Inactivation of Emerging Pathogens and Continuous Room Decontamination Technologies

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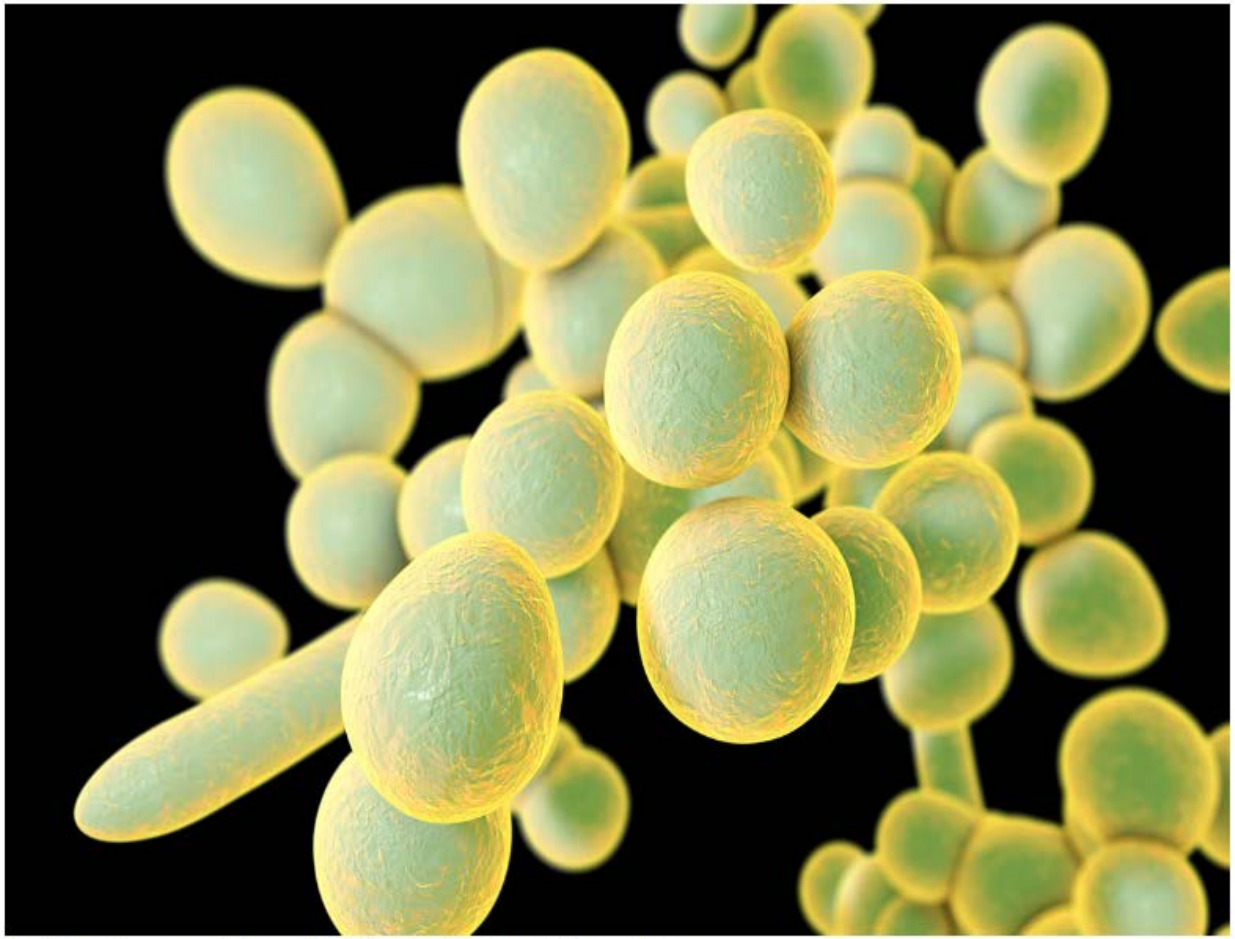
Inactivation of Emerging Pathogens and Continuous Room Decontamination Technologies

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber- *C. auris*, CRE. Anderson, Sexton-CRDT

- Germicidal efficacy against *Candida auris*
- Germicidal activity against carbapenem/colistin *Enterobacteriaceae*
- Continuous room decontamination technologies
  - Visible light disinfection
  - Dilute hydrogen peroxide gas technology
  - Persistent disinfectants

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.
- No hospital disinfectants are registered for use specifically against *C. auris*, and its susceptibility to germicides in not known

Effectiveness of Disinfectants Against *Candida auris* and Other *Candida* Species

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

TABLE 1. Characteristics of the Disinfectants Tested

Disinfectant	Active Components	Contact Time[a]	Sporicidal Claim[b]	*Candida albicans* Claim[c]
Clorox Healthcare bleach germicidal cleaner	Sodium hypochlorite 0.65%	1 min	Yes	Yes
Clorox Healthcare Fuzion cleaner disinfectant	Sodium hypochlorite 0.39%	1 min	Yes	Yes
Clorox germicidal bleach (1:10 dilution)	Sodium hypochlorite 0.825% when diluted	1 min	Yes	Yes
OxyCide daily disinfectant	Peracetic acid 1200 parts per million, hydrogen peroxide <1%, acetic acid	3 min	Yes	Yes
Clorox Healthcare hydrogen peroxide cleaner disinfectant	Hydrogen peroxide 1.4%	1 min[d]	No	Yes
Oxivir Tb	Hydrogen peroxide 0.5%	10 min	No	Yes
White distilled vinegar	Acetic acid >5% (pH 2.0)	3 min[e]	No	No
Purell healthcare surface disinfectant	Ethyl alcohol 29.4%	30 s	No	Yes
Lysol all-purpose cleaner	Alkyl dimethyl benzyl ammonium chlorides	10 min	No	Yes
Virex II 256	Didecyl dimethyl ammonium chloride, n-Alkyl dimethyl benzyl ammonium chloride	10 min	No	Yes

[a]Contact time for disinfectants based on manufacturers' recommendations for *Candida albicans* unless otherwise specified.
[b]Environmental Protection Agency–registered claim against *Clostridium difficile* spores.
[c]Environmental Protection Agency–registered claim against *Candida albicans*.
[d]A 1-minute exposure was used, but the claim is based on a 3-minute exposure.
[e]There is no established contact time for vinegar.

Effectiveness of Disinfectants Against *Candida auris* and Other *Candida* Species

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

In lab testing, sporicidal and IHP disinfectants were highly effective against *C. auris, C. glabrata and C. albicans*. Quats exhibited relatively poor activity against all of the *Candida* species

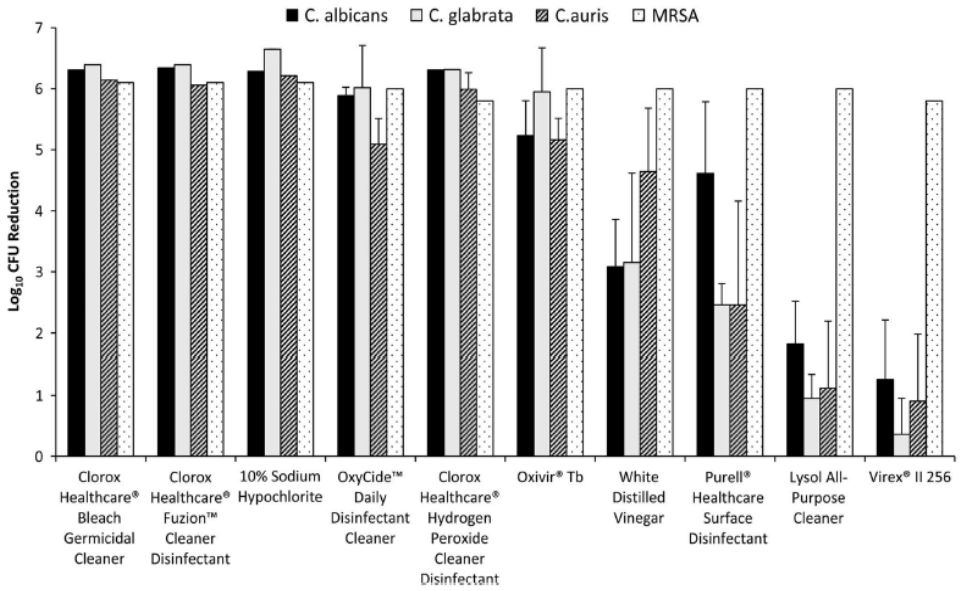


FIGURE 1. Mean log reductions for each of the disinfectants against the 3 *Candida* species and MRSA using the American Society for Testing and Materials (ASTM) Standard Quantitative Carrier Disk Test Method (ASTM E-2197-02).[7] Log reductions were calculated by subtracting viable organisms recovered after exposure to the disinfectants versus deionized water controls. Vinegar, Purell Healthcare Surface Disinfectant, and the 2 quaternary ammonium disinfectants were significantly less effective against the *Candida* species than against MRSA ($P \leq .02$). Error bars show standard error. MRSA, methicillin-resistant *Staphylococcus aureus*.

Efficacy of Disinfectants and Antiseptics against *Candida auris*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

- ≥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%

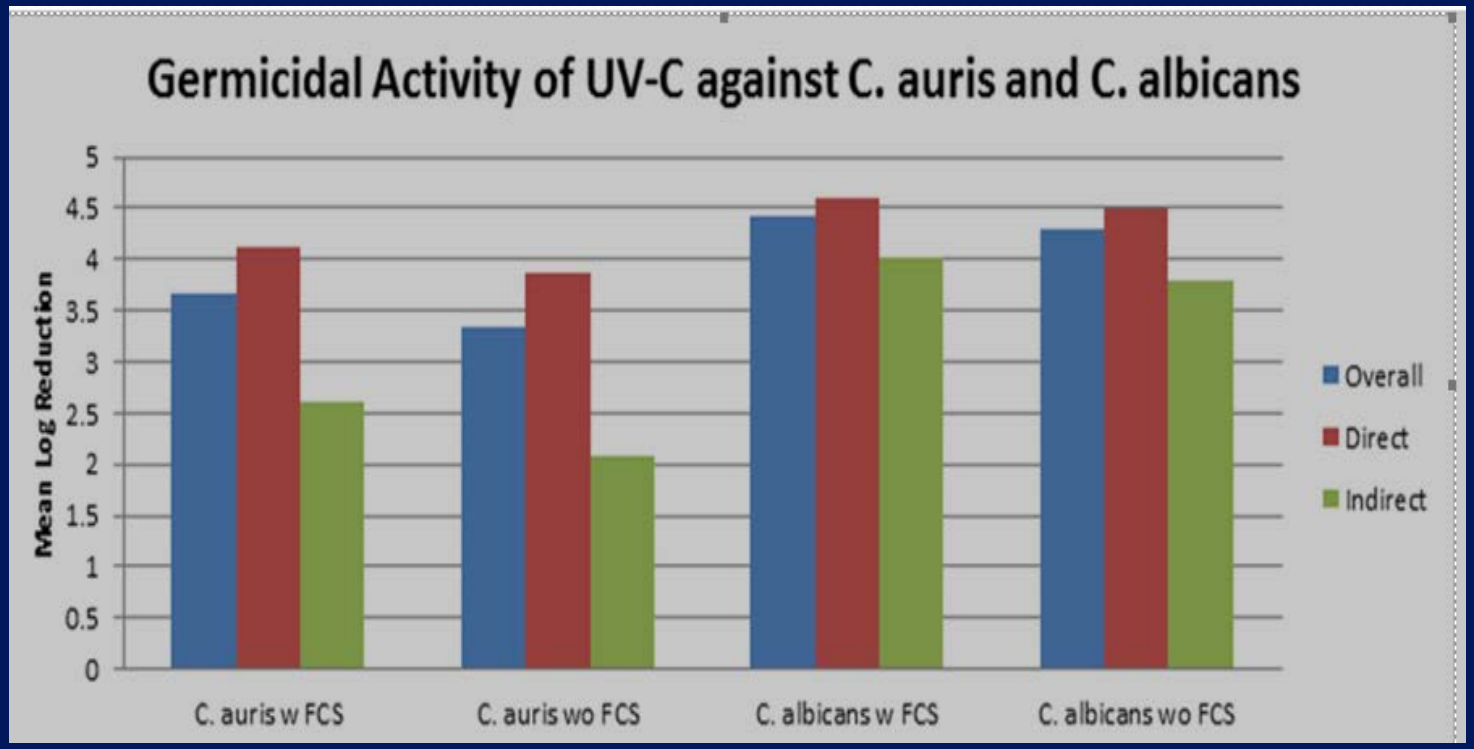
Efficacy of Disinfectants and Antiseptics against *Candida auris*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

- ≤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

Germicidal Activity of UV-C Against *C. auris* and *C. albicans*

UNC Hospitals, 2017



Very good inactivation of *Candida auris* by UV. Used Tru-D bacteria cycle (17-19 minute cycle, 12,000µWs/cm^2).

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

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

- ≥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*)

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

Rutala, Kanamori, Gergen et al. 2017

	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.

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

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

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

Visible Light Disinfection System

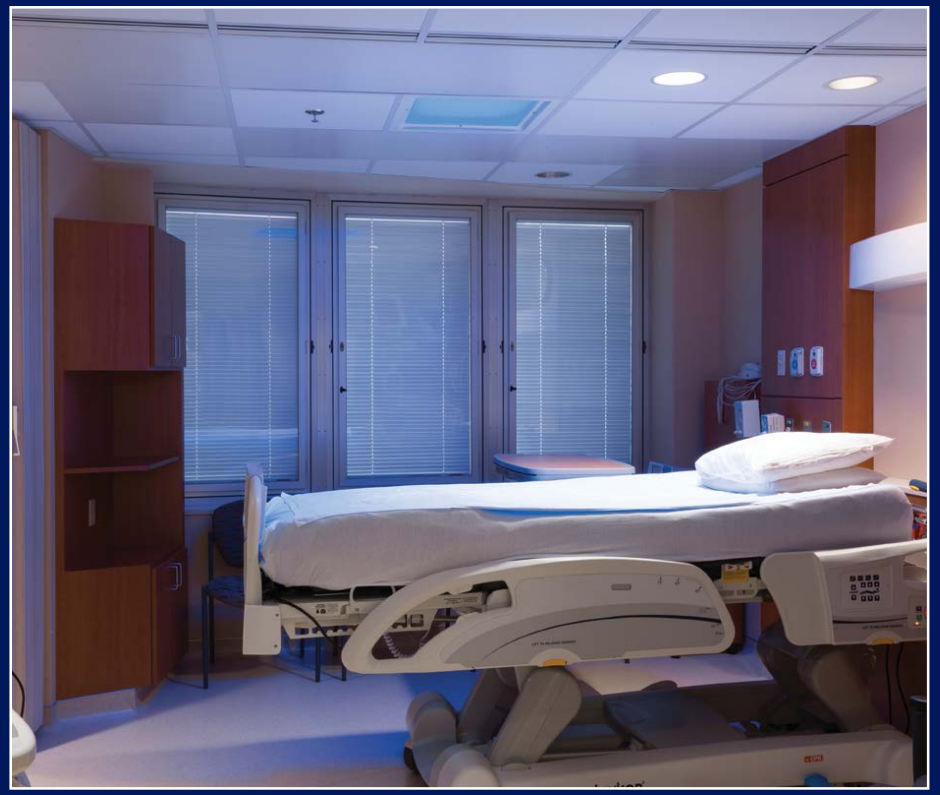
Rutala, Gergen, Kanamori, Sickbert-Bennett, Weber. 2015

- Testing performed using Formica sheets on which a template of a Rodac plate drawn
- Inoculum of 10^4 per Rodac template
- Formica sheets placed in room with 3, 2'x2' overhead LED ceiling fixture (illumination 800lux). Controls Formica sheets in adjacent room with fluorescent lights
- After time (0,1, 3, 6, 24h) DE Neutralizing were used to culture each Formica template

Visible Light Disinfection in a Patient Room

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

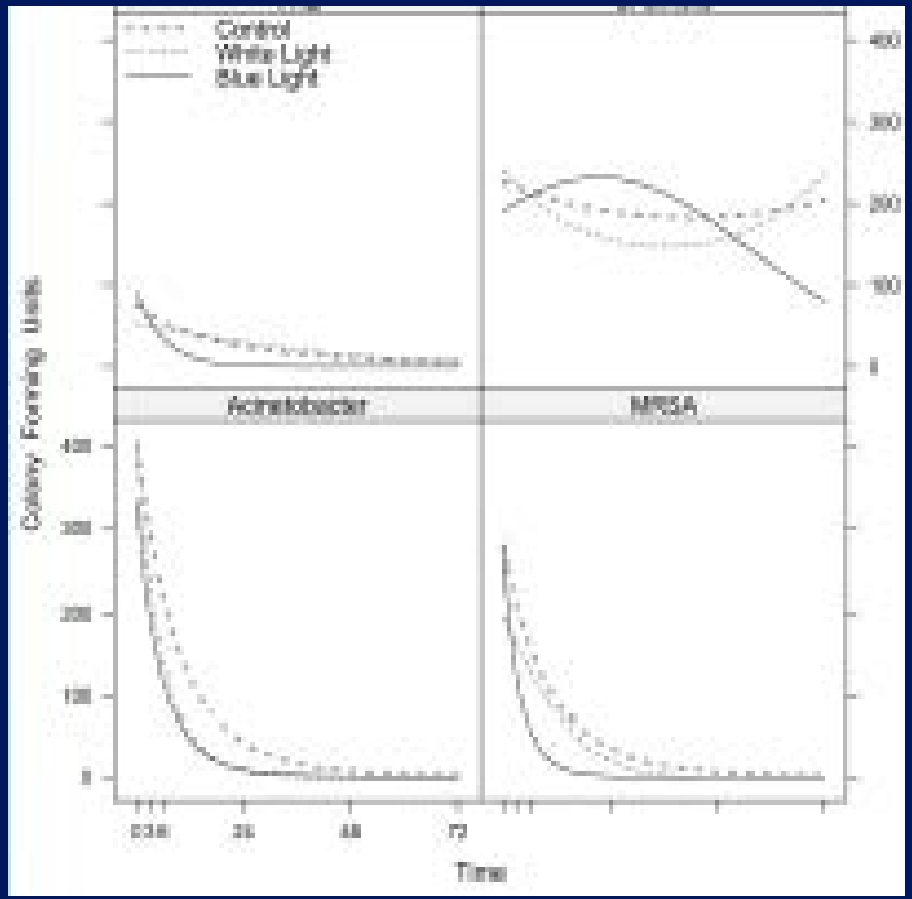
White light



Blue light-increase irradiance, increase kill

Inactivation of Health Pathogens by Continuous Visible Light Disinfection

Rutala et al. APIC 2017



- 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

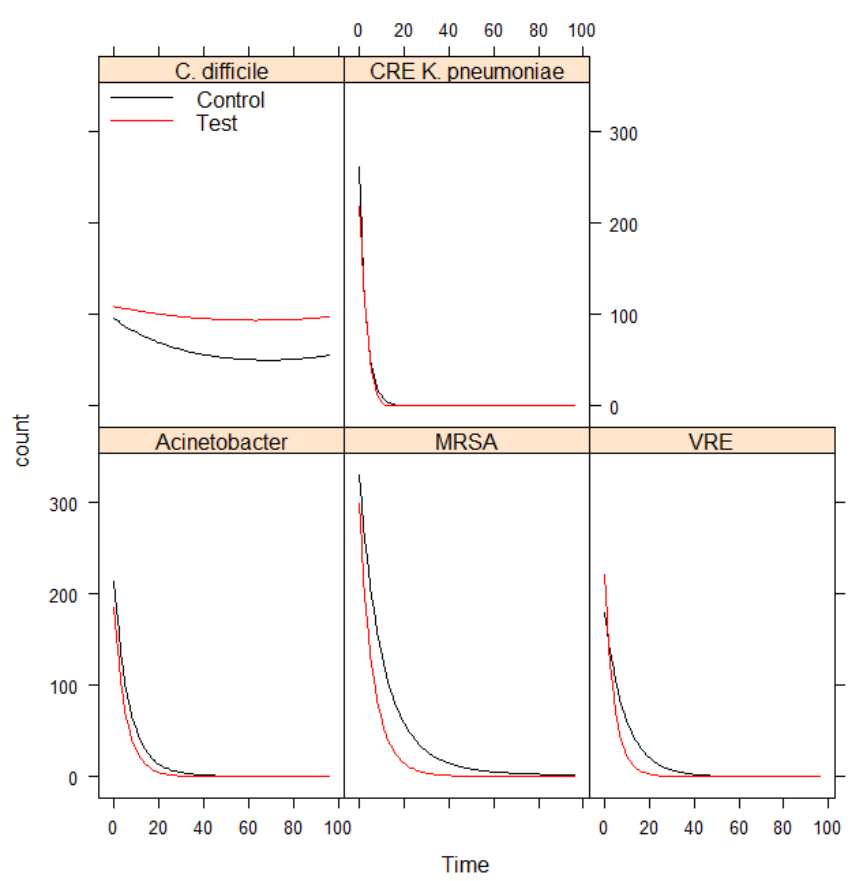
Rutala et al. APIC 2017

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

Inactivation of Health Pathogens by Continuous Visible Light Disinfection

Rutala et al. IDWeek 2017



- We assessed an overhead LED disinfecting system (Vital Vio, high-intensity narrow-spectrum light, 405 nm wavelength) for 5 test organisms
- Study demonstrated germicidal inactivation of MRSA, VRE, MDR-*Acinetobacter* with the continuous LED disinfection.
- There is insufficient evidence that the treatment made a difference in the mean CFUs of CRE *K. pneumonia* and *C. difficile*
- This technology may have promise for decontamination of the healthcare environment

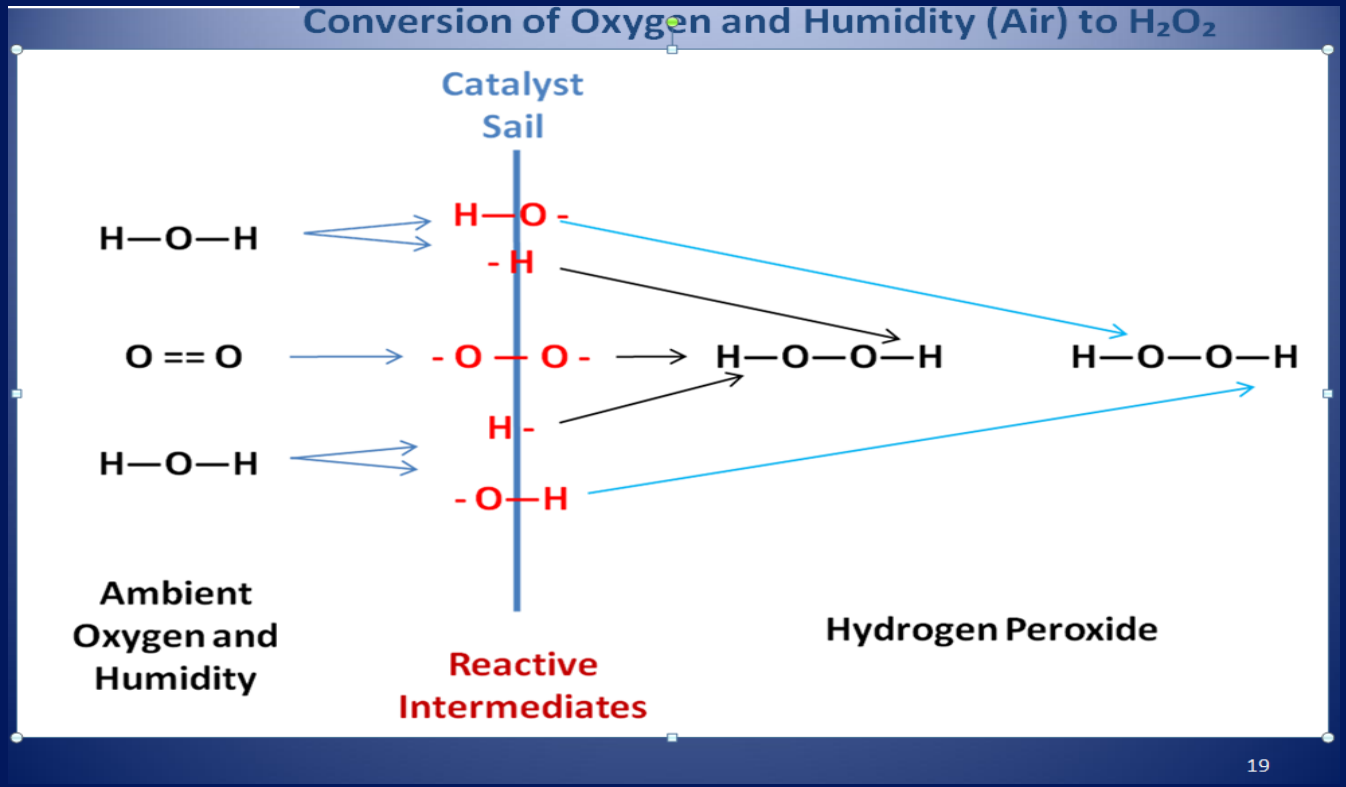
Dilute Hydrogen Peroxide Technology

Lee Antimicrobial Solutions LLC

- Dilute Hydrogen Peroxide (DHP) is a new form of hydrogen peroxide that can provide continuous room decontamination
- LAMS is the inventor of DHP Technology, holding both method and device patents in the US and in nine other countries to date (more pending)
- DHP is already cleared for market by the EPA as a Pesticide Device Technology.
- DHP is made catalytically from ambient humidity and oxygen in the air itself. Uses a UV light in the UVA band to activate the catalyst.

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



Duct-Mounted and Stand-Alone Devices

Uses Harmless Black Light in the UVA Range to Powers its Catalyst

Duct-Mounted Device

Operation of DHP Technology:

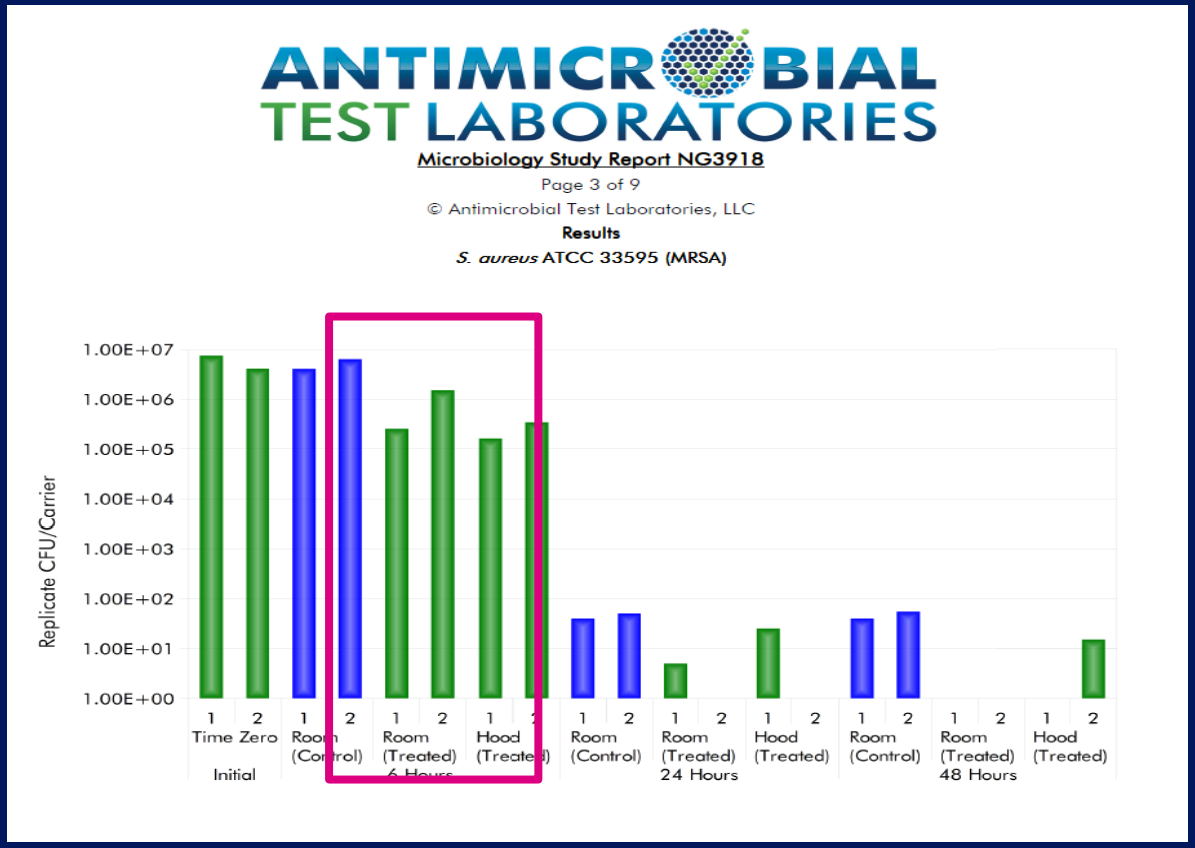
1. Installation: DHP devices are installed in HVAC ducts by simply cutting a small hole in the side of the duct, inserting the device, and bolting the device in place to seal the insertion hole. The device is powered by connection to the nearest electrical source. Stand-Alone DHP devices are available for areas that do not have HVAC ducting and can be bolted to floor or walls.

Stand-Alone Device with On-Board Filter and Fan

Dilute Hydrogen Peroxide Technology

Lee Antimicrobial Solutions LLC

83-95% reduction of MRSA in 6 hours (at 0.6ppm)



Application of Dilute Hydrogen Peroxide Gas Technology for Continuous Room Decontamination

- 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

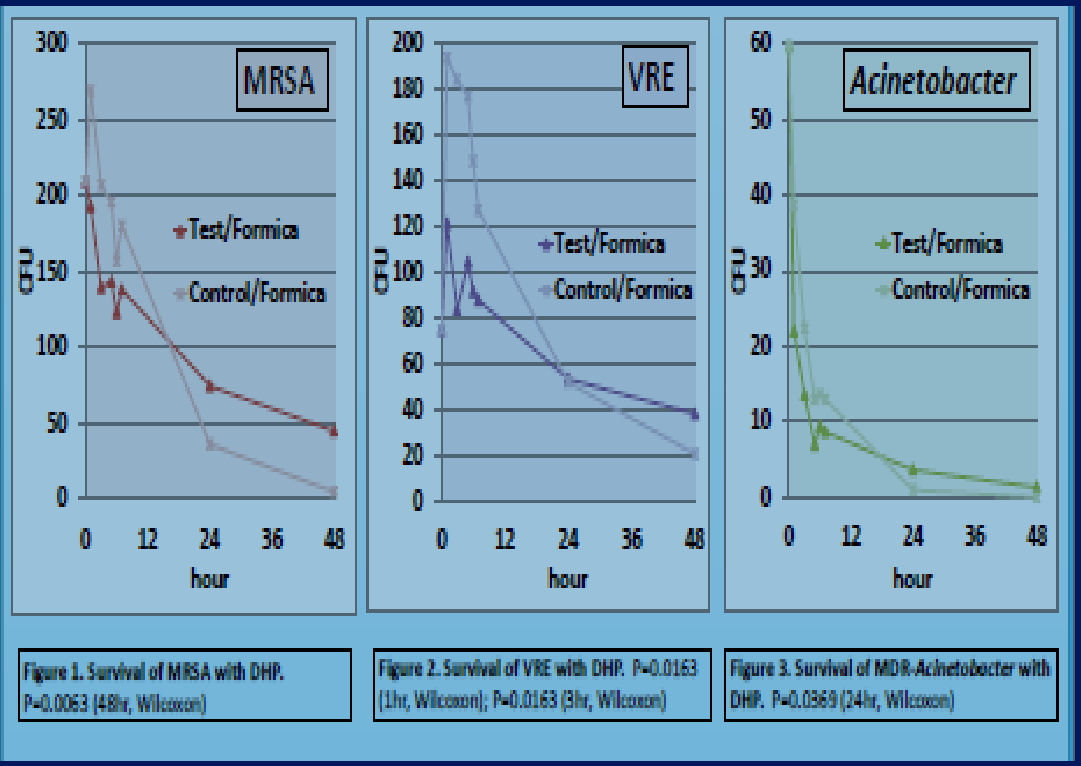


Figure 1. Survival of MRSA with DHP. P=0.0063 (48hr, Wilcoxon)

Figure 2. Survival of VRE with DHP. P=0.0163 (1hr, Wilcoxon); P=0.0163 (9hr, Wilcoxon)

Figure 3. Survival of MDR-Acinetobacter with DHP. P=0.0369 (24hr, Wilcoxon)

- 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

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Major article

Long-term efficacy of a self-disinfecting coating in an intensive care unit

Akrum H. Tamimi PhD, Sheri Carlino BS, Charles P. Gerba PhD *

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Key Words:
Disinfection
Bacteria
Self-disinfecting surface
Efficacy

Background: Cleaning and disinfecting fomites can effectively remove/kill pathogens on surfaces, but studies have shown that more than one-half the time, surfaces are not adequately cleaned or are recontaminated within minutes. This study evaluated a product designed to create a long-lasting surface coating that provides continuous disinfecting action.

Methods: This study was performed in an intensive care unit (ICU) in a major hospital. Various sites within the ICU were cultured before treatment and then at 1, 2, 4, 8, and 15 weeks after application of an antimicrobial coating. Samples were cultured for total bacteria, as well as *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococcus, and carbapenemase-resistant Enterobacteriaceae.

Results: The average bacterial count on all treated surfaces was reduced by >99% (2 logs) for at least 8 weeks after treatment. Overall, average levels of bacteria never returned to those observed before treatment even after 15 weeks. Antibiotic-resistant bacteria were found on 25% of the sites tested before treatment, but were isolated at only 1 site during the 15 weeks after treatment.

Conclusions: The product assessed in this study was found to have persisted over 15 weeks in reducing the total number of bacteria and antibiotic resistant bacteria on surfaces within an ICU.

Long-Term Efficacy of a Self-Disinfecting Coating in an ICU

Tamimi, Carlino, Gerba. AJIC 2014. 42:1178-81

Bacterial numbers were 99.9% less at 4 weeks after the treatment, 99% after 8 weeks, and almost 99% after 15 weeks. Must reapply every 3-4 months to ensure effective reduction.

Table 2
Average (arithmetic mean) total bacterial numbers (cfu) isolated on 100 cm^2 from fomites and percent reduction after treatment

		Weeks after treatment				
Variable	Baseline*	1	2	4	8	15
Number of samples	95	81	64	64	64	45
Average number of bacteria	233,064	98	80	43	2,247	3,320
Range	10-7,000,000	10-2,500	10-840	10-2,500	10-44,000	10-57,000
% reduction	NA	99.96	99.97	99.98	99.04	98.58

NA, not applicable.
*Before treatment.

IN VITRO EFFECTIVENESS OF A SILVER COATING AGAINST BACTERIAL CHALLENGE

- Study design: In vitro study
- Study agent: Surfacine (~10 μg/cm^2 silver iodide)
- Methods: Surface coated with Surfacine and then challenged with VRE
- Results:
  - Antimicrobial activity retained despite repeated dry wiping or wiping with a QUAT

Table 3. Effect on vancomycin-resistant Enterococcus (VRE) survival of wiping Surfacine on a treated surface over an extended period

Surface	Intervention	Day 1	Day 6	Day 13
Formica	Control	50	95	120
	Treated	0 (100%)[a]	0 (100%)	0 (100%)
	Treated & wiped	0 (100%)	0 (100%)	0 (100%)

Rutala WA, Weber DJ. Emerg Infect Dis 2001;7:348

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

- Disadvantages
  - Room decontamination/biocidal activity is slow
  - Capital equipment costs are substantial
  - Does not remove dust, dirt, stains that are important to patients and visitors
  - Studies have not shown whether the use will decrease HAIs

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- In general, emerging pathogens are susceptible to currently available disinfectants and technologies (UV).
- New continuous room decontamination technologies (e.g., light disinfection, low conc HP, persistent disinfectants) show promise

THANK YOU!

www.disinfectionandsterilization.org