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

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Former Director, Hospital Epidemiology, Occupational Health and Safety, UNC Health Care, Chapel Hill, NC (1979-2017)
DISCLOSURES
2020-2021

- Consultations
  - PDI (Professional Disposable International)
- Honoraria
  - PDI
- Other
  - Kinnos
Best Practices in Disinfection of Noncritical Surfaces in the Healthcare Setting: A Bundle Approach and New Strategies

• Disinfection of noncritical surfaces in healthcare: A bundle approach
  ■ Overview of how environment contributes to HAIs
  ■ Policy, products, educate/train, compliance, “no touch”

• New Strategies in cleaning and disinfection
  ■ Colorized disinfectant, new sporicide, sporicide at discharge cleaning, emerging pathogens, electrostatic sprayer, continuously active disinfectant
Sources of Healthcare-Associated Pathogens


- Endogenous flora (SSI, UTI, CLABSI): 40-60%
- Exogenous: 20-40% (e.g., cross-infection via contaminated hands [staff, visitors])
- Other (environment): 20%
  - Medical devices
  - Contact with environmental surfaces (direct and indirect contact)
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 HAIs
- 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%; Shaughnessy et al. ICHE 2011;32:201)
- 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 or Patients 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 ENVIRONMENTIAL SURFACES PLAY A ROLE IN TRANSMISSION

- MRSA
- VRE
- *Acinetobacter* spp.
- *Clostridium difficile*
- Norovirus
- Rotavirus
- SARS
# Environmental Contamination

## Endemic and Epidemic MRSA

*Dancer SJ et al. Lancet ID 2008;8(2):101-13*

<table>
<thead>
<tr>
<th></th>
<th>Outbreak</th>
<th>Endemic</th>
<th>Site estimated mean $</th>
<th>Site estimated mean $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td>9%</td>
<td>50-55%</td>
<td>44-60%</td>
<td>24%</td>
</tr>
<tr>
<td>Bed linen</td>
<td>...</td>
<td>38-54%</td>
<td>44%</td>
<td>34%</td>
</tr>
<tr>
<td>Patient gown</td>
<td>...</td>
<td>40-53%</td>
<td>...</td>
<td>34%</td>
</tr>
<tr>
<td>Overbed table</td>
<td>...</td>
<td>18-42%</td>
<td>64-67%</td>
<td>24%</td>
</tr>
<tr>
<td>Blood pressure cuff</td>
<td>13%</td>
<td>25-33%</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Bed or siderails</td>
<td>5%</td>
<td>1-30%</td>
<td>44-60%</td>
<td>21%</td>
</tr>
<tr>
<td>Bathroom door handle</td>
<td>...</td>
<td>8-24%</td>
<td>...</td>
<td>12%</td>
</tr>
<tr>
<td>Infusion pump button</td>
<td>13%</td>
<td>7-18%</td>
<td>...</td>
<td>30%</td>
</tr>
<tr>
<td>Room door handle</td>
<td>11%</td>
<td>4-8%</td>
<td>...</td>
<td>23%</td>
</tr>
<tr>
<td>Furniture</td>
<td>11%</td>
<td>...</td>
<td>44-59%</td>
<td>19%</td>
</tr>
<tr>
<td>Flat surfaces</td>
<td>7%</td>
<td>...</td>
<td>32-38%</td>
<td>...</td>
</tr>
<tr>
<td>Sink taps or basin fitting</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>14%</td>
</tr>
<tr>
<td>Average quoted*</td>
<td>11%</td>
<td>27%</td>
<td>49%</td>
<td>25%</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Survival Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. aureus (including MRSA)</td>
<td>7 days to &gt;12 months</td>
</tr>
<tr>
<td><em>Enterococcus</em> spp. (including VRE)</td>
<td>5 days to &gt;46 months</td>
</tr>
<tr>
<td><em>Acinetobacter</em> spp.</td>
<td>3 days to 11 months</td>
</tr>
<tr>
<td><em>Clostridium difficile</em> (spores)</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><em>Pseudomonas aeruginosa</em></td>
<td>6 hours to 16 months</td>
</tr>
<tr>
<td><em>Klebsiella</em> spp.</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, c

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

two sentences on the right side are cut off; it continues with: "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 HAIs

• 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
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
A Bundle Approach to Surface Disinfection

- 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 (and new strategies)
Disinfection of Noncritical Surfaces Bundle

NL Havill AJIC 2013;41:S26-30; Rutala, Weber. AJIC 2019;47:A96-A105

- 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

NL Havill AJIC 2013;41:S26-30; Rutala, Weber. AJIC 2019;47:A96-A105

• 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).
Clean/disinfect at least daily (one-step cleaning and disinfection)
REVIEW 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 some cases “best” practices not scientifically determined.
Blood Pressure Cuff
Non-Critical Patient Care Item
• Disinfecting Noncritical Patient-Care Items
  - Process noncritical patient-care equipment with an 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*
# Effectiveness of Disinfectants Against MRSA and VRE


<table>
<thead>
<tr>
<th>Product</th>
<th>VSE 0.5 min</th>
<th>VSE 5 min</th>
<th>VRE 0.5 min</th>
<th>VRE 5 min</th>
<th>MSSA 0.5 min</th>
<th>MSSA 5 min</th>
<th>MRSA 0.5 min</th>
<th>MRSA 5 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesphe IIse</td>
<td>&gt;4.3</td>
<td>&gt;4.3</td>
<td>&gt;4.8</td>
<td>&gt;4.8</td>
<td>&gt;5.1</td>
<td>&gt;5.1</td>
<td>&gt;4.6</td>
<td>&gt;4.6</td>
</tr>
<tr>
<td>Clorox</td>
<td>&gt;5.4</td>
<td>&gt;5.4</td>
<td>&gt;4.9</td>
<td>&gt;4.9</td>
<td>&gt;5.0</td>
<td>&gt;5.0</td>
<td>&gt;4.6</td>
<td>&gt;4.6</td>
</tr>
<tr>
<td>Lysol Disinfectant</td>
<td>&gt;4.3</td>
<td>&gt;4.3</td>
<td>&gt;4.8</td>
<td>&gt;4.8</td>
<td>&gt;5.1</td>
<td>&gt;5.1</td>
<td>&gt;4.6</td>
<td>&gt;4.6</td>
</tr>
<tr>
<td>Lysol Antibacterial</td>
<td>&gt;5.5</td>
<td>&gt;5.5</td>
<td>&gt;5.5</td>
<td>&gt;5.5</td>
<td>&gt;5.1</td>
<td>&gt;5.1</td>
<td>&gt;4.6</td>
<td>&gt;4.6</td>
</tr>
<tr>
<td>Vinegar</td>
<td>0.1</td>
<td>5.3</td>
<td>1.0</td>
<td>3.7</td>
<td>+1.1</td>
<td>-0.9</td>
<td>+0.6</td>
<td>2.3</td>
</tr>
</tbody>
</table>

**Table 2**

**Disinfectant Activity Against Antibiotic-Susceptible and Antibiotic-Resistant Bacteria**

| Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *S aureus*; VRE, vancomycin-resistant *Enterococcus*; VSE, vancomycin-susceptible *Enterococcus*. Data represent mean of two trials (n=2). Values preceded by “>” represent the limit of detection of the assay. Assays were conducted at a temperature of 20°C and a relative humidity of 45%. Results were calculated as the log of Nf/No, where Nf is the titer of bacteria surviving after exposure and No is the titer of the control. |
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
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*
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.
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.
EVIDENCE THAT ALL TOUCHABLE ROOM SURFACES ARE EQUALLY CONTAMINATED

Huslage K, Rutala W, Gergen M, Sickbert-Bennett S, Weber D
ICHE 2013;34:211-2

JHI 2018;98:90-95

<table>
<thead>
<tr>
<th>Surface (no. of samples)</th>
<th>Precleaning Mean CFUs/RODAC (95% CI)</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>

NOTE. CFU, colony-forming unit; CI, confidence interval.
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.
FIGURE 1. Illustration of high-touch surfaces sampled. Star, surfaces less than or equal to 3 feet from the center of the bed; square, surfaces more than 3 feet from the center of the bed; circle, personal items.
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 charges; 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
• 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)
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
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.
• Cleaning-removes organisms/organic matter
• Disinfection-inactivates organisms
Effectiveness of Different Methods of Surface Disinfection for MRSA

<table>
<thead>
<tr>
<th>Technique (with cotton)</th>
<th>MRSA Log_{10} Reduction (QUAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated cloth</td>
<td>4.41</td>
</tr>
<tr>
<td>Spray (10s) and wipe</td>
<td>4.41</td>
</tr>
<tr>
<td>Spray, wipe, spray (1m), wipe</td>
<td>4.41</td>
</tr>
<tr>
<td>Spray</td>
<td>4.41</td>
</tr>
<tr>
<td>Spray, wipe, spray (until dry)</td>
<td>4.41</td>
</tr>
<tr>
<td>Disposable wipe with QUAT</td>
<td>4.55</td>
</tr>
<tr>
<td>Control: detergent (no disinfectant activity will transfer pathogens)</td>
<td>2.88</td>
</tr>
</tbody>
</table>
Effective Surface Decontamination

Product and Practice = Perfection
Effective Surface Decontamination

Product and Practice = Perfection
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
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
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
Microbiological Disinfectant Hierarchy
Rutala WA, Weber DJ, HICPAC. www.cdc.gov

Most Susceptible

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)
**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)
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
A novel 4% HP was effective against MRSA, CRE, *C. difficile* spores and *C. auris*. HP may be a useful addition to the sporicidal products available in healthcare.

Table. Mean (Standard error) log_{10} reductions in healthcare-associated pathogens using a quantitative carrier test with a 1-minute exposure time

<table>
<thead>
<tr>
<th>Disinfectant</th>
<th><em>C. difficile</em></th>
<th>MRSA</th>
<th>CRE (<em>E. coli</em>)</th>
<th><em>Candida auris</em> (N=2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sani-HyPerCide</td>
<td>4.7 (0.08)</td>
<td>≥6.4 (0)</td>
<td>≥5.6 (0)</td>
<td>&gt;5.1 (0)</td>
</tr>
<tr>
<td>Clorox germicidal bleach</td>
<td>≥6.7 (0)</td>
<td>≥6.4 (0)</td>
<td>≥5.6 (0)</td>
<td>≥6.1 (0)</td>
</tr>
<tr>
<td>OxyCide</td>
<td>≥5.0 (0)</td>
<td>≥5.48 (0)</td>
<td>≥5.6 (0)</td>
<td>≥5.1 (0)</td>
</tr>
<tr>
<td>Oxivir 1</td>
<td>2.6 (0.3)</td>
<td>≥6.5 (0)</td>
<td>6.2 (0.3)</td>
<td>≥5.1 (0)</td>
</tr>
</tbody>
</table>
Asymptomatic carriers contribute to *C. difficile* transmission

1. Curry SR. Clin Infect Dis 2013 (29% of hospital-associated CDI cases linked to carriers by MLVA); 2. Blixt T. Gastroenterol 2017;152:1031 (exposure to carriers increased CDI risk); 3. Longtin Y. JAMA Int Med 2016 (screening for and isolating carriers reduced CDI by 63%); 4. Samore MH. Am J Med 1996;100:32 (only 1% of cases linked to asymptomatic carriers - roommates and adjacent rooms - by PFGE/REA); 5. Eyre DW. PLOS One 2013;8:e78445 (18 carriers: no links to subsequent CDI cases); 6. Lisenmyer K. Clin Infect Dis 2018 (screening and isolation of carriers associated with control of a ward outbreak); 7. Paquet-Bolduc B. Clin Infect Dis 2018 (unit-wide screening and isolation of carriers not associated with shorter outbreak durations vs historical controls); 8. Donskey CJ. Infect Control Hosp Epidemiol 2018 (14% of healthcare-associated CDI cases linked to LTCF asymptomatic carriers); 9. Kong IY. Clin Infect Dis 2018 (23% of healthcare-associated CDI linked to carriers vs 42% to CDI cases and 35% to carriers or cases)
Interventions focused on CDI rooms

Sporicidal disinfection only in CDI rooms

CDI rooms

Non-CDI rooms

Interventions addressing CDI cases and asymptomatic carriers

Sporicidal disinfection in CDI and non-CDI rooms

C. difficile slides courtesy Dr. Donskey
The percentage of rooms contaminated with *C. difficile* was significantly reduced during the period with a sporicidal product was used (5% vs 24%). Results suggest sporicidal disinfectant in all postdischarge rooms could potentially be beneficial in reducing the risk for *C. difficile* transmission from contaminated surfaces.
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
  - 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
  ■ 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 (ES, Nursing, IP, Pt Equip) to create a standardized plan for cleaning patient rooms and pieces of patient equipment throughout the hospital
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
Effective Surface Decontamination

Product and Practice = Perfection
Mean = 32%

>110,000 Objects

Thoroughness of Environmental Cleaning
Carling et al. ECCMID, Milan, Italy, May 2011

<table>
<thead>
<tr>
<th>Cleaned</th>
<th>Daily Cleaning</th>
<th>Terminal Cleaning</th>
</tr>
</thead>
</table>
| HEHSG HOSP | 14 Sites | 40%
| IOWA HOSP | 16 Sites | 60%
| OTHER HOSP | 7 Sites | 40%
| OPERATING ROOMS | 7 Sites | 60%
| NICU | 7 Sites | 40%
| EMS VEHICLES | 4 Sites | 60%
| ICU DAILY | 4 Sites | 30%
| AMB CHEMO | 4 Sites | 50%
| MD CLINIC | 9 Sites | 30%
| LONG TERM | 4 Sites | 50%
| DIALYSIS | | 30%
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)
TERMINAL ROOM CLEANING: DEMONSTRATION OF IMPROVED CLEANING

- Evaluated cleaning before and after an intervention to improve cleaning
- 36 US acute care hospitals
- Assessed cleaning using a fluorescent dye

**Interventions**
- Increased education of environmental service workers
- Feedback to environmental service workers

†Regularly change “dotted” items to prevent targeting objects

Carling PC, et al. ICHE 2008;29:1035-41
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.
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.
The level of microbial contamination of room surfaces is similar regardless of how often they are touched both before and after cleaning. Therefore, all surfaces that are touched must be cleaned and disinfected.
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

Colorized disinfectant slides courtesy of Kevin Tyan and Rachael Sparks
Colorized disinfection – empowers behavior change to improve coverage

- Increased visibility when disinfecting surfaces, fewer missed spots
- Real-time quality control that allows staff to monitor thoroughness of cleaning
Cleveland VA Medical Center found the colorized disinfectant to quantifiably improve thoroughness of cleaning.
Efficacy and skin toxicity testing of colorized disinfectant®

- 3rd party testing: the colorized disinfectant is a non-irritant and does not reduce efficacy of disinfectant
Bleach wipes alone caused severe corrosion (> 5 mils per year [mpy], 1 normal) while the addition of colorized disinfectant both significantly reduced corrosion rate (< 2 mpy) and prevented discoloration of the metal.

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 (and new strategies)
RATIONALE FOR ENHANCED TERMINAL DISINFECTION OF ROOMS OF PATIENTS WITH CDI

RELATIVE RISK OF PATHOGEN ACQUISITION IF PRIOR ROOM OCCUPANT INFECTED

- MRSA (Huang S, 2006)
- VRE* (Drees M, 2008)
- VRE (Huang S, 2006)
- MDR Pseudomonas (Nseir S, 2011)
- VRE^ (Drees M, 2008)
- C. diff (Shaughnessy M, 2011)
- MDR Acinetobacter (Nseir S, 2011)

* Prior room occupant infected; ^Any room occupant in prior 2 weeks infected
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)
Enhanced Disinfection Leading to Reduction of Microbial Contamination and a Decrease in Patient Col/Infection


<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)</td>
<td>60.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Reduction (%)</td>
<td></td>
<td>94</td>
</tr>
<tr>
<td>Colonization/Infection (rate)</td>
<td>2.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Reduction (%)</td>
<td></td>
<td>35</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.
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).
New Strategies in Cleaning and Disinfection

- New Strategies in Cleaning and Disinfection
  - New sporicide-4% HP
  - Sporicide in all discharge patient rooms
  - Colorized disinfectant
  - Inactivation of *C. auris*, CRE, SARS-CoV-2
  - Electrostatic sprayer
  - Continuous room decontamination
Germicidal Activity against Carbapenem/Colistin-Resistant *Enterobacteriaceae* Using a Quantitative Carrier Test Method

Hajime Kanamori, a,b William A. Roluta, a,b Maria F. Gergen, a Emily E. Sickbert-Bennett, a,b David J. Weber a,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
  - ~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

*Candida auris* causes multidrug-resistant infections that can result in organ failure

Katerina 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.
- Several disinfectants (~30) are registered with the EPA for claims against *C. auris*, and its susceptibility to germicides is in the scientific literature.
Recovery of *Candida* species on moist versus dry surfaces

Piedrahita C. Environmental surfaces in healthcare facilities are a potential source for transmission of *C. auris* and other *Candida* species. ICHE 2017;38:1107-9.
Efficacy of Disinfectants and Antiseptics against *Candida auris*
Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, ICHE 2019

- $\geq 3 \log_{10}$ reduction (*C. auris*, 1m, 5% FCS, QCT)
  - 0.20% peracetic acid
  - 2.4% glutaraldehyde
  - 0.65% hydrogen peroxide, 0.14% per oxyacetic 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, ICHE 2019

- $\leq 3 \log_{10}$ (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
• **Centers for Disease Control & Prevention** says the virus spreads from person to person mainly through respiratory droplets from coughing, sneezing or talking in close proximity to each other, but the CDC has also said it may be possible for a person to get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose or possibly their eyes. CDC clarified while it is still possible that a person can catch it from touching a contaminated surface, it’s “not thought to be the main way the virus spreads.”
Transmission of SARS-CoV-2

- Droplet (< 6 feet)
- Direct-person-to-person via respiratory aerosols
- Indirect (via the contaminated environment); not main route
- Asymptomatic (infection transmission demonstrated)
- Pre-symptomatic—highly likely
Contamination of SARS-CoV-2 RNA by PCR on environmental surfaces and medical devices have been documented. Rate varies from 0-75% (median 12.1%).
## Role of Healthcare Surface Environment in SARS-CoV-2 Transmission

Kanamori, Weber, Rutala, Clin Infect Dis, [https://doi.org/10.1093/cid/ciaa1467](https://doi.org/10.1093/cid/ciaa1467), 28 September 2020

<table>
<thead>
<tr>
<th>SARS-CoV-2 RNA</th>
<th>Bed rail</th>
<th>Sink</th>
<th>BP monitor</th>
<th>Infusion pump</th>
<th>Keyboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedside table</td>
<td>Floor</td>
<td>ECG monitor</td>
<td>Fluid stand</td>
<td>Phone</td>
<td></td>
</tr>
<tr>
<td>Chair</td>
<td>Toilet seat</td>
<td>Oxygen regulator</td>
<td>Hand sanitizer</td>
<td>Computer mouse</td>
<td></td>
</tr>
<tr>
<td>Doorknob</td>
<td>Toilet bowl</td>
<td>Oxygen mask</td>
<td>Trash can</td>
<td>Door</td>
<td></td>
</tr>
<tr>
<td>Light switches</td>
<td>Stethoscope</td>
<td>CT scanner</td>
<td>Self-service printer</td>
<td>Glass window</td>
<td></td>
</tr>
<tr>
<td>Call button</td>
<td>Pulse oximetry</td>
<td>Ventilator</td>
<td>Desktop</td>
<td>PPE storage area</td>
<td></td>
</tr>
<tr>
<td>Centrifuge</td>
<td>Biosafety cabinet</td>
<td>Infant bed</td>
<td>Air outlet</td>
<td>Ambu bag</td>
<td></td>
</tr>
<tr>
<td>TV remote</td>
<td>Bed sheet</td>
<td>Urinary catheters</td>
<td>TV</td>
<td>Beepers</td>
<td></td>
</tr>
<tr>
<td>Elevator buttons</td>
<td>Ventilator tubing</td>
<td>Glove boxes</td>
<td>Touch screen</td>
<td>All surfaces in nurse’s station</td>
<td></td>
</tr>
</tbody>
</table>

All surfaces in nurse’s station
Do established infection prevention measures prevent spread of SARS-CoV-2 to the hospital environment beyond the patient room?

Jerry et al. J Hosp Infection 2020

Contamination rate: patient room-42% (11/26); nurse’s station-3%; post terminal clean-4% (1/25)

<table>
<thead>
<tr>
<th>Sites of swabs/air samples and results</th>
<th>Grand total</th>
<th>Detected</th>
<th>Not detected</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COVID-19 patient’s room</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed rail</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Bedside table</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Call bell</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Patient bell</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Remote for bed</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Toilet door handle</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>26</strong></td>
<td><strong>11</strong></td>
<td><strong>15</strong></td>
</tr>
<tr>
<td><strong>Nurses’ station COVID-19 cohort ward</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desk</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Keyboard</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Telephone</td>
<td>10</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
<td><strong>1</strong></td>
<td><strong>29</strong></td>
</tr>
<tr>
<td><strong>Patient room post-terminal clean</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed rail</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Bedside table</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Call bell</td>
<td>5</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Patient chair-arm</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Toilet door handle</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>25</strong></td>
<td><strong>1</strong></td>
<td><strong>24</strong></td>
</tr>
</tbody>
</table>
Pt 1 and 2-2/48-4% (closed suction to ventilator) pt 3-13/28-46% (high-flow oxygen therapy via nasal cannula, non-invasive ventilation). Found viable virus (7/28-25%) only on surfaces within droplet distance. All air samples negative.
Found viable virus only on surface within droplet distance.
# Inactivation of Coronavirus

Kampf G. J Hosp Infect 2020

<table>
<thead>
<tr>
<th>Biocidal agent</th>
<th>Concentration</th>
<th>Virus</th>
<th>Strain / isolate</th>
<th>Exposure time</th>
<th>Reduction of viral infectivity (log₁₀)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ethanol</strong></td>
<td>95%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 5.5</td>
<td>[29]</td>
</tr>
<tr>
<td></td>
<td>85%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 5.5</td>
<td>[29]</td>
</tr>
<tr>
<td></td>
<td>80%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 4.3</td>
<td>[29]</td>
</tr>
<tr>
<td></td>
<td>80%</td>
<td>MERS-CoV</td>
<td>Strain EMC</td>
<td>30 s</td>
<td>&gt; 4.0</td>
<td>[14]</td>
</tr>
<tr>
<td></td>
<td>78%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 5.0</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>70%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>&gt; 3.9</td>
<td>[30]</td>
</tr>
<tr>
<td><strong>2-Propanol</strong></td>
<td>70%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 3.3</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 3.0</td>
<td>[14]</td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>MERS-CoV</td>
<td>Strain EMC</td>
<td>30 s</td>
<td>≥ 3.3</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>70%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 3.7</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>&gt; 3.7</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>CCV</td>
<td>Strain L-71</td>
<td>10 min</td>
<td>&gt; 3.7</td>
<td>[30]</td>
</tr>
<tr>
<td><strong>2-Propanol and 1-propanol</strong></td>
<td>45% and 30%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>30 s</td>
<td>≥ 4.3</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>0.2%</td>
<td>HCoV</td>
<td>ATCC VR-759 (strain OC43)</td>
<td>10 min</td>
<td>0.0</td>
<td>[31]</td>
</tr>
<tr>
<td><strong>Benzalkonium chloride</strong></td>
<td>0.05%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>&gt; 3.7</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>0.05%</td>
<td>CCV</td>
<td>Strain L-71</td>
<td>10 min</td>
<td>&gt; 3.7</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>CCV</td>
<td>Strain S378</td>
<td>3 d</td>
<td>&gt; 4.0</td>
<td>[32]</td>
</tr>
<tr>
<td><strong>Didecyldimethyl ammonium chloride</strong></td>
<td>0.0025%</td>
<td>CCV</td>
<td>Strain S378</td>
<td>3 d</td>
<td>&gt; 4.0</td>
<td>[32]</td>
</tr>
<tr>
<td><strong>Chlorhexidine</strong></td>
<td>0.02%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>0.7 – 0.8</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>0.02%</td>
<td>CCV</td>
<td>Strain L-71</td>
<td>10 min</td>
<td>0.3</td>
<td>[30]</td>
</tr>
<tr>
<td><strong>Digluconate</strong></td>
<td>0.21%</td>
<td>MHV</td>
<td>Strain MHV-1</td>
<td>30 s</td>
<td>≥ 4.0</td>
<td>[33]</td>
</tr>
<tr>
<td></td>
<td>0.01%</td>
<td>CCV</td>
<td>Strain L-71</td>
<td>10 min</td>
<td>1.1</td>
<td>[30]</td>
</tr>
<tr>
<td><strong>Sodium hypochlorite</strong></td>
<td>0.001%</td>
<td>MHV</td>
<td>Strains MHV-2 and MHV-N</td>
<td>10 min</td>
<td>0.3 – 0.6</td>
<td>[30]</td>
</tr>
<tr>
<td></td>
<td>0.001%</td>
<td>CCV</td>
<td>Strain L-71</td>
<td>10 min</td>
<td>0.9</td>
<td>[30]</td>
</tr>
<tr>
<td><strong>Hydrogen peroxide</strong></td>
<td>0.5%</td>
<td>HCoV</td>
<td>Strain 229E</td>
<td>1 min</td>
<td>&gt; 4.0</td>
<td>[34]</td>
</tr>
<tr>
<td><strong>Formaldehyde</strong></td>
<td>1%</td>
<td>SARS-CoV</td>
<td>Isolate FFM-1</td>
<td>2 min</td>
<td>&gt; 3.0</td>
<td>[28]</td>
</tr>
</tbody>
</table>
CDC recommends that an EPA-registered disinfectant on the EPA’s List N that has qualified under the emerging pathogen program for use against SARS-CoV-2 be chosen for the COVID-19 patient care.

List N has >500 entries and 32 different active ingredients (Quats, chlorine, etc)
Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants


Most Resistant

Prions
Spores \((C.\ difficile)\)
Mycobacteria
Non-Enveloped Viruses \((\text{norovirus, adeno})\)
Fungi
Bacteria \((\text{MRSA, VRE, Acinetobacter})\)

Most Susceptible

Enveloped Viruses \((\text{SARS-CoV-2})\)
List N Tool: COVID-19 Disinfectants
32 Active Ingredients

- Ethyl alcohol
- Hydrogen peroxide
- Hypochlorous acid
- Isopropyl alcohol
- Peracetic acid
- Phenolic
- Quaternary ammonium
List N Tool: COVID-19 Disinfectants

https://cfpub.epa.gov/giwiz/disinfectants/index.cfm

Search EPA's list of products for use against SARS-CoV-2, the virus that causes COVID-19, by selecting one or more of the corresponding criteria above. All products on this list meet EPA's criteria for use against SARS-CoV-2, the virus that causes COVID-19. These products are for use on surfaces, NOT humans. At any point, click the "Show Results" button to view your customized list of results. Select as many, or as few, criteria as you would like. Click the "Clear Results" button to remove all previous selections and start over. Click "Browse All" to display all products.
Evaluation of an electrostatic spray disinfectant technology for rapid decontamination of portable equipment and large open areas in the era of SARS-CoV-2

Jennifer L. Cadnum, BS, Annette L. Jencson, CIC, Scott H. Livingston, MD, Daniel F. Li, BS, Sarah N. Redmond, BS, Basya Pearlmutter, BS, Brigid M. Wilson, PhD, and Curtis J. Donskey, MD

Abstract

In the setting of the coronavirus disease 2019 pandemic, efficient methods are needed to decontaminate shared portable devices and large open areas such as waiting rooms. We found that wheelchairs, portable equipment, and waiting room chairs were frequently contaminated with potential pathogens. After minimal manual precleaning of areas with visible soiling, application of a dilute sodium hypochlorite disinfectant using an electrostatic sprayer provided rapid and effective decontamination and eliminated the benign virus bacteriophage MS2 from inoculated surfaces.
Efficacy of Disinfectant Electrostatic Spray (positive charged droplets attracted to negatively charged surfaces or microbes) in Reducing Pathogen Contamination
Cadnum et al. AJIC 2020

Picture of electrostatic sprayer
(0.25% sodium hypochlorite)

Efficacy of disinfectant spray
(waiting room chairs)
Summary of Electrostatic Sprayer Issues

- Optimal droplet size is between 40-70μ; what is the droplet size of the proposed unit?
- Spray patterns vary tremendously across vendors and even across products from a single vendor.
- EPA demands that all surfaces being disinfected be thoroughly wetted for the contact time of the specific disinfectant.
- Person applying the disinfectant may need to wear full PPE because of inhalation concerns.
- Electrostatic sprayer does not replace the initial cleaning and disinfecting that EVS performs.
- Cadnum/Donskey study used sporicidal disinfectant alone with no pre-cleaning or wiping.
- Electrostatic sprayers might be most useful for items and areas that are not amenable to standard cleaning and disinfection (Cadnum/Donskey).
- Effectiveness on soft surfaces?
- Considerations for purchase include: coverage requirements, weight of loaded device; ease of handling; effective distance; particulate size; and disinfectant safety.
- Electrostatic sprayers are promoted as a “get in” and “get out” time saving technology.
- How many seconds per square foot with a sprayer to properly treat the surface.
- Equipment can be easily misused (must prevent misuse and consider sprayer, time allotted to perform, disinfectant, surface [soft v hard], space/area to disinfect, level of cleaning prior to application, user training).
Continuous Room Decontamination Technologies for Disinfection of the Healthcare Environment

Weber, Rutala et al. AJIC. 2019;47:A72; Rutala et al. ICHE 2019

• Visible light disinfection through LEDs
• Dry/dilute hydrogen peroxide
• Self-disinfecting surfaces (e.g., copper)
• Far UV 222 nm
• Bipolar ionization
• Multijet cold air plasma
• Continuously active disinfectant (CAD) or persistent disinfectant that provides continuous disinfection action
  ■ Allows continued disinfection and may eliminate the problem of recontamination
  ■ Patients, staff and visitors can remain in the room
Microbial Assessment of Recontamination with *Acinetobacter* in Patient Room Environment in Burn Units

Rutala et al. AJIC. 2020; 48 Suppl;S20

- **Purpose:** assess how much environmental sites (e.g., chair, bedrail, overbed table, stock cabinet, IV pump, etc.) become recontaminated with *Acinetobacter* over time after cleaning/disinfection.

- **Results:**
  - At baseline all environmental sites sampled except overbed table were contaminated with *Acinetobacter*.
  - No *Acinetobacter* were detected except bed rail just after cleaning/disinfection.
  - First time to recontamination with *Acinetobacter* was 3 hours at chair, 2 hours at overbed table, 3 hours at stock cabinet, and 2 hours at IV pump. No recontamination was observed at the monitor.
  - The level of *Acinetobacter* contamination on surfaces was occasionally high (e.g., when a stock cabinet was sampled at 5 hours, 75 of 96 CFU were *Acinetobacter*).
  - The amount of recontamination with aerobes and *Acinetobacter* on some surfaces tended to increase over time.
Surfaces should be hygienically clean (not sterile)-free of pathogens in sufficient numbers to prevent human disease
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^≥3.75, 30min dry) over 48hr

At the end of the study and at least 48 hours later, the ability of the test surface to kill microbes (99.9%) within 1 min is measured using the last inoculation (10^6)
4-5 log\(_{10}\) reduction in 5 min over 24 hr for most pathogens; ~99% reduction with *Klebsiella* and CRE *Enterobacter*. Redmond et al. found 5 log\(_{10}\) reduction for CRE *Enterobacter, K. pneumoniae*, MRSA, VRE, and *C. auris*.

<table>
<thead>
<tr>
<th>Test Pathogen</th>
<th>Mean Log(_{10}) Reduction , 95% CI n=4</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.aureus*</td>
<td>4.4 (3.9, 5.0)</td>
</tr>
<tr>
<td>S.aureus (formica)</td>
<td>4.1 (3.8, 4.4)</td>
</tr>
<tr>
<td>S.aureus (stainless steel)</td>
<td>5.5 (5.2, 5.9)</td>
</tr>
<tr>
<td>VRE</td>
<td>≥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>≥5.0</td>
</tr>
<tr>
<td><em>K pneumoniae</em></td>
<td>1.5 (1.4, 1.6)</td>
</tr>
<tr>
<td>CRE <em>E.coli</em></td>
<td>3.0 (2.6, 3.4)</td>
</tr>
<tr>
<td>CRE <em>Enterobacter</em></td>
<td>2.0 (1.6, 2.4)</td>
</tr>
<tr>
<td>CRE <em>K pneumoniae</em></td>
<td>2.1 (1.8, 2.4)</td>
</tr>
</tbody>
</table>
Comparison of CAD with Three Disinfectants Using EPA Method and *S. aureus*


<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>
Will the continuously active disinfectant kill viruses like coronaviruses?
A novel disinfectant studied using an EPA protocol (wears/re-inoculations) demonstrated excellent continuous antiviral activity (i.e., $>4.5\log_{10}$ reduction) in 1 minute after 48 hours for a human coronavirus, 229E.

<table>
<thead>
<tr>
<th>Carrier Treatment with Wears and Re-inoculations</th>
<th>Contact Time</th>
<th>Mean Viral Recovery Titer per Carrier ($\log_{10}$)</th>
<th>$\log_{10}$ Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (sterile water, n=3)</td>
<td>1 minute</td>
<td>$6.00 \pm 0.25$</td>
<td>N.A.</td>
</tr>
<tr>
<td>Test disinfectant (n=3)</td>
<td>1 minute</td>
<td>$\leq 1.50 \pm 0.00$</td>
<td>$&gt;4.50$</td>
</tr>
</tbody>
</table>
Best Practices in Disinfection of Noncritical Surfaces in the Healthcare Setting: A Bundle Approach and New Strategies

• Disinfection of noncritical surfaces in healthcare: A bundle approach
  ■ Overview of how environment contributes to HAIs
  ■ Policy, products, educate/train, compliance, “no touch”

• New Strategies in cleaning and disinfection
  ■ Colorized disinfectant, new sporicide, sporicide at discharge cleaning, emerging pathogens, electrostatic sprayer, continuously active disinfectant
THANK YOU!
www.disinfectionandsterilization.org