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# **Unknown or Hidden Reservoirs of Infection and Prevention Strategy**

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# Environmental Strategies to Reduce Infections

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- Role of hospital surfaces in disease transmission
- Environmental Infection Control
  - Hospital privacy curtains
  - Water walls and electronic faucets
  - Prevention strategies



# THE ROLE OF THE ENVIRONMENT IN DISEASE TRANSMISSION

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- Over the past decade there has been a growing appreciation that environmental contamination makes a contribution to HAI with MRSA, VRE, *Acinetobacter*, norovirus and *C. difficile*
- Surface disinfection practices are currently not effective in eliminating environmental contamination (~32% of objects not cleaned/disinfected)
- Inadequate terminal cleaning of rooms occupied by patients with MDR pathogens places the next patients in these rooms at increased risk of acquiring these organisms

# PROVING THAT ENVIRONMENTAL CONTAMINATION LEADS TO NOSOCOMIAL INFECTIONS

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- Demonstration of microbial persistence in the environment: *In vitro* studies and environmental samples
- Demonstration of frequent environmental contamination
- Demonstration of HCP hand contamination
- Relationship between level of environmental contamination and hand contamination
- Demonstration of person-to-person transmission (molecular link)
- Demonstration that being housed in a room previously occupied by a patient with the pathogen of interest is a risk factor for disease
- Demonstration that improved surface cleaning/disinfection reduces disease incidence

# EVALUATION OF HOSPITAL ROOM ASSIGNMENT AND ACQUISITION OF CDI

- Study design: Retrospective cohort analysis, 2005-2006
- Setting: Medical ICU at a tertiary care hospital
- Methods: All patients evaluated for diagnosis of CDI 48 hours after ICU admission and within 30 days after ICU discharge
- Results (acquisition of CDI)
  - Admission to room previously occupied by CDI = 11.0%
  - Admission to room not previously occupied by CDI = 4.6% (p=0.002)

Shaughnessy MK, et al. ICHE 2011;32:201-206

TABLE 3. Multivariate Analysis of Risk Factors for Acquisition of *Clostridium difficile* Infection (CDI)

Risk factor	HR (95% CI)	P
Prior room occupant with CDI	2.35 (1.21–4.54)	.01
Greater age	1.00 (0.99–1.01)	.71
Higher APACHE III score	1.00 (1.00–1.01)	.06
Proton pump inhibitor use	1.11 (0.44–2.78)	.83
Antibiotic exposure		
Norfloxacin	0.38 (0.05–2.72)	.33
Levofloxacin	1.08 (0.67–1.73)	.75
Ciprofloxacin	0.49 (0.15–1.67)	.23
Fluoroquinolones	1.17 (0.72–1.91)	.53
Clindamycin	0.45 (0.14–1.42)	.17
Third- or fourth-generation cephalosporins	1.17 (0.76–1.79)	.48
Carbapenems	1.05 (0.63–1.75)	.84
Piperacillin-tazobactam	1.31 (0.82–2.10)	.27
Other penicillin	0.47 (0.23–0.98)	.04
Metronidazole	1.31 (0.83–2.07)	.24
Vancomycin		
Oral	1.38 (0.32–5.89)	.67
Intravenous	1.55 (0.88–2.73)	.13
Aminoglycosides	1.27 (0.78–2.06)	.35
Multiple (≥3 antibiotic classes)	1.28 (0.75–2.21)	.37

NOTE. APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; HR, hazard ratio.

# RELATIVE RISK OF PATHOGEN ACQUISITION IF PRIOR ROOM OCCUPANT INFECTED



\* Prior room occupant infected; ^Any room occupant in prior 2 weeks infected

# Multiple publications (>20) suggest that environmental disinfection interventions can reduce acquisition of healthcare-associated pathogens. AJIC. 2013.41:S12.

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## Major article

# Does improving surface cleaning and disinfection reduce health care-associated infections?

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**Key Words:**  
Environment  
Cleaning  
Transmission

Contaminated environmental surfaces provide an important potential source for transmission of health care-associated pathogens. In recent years, a variety of interventions have been shown to be effective in improving cleaning and disinfection of surfaces. This review examines the evidence that improving environmental disinfection can reduce health care-associated infections.

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Contaminated environmental surfaces provide an important potential source for transmission of many health care associated pathogens.<sup>1,6</sup> These include *Clostridium difficile*, methicillin resistant

infected with health care associated pathogens shed organisms onto their skin, clothing, bedding, and nearby environmental surfaces.<sup>12</sup> In addition to surfaces in rooms, portable equipment



# Soft Surface Disinfection

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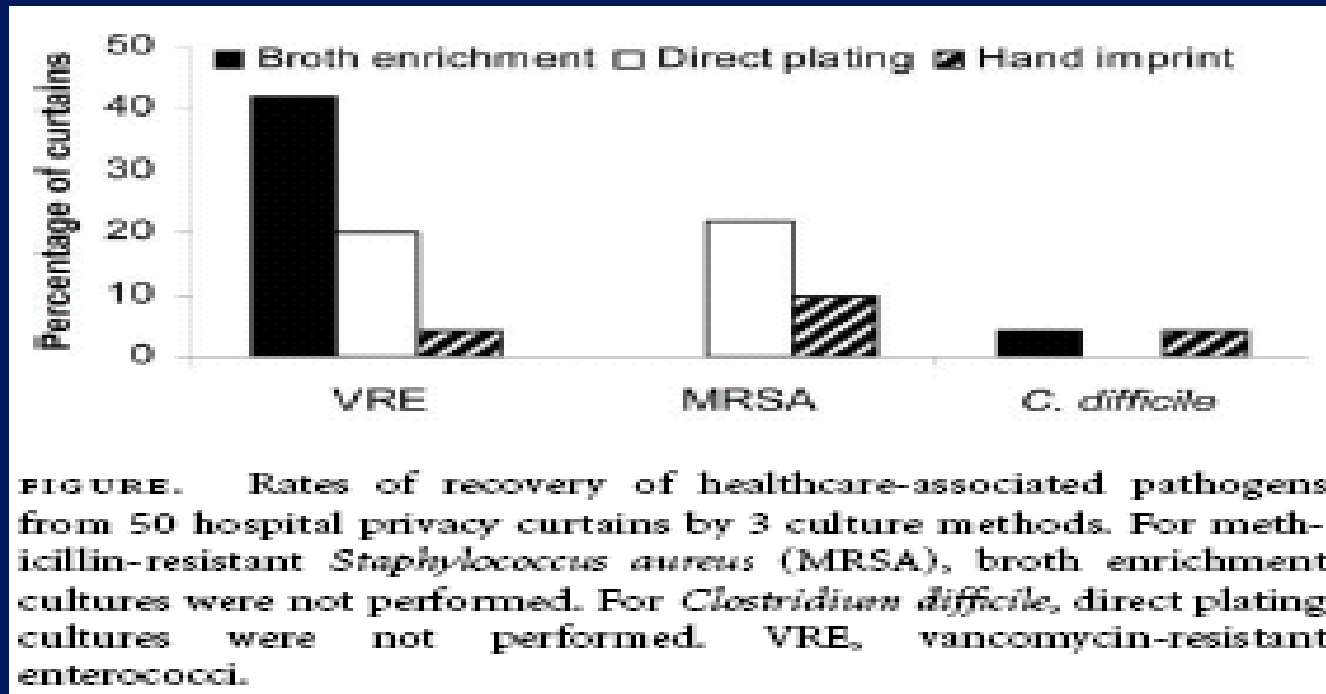
- Bacteria can be found everywhere-both hard and soft surfaces
- Hospitals have cleaning routines for hard surfaces but commonly no cleaning routine for soft surfaces
- Household soft surfaces
  - Furniture, mattresses, pillows, privacy curtains
- What can you do-steam vapor sanitation, UV-C, sprays, VHP
- Disinfectant used for “hard, nonporous surfaces”, so use on soft surfaces would be violation of the label

# Hospital Privacy Curtains



# CONTAMINATION OF HOSPITAL CURTAINS

42% of privacy curtains contaminated with VRE, 22% MRSA and 4% *C. difficile*



# Contamination of Hospital Privacy Curtains

Rutala, Gergen, Weber. AJIC, In press.

MICU-CP for:	Before Disinfection CFU/5 Rodacs (#Path)
MRSA	330 (10 MRSA)
MRSA	186 (24 VRE)
MRSA	108 (10 VRE)
VRE	75 (4 VRE)
VRE	68 (2 MRSA)
VRE	98 (40 VRE)
MRSA	618 (341 MRSA)
MRSA	55 (1 VRE)
MRSA, VRE	320 (0 MRSA, 0 VRE)
MRSA	288 (0 MRSA)
Mean	2146/10=215 (432/10=43)

# IMPROVED HYDROGEN PEROXIDE (HP) SURFACE DISINFECTANT

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- **Advantages**
  - **30 sec -1 min bactericidal and virucidal claim (fastest non-bleach contact time)**
  - **5 min mycobactericidal claim**
  - **Safe for workers (lowest EPA toxicity category, IV)**
  - **Benign for the environment; noncorrosive; surface compatible**
  - **One step cleaner-disinfectant**
  - **No harsh chemical odor**
  - **EPA registered (0.5% RTU, 1.4% RTU, wet wipe)**
- **Disadvantages**
  - **More expensive than QUAT**

## BACTERICIDAL ACTIVITY OF DISINFECTANTS ( $\log_{10}$ reduction) WITH A CONTACT TIME OF 1m WITH/WITHOUT FCS. Rutala et al. ICHE. 2012;33:1159

Improved hydrogen peroxide is significantly superior to standard HP at same concentration and superior or similar to the QUAT tested

Organism	IHP-0.5%	0.5% HP	IHP Cleaner-Dis 1.4%	1.4% HP	3.0% HP	QUAT
MRSA	>6.6	<4.0	>6.5	<4.0	<4.0	5.5
VRE	>6.3	<3.6	>6.1	<3.6	<3.6	4.6
MDR-Ab	>6.8	<4.3	>6.7	<4.3	<4.3	>6.8
MRSA, FCS	>6.7	NT	>6.7	NT	<4.2	<4.2
VRE, FCS	>6.3	NT	>6.3	NT	<3.8	<3.8
MDR-Ab, FCS	>6.6	NT	>6.6	NT	<4.1	>6.6

# Hospital Privacy Curtains

(pre- and post-intervention study; sampled curtain, sprayed “grab area” 3x from 6-8” with 1.4% IHP and allowed 2 minute contact; sampled curtain). Rutala et al. AJIC, In press.



# Decontamination of Curtains with Activated HP (1.4%)

Rutala, Gergen, Weber. AJIC. In press.

MICU-CP for:	Before Disinfection CFU/5 Rodacs (#Path)	After Disinfection CFU/5 Rodacs (#Path)	% Reduction
MRSA	330 (10 MRSA)	21*(0 MRSA)	93.6%
MRSA	186 (24 VRE)	4* (0 VRE)	97.9%
MRSA	108 (10 VRE)	2* (0 VRE)	98.2%
VRE	75 (4 VRE)	0 (0 VRE)	100%
VRE	68 (2 MRSA)	2* (0 MRSA)	97.1%
VRE	98 (40 VRE)	1* (0 VRE)	99.0%
MRSA	618 (341 MRSA)	1* (0 MRSA)	99.8%
MRSA	55 (1 VRE)	0 (0 MRSA)	100%
MRSA, VRE	320 (0 MRSA, 0 VRE)	1* (0 MRSA, 0 VRE)	99.7%
MRSA	288 (0 MRSA)	1* (0 MRSA)	99.7%
Mean	2146/10=215 (432/10=43)	33*/10=3 (0)	98.5%

\*

All isolates after disinfection were *Bacillus sp*; now treat CP patient curtains at discharge with IHP



# Decontamination of Curtains with Activated HP (1.4%)

Rutala, Gergen, Weber. AJIC. In press

Area/Pathogen	Before Disinfection (CFU/rooms=CFU/curtain)	After Disinfection† (CFU/rooms=CFU/curtain)	Reduction (%)
CP ( <i>C. difficile</i> ), non-ICU	86/4 = 22	0/4 = 0	100
CP (2 MRSA, 3 VRE), non-ICU	806/5 = 161	21/5 = 4	97.4
CP ( <i>E.coli</i> , ESBL), 2 ICU, 1 non-ICU	376/3 = 125	6/3 = 2	98.4
ED (7 non-isol; 3 isol), outpatient	5,623/10 = 562	160/10 = 16	97.2
Inpatient Rooms, non-ICU	604/5 = 121	82/5 = 16	86.4

†97.5% of the isolates recovered after disinfection were *Bacillus species*

# Decontamination of Curtains with Activated HP (1.4%)

Rutala, Gergen, Weber. AJIC, In press

- Evaluated a “wipe” technique on curtains in 10 ICU patient rooms on isolation for MRSA and/or VRE
- An IHP wipe was applied to the front of the curtain (patient side) and back of the curtain.
- Allowed a 2 minute contact time
- Patient side of the curtain (130 CFUs/curtain) was more contaminated than the outside of the curtain (58 CFUs/curtain)
- Found a 98.7% reduction

# Decontamination of Curtains with Activated HP (1.4%)

Rutala, Gergen, Weber. AJIC, In press

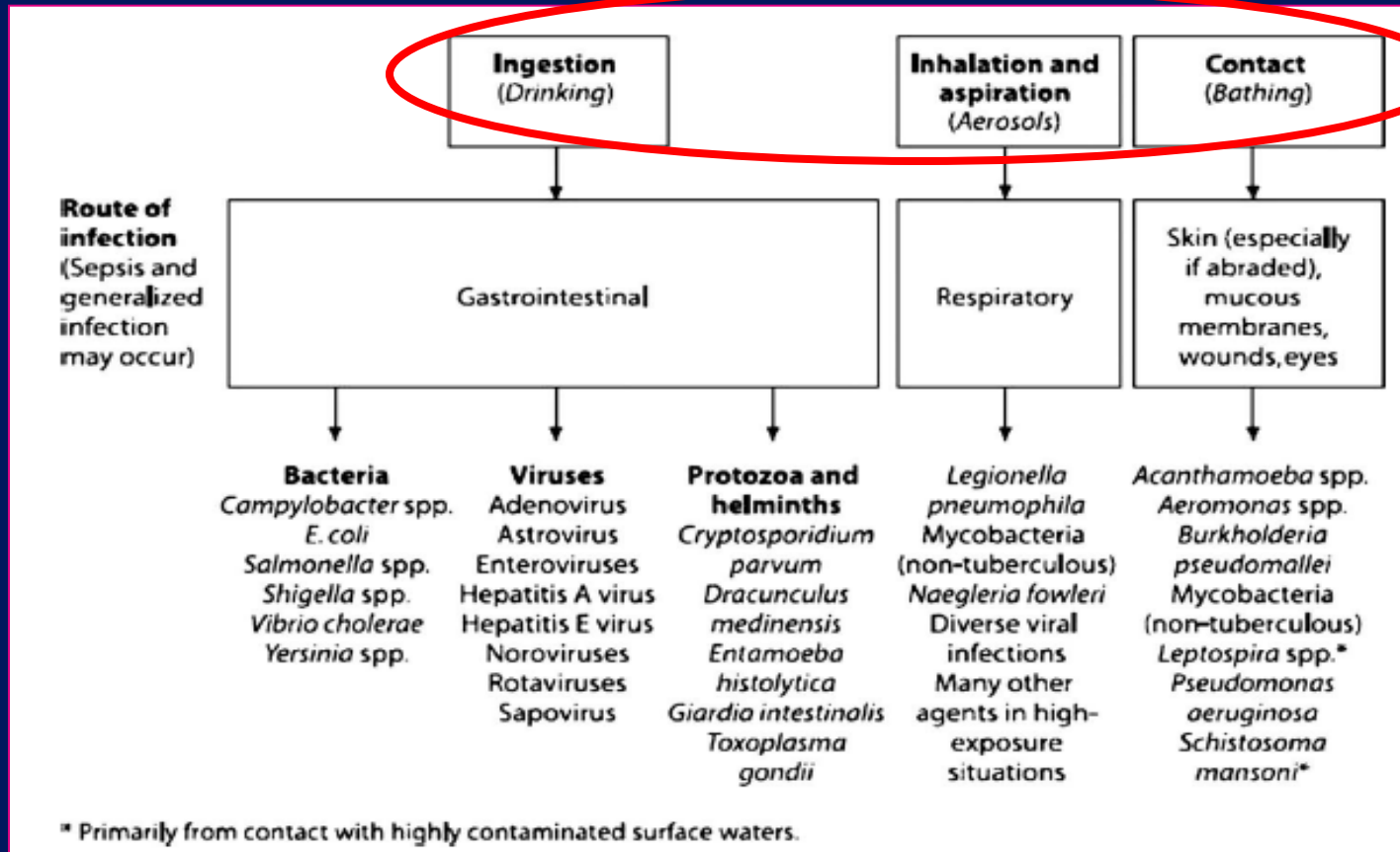
- Privacy curtains could serve as a source for epidemiologically-important pathogens
- We used IHP and found it effective (96.8% reduction in 37 patient rooms)
- Curtains, as with other hand contact surfaces in a patient room, should be decontaminated at some routine frequency
- Cost of decontaminating a curtain with IHP (\$0.01 product costs) would be far less than removing the curtain and replacing with a new curtain between patients (\$4.72, 22 minutes to remove/re-hang x \$12.87/hour salary)

# Water and Healthcare Multiple Uses



# Water-Related Pathogens and Their Disease Transmission Pathways

Exner et al. AJIC 33:S26-40; 2005



# WATER RESERVOIRS

Rutala, Weber. ICHE 1997;18:609

**TABLE**  
WATER AS A RESERVOIR OF NOSOCOMIAL PATHOGENS

<b>Reservoir</b>	<b>Associated Pathogen(s)</b>	<b>Transmission</b>	<b>Importance*</b>	<b>Prevention and Control</b>
Potable water	<i>Pseudomonas</i> , <i>Mycobacteria</i> , <i>Legionella</i>	Contact	Moderate	Follow public health guidelines
Sinks	<i>Pseudomonas</i>	Contact, droplet	Low	Use separate sinks for handwashing and disposal of contaminated fluids
Faucet aerators	<i>Pseudomonas</i>	Contact, droplet	Low	No precautions necessary at present
Showers	<i>Legionella</i>	Inhalation	Low	Prohibit use in immunocompromised patients
Ice and ice machines	<i>Legionella</i> , <i>Enterobacter</i> , <i>Pseudomonas</i> , <i>Salmonella</i> , <i>Cryptosporidia</i>	Ingestion, contact	Moderate	Periodic cleaning; use automatic dispenser (ie, avoid open chest storage compartments in patient areas)
Eyewash stations	<i>Pseudomonas</i> , <i>Legionella</i> , <i>Ameba</i>	Contact	Low	Have available sterile water for eye flush or weekly (or monthly) flush eyewash stations
Dental-unit water systems	<i>Pseudomonas</i> , <i>Legionella</i> , <i>Sphingomonas</i> , <i>Acinetobacter</i>	Contact	Low	Clean water systems
Dialysis water	Gram-negative bacilli	Contact	Moderate	Follow guidelines: dialysate $\leq 2,000$ organisms/mL; water $\leq 200$ organisms/mL



# Water Wall Fountains and Electronic Faucets



# Water Walls Linked to Legionnaires'

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- Palmore et al. ICHE 2009;30:764
  - 2 immunocompromised patients exposed to decorative fountain in radiation oncology; isolates from patients and fountain identical; disinfection with ozone, filter and weekly cleaning
- Houpt et al. ICHE 2012;33:185
  - Lab-confirmed Legionnaires disease was dx in 8 patients; 6 had exposure to decorative fountain (near main entrance to hospital); high counts of *Legionella pneumophila* 1 despite disinfection and maintenance



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# Water Walls and Decorative Water Fountains

Present unacceptable risk in hospitals serving immunocompromised patients (even with standard maintenance and sanitizing methods)

# Electronic Faucets

## A Possible Source of Nosocomial Infection?

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# Electronic Faucets

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- Conserve water
- Conserve energy
- Hygienic
- Hands free
- Barrier free

# Electronic (E) vs Handle-Operated (HO) Faucets

- 100% E vs 30% HO *Legionella* (no cases). Halabi et al. JHI 2001;49:117
- Significant difference HPC levels between brand A (32%) and B (8%) E compared to HO (11%). Hargreaves et al. 2001; 22:202
- No difference in *P. aeruginosa*. Assadian et al. ICHE. 2002;23:44.
- 73% E samples did not meet German water standard vs 0% HO. Chaberny et al. ICHE 2004;25:997
- 39% of water samples from E and 1% from HO yielded *P. aeruginosa*. Merrer et al. Intensive Care Med 2005;31:1715
- 95% E grew *Legionella* compared to 45% HO (water-disruption events). Syndor et al. ICHE 2012; 33:235

# Issues Associated with Electronic Faucets

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- A longer distance between the valve and the tap, resulting in a longer column of stagnant, warm water, which favors production of biofilms
- Reduced water flow; reduced flushing effect (growth favored)
- Valves and pipes made of plastic (enhances adhesion *P. aeruginosa*)

# Prevention Measures

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- Electronic faucets constructed so they do not promote the growth of microorganisms
- A **potential source** of nosocomial pathogens but **more data** are needed to establish role in HAI
- No guideline (but some have recommended) to remove electronic faucets from at-risk patient care areas (BMTU)
- Some have recommended periodic monitoring of water samples for growth of *Legionella*

# CONCLUSIONS

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- The **contaminated surface environment in hospital rooms is important** in the transmission of healthcare-associated pathogens (MRSA, VRE, *C. difficile*)
- **Effective surface disinfection essential** to eliminate the environment as a source for transmission of HA pathogens.
- Privacy curtains could serve as a source for epidemiologically-important pathogens and should be decontaminated at some routine frequency (e.g., discharge cleaning/disinfection)
- **Prohibit water walls/decorative fountains in hospitals serving immunocompromised patients**

# Environmental Strategies to Reduce Infections

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- Role of hospital surfaces in disease transmission
- Environmental Infection Control
  - Hospital privacy curtains
  - Water walls and electronic faucets
  - Prevention strategies



# THANK YOU!

