Principles of Environmental Cleaning and Monitoring the Adequacy of Practices

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Disclosures: Consultant to Soap & Detergent Association, Cardinal Health, BD, Clorox Corporation, 3M Corporation, Advanced Sterilization Products, BIOQUELL PLC. Research support from 3M Corporation, BD, Lumalier.
Environmental Contamination

• Patients with pathogens such as methicillin-resistant *S. aureus* (MRSA), *Clostridium difficile*, vancomycin-resistant enterococci (VRE), and *Acinetobacter* frequently contaminate environmental surfaces in their immediate vicinity

• These organisms can remain viable in the environment for weeks or months
Examples of Contaminated Environmental Surfaces

- Items frequently contaminated near patients include:
  - Bed rails
  - Bed linen
  - Overbed tables
  - Blood pressure cuffs
  - Intravenous pumps
  - Nurse call buttons
  - Urinary collection bags
Cleaning Practices Are Often Suboptimal

- Daily cleaning of surfaces near patients is often performed poorly
- Terminal cleaning of rooms after patient discharge is often inadequate
  - Carling et al. found that only 47% of surfaces targeted for terminal cleaning had been cleaned

Eckstein BC et al. BMC Infect Dis 2007;7:61
Contaminated Surfaces Can Contribute to Transmission

- Contaminated environmental surfaces can contribute to transmission of pathogens
  - By serving as a source from which healthcare workers contaminate their hands or gloves
- Contaminated medical equipment that comes into direct contact with the patient can serve as a source of transmission

Boyce JM et al. Infect Control Hosp Epidemiol 1997;
Contaminated Surfaces Can Contribute to Transmission

- Patients admitted to a room formerly occupied by a patient with VRE or MRSA are at increased risk of acquiring the organism, suggesting that
  - terminal cleaning of rooms was inadequate
  - patients acquire the organism
    - directly from contaminated surfaces
    - from HCWs who contaminate their hands in the room

Huang SS et al. Arch Intern Med 2006;166:1945
Does Increased Cleaning/Disinfection Help Reduce Transmission of Pathogens?

- A number of studies have shown that improved cleaning and disinfection of environmental surfaces can reduce transmission of pathogens such as *C. difficile*, vancomycin-resistant enterococci (VRE), and methicillin-resistant *S. aureus* (MRSA)

Boyce JM et al. Infect Control Hosp Epidemiol 2008;29:723
Reducing Environmental Contamination Reduces VRE Transmission

- Prospective, 9-month study in an MICU included
  - Admission and daily screening of patients
  - Environmental and HCW hand cultures twice weekly

- Study design included
  - Baseline period (1)
  - Education/monitoring/feedback for housekeepers (2)
  - Wash-out period with no specific intervention (3)
  - Multimodal hand hygiene intervention (4)

Reducing Environmental Contamination Reduces VRE Transmission

- Environmental cleaning rate increased significantly
- VRE environmental contamination decreased significantly
- VRE acquisitions by patients decreased significantly
- Other factors analyzed could not explain decreased VRE acquisition rate

# Level of Disinfection/Cleaning Required for Patient Care Equipment

<table>
<thead>
<tr>
<th>Spaulding Classification of Objects</th>
<th>Application</th>
<th>Level of Germicidal Action Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>Entry or penetration into sterile tissue, cavity or bloodstream</td>
<td>Sterilization</td>
</tr>
<tr>
<td>Semi-critical</td>
<td>Contact with mucous membranes, or non-intact skin</td>
<td>High-level Disinfection</td>
</tr>
<tr>
<td>Non-critical</td>
<td>Contact with intact skin</td>
<td>Low-level Disinfection</td>
</tr>
</tbody>
</table>
Non-Critical Items

• Non-critical patient care items
  – Bedpans
  – Blood pressure cuffs
  – Crutches
  – Computers

• Non-critical environmental surfaces
  – Bed rails
  – Bedside or overbed tables
  – Nurse call buttons
  – Furniture in patient rooms
  – Floors

Rutala WA et al.  CDC Guideline for Disinfection & Sterilization
In Healthcare Facilities, 2008
Common Agents Used for Disinfection of Environmental Surfaces

- **Chlorine and Chlorine compounds**
  - Sodium hypochlorite (5.25 – 6.15% solutions) – “bleach”
  - Sodium dichloroisocyanurate tablets
  - Demand-release chlorine dioxide, chloramine-T
- **Ethyl or isopropyl alcohol (70-90%)**
- **Quaternary ammonium germicidal solutions**
- **Phenolic germicidal detergent solutions**
- **Iodophor germicidal solutions**
- **Accelerated hydrogen peroxide solutions**
Sodium hypochlorite (5.25 – 6.15% solutions)  
“household bleach”

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Parts per million (ppm) available chlorine</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>household bleach (undiluted)</td>
<td>52,500 - 61,500</td>
<td></td>
</tr>
<tr>
<td>1:10 dilution of household bleach</td>
<td>5,250 - 6,150</td>
<td>Active against C. difficile spores</td>
</tr>
<tr>
<td>1:50 dilution of household bleach</td>
<td>1,050 - 1,230</td>
<td>Active against Mtb, Norovirus</td>
</tr>
<tr>
<td>1:500 dilution of household bleach</td>
<td>105 - 123</td>
<td>Active against vegetative bacteria</td>
</tr>
</tbody>
</table>
Advantages and Disadvantages of Common Disinfectants

<table>
<thead>
<tr>
<th>Disinfectant</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium hypochlorite (household bleach)</td>
<td>Inexpensive, Fast-acting, Widely available, Active against bacteria, spores, Mtb, viruses</td>
<td>Odor can be irritating, Corrosive to metals, Inactivated by organic material, May discolor fabrics</td>
</tr>
<tr>
<td>Ethyl or isopropyl alcohol (70-90%)</td>
<td>Inexpensive, Widely available, Rapidly effective, Active against bacteria, Mtb, viruses</td>
<td>Not effective against bacterial spores, Not for large surfaces</td>
</tr>
</tbody>
</table>

## Advantages and Disadvantages of Common Disinfectants

<table>
<thead>
<tr>
<th>Disinfectant</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary ammonium</td>
<td>Not too expensive</td>
<td>Not effective against bacterial spores, Mtb, non-enveloped viruses</td>
</tr>
<tr>
<td>compounds</td>
<td>Widely available</td>
<td>May become contaminated</td>
</tr>
<tr>
<td></td>
<td>Good cleaning agents</td>
<td></td>
</tr>
<tr>
<td>Phenolics</td>
<td>Widely available</td>
<td>Use on bassinets may be toxic to infants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor activity against bacterial spores and non-enveloped viruses</td>
</tr>
</tbody>
</table>
New Room Decontamination Methods: Hydrogen Peroxide Vapor

• 2 main hydrogen peroxide vapor technologies are commercially available for room decontamination
  – Micro-condensation process (BIOQUELL)
  – “Dry gas” process (Steris)

• Despite differences in method of application, both technologies have been validated as effective
  – Most experience in healthcare settings is with the micro-condensation process

McAnoy AM: Vaporous Decontamination Methods, Australian Government DSTO 2006
Hydrogen Peroxide Vapor (HPV)

- Ventilation ducts/doors must be taped shut
- HPV injected into empty room until defined dose delivered
- Catalytic converter converts HPV into oxygen & water vapor
- No toxic residuals
- Turn-around time for standard hospital room = ~ 2 hr 20 min
- Highly effective against Mtb, bacterial spores, fungi, viruses
- Has been shown to reduce acquisition of *C. difficile* and vancomycin-resistant enterococci

Boyce JM et al. Infect Control Hosp Epidemiol 200829:723
Otter JA et al. Infect Control Hosp Epidemiol 2009;30:574
Passaretti CL et al. 48th ICAAC, 2008, Abstr K-4214b
New Room Decontamination Methods: Ultraviolet Light Systems

- Automated mobile UV light units that emit UV-C (254 nm range) can be placed in patient rooms after patient discharge and terminal cleaning had been performed.
- Units can be set to kill vegetative bacteria or to kill spores.
- Significantly reduce bacterial counts in patient rooms.
- Easy to use and require relatively short cycle times.
Non-Critical Patient Care Equipment

• Disinfect non-critical medical devices with accepted disinfectant using concentration and contact time recommended by manufacturer
  – Contact time of > 1 min. often effective

• Disinfect non-critical patient care devices when visibly soiled and on a regular basis
  – After use on each patient, or once daily or once weekly

• If dedicated equipment is not available, disinfect items after using on a patient who is being isolated due to resistant microorganisms

Non-Critical Environmental Surfaces

- Disinfect (or clean) environmental surfaces on a regular basis and when visibly soiled
- Follow manufacturers’ recommendations for use of disinfectant (or detergent) products
- Clean walls, window blinds and window curtains in patient-care areas when they are visibly soiled
- Use an approved disinfectant in patient-care areas
  - If contamination by blood/body fluids is possible
  - If contamination by multidrug-resistant organisms is possible
Non-Critical Environmental Surfaces

• Prepare disinfectant (or detergent) solutions as needed, and replace them with fresh solution frequently
  – Replace floor mopping solution every 3 patient rooms
  – Change no less often than at 60-min. intervals

• Decontaminate mop heads and cleaning cloths regularly to prevent contamination

• Detergent and water are adequate for cleaning surfaces in nonpatient-care areas
  – Example: administrative offices
Non-Critical Environmental Surfaces

• Promptly clean and disinfect spills of blood and other potentially infectious materials
  – Use protective gloves and other personal protective equip.
  – Use disinfectant active against HIV or HBV
    • E.g., 1:100 dilution of household bleach for small spill
    • E.g., 1:10 dilution of household bleach for large spill
• In patient-care areas with high rates of *C. difficile* infection or in an outbreak setting
  – Use 1:10 dilution of household bleach
Non-Critical Environmental Surfaces

- Clean and disinfect “high-touch” surfaces on a more frequent schedule than housekeeping surfaces seldom touched by patients and healthcare workers
- Examples of “high-touch” surfaces: bed rails, overbed tables, surfaces in and around patient toilets, nurse call buttons

Sehulster L et al. HICPAC Environmental Guideline
MMWR Recomm Rep 2003;52(RR-10):1
Factors Contributing to Suboptimal Cleaning/Disinfection Practices

• Housekeepers and nursing staff often do not agree on who should clean what
• Housekeepers do not always understand
  – Which detergent/disinfectant to use
  – What concentration should be used
  – How often to change cleaning cloths/mop heads
• Other contributing factors
  – Demands for fast room “turnaround times”
  – Staff shortages and frequent turnover of personnel
Improving Cleaning/Disinfection Practices

• Educate housekeepers regarding recommended cleaning practices and the importance of following hospital cleaning policies
• Ensure compliance by housekeeping staff with cleaning and disinfection procedures
• Develop policies regarding which patient-care equipment and environmental surfaces are to be cleaned by housekeepers and by nursing staff

Sehulster L et al. HICPAC Environmental Guideline MMWR Recomm Rep 2003;52(RR-10):1
Methods for Assessing Cleaning Practices

- **Visual inspection**
  - Check list to assure surfaces have been wiped

- **Marking surfaces with fluorescent dye, and checking to see if marker was removed during cleaning**

- **Culturing surfaces (aerobic colony counts)**
  - Contact agar plates or moistened swab cultures

- **ATP bioluminescence assays to measure cleanliness**

Griffith CJ et al. J Hosp Infect 2000;45:19
Dancer SJ J Hosp Infect 2009;73:378
## Checklist For Daily Cleaning of High-Touch Surface

<table>
<thead>
<tr>
<th>Surface</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrails, bed frame</td>
<td></td>
</tr>
<tr>
<td>Overbed table</td>
<td></td>
</tr>
<tr>
<td>TV remote control</td>
<td></td>
</tr>
<tr>
<td>Nurse call button</td>
<td></td>
</tr>
<tr>
<td>Telephone</td>
<td></td>
</tr>
<tr>
<td>Bathroom: grab bars</td>
<td></td>
</tr>
<tr>
<td>toilet seat</td>
<td></td>
</tr>
<tr>
<td>faucet handles</td>
<td></td>
</tr>
<tr>
<td>Light switches</td>
<td></td>
</tr>
<tr>
<td>Door handles</td>
<td></td>
</tr>
</tbody>
</table>
Fluorescent Dye Marker System for Monitoring Cleaning Practices

- Prospective study conducted in 3 hospitals
- 12 high-touch objects in patient rooms were marked with invisible fluorescent solution after terminal cleaning
  - Marks moistened by disinfectant spray could be removed by wiping surface for 5 seconds with light pressure

Monitoring Cleaning Practices

- After at least 2 patients had occupied the rooms and rooms had been terminally cleaned, target surfaces were evaluated using a portable UV light to see if the marker had been wiped off
- Education and feedback given to cleaning staff
Monitoring Cleaning Practices

- 1404 objects were evaluated before the intervention
- 744 objects were evaluated after the intervention
- Proportion of objects cleaned
  - Before intervention: 47%
  - After interventions: 76 - 92%
- Technique improved in all hospitals (p < 0.001)
- Technique has been adopted in numerous hospitals and has led to improved cleaning practices

Carling PC et al. Infect Control Hosp Epidemiol 2008;29:1
Aerobic Colony Counts

- Methods of culturing environmental surfaces
  - **Moistened swab inoculated onto agar +/- broth enrichment**
    - Most useful for irregularly shaped surfaces
  - **Agar contact plates (Rodac)**
    - Recommended for flat surfaces
    - Yields number of colonies per square inch or centimeter

- Currently, no standard methods for how to obtain & to process specimens for aerobic colony counts
  - Provide data on contamination by important pathogens

- No accepted criteria for defining a surface as “clean” by using aerobic colony counts

Sehulster L et al. MMWR Recomm Rep 2003;52(RR-10):1
Dancer SJ  J Hosp Infect 2004;56:10
Monitoring Cleaning Practices

- ATP bioluminescence methods have been used for years to monitor adequacy of cleaning procedures
  - in beverage and food processing industries
- Methods detect ATP from bacteria, human secretions, food
  \[
  \text{Luciferase} + \text{D-Luciferin} + \text{O}_2 + \text{ATP} \\
  \text{Luciferase} + \text{oxy-luciferin} + \text{CO}_2 + \text{AMP} \rightarrow \text{PP}_i + \text{Light}
  \]
- Amount of light is proportional to concentration of ATP present

Griffith CL et al. J Hosp Infect 2000;45:19
ATP Bioluminescence Assay Systems

Step 1
Use special swab to sample surface

Step 2
Place swab in reaction tube

Step 3
Place tube in luminometer
Results: Relative Light Units
ATP Bioluminescence Assay Systems

- Provide quantitative measure of cleanliness
- Results are available in seconds
- Can be used to educate housekeepers and give them feedback regarding their performance
- Can identify variations in housekeeping practices

Griffith CL et al.  J Hosp Infect 2000;45:19
Boyce JM et al. Infect Control Hosp Epidemiol 2010;31:99
## Advantages and Disadvantages of Methods for Assessing Cleaning Practices

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual inspection</td>
<td>Simple</td>
<td>Does not provide reliable assessment of cleanliness</td>
</tr>
<tr>
<td>Fluorescent marker system</td>
<td>Inexpensive Minimal equipment needed</td>
<td>Must mark surfaces before cleaning, and check them after cleaning</td>
</tr>
<tr>
<td>Aerobic colony counts</td>
<td>Relatively simple Detects presence of pathogens</td>
<td>More expensive Results not available for 48 hrs later</td>
</tr>
<tr>
<td>ATP bioluminescence assay systems</td>
<td>Provides quantitative measure of cleanliness Quick results</td>
<td>More expensive Requires special equipment</td>
</tr>
</tbody>
</table>
Internet Resources

• HICPAC guidelines
  – www.cdc.gov/ncidod/dhqp/gl_environinfection.html
• www.disinfectionandsterilization.org
• www.cleanhospitals.net
  – Click on Clean Environment