Beyond high-touch surfaces: Floors, portable equipment, sinks and other potential sources of healthcare infection transmission

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Hosted by Paul Webber
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Disclosures

- Research support
  - Merck, Pfizer, 3M, EcoLab, GOJO, Altapure
- Consultant
  - Synthetic Biologics
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Objectives

- To understand general principles of pathogen transmission
- To appreciate the potential for floors and portable equipment to contribute to pathogen transmission
- To be aware of recent developments in transmission of pathogens from healthcare facility water systems

General principles
1. Patients and the environment contribute to transmission

Infected Patient → Susceptible Patient

Environment

Contamination of hands with MRSA after contact with:

Patient → Environment

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2. Patients shed pathogens before and after they are diagnosed

- Preemptive isolation
- Extend isolation until discharge
- Resolution of diarrhea
- Contact Precautions
- Test order
- CDI Diagnosis
- Terminal Cleaning
- End of Treatment
- 3-4 weeks after Treatment


Delays in recognition of infectious patients contribute to transmission

- Saudi Arabia outbreak, 2014
  - 27 of 65 (42%) cases healthcare-associated
  - Most transmission occurred before infection diagnosed
- South Korea outbreak, 2015
  - 173/180 (96%) transmissions occurred prior to isolation
  - 83% of transmissions linked to 5 super-spreaders

3 transmission clusters

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3. Antibiotics promote shedding of pathogens

Effect of antibiotics on density of VRE in stool


Environmental VRE contamination, stratified by burden of VRE in stool

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4. Pathogens often coexist

5. Contamination transmission
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Use of benign surrogate markers to study pathogen transmission

Viral DNA (Cauliflower Mosaic Virus)  Live virus (Bacteriophage MS2)


Portable equipment and floors

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Are we missing important environmental sources of transmission?

![Graph showing comparison between pre-intervention, intervention, and post-intervention phases.]

Ray AJ. A Multicenter Randomized Trial to Determine the Effect of an Environmental Disinfection Intervention on the Incidence of Healthcare-Associated CDI. ICHE 2017;38:777-83

Shared portable equipment

- Hospitalized patients frequently have direct or indirect interactions with shared medical equipment and other fomites.
  
- Portable equipment is often contaminated with pathogens, but rarely cleaned.

- Portable equipment has been associated with outbreaks.


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Electronic thermometers

<table>
<thead>
<tr>
<th>Study design</th>
<th>Intervention</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Brooks Quasi-experimental</td>
<td>Replacement of electronic rectal thermometers with disposables</td>
<td>Significant reduction in CDI in a hospital and skilled nursing facility</td>
</tr>
<tr>
<td>2Jernigan Ward cross-over study</td>
<td>Replacement of electronic thermometers with disposables</td>
<td>Significant reduction in CDI with disposable vs. electronic thermometers (RR 0.44; CI 0.21-0.93)</td>
</tr>
</tbody>
</table>


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Dissemination of a non-pathogenic virus from portable electronic thermometers in a LTCF


SICU: Doppler ultrasounds

John A. Contaminated Portable Equipment Is a Potential Vector for Dissemination of Pathogens in the ICU. ICHE 2017;38:1247-9

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**MICU: ECG machines**

![Graph showing percent positive for different categories over time.]

**Cleaning in the MICU**

![Image of a MICU showing cleaning activity.]
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**Portable equipment as a vector for transmission from ward to ward**

**Are floors an under-appreciated source of transmission?**

Deshpande A. Are hospital floors an underappreciated reservoir for transmission of health care-associated pathogens? Am J Infect Control 2017;45:336-8; Fekety R. Am J Med 1981;70:906-8 (floors frequently contaminated with *C. difficile* spores); Muters R. J Hosp Infect 2009;71:43-8 (floors more heavily contaminated with *C. difficile* spores than hands of CDI patients or other environmental sites); Ali S. J Clin Microbiol 2015;53:2578-4 (floors in room and bathroom more heavily contaminated with *C. difficile* spores than other environmental sites); Lemmen SW. J Hosp Infect 2004;56:191-7 (floors frequently contaminated with multi-resistant gram-positive and gram-negative pathogens)
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From floor to socks and shoes

MRSA sock print

MRSA shoe print


From floor to patient

Kopuri S, et al. Evaluation of hospital floors as a potential source of pathogen dissemination using a nonpathogenic virus as a surrogate marker. J Clin Microbiol 2016;54:1374-7 (bacteriophage MS2 disseminated from the floor to the hands of patients and to high-touch surfaces including the nursing station and shared portable equipment)
High-touch surfaces are often in contact with the floor

Deshpande A, et al. Are hospital floors an underappreciated reservoir for transmission of healthcare-associated pathogens? Am J Infect Control 2016;44:336-8 (41% of rooms surveyed had 1 or more high-touch objects in contact with the floor; contact with objects on the floor resulted in hand contamination)

Current floor cleaning methods may be ineffective

Floor cleaning: a neutral detergent was used and the solution and mop head was changed after every 3rd room

Cleaning and disinfection of floors can be more effective

Floor cleaning: a cleaner/disinfectant was used with multiple disposable mop heads used per room


Clothing and personal protective equipment
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Why did personnel acquire Ebola despite use of whole-body coverage PPE?

Hand contamination during patient care despite wearing gown and gloves

<table>
<thead>
<tr>
<th></th>
<th>Gloves contaminated before removal, %</th>
<th>Hands contaminated after glove removal, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>VRE</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td><em>Acinetobacter baumanii</em></td>
<td>29</td>
<td>5</td>
</tr>
<tr>
<td><em>C. difficile</em></td>
<td>ND</td>
<td>24</td>
</tr>
<tr>
<td><em>C. difficile</em></td>
<td>ND</td>
<td>16</td>
</tr>
</tbody>
</table>

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Contamination of skin and clothing during PPE removal


Skin and clothing contamination during removal of contaminated gloves

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Sites of contamination

Contaminated glove removal

Contaminated gown removal

Poor design and lack of training contribute to contamination

Poor design

One size does not fit all

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Improved gown design

Standard Gown (blue) | Alternative Design Gown (yellow)

Smaller thumb hole for snug fit and reduced skin exposure
Increased coverage of palm

Mana TC. ICHE 2017

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Bare below the elbows attire recommended in England

- September 2007: UK Department of Health publishes guidelines about uniforms and work wear in clinical settings.

- The publication of this guidance coincided with the introduction of a ‘bare below the elbows’ policy for hospitals.

Contamination with DNA marker while wearing long- versus short-sleeved coats


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You have an outbreak of multidrug-resistant *Pseudomonas* in your ICU. Which would you consider as a potential source?

- A. Dirty laundry
- B. Contaminated stool softener
- C. Physician’s ties
- D. Contaminated sinks
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You have an outbreak of multidrug-resistant Pseudomonas in your ICU. Which would you consider as a potential source?

- A. Dirty laundry (Zygomycosis)
- B. Contaminated stool softener (B. cepacia)
- C. Physicians’ ties
- D. Contaminated sinks


Organisms linked to sinks

- Pseudomonas aeruginosa
- Klebsiella pneumoniae and K. oxytoca
- Enterobacter cloacae
- Elizabethkingia meningoseptica
- Acinetobacter baumanii
- Stenotrophomonas maltophilia

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**Recovery of potential pathogens from hospital surfaces**

<table>
<thead>
<tr>
<th>Organism</th>
<th>Dry (N=397)</th>
<th>Moist (N=55)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candida</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRSA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VRE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MR-resistant gram-negative</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**From sink to patient**

Kotay S, et al. Spread from the sink to the patient: in situ study using GFP expressing *E. coli* to model bacterial dispersion from sink trap reservoirs. Appl Env Microbiol Feb. 2017

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Improving room design to reduce risk for transmission from sinks

Before renovation

After renovation


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5. How could contaminated ice machines be linked to transmission?

- Ice machines have been linked to transmission of Legionella, *Mycobacterium chelonae*, and *Enterobacter cloacae*

- Genetically related carbapenem-resistant *Acinetobacter baumannii* recovered from the stool of 3 patients, the hands of a nurse, and an ice machine water outlet spout and drain

Kanwar A. A cold hard menace: A contaminated ice machine as a potential source for transmission of carbapenem-resistant *Acinetobacter baumannii*. AJIC 2017

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Contaminated ice machines as a source of pathogen transmission

Kanwar A. A cold hard menace: A contaminated ice machine as a potential source for transmission of carbapenem-resistant Acinetobacter baumannii. AJIC 2017; Kanwar A. Hiding in plain sight: Contaminated ice machines as a potential source for dissemination of pathogens. ICHE in revision.

A patient with history of aortic valve replacement presents with fever and fatigue. Blood cx negative.

- A. Pseudomonas aeruginosa
- B. Legionella species
- C. Non-tuberculous mycobacteria
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LivaNova (Sorin) Heater-Cooler device

Sites of aerosol release in a LivaNova Heater-Cooler device

Holes by the flow and return pipes
Gap in water tank sealing plates

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O R Supply Air Distribution
Air Curtain System

Dissemination of *M. chimaera* to the surgical field despite laminar airflow ventilation


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