Does Improving Surface Cleaning and Disinfection Reduce HAI?
Prof. William Rutala, University of North Carolina
A Webber Training Teleclass

Table: Does Improving Surface Cleaning and Disinfection Reduce Healthcare-Associated Infections?

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role of the environment in disease transmission</td>
</tr>
<tr>
<td>Adequacy of room cleaning and monitoring thoroughness of room cleaning</td>
</tr>
<tr>
<td>Methods for room decontamination</td>
</tr>
<tr>
<td>Does improved surface disinfection reduce HAIs</td>
</tr>
</tbody>
</table>

Table: HEALTHCARE-ASSOCIATED INFECTIONS IN THE US: IMPACT

- 1.7 million healthcare-associated infections (HAIs) per year
- 98,987 deaths due to HAI
  - Pneumonia 35,967
  - Bloodstream 30,665
  - Urinary tract 13,088
  - Surgical site infection 8,205
  - Other 11,062
- 6th leading cause of death (after heart disease, cancer, stroke, chronic lower respiratory diseases, and accidents)

Notes: 1 National Center for Health Statistics, 2004

The A. Denver Russell Memorial Teleclass Lecture (2013)

Professor Allan Denver Russell
(1936-2004)

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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 LEADS TO HAIs
• Frequent environmental contamination
• Microbial persistence in the environment
• HCW hand contamination
• Relationship between level of environmental contamination and hand contamination
• Transmission directly or on hands of HCPs
• Housing in a room previously occupied by a patient with the pathogen of interest is a risk factor for disease
• Improved surface cleaning/disinfection reduces disease incidence

TRANSMISSION MECHANISMS INVOLVING THE SURFACE ENVIRONMENT


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ENVIRONMENTAL CONTAMINATION ENDEMIC AND EPIDEMIC MRSA

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Survival Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. aureus (including MRSA)</td>
<td>7 days to &gt;12 months</td>
</tr>
<tr>
<td>Enterococcus spp. (including VRE)</td>
<td>5 days to &gt;46 months</td>
</tr>
<tr>
<td>Acinetobacter spp.</td>
<td>3 days to 11 months</td>
</tr>
<tr>
<td>Clostridium difficile (spores)</td>
<td>&gt;5 months</td>
</tr>
<tr>
<td>Norovirus (and feline calicivirus)</td>
<td>8 hours to &gt;2 weeks</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>6 hours to 16 months</td>
</tr>
<tr>
<td>Klebsiella spp.</td>
<td>2 hours to &gt;30 months</td>
</tr>
</tbody>
</table>


ENVIRONMENTAL SURVIVAL OF KEY PATHOGENS ON HOSPITAL SURFACES

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)

ACQUISITION OF MRSA ON HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES

ACQUISITION OF MRSA ON HANDS/GLOVES AFTER CONTACT WITH CONTAMINATED EQUIPMENT

TRANSFER OF MRSA FROM PATIENT OR ENVIRONMENT TO IV DEVICE AND TRANSMISSION OF PATHOGEN

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TRANSMISSION MECHANISMS INVOLVING THE SURFACE ENVIRONMENT

ACQUISITION OF C. difficile ON PATIENT HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES AND THEN INCUBATION OF MOUTH

Does Improving Surface Cleaning and Disinfection Reduce Healthcare-Associated Infections?

Objectives

• Role of the environment in disease transmission
• Adequacy of room cleaning and monitoring thoroughness of room cleaning
• Methods for room decontamination
• Does improved surface disinfection reduce HAIs

Thoroughness of Environmental Cleaning

Carling PC et al. ECCMID, Milan, Italy, May 2011

RELATIVE RISK OF PATHOGEN ACQUISITION IF PRIOR ROOM OCCUPANT INFECTED

EVALUATION OF HOSPITAL ROOM ASSIGNMENT AND ACQUISITION OF CDI

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

Mean proportion of surfaces disinfected at is 32%
Terminal cleaning methods ineffective (products effective practices deficient [surfaces not wiped]) in eliminating epidemiologically-important pathogens

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 Infection Preventionist unbeknown to EVS, after EVS cleaning, markings are reassessed)

Target After Marking

SURFACE EVALUATION USING ATP BIOLUMINESCENCE

Target Enhanced

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.

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ENVIRONMENTAL CONTAMINATION LEADS TO HAs
Suboptimal Cleaning

- 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

Does Improving Surface Cleaning and Disinfection Reduce Healthcare-Associated Infections?

Objectives

- Role of the environment in disease transmission
- Adequacy of room cleaning and monitoring thoroughness of room cleaning
- Methods for room decontamination
- Does improved surface disinfection reduce HAs

DISINFECTION AND STERILIZATION

- 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 but high numbers of bacterial spores
  - NONCRITICAL - objects that touch only intact skin require low-level disinfection

LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

<table>
<thead>
<tr>
<th>Germicide</th>
<th>Exposure time</th>
<th>Use Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl or isopropyl alcohol</td>
<td>&gt; 1 min</td>
<td>70-90%</td>
</tr>
<tr>
<td>Chlorine</td>
<td>100ppm</td>
<td>(1:500 dilution)</td>
</tr>
<tr>
<td>Phenolic</td>
<td>UD</td>
<td></td>
</tr>
<tr>
<td>Iodophor</td>
<td>UD</td>
<td></td>
</tr>
<tr>
<td>Quaternary ammonium</td>
<td>UD</td>
<td></td>
</tr>
<tr>
<td>Improved hydrogen peroxide (HP)</td>
<td>0.5%, 1.4%</td>
<td></td>
</tr>
</tbody>
</table>

UD=Manufacturer’s recommended use dilution

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.

Effective Surface Decontamination
Practice and Product

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EFFECTIVENESS OF DISINFECTANTS AGAINST MRSA AND VRE

<table>
<thead>
<tr>
<th>Product</th>
<th>S. aureus</th>
<th>Enterococcus</th>
<th>MRSA</th>
<th>VRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated cloth</td>
<td>4.41</td>
<td>4.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray (10s) and wipe</td>
<td>4.41</td>
<td>4.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray, wipe, spray (1m), wipe</td>
<td>4.41</td>
<td>4.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray</td>
<td>4.41</td>
<td>4.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray, wipe, spray (until dry)</td>
<td>4.41</td>
<td>4.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposable wipe with QUAT</td>
<td>4.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control detergent</td>
<td>2.68</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


SURFACE DISINFECTION
Effectiveness of Different Methods, Rutala et al. 2012

Wipes
Cotton, Disposable, Microfiber, Nonwoven Spunlace

Wipe should have sufficient wetness to achieve the disinfectant contact time. Discontinue use of a disposable wipe if it no longer leaves the surface visibly wet for >1m.

Surface Disinfection

- Wipe all "touchable" or "hand contact" surfaces with sufficient wetness to achieve the disinfectant contact time (≥1 minute).
- Daily disinfection of surfaces (vs cleaned when soiled) in rooms of patients with CDI and MRSA reduced acquisition of pathogens on hands after contact with surfaces and on hands caring for the patient.

Daily Disinfection of High-Touch Surfaces
Kundrapu et al. ICHE 2012;33:1039

Daily disinfection of high-touch surfaces (vs cleaned when soiled) with sporicidal disinfectant 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.

Does Improving Surface Cleaning and Disinfection Reduce Healthcare-Associated Infections?
Objectives

- Role of the environment in disease transmission
- Adequacy of room cleaning and monitoring thoroughness of room cleaning
- Methods for room decontamination
- Does improved surface disinfection reduce HAIs

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Environmental Disinfection Interventions
1. Cleaning product substitutions
2. Improvements in the effectiveness of cleaning and disinfection practices
   - Education
   - Audit and feedback
   - Addition of housekeeping personnel or specialized cleaning staff
3. Automated technologies

Disinfectant Product Substitutions
Donskey C.J. AJIC. May 2013

- Six of the 7 interventions were quasi-experimental studies in which rates were compared before and after interventions with no concurrent control group
- Confounding factors not reported (e.g., hand hygiene or Contact Precaution compliance)
- Decrease in the incidence in 6 of 7 studies

Substitution of Hypochlorite for Non-Sporicidal Cleaning Agents to Control C. difficile

<table>
<thead>
<tr>
<th>Ref</th>
<th>Setting</th>
<th>Effect on CDI Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medical Ward</td>
<td>Outbreak ended</td>
</tr>
<tr>
<td>2</td>
<td>Bone marrow transplant (BMT) unit, Medical Ward, ICU</td>
<td>Significant decrease on BMT unit, but not on the other 2 wards</td>
</tr>
<tr>
<td>3</td>
<td>2 medical wards (crossover study)</td>
<td>Decreased on 1 of 2 wards</td>
</tr>
<tr>
<td>4</td>
<td>Medical and surgical ICUs</td>
<td>Decreased on both units</td>
</tr>
<tr>
<td>5</td>
<td>3 hospitals</td>
<td>40% decrease in prevalence density of CDI</td>
</tr>
<tr>
<td>6</td>
<td>2 medical wards</td>
<td>95% decrease in hospital acquired CDI</td>
</tr>
</tbody>
</table>

Effect of Environmental Disinfection with 10% Bleach on CDI Rates
(results suggest greater impact when baseline incidence is high)

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Environmental Disinfection Interventions
Donskey CJ. AJIC. May 2013.

1. Cleaning product substitutions
2. Improvements in the effectiveness of cleaning and disinfection practices
   - Education
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Cleaning Interventions Associated with Reduced Acquisition of Pathogens

<table>
<thead>
<tr>
<th>Ref</th>
<th>Setting/Organisation</th>
<th>Intervention</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Burn ICU/VRE</td>
<td>Weekly daily cleaning</td>
<td>Outbreak ended</td>
</tr>
<tr>
<td>2</td>
<td>Medical ICU/VRE</td>
<td>Improved daily and terminal cleaning</td>
<td>Outbreak ended</td>
</tr>
<tr>
<td>3</td>
<td>ICU: VRE MRSA</td>
<td>Feedback using fluorescent markers, bucket cleaning</td>
<td>↓ environmental contamination</td>
</tr>
<tr>
<td>4</td>
<td>Neuro ICU Acinetobacter</td>
<td>Hypochlorite and education of cleaning staff</td>
<td>↓ environmental contamination Outbreak ended</td>
</tr>
<tr>
<td>5</td>
<td>Surgical ward/MRSA</td>
<td>Increased cleaning hours/wk including shared equipment and dust</td>
<td>↓ environmental contamination</td>
</tr>
<tr>
<td>6</td>
<td>2 surgical wards MRSA</td>
<td>1 additional cleaner; 6 month cross-over design</td>
<td>↓ environmental contamination</td>
</tr>
</tbody>
</table>

CDI Decreased When Bleach Substituted for QUAT
(higher study quality-repeated treatment design)


Incidence Decreased on the Ward with the Higher Baseline CDI Rate
(no decrease in environmental contamination during hypochlorite periods-application of chlorine suboptimal?)


Cleaning Interventions Associated with Reduced Acquisition of Pathogens

<table>
<thead>
<tr>
<th>Ref</th>
<th>Monitoring of disinfection</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>environmental contamination</td>
<td>Outbreak ended</td>
</tr>
<tr>
<td>2</td>
<td>environmental contamination</td>
<td>VRE acquisition</td>
</tr>
<tr>
<td>3</td>
<td>% of rooms contaminated with MRSA or VRE after cleaning (27% vs. 46%)</td>
<td>↓ acquisition of MRSA and VRE</td>
</tr>
<tr>
<td>4</td>
<td>environmental contamination</td>
<td>Outbreak ended</td>
</tr>
<tr>
<td>5</td>
<td>environmental contamination (11% to 0.7%)</td>
<td>MRSA acquisition</td>
</tr>
<tr>
<td>6</td>
<td>microbial contamination 33%</td>
<td>↓ MRSA infections 27%</td>
</tr>
</tbody>
</table>

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Improve Effectiveness of Cleaning/Disinfection
Donskey CJ. AJIC. May 2013

- Seven of the 9 interventions, pathogen acquisition was reduced or an outbreak resolved.
- Decrease in environmental contamination in 8 of 9 studies
- Interventions included: variety of different cleaning strategies (daily disinfection and/or disinfection of portable equipment, education of housekeepers, new protocols or checklists and designation of responsibility for cleaning specific items).

Reduction in Acquisition of VRE after Enforcement of Routine Cleaning
Period 1-baseline; 2-educ/thorough cleaning 3-“washout”; 4-HH

<table>
<thead>
<tr>
<th>Ref</th>
<th>Measurement</th>
<th>Baseline</th>
<th>Intervention</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>% sites positive for VRE after cleaning</td>
<td>10%</td>
<td>3-4%</td>
<td>↓ VRE acquisition (hazard ratio 0.36)</td>
</tr>
<tr>
<td>2/3</td>
<td>% rooms with &gt;1 sites positive for MRSA or VRE after cleaning</td>
<td>45%</td>
<td>27%</td>
<td>↓ acquisition of MRSA by 49% and VRE by 29%</td>
</tr>
</tbody>
</table>


Environmental Disinfection Interventions
Donskey CJ. AJIC. May 2013.

1. Cleaning product substitutions (improved effectiveness)
2. Improvements in the effectiveness of cleaning and disinfection practices
   - Education
   - Audit and feedback
   - Addition of housekeeping personnel or specialized cleaning staff
3. Automated technologies

NEW “NO TOUCH” APPROACHES TO ROOM DECONTAMINATION
Supplement Surface Disinfection

Do we have to get to zero contamination after disinfection to reduce infections?

<table>
<thead>
<tr>
<th>Ref</th>
<th>Measurement</th>
<th>Baseline</th>
<th>Intervention</th>
<th>Effect</th>
</tr>
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<tbody>
<tr>
<td>1</td>
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Touch (manual disinfection not thorough) vs No-Touch (mechanical)

No Touch
(supplements but do not replace surface cleaning/ disinfection; avoids the need for “touch” and the problems associated with manual disinfection)

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**ROOM DECONTAMINATION UNITS**
Rutala, Weber. ICHE. 2011;32:743

UV and HP systems have been demonstrated to be effective against various healthcare-associated pathogens

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>UV</th>
<th>HP</th>
<th>Vitamin C</th>
<th>Medium</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>100%</td>
<td>Yes</td>
</tr>
<tr>
<td>C. difficile</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>100%</td>
<td>Yes</td>
</tr>
<tr>
<td>VRE</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>100%</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Automated Disinfection Devices
  
  **Donskey CJ. AJIC. May 2013**

  - Hydrogen peroxide vapor has been used in outbreak settings and has been associated with reductions in colonization or infection with pathogens.
  - Boyce et al demonstrated that HP vapor for terminal disinfection of CDI rooms was associated with a significant reduction in the incidence of CDI

  Before HP vapor
  After HP vapor

  % sites contaminated
  26% 0%


  **Reduction in CDI on 5 High-Incidence Wards with Hydrogen Peroxide Vapor Disinfection**

  **Equipment Associated with Outbreaks**

  (Disinfection or replacement of contaminated equipment effective in eliminating outbreaks. Donskey CJ. AJIC May 2013)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>MRSA</th>
<th>C. difficile</th>
<th>VRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasonic nebulizers</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrotherapy equipment</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic thermometers</td>
<td>3, 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**Does Improving Surface Cleaning and Disinfection Reduce Healthcare-Associated Infections?**

**Summary**

- Multiple publications suggest that environmental disinfection interventions can reduce acquisition of healthcare-associated pathogens
- Additional high-quality studies are needed
- Reductions in pathogen acquisition have been achieved despite less than perfect room disinfection

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Acknowledgment

- Several slides provided by Curtis J. Donskey, MD, Cleveland VA Medical Center and Case Western Reserve School of Medicine, Cleveland, OH. June 2012

www.disinfectionandsterilization.org

THANK YOU!

08 May (Free WHO Teleclass – Europe – Special Lecture for May 5)
HAND HYGIENE PROMOTION UNIVERSAL SPREAD: IMPACT AND PATIENT PARTICIPATION
Speaker: Prof. Didier Pittet, University of Geneva Hospitals
Margaret Murphy, Patients for Patient Safety, WHO

09 May
SURVEILLANCE OF HEALTHCARE ASSOCIATED INFECTION IN ACUTE CARE SETTINGS
Speaker: Teresa Horan, Rollins School of Public Health, Emory University

May 16
WHAT’S NEW IN TECHNOLOGIC INNOVATIONS FOR THE PREVENTION OF INTRAVASCULAR CATHETER-ASSOCIATED BLOODSTREAM INFECTION
Speaker: Prof Mark Rupp, University of Nebraska Medical Center

30 May
PREVENTING CATHETER-ASSOCIATED URINARY TRACT INFECTIONS IN ACUTE CARE SETTINGS

www.webbertraining.com/schedulepl.php

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