Role of Hospital Surfaces in Disease Transmission

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Role of Hospital Surfaces in Disease Transmission

- Review the role of environmental surfaces
- Review the use of low-level disinfectants and the selection of the ideal disinfectant
- Review “best” practices for environmental cleaning and disinfection
- Discuss options for evaluating environmental cleaning and disinfection
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Environmental Contamination Leads to HAIs


- 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 previous patient’s 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)
EVALUATION OF HOSPITAL ROOM ASSIGNMENT AND ACQUISITION OF CDI

- **Study design**: Retrospective cohort analysis, 2005-2006
- **Setting**: Medical ICU at a tertiary care hospital
- **Methods**: All patients evaluated for diagnosis of CDI 48 hours after ICU admission and within 30 days after ICU discharge
- **Results (acquisition of CDI)**
  - Admission to room previously occupied by CDI = 11.0%
  - Admission to room not previously occupied by CDI = 4.6% (p=0.002)

Shaughnessy MK, et al. ICHE 2011;32:201-206

| TABLE 3. Multivariate Analysis of Risk Factors for Acquisition of Clostridium difficile Infection (CDI) |
|---------------------------------------------------------------|-------------------------------------------------|---------------------------------|
| Risk factor                              | HR (95% CI)         | P   |
| Prior room occupant with CDI           | 2.35 (1.21–4.54)        | .01  |
| Greater age                             | 1.00 (0.99–1.01)        | .71  |
| Higher APACHE III score                 | 1.00 (1.00–1.01)        | .06  |
| Proton pump inhibitor use               | 1.11 (0.44–2.78)        | .83  |
| Antibiotic exposure                     |                       |      |
| Norfloxacin                             | 0.38 (0.05–2.72)        | .33  |
| Levoxacin                               | 1.08 (0.67–1.73)        | .75  |
| Ciprofloxacin                           | 0.49 (0.15–1.67)        | .23  |
| Fluoroquinolones                        | 1.17 (0.72–1.91)        | .53  |
| Clindamycin                             | 0.45 (0.14–1.42)        | .17  |
| Third- or fourth-generation cephalosporins | 1.17 (0.76–1.79)       | .48  |
| Carbenems                                | 1.05 (0.63–1.75)        | .84  |
| Piperacillin-tazobactam                 | 1.31 (0.82–2.10)        | .27  |
| Other penicillin                        | 0.47 (0.23–0.98)        | .04  |
| Metronidazole                           | 1.31 (0.83–2.07)        | .24  |
| Vancomycin                               |                       |      |
| Oral                                     | 1.38 (0.32–5.89)        | .67  |
| Intravenous                              | 1.55 (0.88–2.73)        | .13  |
| Aminoglycosides                          | 1.27 (0.78–2.06)        | .35  |
| Multiple (≥3 antibiotic classes)        | 1.28 (0.75–2.21)        | .37  |

Note. APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; HR, hazard ratio.
TRANSMISSION MECHANISMS INVOLVING THE SURFACE ENVIRONMENT

Acquisition of EIP on Hands of Healthcare Providers after Contact with Contaminated Environmental Sites and Transfer to Other Patients
TRANSMISSION MECHANISMS INVOLVING THE SURFACE ENVIRONMENT

Acquisition of EIP on Hands of Patient after Contact with Contaminated Environmental Sites and Transfers EIP to Eyes/Nose/Mouth
Environmental Contamination Leads to HAIs

- By contaminating hands/gloves via contact with the environment and transfer to patient, or patient self inoculation
- Surface should be hygienically clean (not sterile)-free of pathogens in sufficient numbers to prevent human disease
- Two environmental surface concerns
  - Discharge/terminal-new patient in room
  - Daily room decontamination
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
KEY PATHOGENS WHERE ENVIRONMENTAL SURFACES PLAY A ROLE IN TRANSMISSION

- MRSA
- VRE
- *Acinetobacter* spp.
- *Clostridium difficile*
- Norovirus
- Rotavirus
- SARS
### Environmental Contamination: Endemic and Epidemic MRSA


<table>
<thead>
<tr>
<th>Site</th>
<th>Outbreak (%)</th>
<th>Endemic (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Floor</strong></td>
<td>9</td>
<td>50–55%</td>
</tr>
<tr>
<td><strong>Bed linen</strong></td>
<td>..</td>
<td>38–54%</td>
</tr>
<tr>
<td><strong>Patient gown</strong></td>
<td>..</td>
<td>40–53%</td>
</tr>
<tr>
<td><strong>Overbed table</strong></td>
<td>..</td>
<td>18–42%</td>
</tr>
<tr>
<td><strong>Blood pressure cuff</strong></td>
<td>13%</td>
<td>25–33%</td>
</tr>
<tr>
<td><strong>Bed or siderails</strong></td>
<td>5%</td>
<td>1–30%</td>
</tr>
<tr>
<td><strong>Bathroom door handle</strong></td>
<td>..</td>
<td>8–24%</td>
</tr>
<tr>
<td><strong>Infusion pump button</strong></td>
<td>13%</td>
<td>7–18%</td>
</tr>
<tr>
<td><strong>Room door handle</strong></td>
<td>11%</td>
<td>4–8%</td>
</tr>
<tr>
<td><strong>Furniture</strong></td>
<td>11%</td>
<td>44–59%</td>
</tr>
<tr>
<td><strong>Flat surfaces</strong></td>
<td>7%</td>
<td>32–38%</td>
</tr>
<tr>
<td><strong>Sink taps or basin fitting</strong></td>
<td>..</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Average quoted</strong></td>
<td>11%</td>
<td>27%</td>
</tr>
</tbody>
</table>

**Site estimated mean**:

- Floor: 34.5%
- Bed linen: 41%
- Patient gown: 40.5%
- Overbed table: 40%
- Blood pressure cuff: 21%
- Bed or siderails: 27%
- Bathroom door handle: 14%
- Infusion pump button: 19%
- Room door handle: 21.5%
- Furniture: 27%
- Flat surfaces: 21.5%
- Sink taps or basin fitting: 23.5%
- Average quoted: 37%
# Environmental Survival of Key Pathogens on Hospital Surfaces

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Survival Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S. aureus</em> (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><em>Norovirus</em> (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?

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b Case Western Reserve University School of Medicine, Cleveland, OH

Key Words:
Environment
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
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.

**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.
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- This supports comprehensive disinfecting regimens (goal is not sterilization) to reduce the risk of acquiring a pathogen from the healthcare environment/equipment
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EH Spaulding believed that how an object will be disinfected depended on the object’s intended use:

- **CRITICAL** - objects which enter normally sterile tissue or the vascular system or through which blood flows should be sterile.

- **SEMICRITICAL** - objects that touch mucous membranes or skin that is not intact require a disinfection process (high-level disinfection [HLD]) that kills all microorganisms; however, small numbers of bacterial spores are permissible.

- **NONCRITICAL** - objects that touch only intact skin require low-level disinfection.
Effective Surface Decontamination

Product and Practice = Perfection
Effective Surface Decontamination

Product and Practice = Perfection
LOW-LEVEL DISINFECTION FOR NONCRITICAL
EQUIPMENT AND SURFACES

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>Peracetic acid with HP (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)

Most Susceptible

Enveloped Viruses (HIV, HSV, Flu)
Quaternary ammonium compounds
(e.g., didecyl dimethyl ammonium bromide, dioctyl dimethyl ammonium bromide)

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bactericidal, fungicidal, virucidal against enveloped viruses (e.g., HIV)</td>
<td>Not sporicidal</td>
</tr>
<tr>
<td>Good cleaning agents</td>
<td>In general, not tuberculocidal and virucidal against non-enveloped viruses</td>
</tr>
<tr>
<td>EPA registered</td>
<td>High water hardness and cotton/gauze can make less microbicidal</td>
</tr>
<tr>
<td>Surface compatible</td>
<td>A few reports documented asthma as result of exposure to benzalkonium chloride</td>
</tr>
<tr>
<td>Persistent antimicrobial activity when undisturbed</td>
<td>Affected by organic matter</td>
</tr>
<tr>
<td>Inexpensive (in dilutable form)</td>
<td>Multiple outbreaks ascribed to contaminated benzalkonium chloride</td>
</tr>
<tr>
<td>Not flammable</td>
<td></td>
</tr>
</tbody>
</table>
## Alcohol


### Advantages
- Bactericidal, tuberculocidal, fungicidal, virucidal
- Fast acting
- Non-corrosive
- Non-staining
- Used to disinfect small surfaces such as rubber stoppers on medication vials
- No toxic residue

### Disadvantages
- Not sporicidal
- Affected by organic matter
- Slow acting against non-enveloped viruses (e.g., norovirus)
- No detergent or cleaning properties
- Not EPA registered
- Damage some instruments (e.g., harden rubber, deteriorate glue)
- Flammable (large amounts require special storage)
- Evaporates rapidly making contact time compliance difficult
- Not recommended for use on large surfaces
- Outbreaks ascribed to contaminated alcohol
Quat/Alcohol vs Quat

- Adenovirus is a hardy virus that is relatively resistant to disinfectants
- Quat about $<0.5 \log_{10}$ reduction against adenovirus with 1m exposure time
- Accelerated hydrogen peroxide (0.5%) demonstrates $\sim0.7 \log_{10}$ reduction against adenovirus with 1m exposure time
- Quat/Alcohol demonstrates a $\sim4 \log_{10}$ reduction against adenovirus with 1m exposure time
- Chlorine ($\sim5000$ppm) demonstrates a $\sim5 \log_{10}$ reduction against adenovirus with 1m exposure time
- Quat/Alcohol has improved virucidal activity compared to Quat and accelerated hydrogen peroxide
Improved Hydrogen Peroxide

Advantages
- Bactericidal, tuberculocidal, fungicidal, virucidal
- Fast efficacy
- Easy compliance with wet-contact times
- Safe for workers (lowest EPA toxicity category, IV)
- Benign for the environment
- Surface compatible
- Non-staining
- EPA registered
- Not flammable

Disadvantages
- More expensive than most other disinfecting actives
- Not sporicidal at low concentrations
## Sodium Hypochlorite


### Advantages
- Bactericidal, tuberculocidal, fungicidal, virucidal
- Sporicidal
- Fast acting
- Inexpensive (in dilutable form)
- Not flammable
- Unaffected by water hardness
- Reduces biofilms on surfaces
- Relatively stable (e.g., 50% reduction in chlorine concentration in 30 days)
- Used as the disinfectant in water treatment
- EPA registered

### Disadvantages
- Reaction hazard with acids and ammonias
- Leaves salt residue
- Corrosive to metals (some ready-to-use products may be formulated with corrosion inhibitors)
- Unstable active (some ready-to-use products may be formulated with stabilizers to achieve longer shelf life)
- Affected by organic matter
- Discolors/stains fabrics
- Potential hazard is production of trihalomethane
- Odor (some ready-to-use products may be formulated with odor inhibitors). Irritating at high concentrations.
Advantages

- Bactericidal, tuberculocidal, fungicidal, virucidal
- Inexpensive (in dilutable form)
- Non-staining
- Not flammable
- EPA registered

Disadvantages

- Not sporicidal
- Absorbed by porous materials and irritate tissue
- Depigmentation of skin caused by certain phenolics
- Hyperbilirubinemia in infants when phenolic not prepared as recommended
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
# Key Considerations for Selecting the Ideal Disinfectant for Your Facility


<table>
<thead>
<tr>
<th>Consideration</th>
<th>Question to Ask</th>
<th>Score (1-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kill Claims</td>
<td>Does the product kill the most prevalent healthcare pathogens</td>
<td></td>
</tr>
<tr>
<td>Kill Times and Wet-Contact Times</td>
<td>How quickly does the product kill the prevalent healthcare pathogens. Ideally, contact time greater than or equal to the kill claim.</td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td>Does the product have an acceptable toxicity rating, flammability rating</td>
<td></td>
</tr>
<tr>
<td>Ease-of-Use</td>
<td>Odor acceptable, shelf-life, in convenient forms (wipes, spray), water soluble, works in organic matter, one-step (cleans/disinfects)</td>
<td></td>
</tr>
<tr>
<td>Other factors</td>
<td>Supplier offer comprehensive training/education, 24-7 customer support, overall cost acceptable (product capabilities, cost per compliant use, help standardize disinfectants in facility)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Consider the 5 components shown, give each product a score (1 is worst and 10 is best) in each of the 5 categories, and select the product with the highest score as the optimal choice (maximum score is 50).
Most prevalent pathogens causing HAI (~75% easy to kill)

- **S. aureus** (15.6%)
- **E. coli** (11.5%)
- Coag neg Staph (11.4%)
- **Klebsiella** (8.0%)
- **P. aeruginosa** (8.0%)
- **E. faecalis** (6.8%)
- **C. albicans** (5.3%)
- **Enterobacter** sp. (4.7%)
- Other **Candida** sp (4.2%)
- **C. difficile** in top 2-3 past 5 years

Common causes of outbreaks and ward closures (relatively hard to kill)

- **C. difficile** spores
- Norovirus
- Rotavirus
- Adenovirus
### EFFECTIVENESS OF DISINFECTANTS AGAINST MRSA AND VRE


#### TABLE 2
Disinfectant Activity Against Antibiotic-Susceptible and Antibiotic-Resistant Bacteria

<table>
<thead>
<tr>
<th>Product</th>
<th>Log&lt;sub&gt;10&lt;/sub&gt; Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VSE</td>
</tr>
<tr>
<td></td>
<td>0.5 min</td>
</tr>
<tr>
<td>Vesphene Ilse</td>
<td>&gt;4.3</td>
</tr>
<tr>
<td>Clorox</td>
<td>&gt;5.4</td>
</tr>
<tr>
<td>Lysol Disinfectant</td>
<td>&gt;4.3</td>
</tr>
<tr>
<td>Lysol Antibacterial</td>
<td>&gt;5.5</td>
</tr>
<tr>
<td>Vinegar</td>
<td>0.1</td>
</tr>
</tbody>
</table>

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.
Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants

Most Resistant

- Prions
- Spores (*C. difficile*)
- Mycobacteria
- Non-Enveloped Viruses (norovirus)
- Fungi
- Bacteria (MRSA, VRE, Acinetobacter)

Most Susceptible

- Enveloped Viruses
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)
- 34 registered products; most chlorine-based, some HP/PA-based
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- Discuss new “no touch” technologies for room decontamination and reduction of HAIs
Effective Surface Decontamination

Product and Practice = Perfection
SHOULD WE CONCENTRATE ON "HIGH TOUCH" OR "HIGH RISK" OBJECTS

No, not only "high risk" (all surfaces). "High touch" objects only recently defined and "high risk" objects not scientifically defined.
DEFINING HIGH TOUCH SURFACES

DEFINING HIGH TOUCH SURFACES

MICROBIAL BURDEN ON ROOM SURFACES AS A FUNCTION OF FREQUENCY OF TOUCHING


<table>
<thead>
<tr>
<th>Surface</th>
<th>Prior to Cleaning</th>
<th>Post Cleaning (mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean CFU/RODAC (95% CI)</td>
<td>Mean CFU/RODAC (95% CI)</td>
</tr>
<tr>
<td>High</td>
<td>71.9 (46.5-97.3)</td>
<td>9.6</td>
</tr>
<tr>
<td>Medium</td>
<td>44.2 (28.1-60.2)</td>
<td>9.3</td>
</tr>
<tr>
<td>Low</td>
<td>56.7 (34.2-79.2)</td>
<td>5.7</td>
</tr>
</tbody>
</table>

- 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.
<table>
<thead>
<tr>
<th>Object</th>
<th>Percentage cleaned</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Range</td>
</tr>
<tr>
<td>Sink</td>
<td>82 ± 12</td>
<td>57-97</td>
</tr>
<tr>
<td>Toilet seat</td>
<td>76 ± 18</td>
<td>40-98</td>
</tr>
<tr>
<td>Tray table</td>
<td>77 ± 15</td>
<td>53-100</td>
</tr>
<tr>
<td>Bedside table</td>
<td>64 ± 22</td>
<td>23-100</td>
</tr>
<tr>
<td>Toilet handle</td>
<td>60 ± 22</td>
<td>23-89</td>
</tr>
<tr>
<td>Side rail</td>
<td>60 ± 21</td>
<td>25-96</td>
</tr>
<tr>
<td>Call box</td>
<td>50 ± 19</td>
<td>9-90</td>
</tr>
<tr>
<td>Telephone</td>
<td>49 ± 16</td>
<td>18-86</td>
</tr>
<tr>
<td>Chair</td>
<td>48 ± 28</td>
<td>11-100</td>
</tr>
<tr>
<td>Toilet door knobs</td>
<td>28 ± 22</td>
<td>0-82</td>
</tr>
<tr>
<td>Toilet hand hold</td>
<td>28 ± 23</td>
<td>0-90</td>
</tr>
<tr>
<td>Bedpan cleaner</td>
<td>25 ± 18</td>
<td>0-79</td>
</tr>
<tr>
<td>Room door knobs</td>
<td>23 ± 19</td>
<td>2-73</td>
</tr>
<tr>
<td>Bathroom light switch</td>
<td>20 ± 21</td>
<td>0-81</td>
</tr>
</tbody>
</table>

**Note.** 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.
BEST PRACTICES FOR ROOM DISINFECTION

- Follow the CDC Guideline for Disinfection and Sterilization with regard to choosing an appropriate germicide and best practices for environmental disinfection
- Appropriately train environmental service workers on proper use of PPE and clean/disinfection of the environment
- Have environmental service workers use checklists to ensure all room surfaces are cleaned/disinfected
- Assure that nursing and environmental service have agreed what items (e.g., sensitive equipment) are to be clean/disinfected by nursing and what items (e.g., environmental surfaces) are to be cleaned/disinfected by environmental service workers. Staff must have sufficient time. Increasing workload compromising infection control activities.
- Use a method (e.g., fluorescent dye, ATP) to ensure proper cleaning
Role of Hospital Surfaces in Disease Transmission

- Review the role of environmental surfaces
- Review the use of low-level disinfectants and the selection of the ideal disinfectant
- Review “best” practices for environmental cleaning and disinfection
- Discuss options for evaluating environmental cleaning and disinfection
- Discuss new “no touch” technologies for room decontamination and reduction of HAIs
Thoroughness of Environmental Cleaning

Carling P. AJIC 2013;41:S20-S25

Mean = 32%

>110,000 Objects
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)
DAZO Solution (AKA – Goo)
TARGET ENHANCED
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
SURFACE EVALUATION USING ATP BIOLUMINESCENCE

Swab surface → luciferase tagging of ATP → Hand held luminometer

Used in the commercial food preparation industry to evaluate surface cleaning before reuse and as an educational tool for more than 30 years.
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
Colorized disinfection – improved coverage

- Increased visibility when disinfecting surfaces, fewer missed spots
- Real-time quality control that allows staff to monitor thoroughness of cleaning
Novel Chemical Additive That Colorizes Disinfectant to Improve Visualization of Surface Coverage

Mustapha et al. AJIC; 2018:48:191-121

By improving thoroughness will it reduce microbial contamination and reduce transmission?

**Fig 1.** (A) Percentage of sites correctly identified by personnel as having or not having bleach application when testing occurred within 30 seconds of application. Sites were identified based on whether Highlight solution (Kinnos Inc, Brooklyn, NY) was added to colorize the bleach solution. (B) Image of a bed rail with application of bleach and bleach-plus-Highlight.
These interventions not enough to achieve consistent and high rates of cleaning/disinfection

No Touch

(supplements but do not replace surface cleaning/disinfection)
Role of Hospital Surfaces in Disease Transmission

- Review the role of environmental surfaces
- Review the use of low-level disinfectants and the selection of the ideal disinfectant
- Review “best” practices for environmental cleaning and disinfection
- Discuss options for evaluating environmental cleaning and disinfection
- Discuss new “no touch” technologies for room decontamination and reduction of HAIs
“NO TOUCH” APPROACHES TO ROOM DECONTAMINATION
(UV/VHP~20 microbicidal studies, 12 HAI reduction studies; will not discuss technology with limited data)
Touch (Wiping) vs No-Touch (Mechanical)

No Touch
(supplements but do not replace surface cleaning/disinfection)
Formica Placement in the Patient Room

- Toilet seat
- Back of head-of-the-bed
- Back-of-computer
- Bedside table (far side)
- Side of sink
- Foot of bed, facing the door
- Bathroom door
UV Room Decontamination


- Fully automated, self calibrates, activated by hand-held remote
- Room ventilation does not need to be modified
- Uses UV-C (254 nm range) to decontaminate surfaces
- Measures UV reflected from walls, ceilings, floors or other treated areas and calculates the operation total dosing/time to deliver the programmed lethal dose for pathogens.
- UV sensors determines and targets highly-shadowed areas to deliver measured dose of UV energy
- After UV dose delivered (36,000µWs/cm² for spore, 12,000µWs/cm² for bacteria), will power-down and audibly notify the operator
- Reduces colony counts of pathogens by >99.9% within 20 minutes
TABLE 1. UV-C Decontamination of Formica Surfaces in Patient Rooms Experimentally Contaminated with Methicillin-Resistant *Staphylococcus aureus* (MRSA), Vancomycin-Resistant *Enterococcus* (VRE), Multidrug-Resistant (MDR) *Acinetobacter baumannii*, and *Clostridium difficile* Spores

<table>
<thead>
<tr>
<th>Organism</th>
<th>Inoculum</th>
<th>No. of samples</th>
<th>Decontamination, log$_{10}$ reduction, mean (95% CI)</th>
<th>UV-C line of sight</th>
<th>No. of samples</th>
<th>Decontamination, log$_{10}$ reduction, mean (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>4.88 log$_{10}$</td>
<td>50</td>
<td>3.94 (2.54–5.34)</td>
<td>Direct</td>
<td>10</td>
<td>4.31 (3.13–5.50)</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VRE</td>
<td>4.40 log$_{10}$</td>
<td>47</td>
<td>3.46 (2.16–4.81)</td>
<td></td>
<td>15</td>
<td>3.90 (2.99–4.81)</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDR A. baumannii</td>
<td>4.64 log$_{10}$</td>
<td>47</td>
<td>3.88 (2.59–5.16)</td>
<td></td>
<td>10</td>
<td>4.21 (3.27–5.15)</td>
<td>.07</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. difficile spores</td>
<td>4.12 log$_{10}$</td>
<td>45</td>
<td>2.79 (1.20–4.37)</td>
<td></td>
<td>10</td>
<td>4.04 (3.71–4.37)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Note: The table presents the results of UV-C decontamination of surfaces contaminated with various organisms, showing the reduction in log$_{10}$ units of microbial load post-treatment.
# Effectiveness of UV Devices on Reducing MDROs on Carriers

<table>
<thead>
<tr>
<th>Author, year</th>
<th>UV system</th>
<th>MDROs</th>
<th>Time (min)</th>
<th>Energy (µW/cm²)</th>
<th>Log₁₀ reduction direct (indirect)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutala, 2010²⁷</td>
<td>UV-C, Tru-D</td>
<td>MRSA, VRE, A</td>
<td>~15</td>
<td>12,000</td>
<td>4.31 (3.85), 3.90 (3.25), 4.21 (3.79)</td>
</tr>
<tr>
<td>Rutala, 2010²⁷</td>
<td>UV-C, Tru-D</td>
<td>Cd</td>
<td>~50</td>
<td>36,000</td>
<td>4.04 (2.43)</td>
</tr>
<tr>
<td>Boyce, 2011²⁸</td>
<td>UV-C, Tru-D</td>
<td>Cd</td>
<td>67.8 (1 stage)</td>
<td>22,000</td>
<td>1.7-2.9</td>
</tr>
<tr>
<td>Havill, 2012²⁹</td>
<td>UV-C, Tru-D</td>
<td>Cd</td>
<td>73 (mean)</td>
<td>22,000</td>
<td>2.2</td>
</tr>
<tr>
<td>Rutala, 2013³⁰</td>
<td>UV-C, Tru-D</td>
<td>MRSA</td>
<td>25</td>
<td>12,000</td>
<td>4.71 (4.27)</td>
</tr>
<tr>
<td>Rutala, 2013³⁰</td>
<td>UV-C, Tru-D</td>
<td>Cd</td>
<td>43</td>
<td>22,000</td>
<td>3.41 (2.01)</td>
</tr>
<tr>
<td>Mahida, 2013³¹</td>
<td>UV-C, Tru-D</td>
<td>OR: MRSA, VRE</td>
<td>49</td>
<td>12,000</td>
<td>≥4.0 (≥4.0), 3.5 (2.4)</td>
</tr>
<tr>
<td>Mahida, 2013³¹</td>
<td>UV-C, Tru-D</td>
<td>Single patient room: VRE, A, As</td>
<td>23-93</td>
<td>12,000</td>
<td>≥4.0 (&gt;2.3), ≥4.0 (1.7), ≥4.0 (2.0)</td>
</tr>
<tr>
<td>Rutala, 2014³²</td>
<td>UV-C, Optimum</td>
<td>MRSA</td>
<td>5</td>
<td>NS</td>
<td>4.10 (2.74)</td>
</tr>
<tr>
<td>Rutala, 2014³²</td>
<td>UV-C, Optimum</td>
<td>Cd</td>
<td>10</td>
<td>NS</td>
<td>3.35 (1.80)</td>
</tr>
<tr>
<td>Nerandzic, 2015³³</td>
<td>UV, PX, Xenon</td>
<td>Cd, MRSA, VRE</td>
<td>10 at 4 ft (2 cycles)</td>
<td>NS</td>
<td>0.55, 1.85, 0.6</td>
</tr>
</tbody>
</table>

A, *Acinetobacter* spp; As, *Aspergillus*; Cd, *Clostridium difficile*; MDRO, multidrug-resistant organism; MRSA, methicillin-resistant *Staphylococcus aureus*; NS, not stated; OR, operating room; PX, pulsed xenon; UV, ultraviolet light; VRE, vancomycin-resistant enterococci.

# Effectiveness of UV Devices on Reducing MDROs in Contaminated Patient Rooms

<table>
<thead>
<tr>
<th>Author, year</th>
<th>UV system</th>
<th>MDROs</th>
<th>Time (min); energy (µW/cm²)</th>
<th>Positive sites (before and after) (%)</th>
<th>Log₁₀ reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutala, 2010²⁷</td>
<td>UV-C, Tru-D</td>
<td>MRSA</td>
<td>~15; 12,000</td>
<td>20.2, 0.5</td>
<td>1.30</td>
</tr>
<tr>
<td>Nerandzic, 2010³⁴</td>
<td>UV-C, Tru-D</td>
<td>MRSA, VRE</td>
<td>20; 12,000</td>
<td>10.7, 0.8; 2.7, 0.38</td>
<td>0.68; 2.52</td>
</tr>
<tr>
<td>Nerandzic, 2010³⁴</td>
<td>UV-C, Tru-D</td>
<td>Cd</td>
<td>45; 22,000</td>
<td>3.4, 0.38</td>
<td>1.39;</td>
</tr>
<tr>
<td>Stibich, 2011³⁵</td>
<td>UV, PX, Xenex</td>
<td>VRE</td>
<td>12; NS</td>
<td>8.2, 0</td>
<td>1.36</td>
</tr>
<tr>
<td>Anderson, 2013³⁶</td>
<td>UV-C, Tru-D</td>
<td>All, VRE, A</td>
<td>25; 12,000</td>
<td>NS; 11, 1; 13, 3</td>
<td>1.35; 1.68; 1.71</td>
</tr>
<tr>
<td>Anderson, 2013³⁶</td>
<td>UV-C, Tru-D</td>
<td>Cd</td>
<td>45; 22,000</td>
<td>10, 5</td>
<td>1.16</td>
</tr>
<tr>
<td>Jinadatha, 2015³⁷</td>
<td>UV, PX, Xenex</td>
<td>MRSA</td>
<td>15 (3 cycles of 5 min); NS</td>
<td>70, 8</td>
<td>2.0</td>
</tr>
<tr>
<td>Nerandzic, 2015³³</td>
<td>UV, PX, Xenex</td>
<td>MRSA, VRE, Cd</td>
<td>10 (2 cycles of 5 min); NS</td>
<td>10, 2; 4, 0.9; 19, 8</td>
<td>0.90, 1.08, NS</td>
</tr>
<tr>
<td>Jinadatha, 2015³⁷</td>
<td>UV-PX, Xenex</td>
<td>MRSA</td>
<td>15 (3 cycles of 5 min); NS</td>
<td>NS, NS</td>
<td>0.63</td>
</tr>
</tbody>
</table>

*Acinetobacter* spp; *All*, all target organisms; *Cd*, *Clostridium difficile*; *MDRO*, multidrug-resistant organism; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *NS*, not stated; *PX*, pulsed xenon; *UV*, ultraviolet light; *VRE*, vancomycin-resistant enterococci.

### HP Systems for Decontamination of the Hospital Environment

Falagas et al. J Hosp Infect. 2011;78:171

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>HP System</th>
<th>Pathogen</th>
<th>Before HPV</th>
<th>After HPV</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>French, 2004</td>
<td>VHP</td>
<td>MRSA</td>
<td>61/85-72%</td>
<td>1/85-1%</td>
<td>98</td>
</tr>
<tr>
<td>Bates, 2005</td>
<td>VHP</td>
<td>Serratia</td>
<td>2/42-5%</td>
<td>0/24-0%</td>
<td>100</td>
</tr>
<tr>
<td>Jeanes, 2005</td>
<td>VHP</td>
<td>MRSA</td>
<td>10/28-36%</td>
<td>0/50-0%</td>
<td>100</td>
</tr>
<tr>
<td>Hardy, 2007</td>
<td>VHP</td>
<td>MRSA</td>
<td>7/29-24%</td>
<td>0/29-0%</td>
<td>100</td>
</tr>
<tr>
<td>Dryden, 2007</td>
<td>VHP</td>
<td>MRSA</td>
<td>8/29-28%</td>
<td>1/29-3%</td>
<td>88</td>
</tr>
<tr>
<td>Otter, 2007</td>
<td>VHP</td>
<td>MRSA</td>
<td>18/30-60%</td>
<td>1/30-3%</td>
<td>95</td>
</tr>
<tr>
<td>Boyce, 2008</td>
<td>VHP</td>
<td>C. difficile</td>
<td>11/43-26%</td>
<td>0/37-0%</td>
<td>100</td>
</tr>
<tr>
<td>Bartels, 2008</td>
<td>HP dry mist</td>
<td>MRSA</td>
<td>4/14-29%</td>
<td>0/14-0%</td>
<td>100</td>
</tr>
<tr>
<td>Shapey, 2008</td>
<td>HP dry mist</td>
<td>C. difficile</td>
<td>48/203-24%; 7</td>
<td>7/203-3%; 0.4</td>
<td>88</td>
</tr>
<tr>
<td>Barbut, 2009</td>
<td>HP dry mist</td>
<td>C. difficile</td>
<td>34/180-19%</td>
<td>4/180-2%</td>
<td>88</td>
</tr>
<tr>
<td>Otter, 2010</td>
<td>VHP</td>
<td>GNR</td>
<td>10/21-48%</td>
<td>0/63-0%</td>
<td>100</td>
</tr>
</tbody>
</table>
Clinical Trials Using UV for Terminal Room Decontamination to Reduce HAIs

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Design</th>
<th>Pathogens</th>
<th>Reduction in HAIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levin, 2013</td>
<td>Before-After, Pulsed Xenon</td>
<td>CDI</td>
<td>Yes</td>
</tr>
<tr>
<td>Hass, 2014</td>
<td>Before-After, Pulsed Xenon</td>
<td>CDI, MRSA, VRE, MDRO-GNR</td>
<td>Yes</td>
</tr>
<tr>
<td>Miller, 2015</td>
<td>Before-After, Pulsed Xenon</td>
<td>CDI</td>
<td>Yes</td>
</tr>
<tr>
<td>Nagaraja, 2015</td>
<td>Before-After, Pulsed Xenon</td>
<td>CDI</td>
<td>Yes (p=0.06)</td>
</tr>
<tr>
<td>Pegues, 2015</td>
<td>Before-After, Optimum</td>
<td>CDI</td>
<td>Yes</td>
</tr>
<tr>
<td>Anderson, 2017</td>
<td>Randomized-controlled trial, Tru-D</td>
<td>MRSA, VRE, CDI</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Enhanced Disinfection Leading to Reduction of Microbial Contamination and a Decrease in Patient Col/Infection

Anderson et al. Lancet 2017;289:805; Rutala et al. ICHE 2018;38:1118-1121

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.
### Clinical Trials Using HP for Terminal Room Disinfection to Reduce HAIs


<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Design</th>
<th>Pathogen</th>
<th>Reduction in HAIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boyce, 2008</td>
<td>Before-After</td>
<td>CDI</td>
<td>Yes</td>
</tr>
<tr>
<td>Cooper, 2011</td>
<td>Before-After</td>
<td>CDI</td>
<td>Decrease cases (incidence not stated)</td>
</tr>
<tr>
<td>Passaretti, 2013</td>
<td>Prospective cohort</td>
<td>MRSA, VRE, CDI</td>
<td>Yes, in all MDROs</td>
</tr>
<tr>
<td>Manian, 2013</td>
<td>Before-After</td>
<td>CDI</td>
<td>Yes</td>
</tr>
<tr>
<td>Mitchell, 2014</td>
<td>Before-After</td>
<td>MRSA</td>
<td>Yes</td>
</tr>
</tbody>
</table>
This technology ("no touch"-UV/HP) should be used (capital equipment budget) for terminal room disinfection (e.g., after discharge of patients on Contact Precautions).
UV ROOM DECONTAMINATION:
ADVANTAGES AND DISADVANTAGES

Rutala WA, Weber DJ. AJIC 2013;41:s36

• Advantages
  ■ Reliable biocidal activity against a wide range of pathogens
  ■ Studies demonstrating a reduction in HAIs
  ■ Surfaces and equipment decontaminated
  ■ Room decontamination is rapid (5-25 min) for vegetative bacteria
  ■ HVAC system does not need to be disabled and room does not need to be sealed
  ■ UV is residual free and does not give rise to health and safety concerns
  ■ No consumable products so operating costs are low (key cost = acquisition)

• Disadvantages
  ■ Can only be done for terminal disinfection (i.e., not daily cleaning)
  ■ All patients and staff must be removed from room
  ■ Substantial capital equipment costs
  ■ Does not remove dust and stains which are important to patients/visitors
  ■ Sensitive use parameters (e.g., UV dose delivered)
HP ROOM DECONTAMINATION:
ADVANTAGES AND DISADVANTAGES

Rutala WA, Weber DJ. AJIC 2013;41:s36

- Advantages
  - Reliable biocidal activity against a wide range of pathogens
  - Studies demonstrate a reduction in HAIs
  - Surfaces and equipment decontaminated
  - Residual free and does not give rise to health and safety concerns (aeration units convert HPV into oxygen and water)
  - Useful for disinfecting complex equipment and furniture
  - Does not require direct or indirect line of sight

- Disadvantages
  - Can only be done for terminal disinfection (i.e., not daily cleaning)
  - All patients and staff must be removed from room
  - Decontamination takes approximately 2.0 hours
  - HVAC system must be disabled and the room sealed with tape
  - Substantial capital equipment costs
  - Does not remove dust and stains which are important to patients/visitors
  - Sensitive use parameters (e.g., HP concentration)
Role of Hospital Surfaces in Disease Transmission

- Review the role of environmental surfaces
- Review the use of low-level disinfectants and the selection of the ideal disinfectant
- Review “best” practices for environmental cleaning and disinfection
- Discuss options for evaluating environmental cleaning and disinfection
- Discuss new “no touch” technologies for room decontamination and reduction of HAIs
Role of Hospital Surfaces in Disease Transmission

- Disinfection of noncritical environmental surfaces/equipment is an essential component of infection prevention.
- Disinfection should render surfaces and equipment free of pathogens in sufficient numbers to cause human disease.
- When determining the optimal disinfecting product, consider the 5 components (kill claims/time, safety, ease of use, others) and select the product with the highest score as the best choice for your healthcare facility.
- Implement a method to improve the thoroughness of cleaning.
- Goal: Product + Practice = Perfection.
- An enhanced method of room decontamination is superior to a standard method.
- “No touch” technology should be used at discharge for CP patients.
THANK YOU!

www.disinfectionandsterilization.org