Environmental Control of *Clostridium difficile*

Carol McLay DrPH, MPH, RN, CIC

Image from www.cdc.gov
Disclosures

The speaker, Carol McLay, discloses no actual or potential conflicts of interest in relation to the program/presentation.
Session Objectives

• Examine burden and epidemiology of *Clostridium difficile* infection (CDI)
• Discuss importance of contaminated surface environment in transmission of healthcare-associated pathogens
• Describe best practices for environmental cleaning, assessment of adequacy of room disinfection practices to minimize transmission
• Compare and contrast "no touch" methods room decontamination
Estimated Annual U.S Burden

- 435,000 CDI cases\(^1\)
- 293,000 healthcare-associated
  - 107,000 hospital-onset
  - 104,000 nursing home-onset
  - 81,000 community-onset, healthcare facility associated
- 160,000 community associated
  - 82% associated with outpatient healthcare exposure

**Overall, 94% of CDI cases related to healthcare**

- 29,000 deaths
- $4.8 billion in excess healthcare costs\(^2\)

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**Notes:**
- CO-HCA: Community onset healthcare-associated
- NHO: Nursing home onset
- HO: Hospital onset
Healthcare Burden

- *C. difficile* most commonly reported pathogen in 2011 multistate prevalence survey of healthcare-associated infections (HAI)\(^1\)
  - 12.1% of 452 HAIs caused by CDI
  - Rates of CDI per 1,000 discharges have risen through 2013\(^2\)

Burden of CDI

• 1 out of every 5 patients with healthcare-associated CDI experienced recurrence
• 1 out of 9 patients aged ≥65 died within 30 days of diagnosis
• 2/3 of CDI associated with inpatient stay but only 24% of total cases occurred during hospitalization
Changing Epidemiology

• Increasing morbidity and mortality noted beginning in 2000
• Outbreaks in US & Canada (>200 deaths)
• A new, hypervirulent strain was detected
  – Strain typed BI/NAP1/027
Preventing *C. difficile* is Now a National Priority!

National Action Plan for Combating Antibiotic Resistance
Issued by the White House in March 2015

2015 → 2020

- Goal to reduce incidence of overall *C. difficile* infections by 50% compared to rates in 2011
- Implementation of plan and tracking of outcomes will be accomplished by several government agencies
Microbiology

- Anaerobic, gram-positive rod
- Fastidious in vegetative state, capable of sporulating when challenged
- Capacity to form spores enables organism to persist in environment

Image from https://commons.wikimedia.org/wiki/File%3ACdiffx.jp
By Cjc2nd (Own work)
Importance of Spores

- Resistant to heat, drying, pressure, many disinfectants
- Resistant to all antibiotics; antibiotics only kill or inhibit actively growing bacteria
- Survive well in hospital environment
- Not a reproductive form, represent a survival strategy

Image from https://microbewiki.kenyon.edu/index.php/File:Spores.png#filelinks
Symptoms of CDI

- Asymptomatic colonization
- Diarrhea
- Abdominal pain, distension
- Fever
- Pseudomembranous colitis
- Toxic megacolon
- Perforated colon → sepsis → death
Host Risk Factors

• Female
• White
• Increasing age (>65, >>80)
• Co-morbidity
• Exposure to healthcare facility
• Immunosuppression
Modifiable Risk Factors

• Exposure to antibiotics
• Exposure to *C. difficile* spores
• Gastric acid suppression
Source of Infections

• Spores in healthcare environment associated with ill patients
• Asymptomatic carriers in those same environments
• False negative lab tests (low sensitivity)
• Unknown in community based infections, but food has been implicated\(^1\)

Role of the Environment

Hospital rooms and healthcare equipment items are dirty

– Only 50% of surfaces are “cleaned”
– Surfaces are contaminated
  • C. difficile (75%)
  • VRE (70%)
  • MRSA (64%)

Carling et al. ICHE 2008
McFarland et al. NEJM 1989
Boyce JHI 2007
Environmental Contamination and Hands of Personnel

Strong correlation between intensity of environmental contamination and hand contamination

<table>
<thead>
<tr>
<th>Environment contamination</th>
<th>Hand contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25%</td>
<td>0%</td>
</tr>
<tr>
<td>26-50%</td>
<td>8%</td>
</tr>
<tr>
<td>&gt;50%</td>
<td>36%</td>
</tr>
</tbody>
</table>

Weber DJ et al, AJIC 2013; S105-S110
Environmental Contamination and Hands of Personnel

• Acquisition of *C. difficile* spores on gloved hands may be as likely following contact with commonly touched surfaces as after contact with patient’s skin\(^1\)

• *C. difficile* frequently isolated from hands of healthcare personnel on wards without any known infected patient\(^2\)

Contamination of the Environment and Transmission of Pathogens in Healthcare Settings

Otter JA et al. ICHE 2011; 32:687-699
Survey of surfaces outside of patient rooms for *C. difficile*

- 31% of physician work areas contaminated
- 10% of nursing areas
- 26% of desktop computers
- 100% of doorknobs
- 33% of portable electronic devices

Dumford et al. AJIC 2009
Prevention Practices

• Improved handwashing compliance
• Healthcare personnel, patient and family education
• Antimicrobial stewardship
• Contact precautions
• Alert system
• CDI surveillance, analysis and reporting
• Environmental services
Alcohol Gels and Hand Hygiene

• Alcohol-based gels appear to be less able to remove *C. difficile* spores
• However, in general they:
  – Provide an excellent method of hand hygiene effective against many common nosocomial pathogens
  – Are convenient thereby increasing compliance
  – Have not been implicated in CDI outbreaks
• In the setting of a CDI outbreak or increased rates, visitors and healthcare workers should wash hands with soap and water after caring for patients with *C. difficile*
Environmental Cleaning

Key Principles

• **High touch items**
  – Ensure adequate cleaning

• **Disinfectant preparation**
  – Ensure proper preparation and use of disinfectants, includes appropriate:
    • Dilution
    • Storage
    • Application
    • Contact time

• **Proper use of disinfectants**
  – Factors that influence disinfectant effectiveness:
    • Porosity of surface
    • Crevices or ridges
Cleaning Patient Rooms

• **Daily cleaning**
  – Disinfect horizontal, vertical, contact surfaces with cotton or microfiber cloth using disinfectant-detergent solution
  – Spot clean walls
  – Clean disinfect sink/toilet
  – Damp mop floor
  – Clean to dirty

• **Terminal Cleaning**
  – As above, also disinfect mattress
  – Curtains?

• **Isolation Room Cleaning**
  – As above, staff to wear PPE
Spore Removal

• Meticulous cleaning with any cleaner/disinfectant reduces number of spores
• Greater reduction, inactivation achieved with sporicidal agent
• Removal of spores influenced by contact time (duration of wetness) and texture of surface
C. Difficile
EPA-Registered Products

• LIST K: EPA’s Registered Antimicrobial Products Effective against Clostridium difficile Spores

https://www.epa.gov/pesticide-registration/list-k-epas-registered-antimicrobial-products-effective-against-clostridium

• 35 registered products; most chlorine base, some hydrogen peroxide-based
Environmental Disinfection Interventions

- Cleaning products substitution
- Improvements in the effectiveness of disinfection practices
  - Education
  - Audit and feedback
  - Addition of housekeeping personnel or specialized cleaning staff
- Automated technologies
Types of audit

• **Direct observation**
  – Visual assessment
  – Observation of performance

• **Indirect observation**
  – Patient/resident satisfaction surveys

• **Measurements of cleanliness**
  – Environmental cultures
  – ATP bioluminescence
  – Environmental marking
Options for Evaluating Environmental Cleaning

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Environmental Evaluation Workgroup
December 2010

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2Carney Hospital and Boston University School of Medicine, Boston, MA; Dr. Philip Carling has been compensated as a consultant of Ecolab and Steris. He owns a patent for the fluorescent targeting evaluation system described in this document (DAZO Fluorescent Marking Gel).
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Introduction
In view of the evidence that transmission of many healthcare acquired pathogens (HAPs) is related to contamination of near-patient surfaces and equipment, all hospitals are encouraged to develop programs to optimize the thoroughness of high touch surface cleaning as part of terminal room cleaning at the time of discharge or transfer of patients. Since dedicated resources to implement objective monitoring programs may need to be developed, hospitals can initially implement a basic or Level I program, the elements of which are outlined below.
ATP Testing

- Uses bioluminescent technology to detect ATP from organic material
- Device provides digital reading
- Most useful in comparison of before and after cleaning
Fluorescent Marking Gel
Advantages and Disadvantages of Methods for Assessing Cleaning Practices

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
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<tbody>
<tr>
<td>Visual inspection</td>
<td>Simple</td>
<td>Does not provide reliable assessment of cleanliness</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluorescent marker system</td>
<td>Easy to apply</td>
<td>Must mark surfaces before cleaning, and check them after cleaning</td>
</tr>
<tr>
<td></td>
<td>Removal signifies cleaning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effective training tool for ES</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</td>
</tr>
<tr>
<td>ATP bioluminescence assay systems</td>
<td>Evaluates current cleanliness</td>
<td>More expensive</td>
</tr>
<tr>
<td></td>
<td>Ease of use, quick results</td>
<td>Requires special equipment</td>
</tr>
<tr>
<td></td>
<td>Effective training tool for ES</td>
<td>Specificity ~ 57%</td>
</tr>
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“No Touch” Disinfection Technologies

• Fogging Systems
  – Aerosolized Hydrogen Peroxide
  – Hydrogen Peroxide Vapor

• Ultraviolet Irradiation
  – Mercury Based
  – Pulse Xenon
Other Technology

- Antimicrobial surfaces
- Antimicrobial paint
- Air filters
- Visible Light
Effectiveness of ultraviolet devices and hydrogen peroxide systems for terminal room decontamination: Focus on clinical trials

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Key Words:
Health care–associated infections
ultraviolet light
ultraviolet C
pulse xenon
hydrogen peroxide systems
room decontamination
surface environment

Over the last decade, substantial scientific evidence has accumulated that indicates contamination of environmental surfaces in hospital rooms plays an important role in the transmission of key health care–associated pathogens (eg, methicillin-resistant Staphylococcus aureus, vancomycin-resistant enterococci, Clostridium difficile, Acinetobacter spp). For example, a patient admitted to a room previously occupied by a patient colonized or infected with one of these pathogens has a higher risk for acquiring one of these pathogens than a patient admitted to a room whose previous occupant was not colonized or infected. This risk is not surprising because multiple studies have demonstrated that surfaces in hospital rooms are poorly cleaned during terminal cleaning. To reduce surface contamination after terminal cleaning, no touch methods of room disinfection have been developed. This article will review the no touch methods, ultraviolet light devices, and hydrogen peroxide systems, with a focus on clinical trials which have used patient colonization or infection as an outcome.

Multiple studies have demonstrated that ultraviolet light devices and hydrogen peroxide systems have been shown to inactivate microbes experimentally plated on carrier materials and placed in hospital rooms and to decontaminate surfaces in hospital rooms naturally contaminated with multidrug-resistant pathogens. A growing number of clinical studies have demonstrated that ultraviolet devices and hydrogen peroxide systems when used for terminal disinfection can reduce colonization or health care–associated infections in patients admitted to these hospital rooms.

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Aerosolized hydrogen peroxide systems (aHP)

- Produce pressure-generated aerosol that contains hydrogen peroxide and silver
- Disinfectant is introduced to the environment as sample particle
- Spontaneously converted into water and oxygen
Aerosolized Hydrogen Peroxide Systems (aHP)

- aHP is easy to use
- Vents and doors must be sealed
- Safety monitors must be used to monitor the concentration of hydrogen peroxide in the environment
- Cycle time is 2 h for single cycle
- Distribution of the disinfectant on surfaces is not homogenous
Vaporized Hydrogen Peroxide Systems

• Less straightforward than aHP and UVC
• Requires two units (a generator and an aeration unit)
• Doors and air vents must be sealed during the process
• Safety monitors are required to ensure that no disinfectant leakage occurs during the process and to verify that the concentration of HP inside the room is below health and safety exposure limits
• The cycle times are 1.5-8 hours
Mercury-based UVC

• Deliver doses of, 254 nm range, UVC
• Radiation moves in straight lines
• Ineffective on surfaces that are outside the radiation range
• Must move the system in the space several times
Pulsed-Xenon Ultraviolet (PX-UV)

• Emit broad spectrum UV in short pulses (camera flashes)
• Machine is usually placed in multiple room locations
• Has a relatively short cycle time
• Need to move the system to several locations within the room
UV Irradiation

Pros:
• Reliable biocidal activity against a wide range of pathogens
• Rapid (∼15 minutes) for vegetative bacteria, *C. difficile* (∼50 minutes)
• HVAC does not need to be disabled, room does not need to be sealed
• Residual-free and does not give rise to health or safety concerns
• No consumables
UV Irradiation

Cons:

• All patients and staff must be removed from the room
• Used only for terminal disinfection
• Capital equipment costs are substantial
• Cleaning must precede UV decontamination
• Requires that equipment and furniture be moved away from walls
Aerosolized/Vaporized Hydrogen Peroxide Systems

Pros

• Biocidal activity against a wide range of pathogens including *C. difficile*
• Useful for disinfecting complex equipment and furniture
• HP is residual-free and does not give rise to health or safety concerns
Aerosolized/Vaporized Hydrogen Peroxide Systems

**Cons**

- All patients and staff must be removed from the room
- Terminal disinfection only
- HVAC system must be disabled, doors must be closed with gaps sealed by tape
- Capital equipment costs are substantial.
- Requires ~3–5 hours.
Selecting and Validating a “No Touch” System

• Must pre-clean before using a “no touch” system.
• Perform a needs assessment.
  – Do we need a “no touch” system?
  – What are we trying to prevent?
• Evaluate more than one system:
  – On paper (simulation) and on site
  – Evaluate system usability
• Perform post-implementation evaluation:
  – Use pre determined metrics
  – Did it meet our prevention objectives?
If given a choice between improving infection control by changing human behavior or new technology, go with new technology every time.”

Robert A. Weinstein, MD

Collaboration between IP and EVS

• Collaboration
• Communication
• Teamwork
Major article

Working relationships of infection prevention and control programs and environmental services and associations with antibiotic-resistant organisms in Canadian acute care hospitals

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Key Words:
Methicillin-resistant Staphylococcus aureus
Vancomycin-resistant Enterococcus
Clostridium difficile infection

Background: Environmental contamination in hospitals with antibiotic-resistant organisms (AROs) is associated with patient contraction of AROs. This study examined the working relationship of Infection Prevention and Control (IPAC) and Environmental Services and the impact of that relationship on ARO rates.

Methods: Lead infection control professionals completed an online survey that assessed the IPAC and...
Top Ten Tips

1. Invite infection prevention and control (IPC) to EVS staff and committee meetings and vice versa.

2. Share statistics on infection rates, hand hygiene data, current clinical alerts (i.e., Influenza, Ebola Virus Disease, etc.); EVS should share data supporting current EOC compliance.

3. Allot time for Q&A at the end of each meeting to address frontline concerns or questions.

4. Encourage frontline staff members to share all material from meetings with their units/departments.

5. Standardize products for both clinical staff and environmental services to use; select a product that is easy to recognize and use.
Top Ten Tips

6. Train staff on product utilization and compatibility
7. Strategically post educational signage near the product to reinforce appropriate use
8. Attach brackets to mobile computers, multi-patient use equipment (e.g., vital signs machines), and on walls outside every patient room to provide easy access for cleaning and disinfection tools
9. All compliance tools should clearly indicate the contact time. Reinforce!
10. Never stop exploring new avenues for collaboration!
Conclusions

• CDI is an important cause of healthcare associated infections
• Environmental contamination due to *C. difficile* is common, serves as source of infection either directly or via hands of personnel
• Meticulous cleaning and disinfection essential
• Monitoring and feedback optimize performance
• “No-touch” disinfection technology shows promise but requires further evaluation
• Collaboration between IPC and EVS improve patient outcomes
Thank you