Inactivation of Emerging Pathogens and Continuous Room Decontamination Technologies

William A. Rutala, Ph.D., M.P.H.
Director, Statewide Program for Infection Control and Epidemiology, Research Professor of Medicine, University of North Carolina (UNC)
Former Director, Hospital Epidemiology, Occupational Health and Safety Program, UNC Health Care, Chapel Hill
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>
<thead>
<tr>
<th>Disinfectant</th>
<th>Active Components</th>
<th>Contact Time</th>
<th>Sporicidal Claim</th>
<th><em>Candida albicans</em> Claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clorox Healthcare bleach germicidal cleaner</td>
<td>Sodium hypochlorite 0.65%</td>
<td>1 min</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Clorox Healthcare Fuzion cleaner disinfectant</td>
<td>Sodium hypochlorite 0.39%</td>
<td>1 min</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Clorox germicidal bleach (1:10 dilution)</td>
<td>Sodium hypochlorite 0.825% when diluted</td>
<td>1 min</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>OxyCide daily disinfectant</td>
<td>Peracetic acid 1200 parts per million, hydrogen peroxide &lt;1%, acetic acid</td>
<td>3 min</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Clorox Healthcare hydrogen peroxide cleaner disinfectant</td>
<td>Hydrogen peroxide 1.4%</td>
<td>1 min</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Oxivir Tb</td>
<td>Hydrogen peroxide 0.5%</td>
<td>10 min</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>White distilled vinegar</td>
<td>Acetic acid &gt;5% (pH 2.0)</td>
<td>3 min</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Purell healthcare surface disinfectant</td>
<td>Ethyl alcohol 29.4%</td>
<td>30 s</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Lysol all-purpose cleaner</td>
<td>Alkyl dimethyl benzyl ammonium chlorides</td>
<td>10 min</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Virex II 256</td>
<td>Didecyl dimethyl ammonium chloride, n-Alkyl dimethyl benzyl ammonium chloride</td>
<td>10 min</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*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.
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.
Efficacy of Disinfectants and Antiseptics against *Candida auris*

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

- $\geq 3 \log_{10}$ 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

- $\leq 3 \log_{10}$ (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/cm²).
Efficacy of Disinfectants and Antiseptics against Carbapenem-Resistant *Enterobacteriaceae*
Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

- $\geq 3 \log_{10}$ 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
  - $\sim 5,250$ 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*)
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
Enhanced Disinfection Leading to Reduction of Microbial Contamination and a Decrease in Patient Col/Infection

Rutala, Kanamori, Gergen et al. 2017

<table>
<thead>
<tr>
<th></th>
<th>Standard Method</th>
<th>Enhanced method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quat</td>
<td>Quat/UV</td>
</tr>
<tr>
<td>EIP (mean CFU per room)³</td>
<td>60.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Reduction (%)</td>
<td>94</td>
<td>81</td>
</tr>
<tr>
<td>Colonization/Infection (rate)³</td>
<td>2.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Reduction (%)</td>
<td>35</td>
<td>17</td>
</tr>
</tbody>
</table>

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
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

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Treatment (light)</th>
<th>Time (least number of hours) to achieve sustained microbial reduction of listed percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>25%</td>
</tr>
<tr>
<td>MRSA</td>
<td>White</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td>2</td>
</tr>
<tr>
<td>VRE</td>
<td>White</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td>2</td>
</tr>
<tr>
<td>MDR-Acinetobacter</td>
<td>White</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td>2</td>
</tr>
<tr>
<td>C. difficile</td>
<td>White</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td>56</td>
</tr>
</tbody>
</table>
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 H₂ and O₂ and electron make HP.
Duct-Mounted and Stand-Alone Devices
Uses Harmless Black Light in the UVA Range to Powers its Catalyst

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.
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 organism 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

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

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

Department of Soil, Water, and Environmental Science, University of Arizona, Tucson, AZ

**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 >59% (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.
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.
IN VITRO EFFECTIVENESS OF A SILVER COATING AGAINST BACTERIAL CHALLENGE

- Study design: In vitro study
- Study agent: Surfacine (~10 µg/cm² 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>
<thead>
<tr>
<th>Surface</th>
<th>Intervention</th>
<th>Day 1</th>
<th>Day 6</th>
<th>Day 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formica</td>
<td>Control</td>
<td>50</td>
<td>95</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Treated</td>
<td>0 (100%)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0 (100%)</td>
<td>0 (100%)</td>
</tr>
<tr>
<td></td>
<td>Treated &amp; wiped</td>
<td>0 (100%)</td>
<td>0 (100%)</td>
<td>0 (100%)</td>
</tr>
</tbody>
</table>

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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  ■ Visible light disinfection
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Inactivation of Emerging Pathogens and Continuous Room Decontamination Technologies

- 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