Strategies for Improving Cleaning and Disinfection of Environmental Surfaces in Healthcare Settings
Dr. John Boyce, Hospital of St. Raphael, Yale University
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Strategies for Improving Cleaning and Disinfection of Environmental Surfaces in Healthcare Facilities

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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

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 is inadequate
  - patients acquire the organism
  - directly from contaminated surfaces
  - from HCWs who contaminate their hands in the room

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)

Environments Contamination
- Patients with pathogens such as MRSA, VRE, C. difficile and Acinetobacter frequently contaminate environmental surfaces in their immediate vicinity
- These organisms can remain viable in the environment for weeks or months

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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


Evidence That Environmental Disinfection Reduces Transmission of C. difficile
- CDAD transmission decreased significantly on a high incidence ward after changing from quaternary ammonium to 1:10 solution of sodium hypochlorite (bleach)
- Incidence rose to initial level after a switch back to quaternary ammonium
- 1:10 hypochlorite did not reduce CDAD incidence on low-incidence wards


Evidence That Environmental Disinfection Reduces Transmission of C. difficile
- Hypochlorite disinfection was used in 2 ICUs with increased incidence of CDAD
  - Hypochlorite used in all patient rooms in one ICU
  - Hypochlorite was used in only rooms of patients with CDAD in the other ICU
- Incidence of CDAD decreased in both ICUs, and remained low for 1.5 years


Improving Cleaning/Disinfection Practices
- Based on increasing evidence,
  - CDC’s Healthcare Infection Control Practices Advisory Committee (HICPAC)
  - SHEA/IDSA Healthcare-Associated Infections Task Force
  - Have recommended that healthcare facilities pay greater attention to cleaning and disinfection of equipment and the environment


Factors Contributing to Suboptimal Cleaning/Disinfection Practices
- Housekeepers and nursing staff often do not agree on who should clean what
  - 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


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Monitoring Housekeeping Practices

- Were important surfaces wiped with appropriate disinfectant or detergent?
  - Checklist to be completed by housekeeper
  - Fluorescent dye marker placed by supervisor

- Is surface “clean”?
  - Visual assessment: does the surface look clean?
  - Aerobic colony counts
  - Time consuming; results available in 48 hrs
  - Adenosine triphosphate (ATP) bioluminescence assay
  - Results available immediately

Sherlock O et al. J Hosp Infect 2009

High-Touch Surface Checklist For Daily Cleaning

<table>
<thead>
<tr>
<th>Item</th>
<th>Daily Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrails, bed frame</td>
<td></td>
</tr>
<tr>
<td>Overbed</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

Carling PC et al Clin Infect Dis 2006;42:385

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

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

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**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.
  
  \[
  \text{Luciferase} + \text{D-Luciferin} + \text{O}_2 + \text{ATP} \\
  \text{Luciferase} + \text{oxy-luciferin} + \text{CO}_2 + \text{AMP} + \text{PPi} + \text{Light} \\
  \]
- Amount of light is proportional to concentration of ATP present.

Griffith CL et al. J Hosp Infect 2000;45:19

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**Trial of ATP Bioluminescence Assay System**

- Prospective trial in community-teaching hospital.
  
  - Phase I: ATP bioluminescence method was used to sample 5 high-touch surfaces before/after daily cleaning in 20 rooms.
    – Housekeepers were unaware that cleaning was being monitored.
  
  - Phase II: ATP readings were obtained from same 5 high-touch surfaces before/after daily cleaning in 101 patient rooms on randomly selected nursing units hospital-wide.
    – Goal was to determine the range of ATP readings that could be achieved with reasonably good cleaning technique.
    – Housekeepers were told in advance that the room they were about to clean would be tested before and after daily cleaning.

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**Common Cleaning/Disinfection Methods**

- Liquid disinfectants, or detergents:
  - Spray disinfectant on surface or cleaning cloth & wipe.
  - Soak clean cloth in disinfectant and wipe surface.
  - Use disinfectant-impregnated wipes.
  - “Bucket method”; cloth is soaked in disinfectant, used to drench surfaces, which are kept wet x 10 min; surfaces are wiped dry with clean cloth.

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**3M BioTrace ATP Bioluminescence Method**

- 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

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**Median ATP Readings (RLUs) for 5 High-Touch Surfaces, Before and After Daily Cleaning in 20 Rooms**

**Median Relative Light Unit Readings, Before & After Daily Cleaning in Patient Rooms, Phase II**

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### Liquid Disinfectants
- Traditional liquid disinfectants  
  - Quaternary ammonium compounds (most commonly used)  
  - Phenolics  
  - Alcohols or alcohol-based mixtures  
  - Chlorine-releasing products  
- New or experimental liquid disinfectants  
  - Accelerated hydrogen peroxide  
  - Silver ion zeolite technology  
  - Immobilized polymeric bicocide + insoluble silver salt  
  - Organosilane formulation  
  - Cationic ingredient + chlorhexidine  
  - Copper-based disinfectants

### Disinfection Methods for *C. difficile* and Norovirus outbreaks
- In units with high rate of *C. difficile*-associated disease, use 1:10 dilution of household bleach for routine environmental disinfection  
  - Currently, no products are EPA-registered specifically for inactivating *C. difficile* spores  
  - EPA is evaluating a sodium hypochlorite product for use against *C. difficile* spores, and will likely approve  


- Common surfaces disinfectants have poor activity against Norovirus  
  - Dilute household bleach solution is recommended

### Accelerated hydrogen peroxide
- Accelerated hydrogen peroxide liquid formulation  
- Bactericidal and virucidal in 1 min and mycobactericidal and fungicidal in 5 min  
- More desirable side effects profile than quaternary ammonium-based disinfectants; is more expensive  
- Gained popularity in Canada  
  - Used by 24% of hospitals in one small Canadian survey


### Vapor-Phase Disinfectants (Fumigants)
- Vapor-phase disinfectants  
  - β-propiolactone  
  - Ethylene oxide  
  - Methyl bromide  
  - Ozone  
  - Formaldehyde gas *  
  - Chlorine dioxide gas *  
  - Hydrogen peroxide vapor *

* Used for remediation (decontamination) of equipment or buildings after 2001 anthrax attack

McAnoy AM: Vaporous Decontamination Methods  
Australian Government DSTO 2006

### Hydrogen Peroxide Vapor
- 2 main hydrogen peroxide vapor technologies are commercially available  
  - 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  
Fisher J et al. Pharmaceutical Technology 2004, pg. 68

### Hydrogen Peroxide Vapor Micro-Condensation Process
- Hydrogen peroxide vapor micro-condensation process (Bioquell) has been used in hospitals with epidemic or endemic problems with MRSA, VRE, *C. difficile*, Acinetobacter or other multidrug-resistant Gram negative pathogens  
- Effective against a broad range of healthcare-associated pathogens including *C. difficile* spores

Passaretti C et al. 2009 IDSA/ICAAC meeting, Abstr K-4124b  
Dryden M et al. J Hosp Infect 2006;68:190  

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Impact of Hydrogen Peroxide Vapor (HPV) Room Decontamination on Environmental Contamination and Nosocomial Transmission by Clostridium difficile
- A 10-month prospective trial at Hospital of Saint Raphael
- Collaborators: CDC and BIOQUELL PLC
- Pre- and post-intervention study design
- HPV was injected into sealed patient rooms using HPV generators until a c. 1micron film of HPV was applied
- HPV is then catalytically converted to oxygen and water vapor by an aeration unit
- Cycle time: 12 hrs for entire ward or 3 - 4 hrs for a patient room; current cycle times are 2.3 to 3 hrs
Boyce JM et al. Infect Control Hosp Epidemiol 2008;29:723

Microbiologic Efficacy of HPV Decontamination

<table>
<thead>
<tr>
<th>Before HPV</th>
<th>After HPV</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Swab Cultures</td>
<td># of Cultures (+) for Cdiff</td>
</tr>
<tr>
<td>165</td>
<td>4</td>
</tr>
</tbody>
</table>

(2.4%) (5%) (14%)

# of Sponges Cultured | # of Sponges (+) for Cdiff | # of Sponges Cultured | # of Sponges (+) for Cdiff |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>11</td>
<td>25.6%</td>
<td>37</td>
</tr>
</tbody>
</table>

Conclusion: HPV is efficacious in eradicating Cdiff, MRSA and VRE from environmental surfaces

Impact of HPV Decontamination on Incidence of New Nosocomial CDAD Cases

Reduction in rate: 39%
Reduction in rate: 53%

Boyce JM et al. Infect Control Hosp Epidemiol 2008;29:723

Hydrogen Peroxide “Dry-Mist” System
- Hydrogen peroxide “dry mist” system (Sterinis) injects particles of 8 – 12 microns into room
- Disinfectant contains 5% H₂O₂ + silver ions + phosphoric acid
- Has shown reduction in bacterial contamination in experimental and actual hospital rooms
- Appears to be less efficacious against C. difficile spores than hydrogen peroxide vapor

Bartels MD et al. J Hosp Infect 2008;70:35
Shapey S et al. J Hosp Infect 2008;70:136

Alcohol/Quaternary Ammonium Mist System
- Disinfectant is sprayed onto surfaces; evaporates quickly so no wiping of surfaces is required
- Disinfectant contains 58.6% alcohol + 4-chain quaternary ammonium suspended in carbon dioxide carrier (Biomist); non-flammable
- Significantly reduced VRE and MRSA on hospital surfaces
- No data on C. difficile spores
- Not as consistently effective as 1:10 solution of bleach

Jury LA et al. 2009 SHEA meeting, abstr 278

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Other Area Decontamination Strategies

- Ultraviolet Light Surface Decontamination (Lumalier Tru-D)
- Gaseous ozone
  - Berrington AW J Hosp Infect 1998
  - Sharma M et al. AJIC 2008;36:559
- Super-oxidized water fogging
- Quaternary ammonium “dry mist” system (Zimek)
  - No published studies or data on C. difficile spores

Summary

- Improving cleaning/disinfection practices in hospitals requires
  - Developing detailed protocols, educating housekeepers
  - Monitoring cleaning, providing feedback to housekeepers
- Methods of monitoring the adequacy of cleaning
  - Checklists
  - Using fluorescent markers
  - ATP bioluminescence methods
  - Surface cultures (colony counts)
- New liquid disinfectants, some with persistent activity, are becoming available and warrant further evaluation
- Hydrogen peroxide vapor, mobile UV light systems, and other new area decontamination systems warrant further evaluation to determine their effectiveness and impact on transmission of healthcare-associated pathogens

Summary

- Issues to consider when evaluating liquid disinfectants or area decontamination systems
  - Effectiveness against
    - bacteria, including C. difficile spores
    - viruses, including non-enveloped viruses like Norovirus
  - Ease of application
  - Speed of action or room turn-around time
  - Materials compatibility
  - Adverse effects on housekeepers, patients, environment
  - Impact on pathogen transmission
  - Cost

Selected Guidelines

- HICPAC Environmental guideline
  [www.cdc.gov/ncidod/dhqp/pdf/guidelines/Enviro_guide_03.pdf]
- HICPAC MDRO guideline
- HICPAC Disinfection and Sterilization guideline
- Canadian Hand Hygiene, Disinfection & Sterilization guideline
  [www.phac-aspc.gc.ca/publicat/ccdr-rmtc/98pdf/cdrt44e.pdf]

The Next Few Teleclasses

- 21 Apr. 09: Free British Teleclass Voices of the IPS
  Speaker: IPS Board Members and Guests
- 23 Apr. 09: Economic and Health Benefits of Universal MRSA Screening
  Speaker: Prof. Stephen Hazeneth, University of Arizona Hospitals
- 29 Apr. 09: South Pacific Teleclass Cost of Healthcare in the Southern Hemisphere
  Speaker: Dr. David Hamner, Canberra District Health Laboratories
  Speaker: Bruce Gorman, British Columbia Provincial Infection Control Network
- 19 May. 09: British Teleclass Human Papilloma Virus (HPV) and Vaccination
  Speaker: Dr. Tito Lopez, British Gynaecological Society
- 21 May. 09: The Importance of Health Care Worker and Infection Risk
  Speaker: Prof. Scotti Teitelman, University of Illinois Medical School

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