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

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www.webbertraining.com December 7, 2017

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

3

General principles

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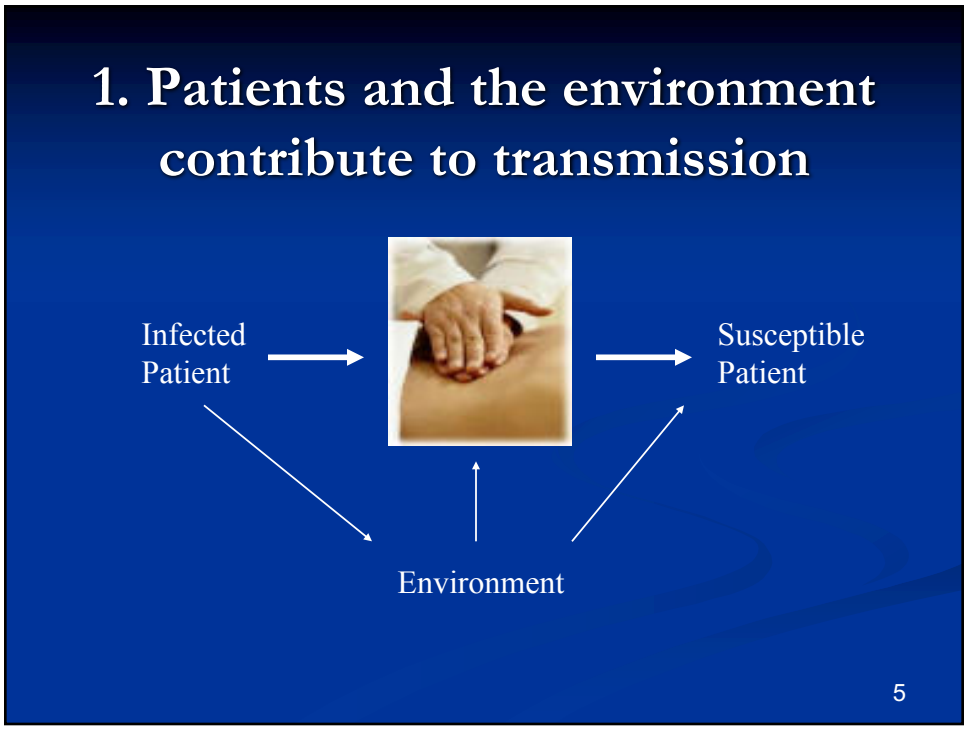
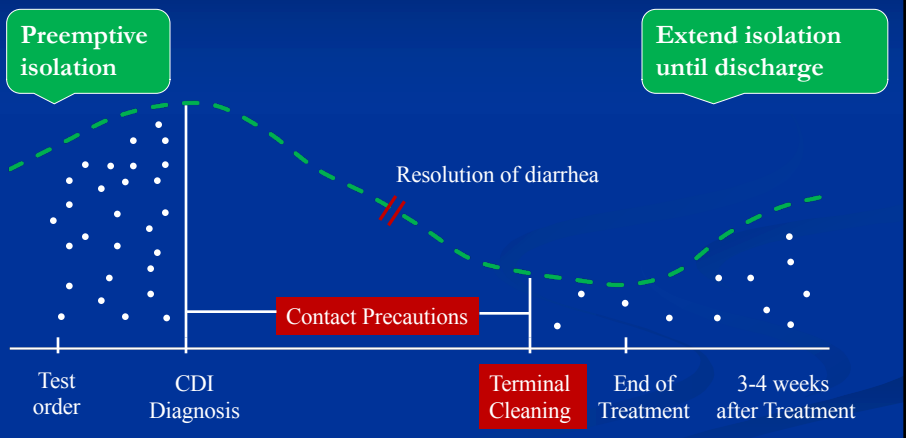

1. Patients and the environment contribute to transmission
Infected Patient
Susceptible Patient
Environment
5


Contamination of hands with MRSA after contact with:
Patient
Environment
Donskey CJ, Eckstein B. N Engl J Med 2009;360:e3; Stiefel U, et al. Infect Control Hosp Epidemiol 2011;32:185-7
6

2. Patients shed pathogens before and after they are diagnosed

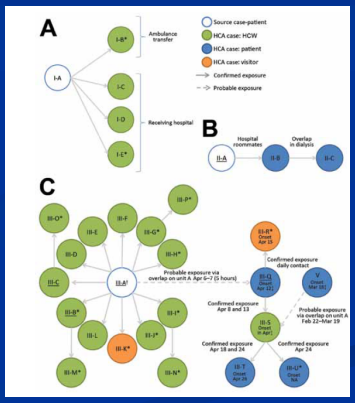


Sunkesula K, et al. Potential for transmission of spores by patients awaiting testing to confirm suspected CDI. ICHE 2013;34:306-8; Sethi AJ, et al. Persistence of skin contamination and environmental shedding of *C. difficile* during and after treatment of CDI. ICHE 2010;31:21-7; Kundrapu S, et al. A randomized trial of daily disinfection of high-touch surfaces in isolation rooms to reduce contamination of healthcare workers' hands. ICHE 2012;33:1039-42.

Delays in recognition of infectious patients contribute to transmission

- Saudi Arabia outbreak, 2014[1,2]
  - 27 of 65 (42%) cases healthcare-associated
  - Most transmission occurred before infection diagnosed
- South Korea outbreak, 2015[3]
  - 173/180 (96%) transmissions occurred prior to isolation
  - 83% of transmissions linked to 5 super-spreaders

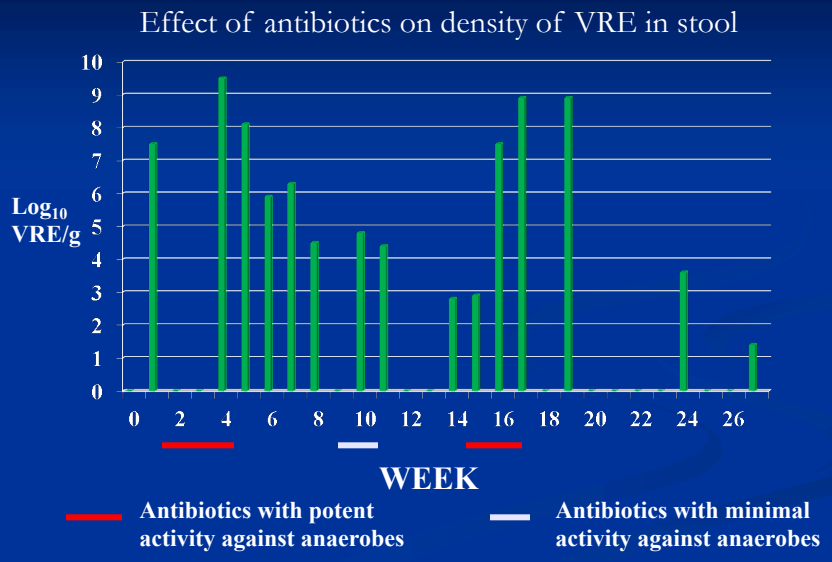
3 transmission clusters



1. Hunter JC, et al. Emerg Infect Dis 2016;22:647-655; 2. Assiri A, et al. NEJM 2013;369:407-16; 3. Woo Kim S, et al. Clin Infect Dis 2017;64:551-7

8

3. Antibiotics promote shedding of pathogens



Donskey CJ, et al. N Engl J Med 2000;343:1925-32

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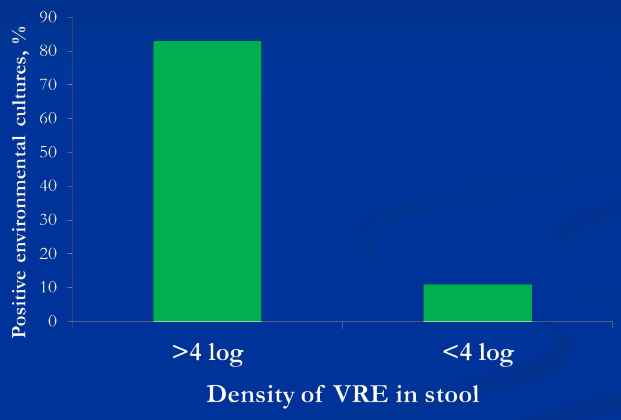
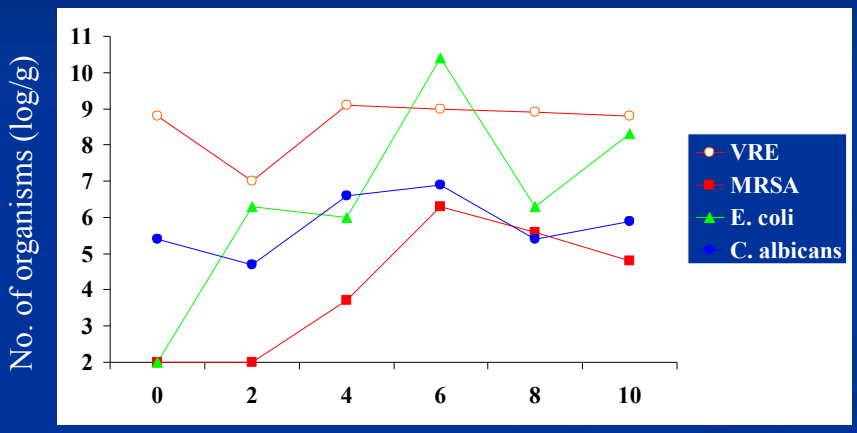
Environmental VRE contamination, stratified by burden of VRE in stool



Donskey CJ, et al. N Engl J Med 2000;343:1925-32

10

4. Pathogens often coexist



Donskey CJ. Clin Infect Dis 2004;39:219

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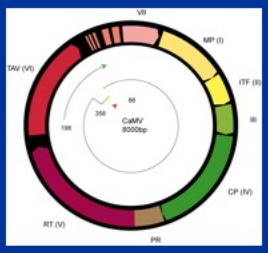
5. Contamination ≠ transmission

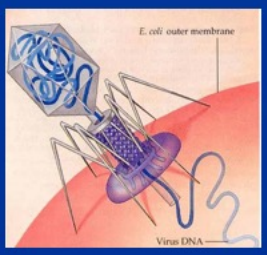
12

Use of benign surrogate markers to study pathogen transmission

Viral DNA (Cauliflower Mosaic Virus)



Live virus (Bacteriophage MS2)



Alhmidi H, et al. Evaluation of Viral Surrogate Markers for Study of Pathogen Dissemination During Simulations of Patient Care. Open Forum Infect Dis 2017;4:ofx128; Sassi HP, et al. Control of the spread of viruses in a LTCF using hygiene protocols. AJIC 2015;43:702-6; Alhmidi H, et al. Dissemination of a Nonpathogenic Viral DNA Surrogate Marker from High-Touch Surfaces in Rooms of LTCF Residents. AJIC pii: S0196-6553(17)30299-7.

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Portable equipment and floors

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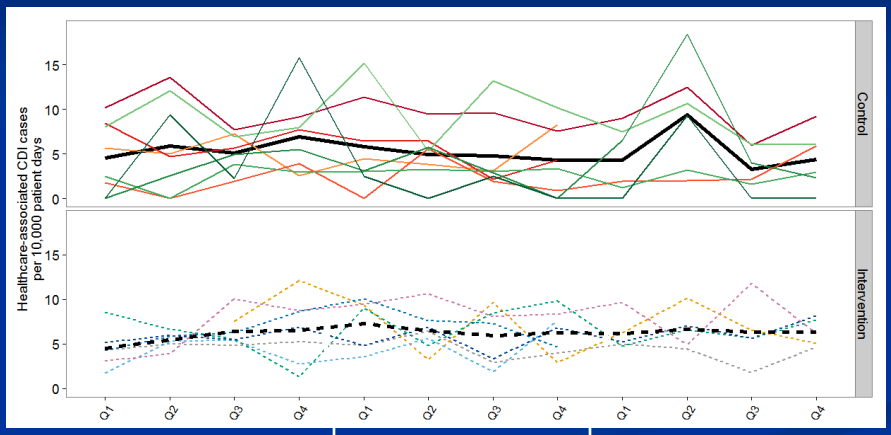
Are we missing important environmental sources of transmission?



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

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Shared portable equipment

- Hospitalized patients frequently have direct or indirect interactions with shared medical equipment and other fomites [1]
- Portable equipment is often contaminated with pathogens, but rarely cleaned [2]
- Portable equipment has been associated with outbreaks [3]

1. Suwantarat N. Quantitative assessment of interactions between hospitalized patients and portable medical equipment and other fomites. AJIC 2017; 2. Havill N. Cleanliness of portable equipment disinfected by nursing staff. Am J Infect Control 2011; 3. Kanamori H. The role of patient care items as a fomite in healthcare-associated outbreaks and infection prevention. Clin Infect Dis 2017

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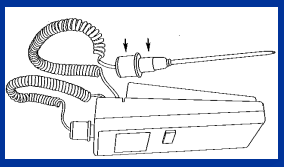
Electronic thermometers

	Study design	Intervention	Outcome
[1]Brooks	Quasi-experimental	Replacement of electronic rectal thermometers with disposables	Significant reduction in CDI in a hospital and skilled nursing facility
[2]Jernigan	Ward cross-over study	Replacement of electronic thermometers with disposables	Significant reduction in CDI with disposable vs. electronic thermometers (RR 0.44; CI 0.21-0.93)



1). Brooks SE et al. Infect Control Hosp Epidemiol 1992;13:98-103;
2). Jernigan JA, et al. Infect Control Hosp Epidemiol 1998;494-9;
3). Livornese LL, et al. Ann Intern Med 1992;117:112-116

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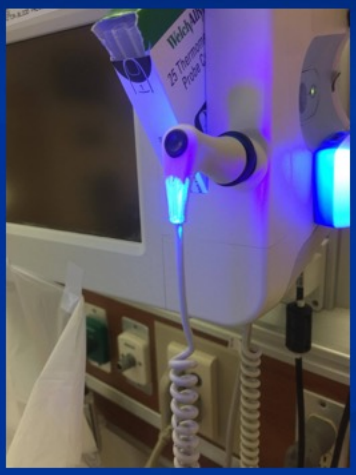
Thermometers



Alhmidi H, et al. Am J Infect Control in press.

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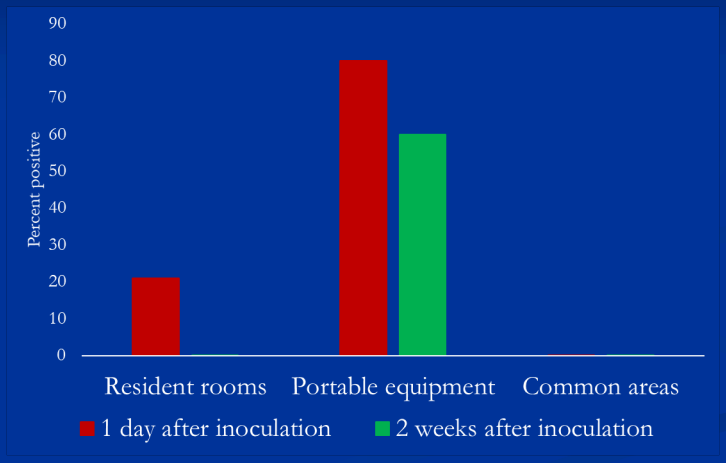
Dissemination of a non-pathogenic virus from portable electronic thermometers in a LTCF



Alhmidi H, et al. Am J Infect Control in press.

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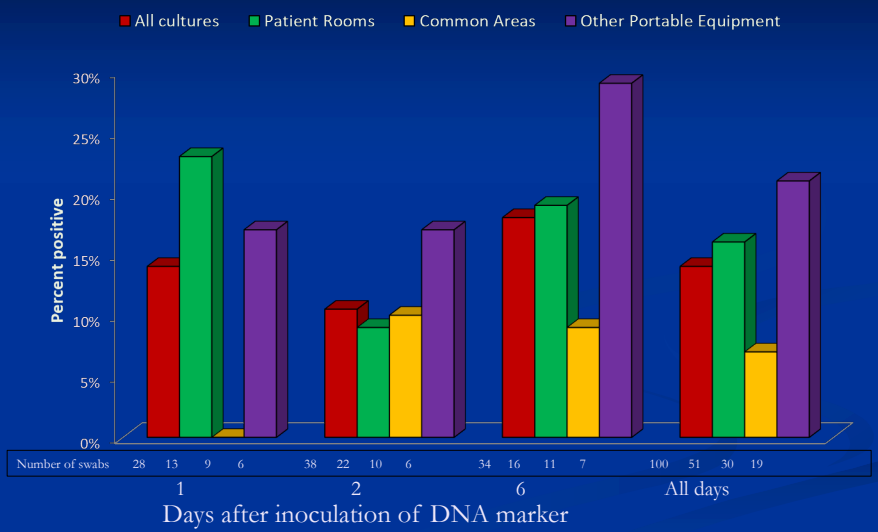
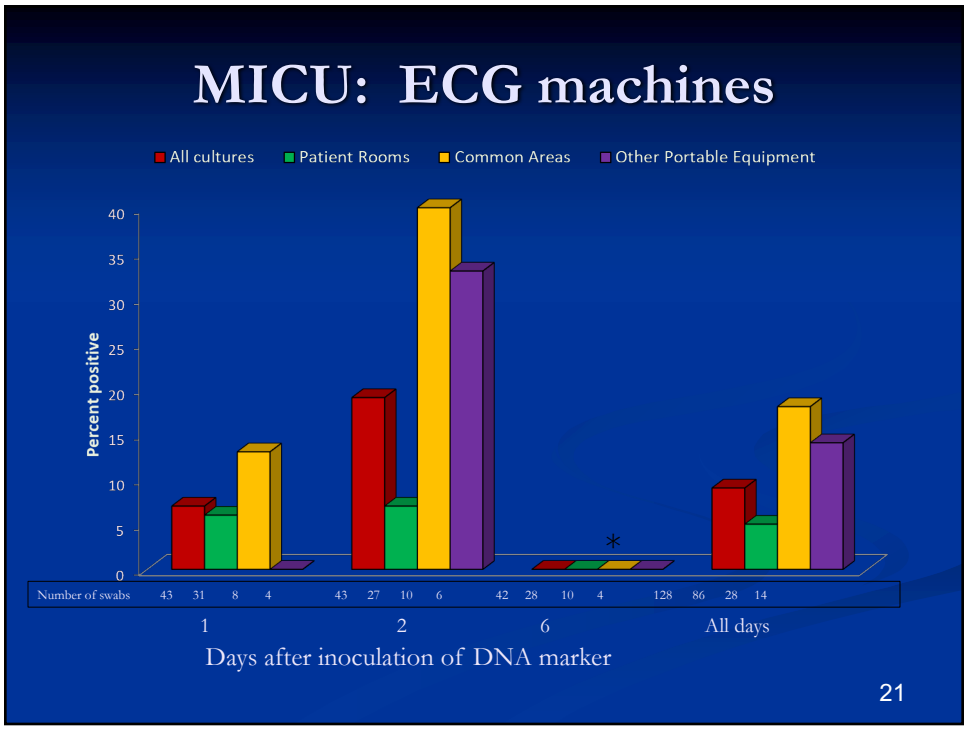
SICU: Doppler ultrasounds



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

20


MICU: ECG machines
All cultures
Patient Rooms
Common Areas
Other Portable Equipment
Percent positive
40
35
30
25
20
15
10
5
0
Number of swabs 43 31 8 4 43 27 10 6 42 28 10 4 128 86 28 14
1
2
6
All days
Days after inoculation of DNA marker
21


Cleaning in the MICU
22

Portable equipment as a vector for transmission from ward to ward

Alhmidi H. Manuscript in progress.

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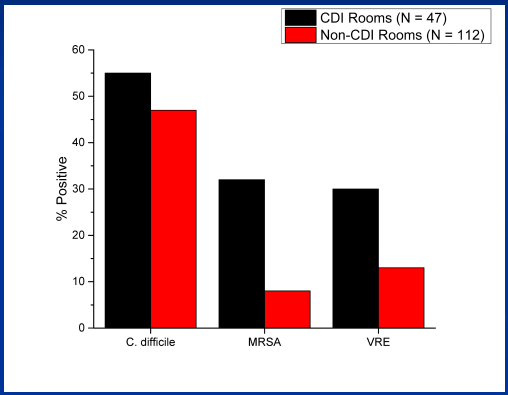
Are floors an under-appreciated source of transmission?



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); Mutters R. J Hosp Infect 2009;71:43-8 (floors more heavily contaminated with *C. difficile* spores than hands of CDI patients or other environmental surfaces); Ali S. J Clin Microbiol 2015;53:2570-4 (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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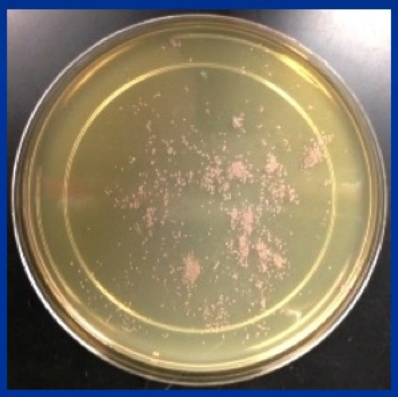
From floor to socks and shoes

MRSA sock print



MRSA shoe print

Galvin J, et al. Patient shoe covers: transferring bacteria from the floor onto surgical bedsheets. Am J Infect Control 2016;44:1430-2; Mahida N, Boswell T. Non-slip socks: a potential reservoir for transmitting multidrug resistant organisms in hospitals? J Hosp Infect 2016;94:273-5 (VRE recovered from 85% of socks and MRSA from 9%)

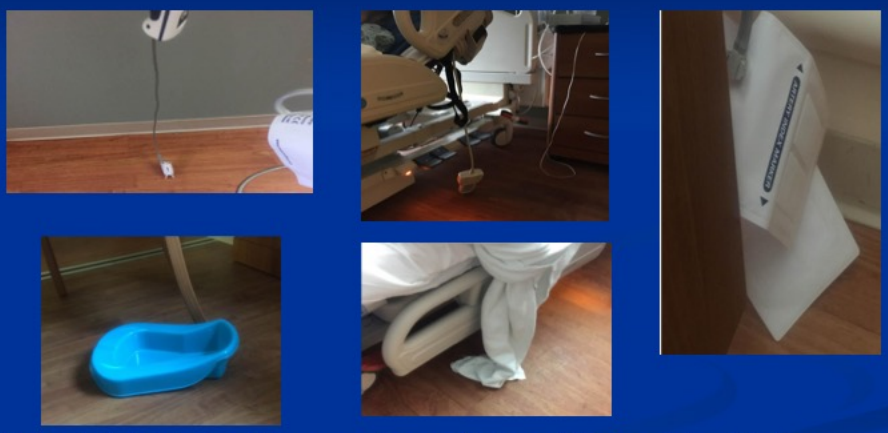
25

From floor to patient

Koganti S, et al. Evaluation of hospital floors as a potential source of pathogen dissemination using a nonpathogenic virus as a surrogate marker. ICHE 2016;37:1374-7 (bacteriophage MS2 disseminated from the floor to the hands of patients and to high-touch surfaces including the nursing station and shared portable equipment)

26

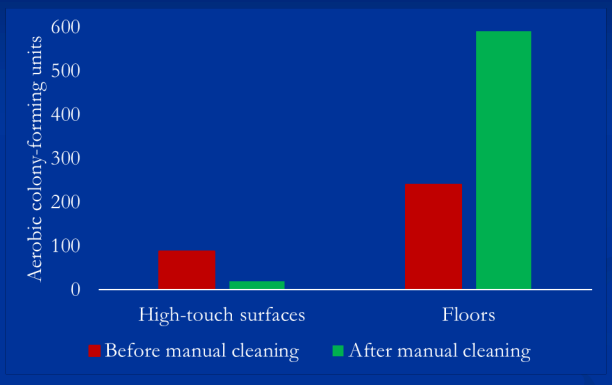
High-touch surfaces are often in contact with the floor



Deshpande A, et al. Are hospital floors an underappreciated reservoir for transmission of health care-associated pathogens? Am J Infect Control 2017;45:336-8 (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)

27

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

Wong T, et al. Am J Infect Control 2016; 44:416-20

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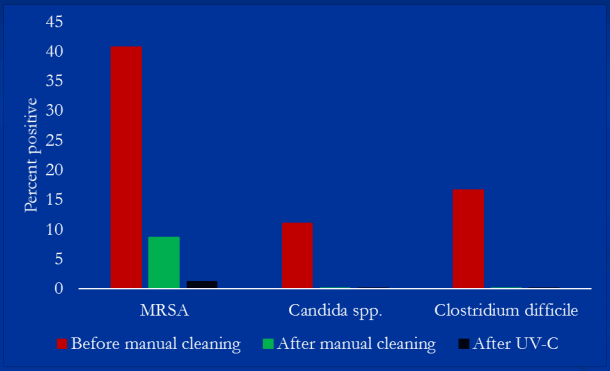
Cleaning and disinfection of floors can be more effective



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

Mustapha A, et al. Am J Infect Control in press

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Clothing and personal protective equipment

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Why did personnel acquire Ebola despite use of whole-body coverage PPE?

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Hand contamination during patient care despite wearing gown and gloves

	Gloves contaminated before removal, %	Hands contaminated after glove removal, %
MRSA	11	3
VRE	10	2
Acinetobacter baumanii	29	5
C. difficile	ND	24
C. difficile	ND	16

Hayden MK, et al. ICHE 2008;29:149-54; Morgan DJ, et al. ICHE 2010;31:716-21; Morgan DJ, et al. Crit Care Med 2012;40:1045-51; Landelle C, et al. ICHE 2014;35:10-5; Tomas M, et al. ICHE 2015.

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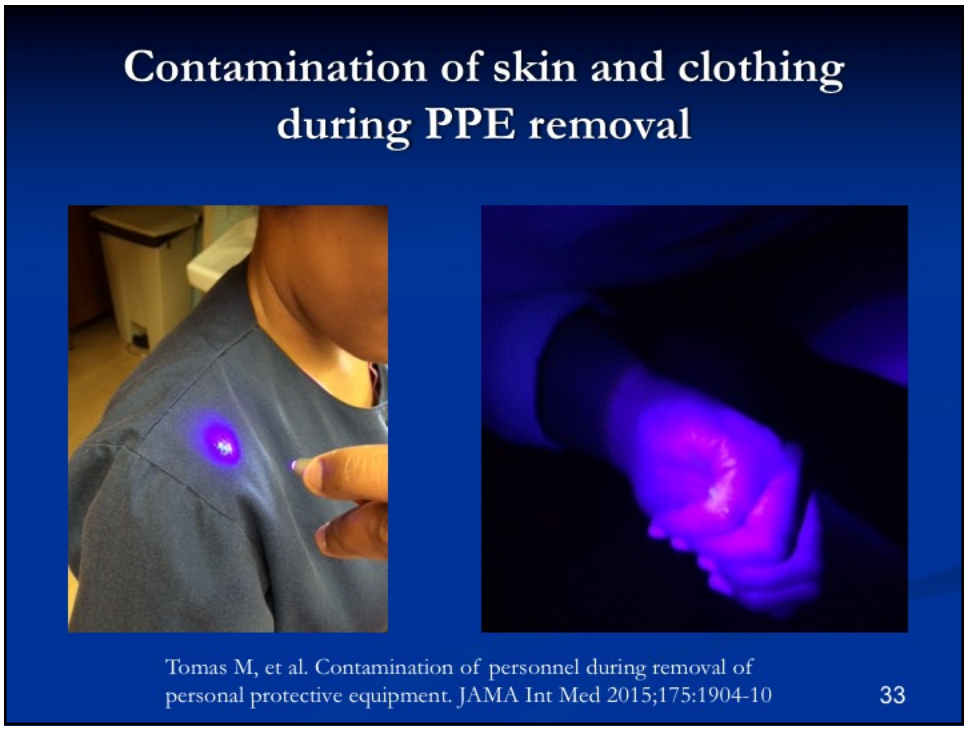
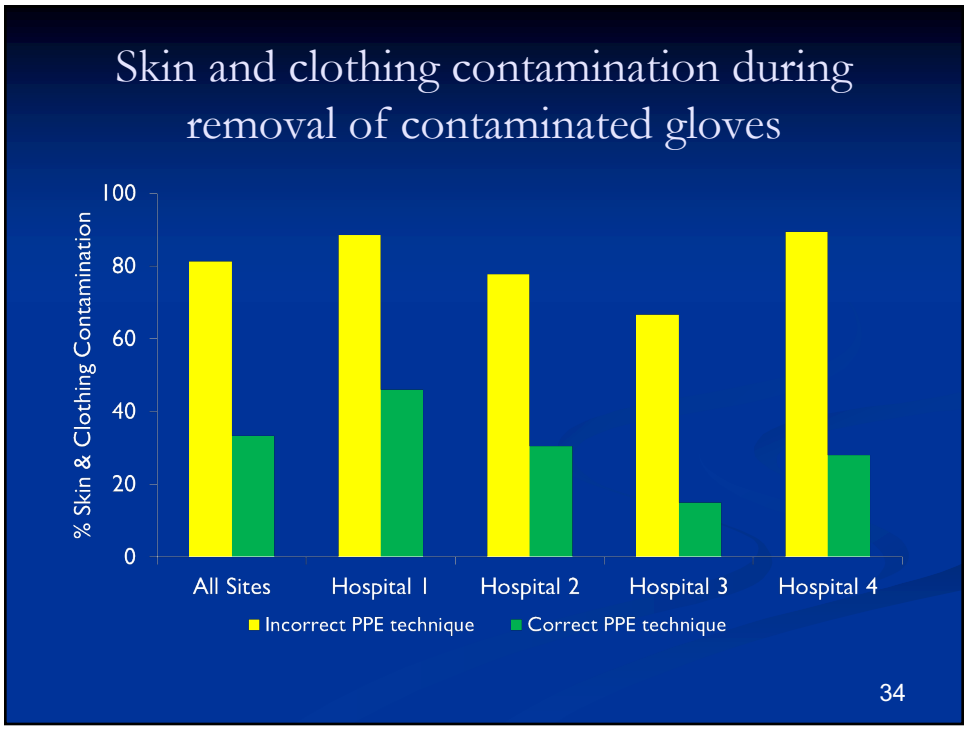
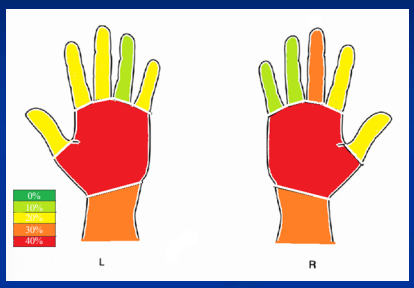
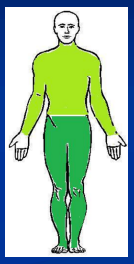

Contamination of skin and clothing during PPE removal
Tomas M, et al. Contamination of personnel during removal of personal protective equipment. JAMA Int Med 2015;175:1904-10
33


Skin and clothing contamination during removal of contaminated gloves
% Skin & Clothing Contamination
100
80
60
40
20
0
All Sites
Hospital 1
Hospital 2
Hospital 3
Hospital 4
Incorrect PPE technique
Correct PPE technique
34

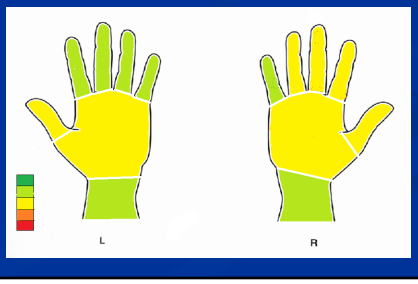
Sites of contamination

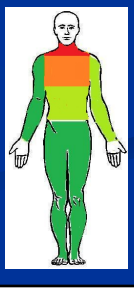
Contaminated glove removal





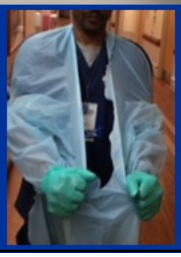
Contaminated gown removal



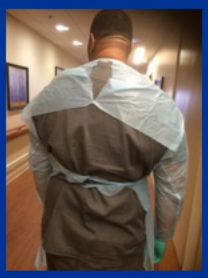


Poor design and lack of training contribute to contamination

Poor design



One size does not fit all



Tomas M, et al. Contamination of personnel during removal of personal protective equipment. JAMA Int Med 2015;175:1904-10

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Improved gown design
Standard Gown (blue)
Alternative Design Gown (yellow)
Elastic band for snug fit at wrist
Smaller thumb hole for snug fit and reduced skin exposure
Increased coverage of palm
Mana TC. ICHE 2017
37


Improved gown design
Standard Gown (blue)
Alternative Design Gown (yellow)
Double elastic neck closure that is easily broken when pulled from front of gown to facilitate easy removal
Frequent tearing of gown material during removal
Mana TC. ICHE 2017
38

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.

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End for traditional doctor's coat

The traditional doctor's white coat is to be changed as part of government plans to tackle hospital infections.

The new style clothing will have short sleeves under guidance to come into effect at the start of next year.

Doctors would also not be allowed to wear long-sleeve shirts, jewellery, or watches as part of the measures.

The doctors' new style coats would feature short sleeves

The Department of Health says cuffs are likely to be "very contaminated", and that other forms of protection such as plastic aprons would be introduced.

It also advises healthcare staff in England against wearing a tie during clinical work.

The new dress code is part of a raft of measures unveiled by Health Secretary Alan Johnson to tackle the spread of

"I'm determined that patient safety, including cleanliness, should be the first priority of every NHS organisation"

Alan Johnson
Health Secretary

Death of the white coat

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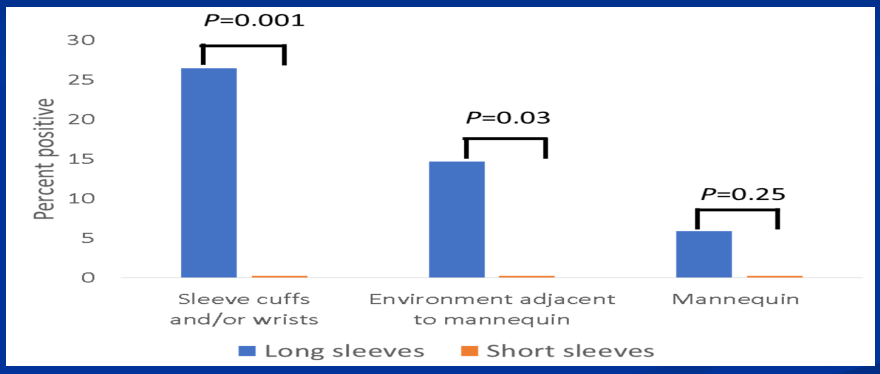
Contamination with DNA marker while wearing long- versus short-sleeved coats



John A. Infect Control Hosp Epidemiol in press.

40

Healthcare facility water systems

41

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

Marquez L, et al An outbreak of *Burkholderia cepacia* complex infections associated with contaminated liquid docusate. ICHE 2017;1-7; Cheng VCC, et al. Hospital outbreak of pulmonary and cutaneous zygomycosis due to contaminated linen items from substandard laundry. Clin Infect Dis 2016;62:714-20 (Hong Kong); Duffy J, et al. Mucormycosis outbreak associated with hospital linens. Pediatr Infect Dis J 2014;33:472-6 (Louisiana); ID Week 2016. Zygomycosis associated with contaminated laundry (*Rhizopus* spp. and Lichtheimia (Absidia) corymbifera)

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Organisms linked to sinks

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

Kanamori H, et al. Clin Infect Dis 2016;62:1423-35 (review on waterborne transmission in healthcare facilities); Hota S, et al. ICHE 2009;30:25-33; Ambrogi V, et al. J Hosp Infect 2016;92:27-9; Wolf I, et al. J Hosp Infect 2014;87:126-30; Roux D, et al. J Hosp Infect 2013;85:106-11; Zhou Z, et al. J Infect Chemother 2016; Aspelund AS, et al. J Hosp Infect 2016;94:13-20; Leitner E, et al. Antimicrob Agents Chemother 2015;59:714-16; Chapuis A, et al. Frontiers Microbiol 2016;7:1-9; Amoureux L, et al. Emerg Infect Dis 2017;23:304-7; Clarivet B, et al. Euro Surveill 2016;21; Knoester M, et al. Clin Microbiol Infect 2014;20:0207-0215; Vergara-Lopez S, et al. Clin Microbiol Infect 2013;19:E490-8; Fusch C, et al. Acta Paediatrica 2015;104:e344-e349; Lowe C, et al. Emerg Infect Dis 2012;18:1242-7;

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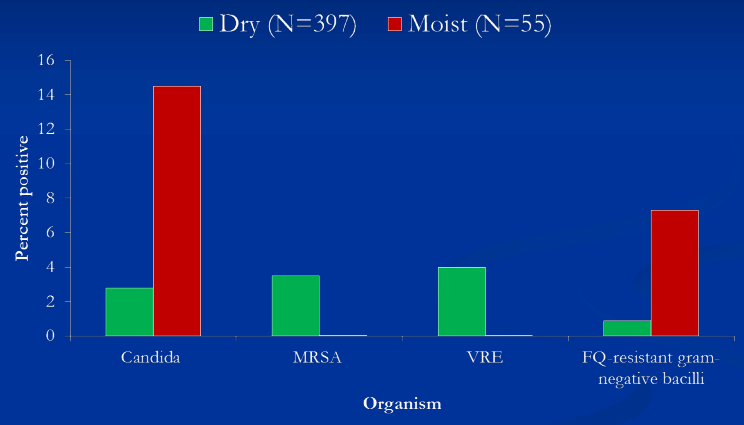
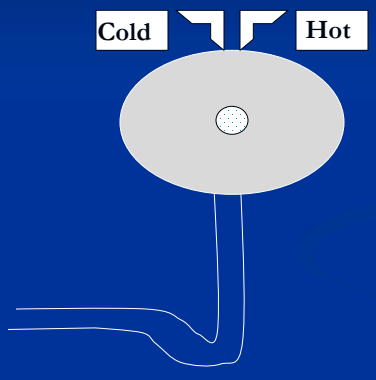
Recovery of potential pathogens from hospital surfaces



Piedrahita C, et al. Environmental Surfaces in Healthcare Facilities are a Potential Source for Transmission of *Candida auris* and other *Candida* species. ICHE 2017;38:1107-9; Jencson AL, et al. Hospital sinks are a potential nosocomial source of *Candida* infections. Clin Infect Dis 2017.

45

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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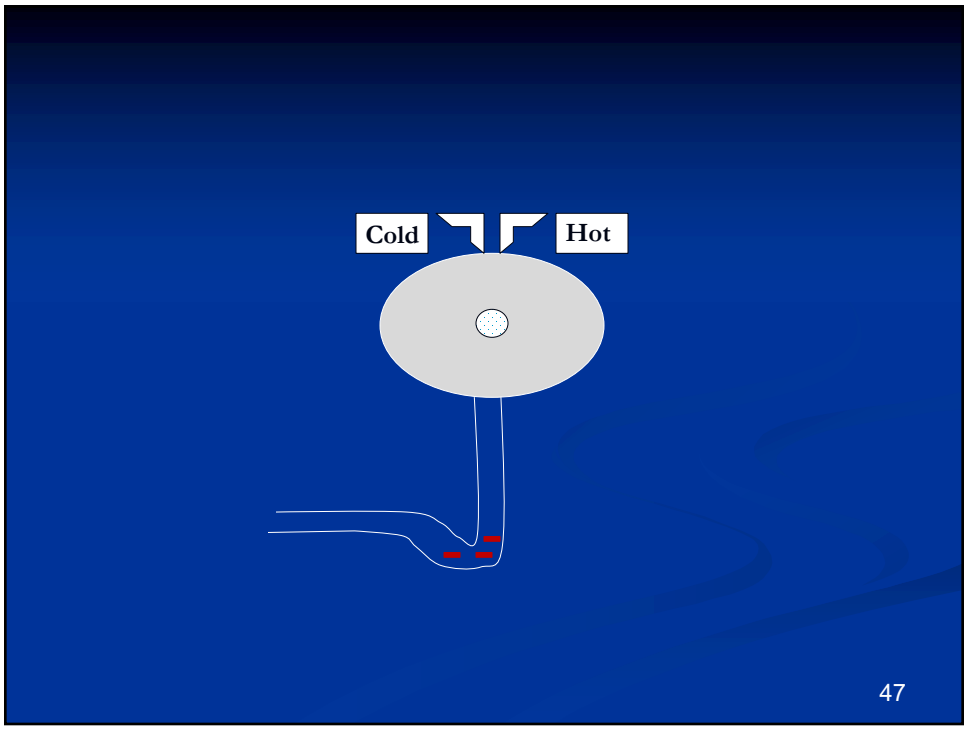
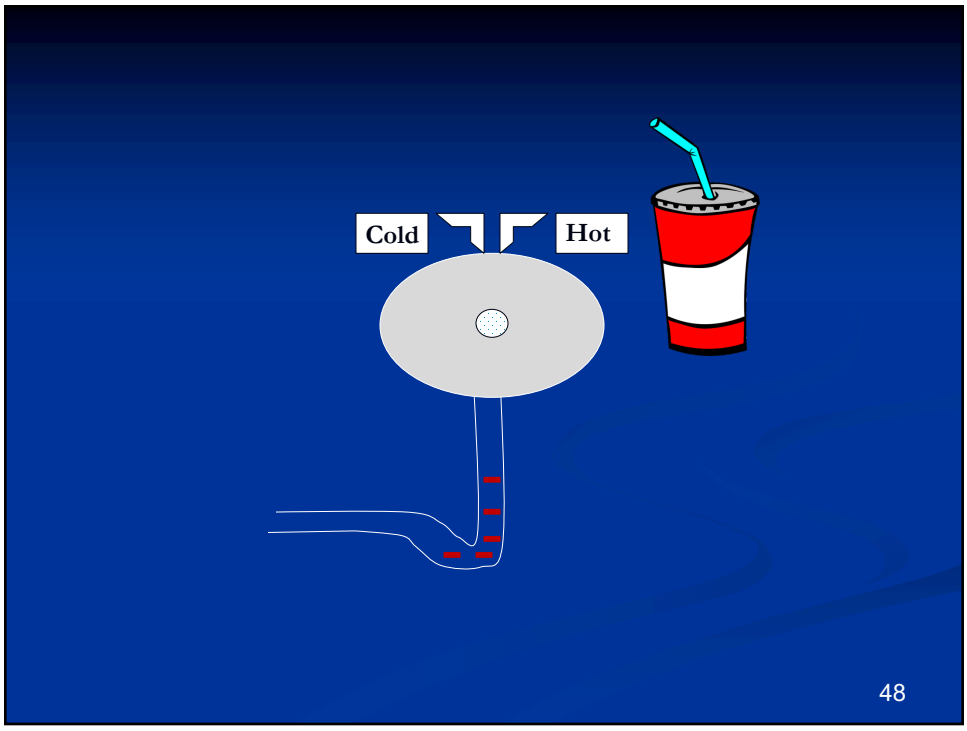
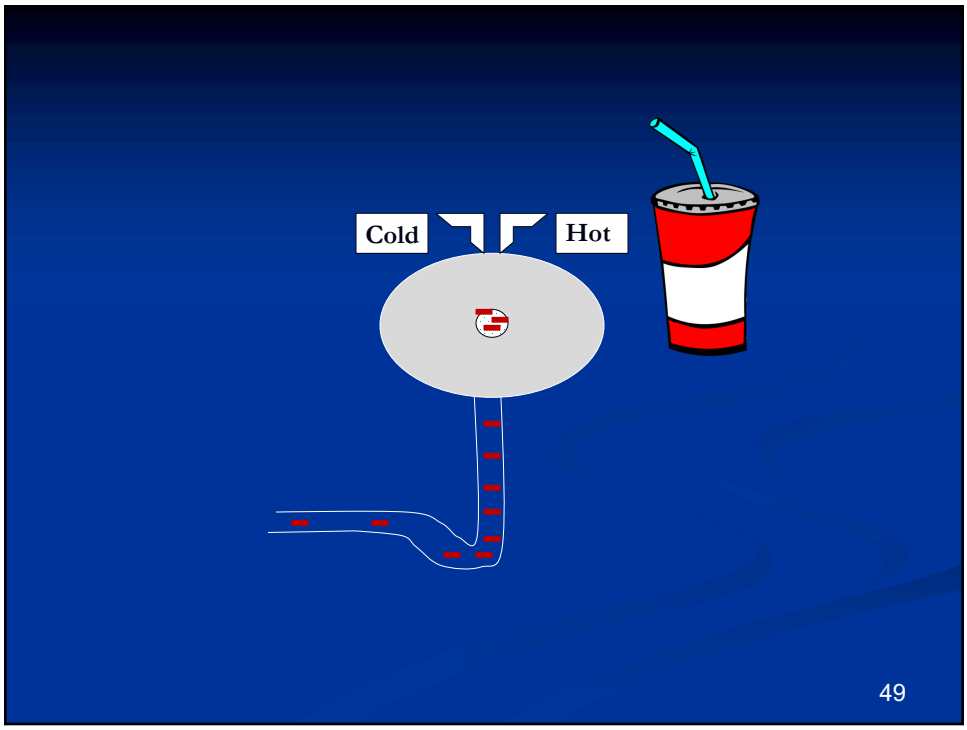
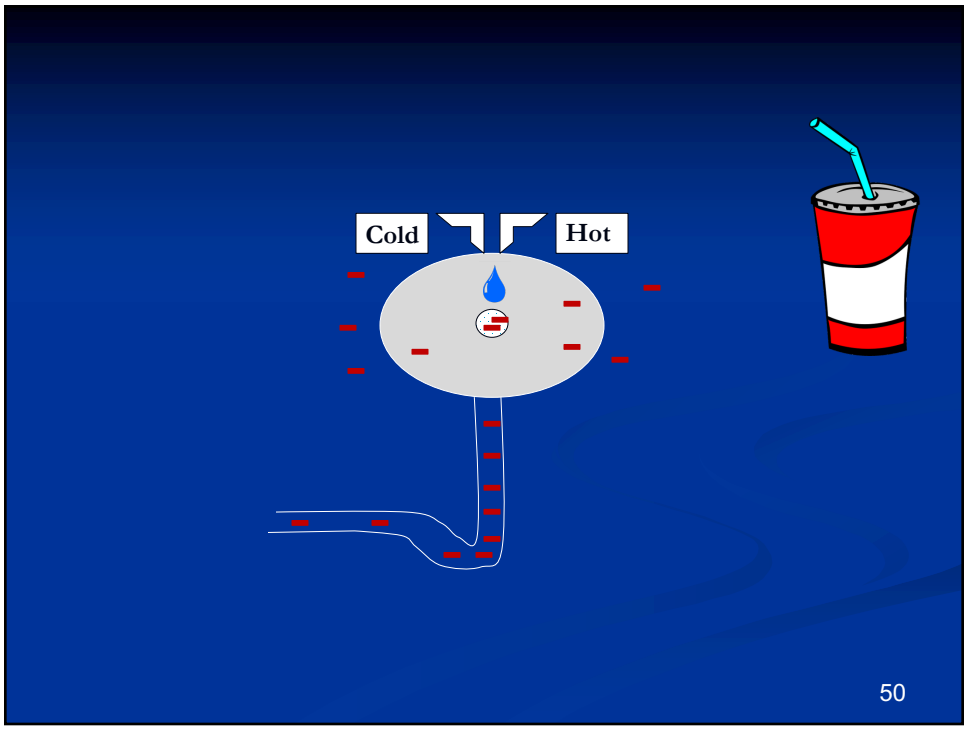

Cold
Hot
47


Cold
Hot
48

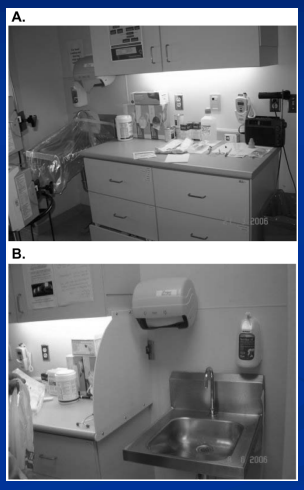

Cold
Hot
49


Cold
Hot
50

Improving room design to reduce risk for transmission from sinks

Before renovation

After renovation



Hota S, et al. Outbreak of multidrug-resistant *P. aeruginosa* colonization and infection secondary to imperfect intensive care unit room design. ICHE 2009;30:25-33.

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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 [1]

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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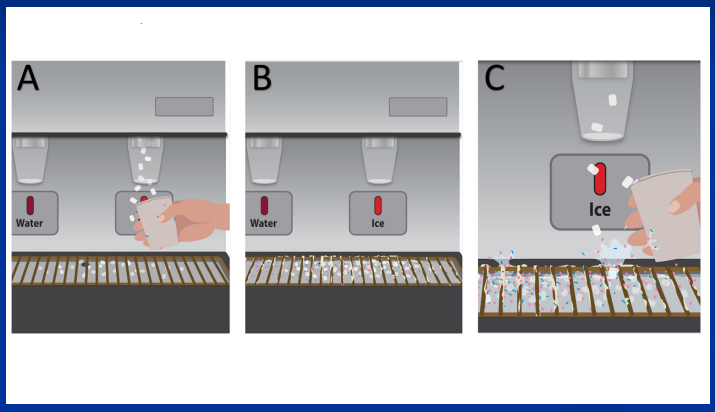
Contaminated ice machines as a source of pathogen transmission



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.

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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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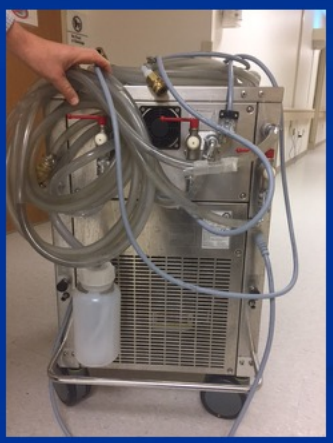
LivaNova (Sorin) Heater-Cooler device



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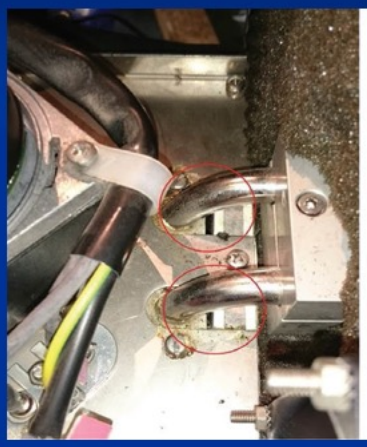
Sites of aerosol release in a LivaNova Heater-Cooler device



Holes by the flow and return pipes

Gap in water tank sealing plates

Chand M, et al. Clin Infect Dis 2016 December

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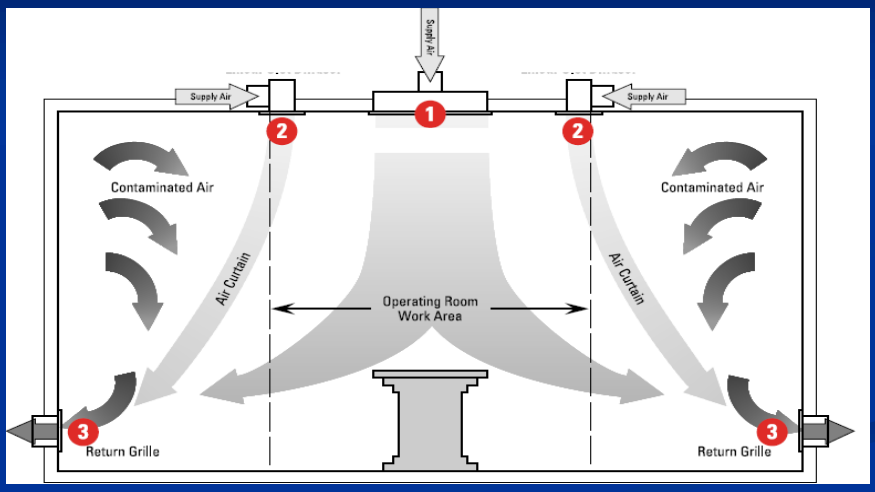
OR Supply Air Distribution Air Curtain System



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

Sommerstein R, et al. Transmission of *M. chimaera* from heater-cooler units during cardiac surgery despite an ultraclean air ventilation system. Emerg Infect Dis 2016;22:1008-13

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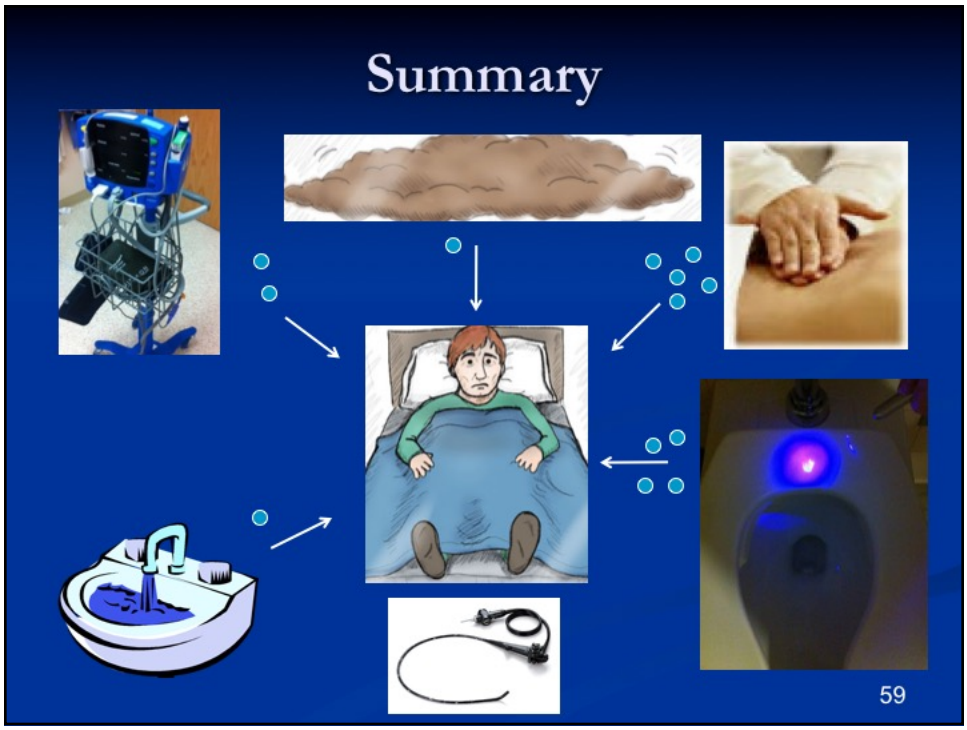

www.webbertraining.com/schedulep1.php

December 14, 2017	*(FREE Teleclass)* **ENHANCED PERFORMANCE FEEDBACK AND PATIENT PARTICIPATION TO IMPROVE HAND HYGIENE COMPLIANCE** Speaker: **Dr. Hugo Sax**, University of Zurich Hospitals, and **Dr. Andrew Stewardson**, Hand Hygiene Australia *Sponsored by GOJO (www.gojo.com)*
January 18, 2018	**USING THE RIGHT MODEL TO CALCULATE THE FINANCIAL IMPLICATIONS OF *CLOSTRIDIUM DIFFICILE* INFECTION** Speaker: **Dr. Mairead Skally**, Beaumont Hospital, Dublin
January 24, 2018	*(FREE … WHO Teleclass - Europe)* **GLOBAL INFECTION PREVENTION AND CONTROL PRIORITIES 2018-2022: A CALL FOR ACTION** Speaker: **Prof. Benedetta Allegranzi**, World Health Organization, Geneva *Sponsored by the World Health Organization, Infection Prevention and Control Global Unit*
January 25, 2018	**PRACTICAL APPROACHES FOR MONITORING CLEANING IN HEALTHCARE FACILITIES** Speaker: **Prof. Curtis Donskey**, Case Western Reserve University, Cleveland


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