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

William A. Rutala, Ph.D., M.P.H., C.I.C.
Director, Statewide Program for Infection Control and Epidemiology and Professor of Medicine, University of North Carolina at Chapel Hill, NC, USA
Former Director, Hospital Epidemiology, Occupational Health and Safety, UNC Health Care, Chapel Hill, NC (1979-2017)
DISCLOSURES
2019

• Consultations
  ■ ASP (Advanced Sterilization Products), PDI

• Honoraria
  ■ PDI, ASP, 3M

• Scientific Advisory Board
  ■ Kinnos

• Grants
  ■ CDC
THANK YOU!

Instituting Practices that Prevent Infectious Disease Transmission via Environment
www.disinfectionandsterilization.org
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.
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
Environmental Contamination Leads to HAI


- 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 HAI
- 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%)

• 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 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 ENVIRONMENTAL SURFACES PLAY A ROLE IN TRANSMISSION

- MRSA
- VRE
- *Acinetobacter* spp.
- *Clostridium difficile*
- Norovirus
- Rotavirus
- SARS
<table>
<thead>
<tr>
<th>Site</th>
<th>Outbreak</th>
<th>Endemic</th>
<th>Site estimated mean$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Floor</strong></td>
<td>9%</td>
<td>50-55%</td>
<td>34.5%</td>
</tr>
<tr>
<td><strong>Bed linen</strong></td>
<td>..</td>
<td>38-54%</td>
<td>41%</td>
</tr>
<tr>
<td><strong>Patient gown</strong></td>
<td>..</td>
<td>40-53%</td>
<td>40.5%</td>
</tr>
<tr>
<td><strong>Overbed table</strong></td>
<td>..</td>
<td>18-42%</td>
<td>40%</td>
</tr>
<tr>
<td><strong>Blood pressure cuff</strong></td>
<td>13%</td>
<td>25-33%</td>
<td>21%</td>
</tr>
<tr>
<td><strong>Bed or siderails</strong></td>
<td>5%</td>
<td>1-30%</td>
<td>27%</td>
</tr>
<tr>
<td><strong>Bathroom door handle</strong></td>
<td>..</td>
<td>8-24%</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Infusion pump button</strong></td>
<td>13%</td>
<td>7-18%</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Room door handle</strong></td>
<td>11%</td>
<td>4-8%</td>
<td>21.5%|</td>
</tr>
<tr>
<td><strong>Furniture</strong></td>
<td>11%</td>
<td>44-59%</td>
<td>27%</td>
</tr>
<tr>
<td><strong>Flat surfaces</strong></td>
<td>7%</td>
<td>32-38%</td>
<td>21.5%</td>
</tr>
<tr>
<td><strong>Sink taps or basin fitting</strong></td>
<td>..</td>
<td>14%</td>
<td>23.5%</td>
</tr>
<tr>
<td><strong>Average quoted</strong></td>
<td>11%</td>
<td>27%</td>
<td>37%</td>
</tr>
</tbody>
</table>

ENVIRONMENTAL SURVIVAL OF KEY PATHOGENS ON HOSPITAL SURFACES

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Survival Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S. aureus (including MRSA)</strong></td>
<td>7 days to &gt;12 months</td>
</tr>
<tr>
<td><strong>Enterococcus spp. (including VRE)</strong></td>
<td>5 days to &gt;46 months</td>
</tr>
<tr>
<td><strong>Acinetobacter spp.</strong></td>
<td>3 days to 11 months</td>
</tr>
<tr>
<td><strong>Clostridium difficile (spores)</strong></td>
<td>&gt;5 months</td>
</tr>
<tr>
<td>Norovirus (and feline calicivirus)</td>
<td>8 hours to &gt;2 weeks</td>
</tr>
<tr>
<td><strong>Pseudomonas aeruginosa</strong></td>
<td>6 hours to 16 months</td>
</tr>
<tr>
<td><strong>Klebsiella spp.</strong></td>
<td>2 hours to &gt;30 months</td>
</tr>
</tbody>
</table>

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)

Major article

Does improving surface cleaning and disinfection reduce health care-associated infections?

Curtis J. Donskey MD a, b, *

a Geriatric Research, Education, and Clinical Center, Cleveland Veterans Affairs Medical Center, Cleveland, OH
b Case Western Reserve University School of Medicine, Cleveland, OH

Key Words: Envirionment, 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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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 HAI's

• 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
Disinfection of Noncritical Surfaces Bundle

• 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
  - 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 to create a standardized plan for cleaning patient rooms and pieces of patient equipment throughout the hospital
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.
Blood Pressure Cuff
Non-Critical Patient Care Item
Surface Disinfection
Noncritical Patient Care

• 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*
Surface Disinfection
Environmental Surfaces

• 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*
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
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 (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.
EVIDENCE THAT ALL TOUCHABLE ROOM SURFACES ARE EQUALLY CONTAMINATED

<table>
<thead>
<tr>
<th>Surface (no. of samples)</th>
<th>Precleaning</th>
<th>Postcleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (n = 40)</td>
<td>71.9 (46.5–97.3)</td>
<td>9.6 (3.8–15.4)</td>
</tr>
<tr>
<td>Medium (n = 42)</td>
<td>44.2 (28.1–60.2)</td>
<td>9.3 (1.2–17.5)</td>
</tr>
<tr>
<td>Low (n = 37)</td>
<td>56.7 (34.2–79.2)</td>
<td>5.7 (2.01–9.4)</td>
</tr>
</tbody>
</table>

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

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


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

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

*HCW, healthcare worker. * Number of contaminated samples/number of samples obtained.
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

- 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)
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

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

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.

- 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 chargers; 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
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
• 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.
PROPERTIES OF AN IDEAL DISINFECTANT

- 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
Effective Surface Decontamination

Product and Practice = Perfection
Effective Surface Decontamination

Product and Practice = Perfection
### Exposure time ≥ 1 min

<table>
<thead>
<tr>
<th>Germicide</th>
<th>Use Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl or isopropyl alcohol</td>
<td>70-90%</td>
</tr>
<tr>
<td>Chlorine</td>
<td>100ppm (1:500 dilution)</td>
</tr>
<tr>
<td>Phenolic</td>
<td>UD</td>
</tr>
<tr>
<td>Iodophor</td>
<td>UD</td>
</tr>
<tr>
<td>Quaternary ammonium (QUAT)</td>
<td>UD</td>
</tr>
<tr>
<td>QUAT with alcohol</td>
<td>RTU</td>
</tr>
<tr>
<td>Improved hydrogen peroxide (HP)</td>
<td>0.5%, 1.4%</td>
</tr>
<tr>
<td>PA with HP, HP, chlorine (C. difficile)</td>
<td>UD</td>
</tr>
</tbody>
</table>

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)
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
MOST PREVALENT PATHOGENS CAUSING HAI

- 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
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](http://www.epa.gov/oppad001/list_k_clostridium.pdf)
- Most registered products are chlorine-based, some HP/PA-based, one 4% HP
No data that demonstrate that disinfection times beyond 1 minute improve microbial reduction and have an infection prevention benefit.
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
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. Webera,b

aDepartment of Hospital Epidemiology, University of North Carolina Health Care, Chapel Hill, North Carolina, USA
bDivision 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*


- $\geq 3 \log_{10}$ 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*)
Deadly, drug-resistant Candida yeast infection spreads in the US
Efficacy of Disinfectants and Antiseptics against *Candida auris*

• $\geq 3 \log_{10}$ 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*


- $\leq 3 \log_{10}$ (most $< 2 \log_{10}$) reduction (*C. auris*, 1m, 5% FCS, QCT)
  - 0.55% OPA
  - 3% hydrogen peroxide
  - Quat, (0.085% QACs)
  - 10% povidone-iodine
  - $\sim 1,050$ ppm chlorine
  - 2% Chlorhexidine gluconate-CHG
  - 4% CHG
  - 0.5% triclosan
  - 1% CHG, 61% ethyl alcohol
  - 1% chloroxylenol
Dry Biofilms on Healthcare Surfaces
Examples of “Dry” Biofilms Recovered from Surfaces
Ledwoch et al. J Hosp Infect 2018;100:e47-e56

Figure 4. Examples of "dry" biofilms recovered from surfaces; magnification ×10,000. (A, B) Patient folders, (C) patient chair, (D) keyboard key. Images of biofilms were coloured in purple to help visualization and contrast using GNU Image manipulation program (GIMP 2.8) software. Images were not otherwise altered.
Biofilms on Instruments and Environmental Surfaces
Alfa, AJIC 2019;47:A39-A45

• Three types of biofilm (microbial community)
  ■ Traditional hydrated biofilm (water content 90%)
  ■ Build-up biofilm—occurs in endoscope channels
  ■ Dry surface biofilm—heterogenous accumulation of organisms and other material in a dry matrix (water content 61%)
    ◆ Raises questions about the inactivation of microbes with a dry surface biofilm by currently used cleaning/disinfecting methods
    ◆ Their role in transmission needs to be established
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
  ■ 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 to create a standardized plan for cleaning patient rooms and pieces of patient equipment throughout the hospital
Disinfection of Noncritical Surfaces Bundle

- Develop policies and procedures
- Select cleaning and disinfecting products
- Educate staff-environmental services and nursing
- Monitor compliance (thoroughness of cleaning, product use) and feedback
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Effective Surface Decontamination

Product and Practice = Perfection
Thoroughness of Environmental Cleaning
Carling et al. ECCMID, Milan, Italy, May 2011

Mean = 32%

DAILY CLEANING
TERMINAL CLEANING

>110,000 Objects
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/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)
Hospitals can improve their thoroughness of terminal room disinfection through fluorescent monitoring.
Fluorescent marker is a useful tool in determining how thoroughly a surface is wiped and mimics the microbiological data better than ATP.
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

Kang et al. J Hosp Infect 2017

Colorized disinfection – contact time compliance

- 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
Increased visibility when disinfecting surfaces, fewer missed spots
Real-time quality control that allows staff to monitor thoroughness of cleaning
By improving thoroughness will it reduce microbial contamination and reduce transmission?
Disinfection of Noncritical Surfaces Bundle

- 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
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)
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" with microbicidal data in literature) should be used (capital equipment budget) for terminal room disinfection (e.g., after discharge of patients on Contact Precautions).
Disinfection of Noncritical Surfaces Bundle

• 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
Our Responsibility to the Future

Institute Practices that Prevent All Infectious Disease Transmission via Environment
Continuous Room Decontamination Technologies for Disinfection of the Healthcare Environment

- Visible light disinfection through LEDs
- Low concentration hydrogen peroxide
- Self-disinfecting surfaces
- Persistent (or continuously active) disinfectant that provides continuous disinfection action
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 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. ICHE 2018;39:1250-1253

<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>

The earliest hour after which the model predicts a sustained reduction of CFUs by the stated percentage for epidemiologically-important pathogens with the “white” light and the “blue” light. “NA” indicates that a sustained reduction of the given was level was not achieved. Note that the largest reduction listed is 90% because the model cannot predict a 100% reduction except after infinite hours have passed.

MDR, multidrug-resistant; MRSA, methicillin-resistant Staphylococcus aureus; VRE, vancomycin-resistant enterococci
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.
Dilute Hydrogen Peroxide Technology

- Dilute Hydrogen Peroxide (DHP) is a new form of hydrogen peroxide that can provide continuous room decontamination.
- 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.
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
Rutala et al. ID Week. San Diego. October 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.
Evaluation of a Continuously Active Disinfectant

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

Abrasion Tester

Test Surface

Abrasion Boat
Evaluation of a Continuously Active Disinfectant
“EPA Protocol for Residual Self-Sanitizing Activity of Dried Chemical Residuals on Hard, Non-Porous Surfaces”

- 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 \( (10^3, 30\text{min dry}) \) over 24hr
- At the end of the study and at least 24 hours later, the ability of the test surface to kill microbes (99.9%) within 5 min is measured using the last inoculation \( (10^6) \)
**Efficacy of a Continuously Active Surface Disinfectant**

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

4-5 log$_{10}$ reduction in 5min over 24hr for most pathogens; ~99% reduction with *Klebsiella* and CR *Enterobacter*.

<table>
<thead>
<tr>
<th>Test Pathogen</th>
<th>Mean Log$_{10}$ Reduction, 95% CI n=4</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S.aureus</em></td>
<td>4.4 (3.9, 5.0)</td>
</tr>
<tr>
<td><em>S.aureus</em> (Formica)</td>
<td>4.1 (3.8, 4.4)</td>
</tr>
<tr>
<td><em>S.aureus</em> (stainless steel)</td>
<td>5.5 (5.2, 5.9)</td>
</tr>
<tr>
<td>VRE</td>
<td>$\geq 4.5$</td>
</tr>
<tr>
<td><em>E.coli</em></td>
<td>4.8 (4.6, 5.0)</td>
</tr>
<tr>
<td><em>Enterobacter sp.</em></td>
<td>4.1 (3.5, 4.6)</td>
</tr>
<tr>
<td><em>Candida auris</em></td>
<td>$\geq 5.0$</td>
</tr>
<tr>
<td><em>K pneumoniae</em></td>
<td>1.5 (1.4, 1.6)</td>
</tr>
<tr>
<td>CR <em>E.coli</em></td>
<td>3.0 (2.6, 3.4)</td>
</tr>
<tr>
<td>CR <em>Enterobacter</em></td>
<td>2.0 (1.6, 2.4)</td>
</tr>
<tr>
<td>CR <em>K pneumoniae</em></td>
<td>2.1 (1.8, 2.4)</td>
</tr>
</tbody>
</table>

*Test surface glass unless otherwise specified*
# Comparison of CAD with Three Disinfectants Using EPA Method and *S. aureus*

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

The table below compares the mean log reduction of *S. aureus* for different disinfectants:

<table>
<thead>
<tr>
<th>Test Disinfectant</th>
<th>Mean Log$_{10}$ Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuously Active Disinfectant</td>
<td>4.4</td>
</tr>
<tr>
<td>Quat-Alcohol</td>
<td>0.9</td>
</tr>
<tr>
<td>Improved hydrogen peroxide</td>
<td>0.2</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Preliminary studies with a new continuously active disinfectant are promising (e.g., 4-5 log\(_{10}\) reduction in 5 min over 24 hr).

Unclear why 99% reduction with Klebsiella and CR Enterobacter; most surfaces have <100 CFU/Rodac.

Continuously active disinfectants may reduce or eliminate the problem of recontamination.
Continuous Room Decontamination Technologies for Disinfection of the Healthcare Environment

Microbial Reductions

- Visible light disinfection through LEDs; 90%, 24h
- Low concentration hydrogen peroxide; not detectable
- Self-disinfecting surfaces
- Persistent (or continuously active) disinfectant that provides continuous disinfection action; ≥99.99% reduction in 5m over 24h
Disinfection of Noncritical Surfaces Bundle

• 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
How Will We Prevent Infections Associated with the Environment?

- Implement evidence-based practices for surface disinfection
  - Evidence-based policies
  - 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 ideally, reduce HAIs at terminal/discharge disinfection (MDROs-Cd, MRSA, VRE)
- When available and supported by peer-reviewed publications, use new continuous room decontamination technology that continuously reduces microbial contamination
THANK YOU!

www.disinfectionandsterilization.org
Microbiological samples were collected using Rodac plates from resident rooms and common areas in 5 local LTCFs.

5 samples from up to 10 environmental surfaces were collected.

EIPs were defined as MRSA, VRE, *C. difficile* and MDR GNR.
## Quantitative Analysis of Microbial Burden on Long-Term Care Facilities Environmental Surfaces

DiBiase et al. ID Week Poster 2018

<table>
<thead>
<tr>
<th>Pathogen Identified</th>
<th>Resident Rooms</th>
<th>Community Rooms</th>
<th>Overall Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Positive Rodac with EIP</td>
<td>EIP Total Counts on Positive Rodacs</td>
<td>EIP Counts per Positive Rodac</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>C. difficile</td>
<td>34</td>
<td>856</td>
<td>25.18</td>
</tr>
<tr>
<td>MRSA</td>
<td>51</td>
<td>2998</td>
<td>58.78</td>
</tr>
<tr>
<td>VRE</td>
<td>1</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>MDR GNR</td>
<td>10</td>
<td>43</td>
<td>4.30</td>
</tr>
</tbody>
</table>
• Varying levels of CFU and EIP on environmental sites at LTCFs were found
• Colonization status of a resident was a strong predictor of higher levels of EIP being recovered from his/her room
• MRSA was the most common EIP recovered from Rodac plates, followed by *C. difficile*
• Infection prevention strategies (e.g., hand hygiene, disinfection, etc) should be performed in the LTCF setting on a routine and consistent basis