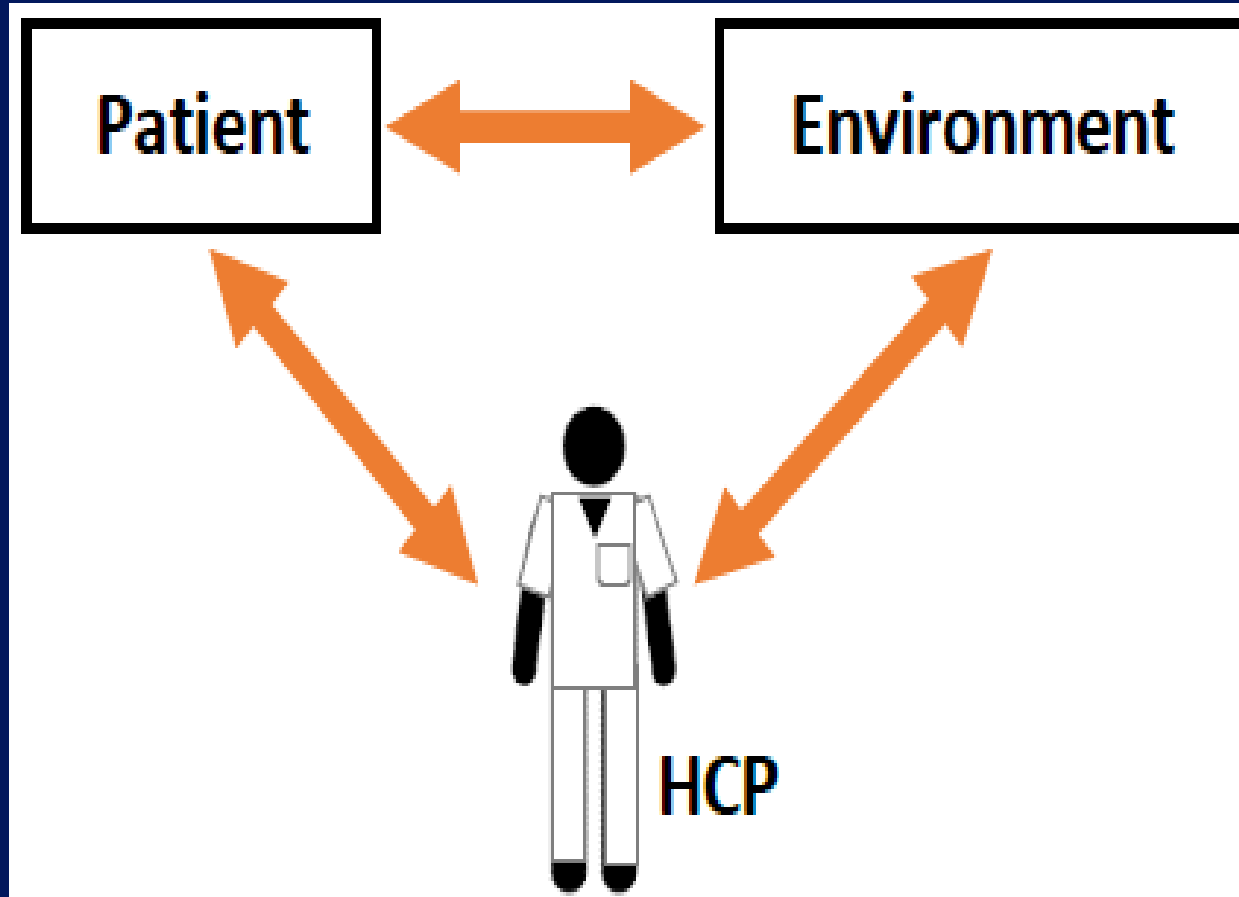
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"Transmission Triangle"

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

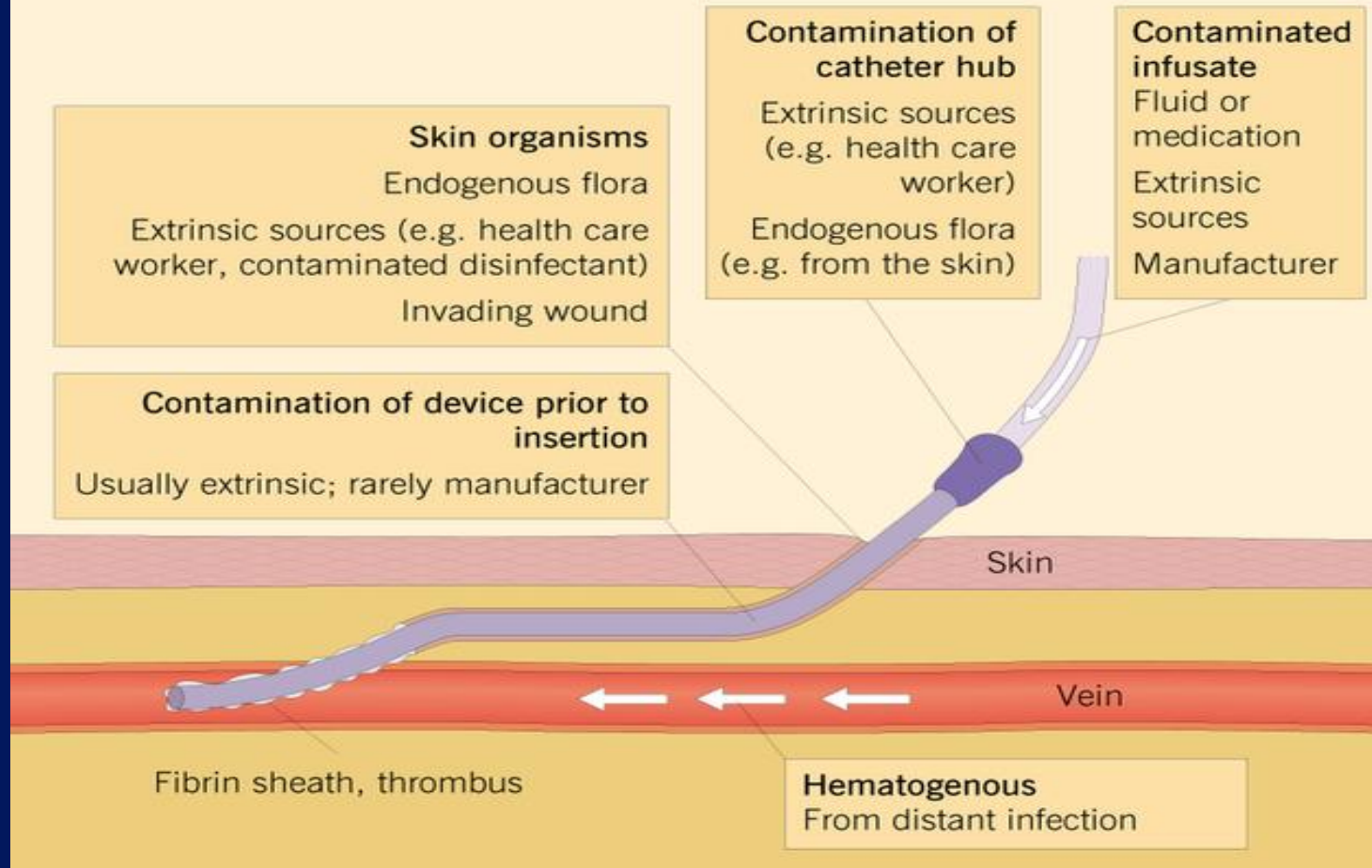
Healthcare-Associated Infections

- Epidemiology of infectious disease (the key to preventing and controlling infectious diseases)
- Impact of infections on patients
- Major sites of HAIs
 - Surgical site infections
 - Bloodstream infections
 - Respiratory infections
 - Urinary tract infections

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POTENTIAL ROUTES OF INFECTION



CHG PATCH



PROTECTIVE DISK WITH CHG

- Bacteria can recolonize the skin and CHG suppresses regrowth
- CHG patch provides contact around the insertion site and 7 day continuous release of CHG provides ongoing antimicrobial protection
- Randomized, controlled trials show CHG patch reduces risk of infection (JAMA 2009;301:1231 and Ann Hematol 2009;88:267)

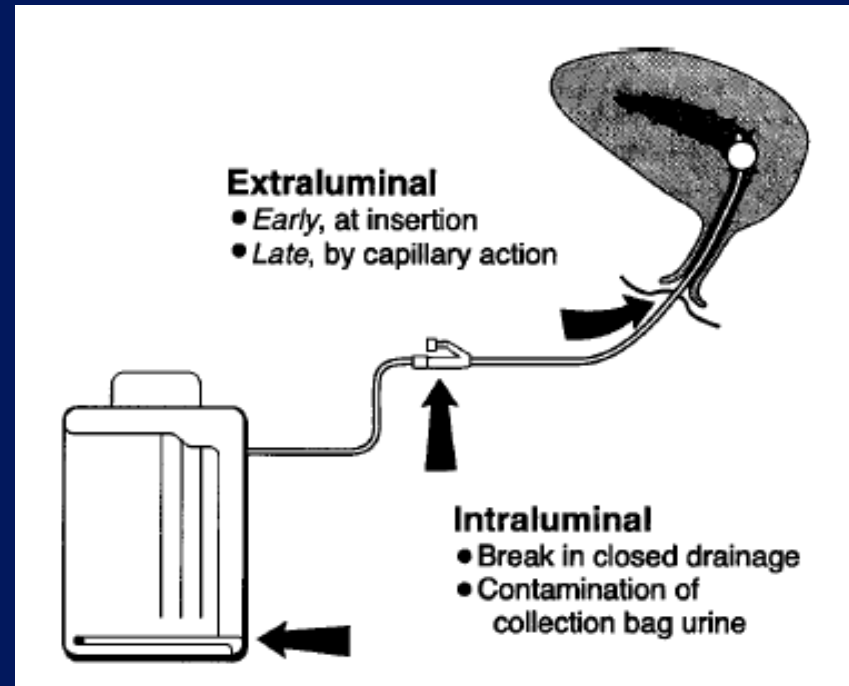
URINARY CATHETER USE

- 15-25% of hospitalized patients
- 5-10% (75,000-150,000) of patients in extended care facilities
- Often placed for inappropriate purposes
- Physicians frequently unaware
 - In a recent survey of US hospitals:
 - ◆ >50% did not monitor which patients were catheterized
 - ◆ 75% did not monitor duration and/or discontinuation

Adapted from CDC: http://www.cdc.gov/HAI/pdfs/toolkits/CAUTItoolkit_3_10.pdf

PATHOGENESIS OF CA-UTI

- Source of microorganisms
 - Endogenous: meatal, rectal, vaginal colonization
 - Exogenous: via contaminated hands of HCP during catheter insertion or manipulation of the collecting system



Catheter-Associated UTIs

- Introduction of bacteria into the bladder at the time of catheter insertion
- Extraluminal migration of bacteria or perianal bacteria into the bladder along the outer surface of the catheter
- Intraluminal retrograde migration of bacteria into the bladder from the drainage bag along the inner surface of the catheter following a catheter care violation

Antimicrobial Catheters



- Cochrane Review (Schumm, Lam, 2008)-23 trial involving 5236 hospital adults in 22 parallel group trials
- Conclusion 1-silver alloy (antiseptic) coated or nitrofurazone impregnated (antibiotic) urinary catheters might reduce infections in hospitalized adults...but the evidence is weak
- More effective antimicrobial coatings and larger trials are needed

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A Review of New Technologies for Environmental Services Summary

- Some gizmos have reduced HAIs (CHG patch)
- New gizmos/gadgets such as disinfection technologies (“no touch”, colorized disinfectant, persistent 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 consistently 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

