Improving Cleaning and Disinfection and How to Monitor the Effectiveness of Surface Disinfection?

John M. Boyce, MD
Infectious Diseases Section
Hospital of Saint Raphael
and
Clinical Professor of Medicine
Yale University School of Medicine
New Haven, CT

Disclosures: Consultant to Soap and Detergent Association, 3M Corporation, Clorox Corporation, Advanced Sterilization Products, BIOQUELL PLC, Cardinal Health
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Improving Cleaning/Disinfection Practices

- Pay close attention to cleaning and disinfection of high-touch surfaces in patient-care areas
- Ensure compliance by housekeeping staff with cleaning and disinfection procedures
- Disinfect (or clean) environmental surfaces on a regular basis, and when surfaces are visibly soiled

Sehulster L et al. MMWR Recomm Rep 2003;52(RR-10):1

Improving Cleaning/Disinfection Practices

- Housekeepers and nursing staff often do not agree on who should clean what
- Housekeepers do not always understand
  - Which detergent/disinfect to use
  - What concentration should be used
  - How often to change cleaning cloths/mop heads
- Develop policies regarding who should clean what
  - Define items to be cleaned/disinfected
    - by nursing staff
    - by housekeeping staff

Dumigan DG et al. AJIC 2010;38:387
### ROUTINE DAILY CLEANING OF PATIENT ROOM

**RESPONSIBLE SERVICE:** Environmental Services

**ITEMS TO BE CLEANED:**
- dust window ledge
- spot clean furniture (chairs)
- wipe down over-bed table
- wipe down side rails
- wipe down TV control
- wipe down bathroom fixtures (faucets, grab bar, shelf, etc.)
- check and adjust
- wipe down door handles (room and bathroom)
- wipe bathroom and patient floor

**PRODUCTS USED TO CLEAN:**
- 1–9. EPA/ICC hosp quat*
- 1–8. EPA/ICC hosp bleach wipe** for Contact CD and Enteric Precautions
- 9. EPA/ICC hosp quat*

**COMMENTS:** 8 Step daily cleaning process

### TRANSFER/DISCHARGE CLEANING OF PATIENT ROOM, AND ANY PATIENT ROOM AT NURSE’S REQUEST (WHEN ROOM IS EMPTY)

**RESPONSIBLE SERVICE:** Environmental Services

**ITEMS TO BE CLEANED:**
- clean bed frame, side rails, mattress (after nursing has stripped bed of all linen)
- clean bedside table, over bed table, phone, call bell
- wipe down flow meters
- wipe down regulators
- dust/clean lighting fixtures
- clean outside canister (clean) of suction container
- clean and wipe down IV poles and pumps that need to remain on the unit, apply sani-strip
- wipe down furniture
- dust all ledges
- clean wall and sharp edges containers and gowns
- wipe down door knobs
- wipe down doorknobs
- wipe down doorknobs
- clean bedside commode, (once emptied by nursing) apply sani-strip
- clean bathroom fixtures, sink, shower, and toilet apply sani-strip
- mop bathroom and patient floor
- pull trash
- change out privacy curtains if soiled or on request

**PRODUCTS USED TO CLEAN:**
- 1–16. EPA/ICC hosp quat*
- 1–15. EPA/ICC hosp bleach wipe** for Contact CD and Enteric Precautions
- 16. EPA/ICC hosp quat*

**COMMENTS:** 8 Step Discharge cleaning process

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### Methods for Assessing Cleaning Practices

- **Visual inspection of surfaces**
  - Check lists sometimes used
- Observation of housekeeper technique
- Fluorescent marker system
- Aerobic colony counts
- ATP bioluminescence assays

Griffith CJ et al. J Hosp Infect 2000;45:19
Dancer SJ J Hosp Infect 2009;73:378

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### Visual Inspection of Surfaces

- Simple, can be conducted in any facility
- Usually performed by housekeeping managers
- Assess surfaces to detect visible dirt/stains
- Problem: Surfaces that appeared clean by visual inspection often failed to pass criteria for cleanliness when tested by objective measures: aerobic colony counts or ATP bioluminescence

Griffith CJ et al. J Hosp Infect 2000;45:19
Cooper RA et al. AJIC 2007;35:338
Observation of Housekeeper Technique

- Covert or overt observation of housekeepers during routine cleaning/disinfection activities
  - Establish variations in amount of time spent cleaning or disinfecting high-touch objects
  - Determine number of disinfectant wipes used/room
  - Detect which surfaces are not wiped adequately
  - Establish if housekeepers are allowing disinfectant to remain on surfaces for appropriate contact time

Boyce JM et al. ICHE 2010;31:99
Guerrero D et al. 2010 Decennial conference, Abstr 60

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

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

Carling PC et al. J Hosp Infect 2008;68:3
Improving Cleaning Practices by Using Fluorescent Marker System

• 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 3 hospitals (p < 0.001)
• This method has been used to improve cleaning practices in several larger studies

Carling PC et al. Infect Control Hosp Epidemiol 2008;29:1
Carling PC et al. Crit Care Med 2010;38:1054

Improving Cleaning Practices by Using Fluorescent Marker System

• Prospective study in 36 acute-care hospitals
  – Hospital size: 25 to 721 beds
• Fluorescent markers applied to 14 types of objects before terminal room disinfection
• 20,646 surfaces checked after terminal cleaning
• Intervention included providing housekeepers with performance feedback

Carling PC et al. ICHE 2008;29:1035

Using Fluorescent Marker System to Decrease MRSA and VRE Contamination

• Prospective study
  – Fluorescent marker placed on 15 types of surfaces
  – Cultures for MRSA & VRE from 6 types of surfaces in 37 patient rooms
  – Intervention included educational campaign and feedback to housekeepers
• Cleaning rate
  – Baseline: 44%
  – Intervention: 71%

Goodman DR et al. ICHE 2008;29:593
Using Fluorescent Marker System to Decrease MRSA and VRE Contamination

- Multivariate analysis revealed:
  - Proportion of removed marks in a given room was significantly predictive of fewer MRSA or VRE cultures
  - However, no direct correlation between the removal of the fluorescent marker from a specific surface and the likelihood that the surface culture would yield MRSA or VRE

Goodman DR et al. ICHE 2008;29:593

Monitoring Hospital Cleanliness Using ATP Bioluminescence Assays

- ATP is present in all organic material, including bacteria, other microorganisms, human secretions and excretions and food
- Highly contaminated surfaces have much ATP present, and yield high bioluminescence readings, clean surfaces yield low ATP readings
- Has been used in food processing and beverage industries for years

Malik RE et al. AJIC 2003;31:181

Monitoring Hospital Cleanliness Using ATP Bioluminescence Assays

- ATP bioluminescence assays have been used to monitor cleanliness of surfaces in hospitals
  - Daily cleaning or terminal cleaning
  - Assess variations in housekeeper performance

Griffith CL et al. J Hosp Infect 2000;45:19
Malik RE et al. AJIC 2003;31:181
Boyce JM et al. Infect Control Hosp Epidemiol 2010;31:99
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

Monitoring Daily Cleaning Practices
Using an ATP Bioluminescence Assay

• 5 high-touch surfaces in patient rooms were sampled before and after daily cleaning
  – Bedside rails, overbed tables, and TV remotes
  – Grab bars and toilet seats in patient bathrooms

• Phase I
  – included 20 rooms
  – housekeepers were not notified that ATP readings were being obtained before and after cleaning

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

Boyce JM et al. ICHE 2009;30:678
**Monitoring Daily Cleaning Practices Using an ATP Bioluminescence Assay**

- **Phase II**
  - Results of Phase I used to
    - Educate housekeepers about the importance of cleaning procedures
    - Give them feedback regarding their performance
  - Then, 105 rooms on randomly selected wards were sampled after daily cleaning
  - Housekeepers were notified in advance that ATP readings would be obtained before and after cleaning

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### Median Relative Light Unit Readings, After Daily Cleaning, Phases I and II

<table>
<thead>
<tr>
<th>Surface</th>
<th>Phase I</th>
<th>Phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrail</td>
<td>800</td>
<td>600</td>
</tr>
<tr>
<td>Overbed</td>
<td>400</td>
<td>300</td>
</tr>
<tr>
<td>Table</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>TV Remote</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Grab bar</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>Toilet Seat</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>

- **P-values:**
  - < .001            < 0.001            .02               .002              .87

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**Variations in Daily Cleaning Practices**

- Housekeepers were observed while performing daily cleaning in patient rooms
- ATP bioluminescence readings were obtained from 5 high-touch surfaces after housekeepers completed daily cleaning
- Median ATP readings were calculated for each housekeeper, for each of the 5 high-touch surfaces

*Boyce JM et al. Infect Control Hosp Epidemiol 2010;31:99*
Comparing Aerobic Colony Counts (ACC) with ATP Readings

- Comparing AACs with ATP results not very useful
- Relatively poor direct correlation between ACCs and ATP readings, expressed as RLUs
  - e.g., Correlation coefficients in study of 100 surfaces in 20 hospital rooms ranged from 0.356 to 0.649
- Reason: ATP detects ALL organic material, not just aerobic bacteria

Boyce JM et al. ICHE 2009;30:678

Assessing Terminal Cleaning Practices Using 3 Methods

- Prospective study to compare how many surfaces would be considered clean, based on
  - Aerobic colony counts obtained by agar contact plates
  - Fluorescent marker method
  - ATP bioluminescence assay system
- 5 high-touch surfaces were sampled in a convenience sample of 100 hospital rooms
- Adjacent surfaces on 5 high-touch surfaces were sampled before and after terminal cleaning
Assessing Terminal Cleaning Practices Using 3 Methods

• Main outcome measures expressed as percent of surfaces sampled after cleaning with:
  – Aerobic colony count < 2.5 cfu/cm²
  – Most or all of fluorescent marker removed
  – ATP reading of < 250 Relative Light Units

• Results to be presented in Tuesday afternoon oral session: Antisepsis/Disinfection/Sterilization

Other Benefits of Monitoring Cleaning/Disinfection Practices

• Quantitative methods have been used to evaluate the effectiveness of newer technologies used to decontaminate patient care areas
  – “Area decontamination” processes

• Monitoring methods have included:
  – Aerobic colony counts using cellulose sponges
  – Aerobic colony counts using agar contact plates
  – Modification of ASTM E-2197 quantitative disk carrier test method

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
Otter JA et al. ICHE 2009;30:574
**Impact of Hydrogen Peroxide Vapor (HPV) Room Decontamination on Environmental Contamination and Nosocomial Transmission by Clostridium difficile**

- A 10-month hospital-based prospective trial
- Pre- and post-intervention study design
- HPV was injected into sealed patient rooms or entire wards using HPV generators
- HPV was injected until a c. 1 micron film of HPV, which is often invisible to the naked eye, is achieved
- The HPV is then catalytically converted to oxygen and water vapor by an aeration unit
- Cycle time: 12 hrs for entire ward or 2.3 - 3 hrs for a patient room

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># Cultures (+) for</td>
</tr>
<tr>
<td>165</td>
<td>Cdiff</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>43</td>
<td>11 (25.6%)</td>
</tr>
</tbody>
</table>

Conclusion: HPV is efficacious in eradicating Cdiff (and MRSA and VRE) from environmental surfaces.

**Impact of Hydrogen Peroxide Vapor (HPV) Room Decontamination on Risk of Acquiring VRE or MRSA**

- Prospective study on 3 intervention wards
- Rooms cultured for VRE and MRSA
- Rooms were decontaminated with HPV whenever possible
- Incidence of VRE and MRSA acquisition determined among patients who were subsequently admitted to the rooms

Passaretti CL et al. 48th ICAAC, Oct 2008, Abstr K-4214b
Impact of Hydrogen Peroxide Vapor (HPV) Room Decontamination on Risk of Acquiring VRE or MRSA

- Rooms were classified as:
  - Missed: preceding room occupant known to have VRE or MRSA, but room NOT decontaminated with HPV
  - Not Done: preceding room occupant NOT known to be colonized or infected with VRE or MRSA, and room NOT decontaminated with HPV
  - HPV: preceding room occupant known to be colonized or infected with VRE or MRSA; room was decontaminated with HPV

Passaretti CL et al. 48th ICAAC, Oct 2008, Abstr K-4214b

Impact of Hydrogen Peroxide Vapor Room Decontamination on Risk of Acquiring VRE or MRSA

<table>
<thead>
<tr>
<th></th>
<th>Acquisition rate (N of acquisitions/ 1000 patient-days)</th>
<th>Adjusted Incidence Rate Ratio</th>
<th>P - Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VRE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missed</td>
<td>10.2</td>
<td>1.0</td>
<td>0.08</td>
</tr>
<tr>
<td>Not Done</td>
<td>6.9</td>
<td>0.59</td>
<td>0.02</td>
</tr>
<tr>
<td>HPV</td>
<td>2.0</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td><strong>MRSA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missed</td>
<td>3.4</td>
<td>1.0</td>
<td>0.26</td>
</tr>
<tr>
<td>Not Done</td>
<td>2.4</td>
<td>0.62</td>
<td>0.11</td>
</tr>
<tr>
<td>HPV</td>
<td>0.6</td>
<td>0.18</td>
<td></td>
</tr>
</tbody>
</table>

Passaretti CL et al. 48th ICAAC, Oct 2008, Abstr K-4214b

Aerosolized Hydrogen Peroxide Dry Mist System

- Aerosol produced contains 8-12 micron particles
  - 5% hydrogen peroxide, < 50 ppm silver ions, < 50 ppm phosphoric acid, < 1ppm Arabica gum and 95% bi-osmotic water

- Cultures obtained before/after cycles have demonstrated significant reductions in bacterial (including spore) counts in laboratory settings and patient care areas
  - Did not completely eradicate C. difficile spores in 2 studies

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

Automated Ultraviolet Light System

- Cultures obtained from surfaces inoculated with *C. difficile*, MRSA, VRE or *S. warneri* were obtained before/after UVC light decontamination
  - > 2-3 log reduction in *C. difficile* spores
  - > 3-4 log reduction of MRSA and VRE
  - > 2 log reduction of *S. warneri*
- Cultures before/after UVC light decontamination revealed
  > 3 log reductions of MRSA, *Acinetobacter* and VRE, and
  > 2 log reduction of *C. difficile*
- Median of 2 log reduction of *C. difficile* spores inoculated on stainless steel disk carriers

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
  - Visual assessment, observation of housekeeper technique, aerobic colony counts, using fluorescent markers, and ATP bioluminescence assay systems
- Monitoring cleaning practices can help establish the effectiveness of new technologies for “area decontamination”

Nerandzic M et al. 2009 ICAAC meeting, Abstr K-2107a
Nerandzic M et al. 2010 Decennial conference, Abstr 214
Rutala WA Martin S. Favero Lectureship 2009
Boyce JM 2010 Decennial Conference, Abstr 59
# 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>Not reliable measure of cleanliness</td>
</tr>
<tr>
<td>Fluorescent marker system</td>
<td>Inexpensive</td>
<td>Must mark surfaces before cleaning, and check them after cleaning</td>
</tr>
<tr>
<td></td>
<td>Minimal equipment needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can improve practices</td>
<td></td>
</tr>
<tr>
<td>Aerobic colony counts</td>
<td>Relatively simple</td>
<td>More expensive</td>
</tr>
<tr>
<td></td>
<td>Detects presence of pathogens</td>
<td>Results not available for 48 hrs later</td>
</tr>
<tr>
<td>ATP bioluminescence assay systems</td>
<td>Provides quantitative measure of cleanliness</td>
<td>More expensive</td>
</tr>
<tr>
<td></td>
<td>Quick results</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can improve practices</td>
<td>Requires special equipment</td>
</tr>
</tbody>
</table>

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## Internet Resources

- **HICPAC guidelines**
  - [www.cdc.gov/hicpac](http://www.cdc.gov/hicpac)
- **www.disinfectionandsterilization.org**
- **www.cleanhospitals.net**
  - Click on Clean Environment
Impact of HPV Decontamination on Incidence of New Nosocomial CDAD Cases

Analysis only for months when epidemic strain was present

Reduction in rate: 39%
P = 0.047

Reduction in rate: 53%
P = 0.26

Advantages and Disadvantages of Terminal Room Disinfection Systems

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid disinfectant</td>
<td>Simple, inexpensive</td>
<td>Often unreliable</td>
</tr>
<tr>
<td>Applied by Housekeeper</td>
<td>Fast; feedback can improve performance</td>
<td>High personnel turnover rates</td>
</tr>
<tr>
<td>Hydrogen Peroxide Vapor system</td>
<td>Eradicates all types of organisms</td>
<td>Longer cycle times</td>
</tr>
<tr>
<td></td>
<td>Can decrease MDROs</td>
<td>Requires more special training</td>
</tr>
<tr>
<td>Aerosolized Hydrogen Peroxide system</td>
<td>Reduces pathogens Shorter cycles than HPV vapor</td>
<td>Not as effective vs C. difficile as HPV Impact on MDROs</td>
</tr>
<tr>
<td>Automated Ultraviolet (UVC) light system</td>
<td>Easy to operate Faster cycle times Little training needed</td>
<td>Lower log reductions than HPV</td>
</tr>
</tbody>
</table>

Other Area Decontamination Strategies

- Ultraviolet Light Surface Decontamination

- Gaseous ozone
  - Berrington AW J Hosp Infect 1998
  - Sharma M et al. AJIC 2008;36:559

- Super-oxidized water fogging

- Alcohol/quaternary ammonium mist system
  - Jury LA et al. 2009 SHEA, abstr 278

- Quaternary ammonium “dry mist” system (Zimek)
Liquid Disinfectants

- Traditional liquid disinfectants
  - Quaternary ammonium compounds (most commonly used)
  - Phenolic: alcohols or alcohol-based mixtures
  - Chlorine-releasing products
    - A new sodium hypochlorite product has received an EPA-approved label claim for efficacy against C. difficile spores
    - A 4.5% accelerated hydrogen peroxide product has been registered by DIN in Canada as sporicidal
  - Sodium hypochlorite is also recommended for surface disinfection during Norovirus outbreaks
    - Accelerated hydrogen peroxide

- Experimental liquid disinfectants
  - Silver ion zeolite technology
  - Immobilized polymeric biocide + insoluble silver salt
  - Cationic ingredient + chlorhexidine