Best Practices for Environmental Infection Control: Surfaces, Water and Air

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DISCLOSURES

2018

- **Consultations**
  - ASP (Advanced Sterilization Products), PDI
- **Honoraria**
  - PDI, ASP, 3M
- **Scientific Advisory Board**
  - Kinnos
- **Grants**
  - CDC

Sources of Healthcare-Associated Pathogens

Weinstein RA. Am J Med 1991:91 (suppl 3B):179S

- Endogenous flora (SSI, UTI, CLABSI): 40-60%
- Exogenous: 20-40% (e.g., cross-infection via contaminated hands [staff, visitors])
- Other (environment): 20%
  - Medical devices/inanimate objects
  - Contact with environmental surfaces (direct and indirect)

Best Practices for Environmental Infection Control: Surfaces, Water and Air

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- Identify the infection prevention strategies to reduce the risk of surfaces
- Review the healthcare outbreaks associated with water reservoirs and discuss control strategies
- Explain what infection prevention measures should be implemented to prevent patient exposure to fungal pathogens

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Environmental Contamination Leads to HAIs

Weber, Kanamori, Rutala. Curr Op Infect Dis 2016:29:424-431



- Evidence environment contributes
- Role-MRSA, VRE, *C. difficile*
- Surfaces are contaminated-~25%
- EIP survive days, weeks, months
- Contact with surfaces results in hand contamination
- Disinfection reduces contamination
- Disinfection (daily) reduces HAIs
- Rooms not adequately cleaned

Admission to Room Previously Occupied by Patient C/I with Epidemiologically Important Pathogen



- Results in the newly admitted patient having an increased risk of acquiring that pathogen by 39-353%
- For example, increased risk for *C. difficile* is 235% (11.0% vs 4.6%)
- Exposure to contaminated rooms confers a 5-6 fold increase in odds of infection, hospitals must adopt proven methods for reducing environmental contamination (Cohen et al. ICHE. 2018;39:541-546)

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.

Acquisition of EIP on Hands of Healthcare Providers after Contact with Contaminated Environmental Sites and Transfer to Other Patients





Acquisition of EIP on Hands of Patient after Contact with Contaminated Environmental Sites and Transfers EIP to Eyes/Nose/Mouth



KEY PATHOGENS WHERE ENVIRONMENTIAL SURFACES PLAY A ROLE IN TRANSMISSION

- MRSA
- VRE
- *Acinetobacter* spp.
- *Clostridium difficile*
- Norovirus
- Rotavirus
- SARS

ENVIRONMENTAL CONTAMINATION ENDEMIC AND EPIDEMIC MRSA

	Outbreak	Endemic				Site estimated mean§
	Rampling et al[27]*	Boyce et al[48]*	Sexton et al[51]†	Lemmen et al[50]*‡	French et al[64]*	
Floor	9%	50–55%	44–60%	24%	..	34·5%
Bed linen	..	38–54%	44%	34%	..	41%
Patient gown	..	40–53%	..	34%	..	40·5%
Overbed table	..	18–42%	64–67%	24%	..	40%
Blood pressure cuff	13%	25–33%	..	..	..	21%
Bed or siderails	5%	1–30%	44–60%	21%	43%	27%
Bathroom door handle	..	8–24%	..	12%¶	..	14%
Infusion pump button	13%	7–18%	..	30%	..	19%
Room door handle	11%	4–8%	..	23%	59%	21·5%‖
Furniture	11%	..	44–59%	19%	..	27%
Flat surfaces	7%	..	32–38%	..	..	21·5%
Sink taps or basin fitting	..	..	..	14%	33%	23·5%
Average quoted**	11%	27%	49%	25%	74%	37%

Dancer SJ et al. Lancet ID 2008;8(2):101-13

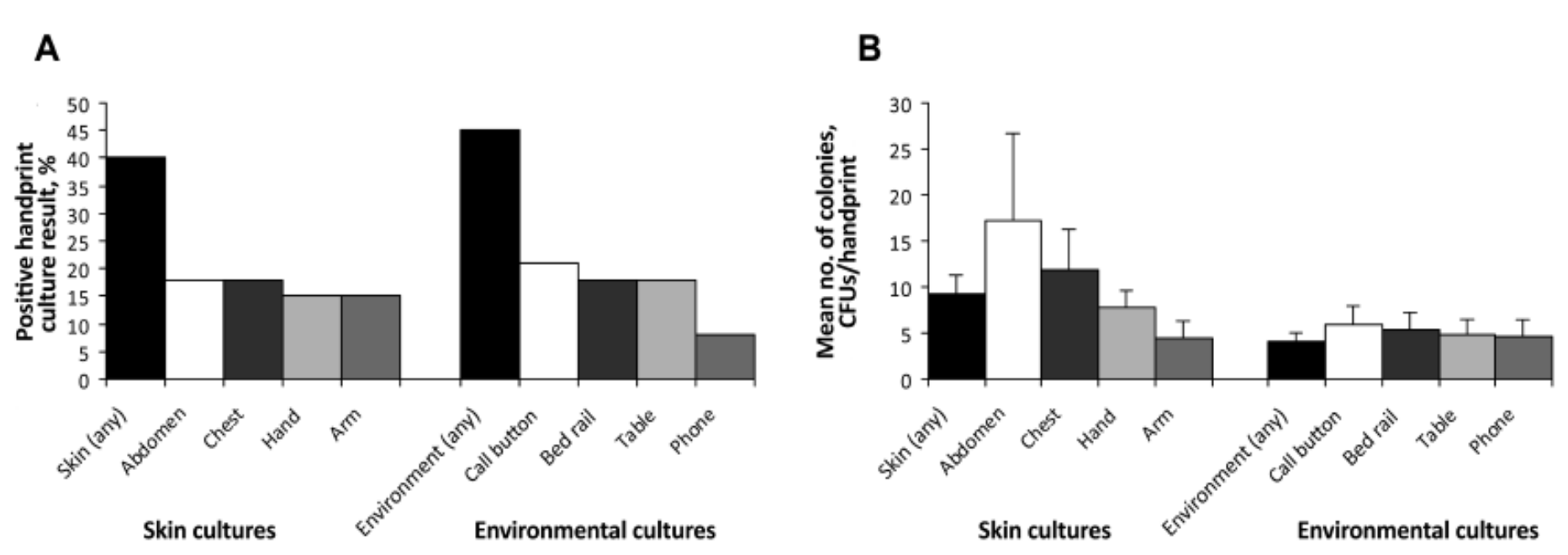
ENVIRONMENTAL SURVIVAL OF KEY PATHOGENS ON HOSPITAL SURFACES

Pathogen	Survival Time
S. aureus (including MRSA)	7 days to >12 months
Enterococcus spp. (including VRE)	5 days to >46 months
Acinetobacter spp.	3 days to 11 months
Clostridium difficile (spores)	>5 months
Norovirus (and feline calicivirus)	8 hours to >2 weeks
Pseudomonas aeruginosa	6 hours to 16 months
Klebsiella spp.	2 hours to >30 months

Adapted from Hota B, et al. Clin Infect Dis 2004;39:1182-9 and Kramer A, et al. BMC Infectious Diseases 2006;6:130

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)



Stiefel U, et al. ICHE 2011;32:185-187

Use of a Daily Disinfectant Cleaner Instead of a Daily Cleaner Reduced HAI Rates

Alfa et al. AJIC 2015.43:141-146

- Method: Improved hydrogen peroxide disposable wipe was used once per day for all high-touch surfaces to replace cleaner
- Result: When cleaning compliance was ≥ 80%, there was a significant reduction in cases/10,000 patient days for MRSA, VRE and *C. difficile*
- Conclusion: Daily use of disinfectant applied to environmental surfaces with a 80% compliance was superior to a cleaner because it resulted in significantly reduced rates of HAIs caused by *C. difficile*, MRSA, VRE

It appears that not only is disinfectant use important but how often is important

Daily disinfection vs clean when soiled

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 (PA) 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**

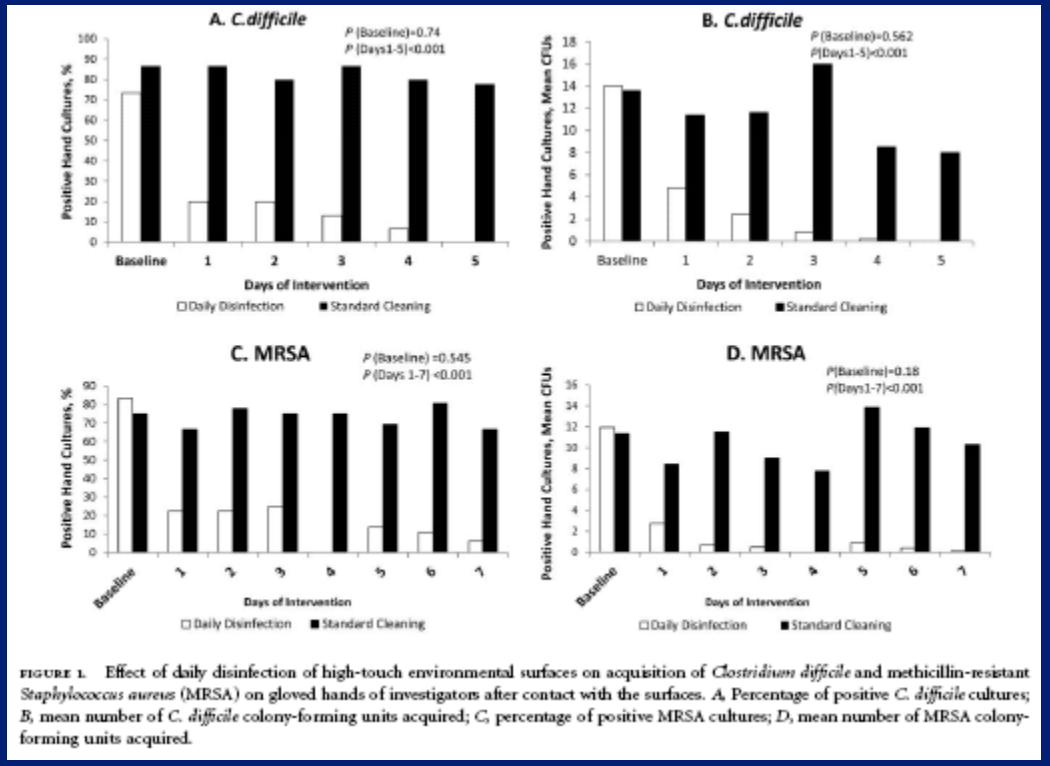


FIGURE 1. Effect of daily disinfection of high-touch environmental surfaces on acquisition of *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus* (MRSA) on gloved hands of investigators after contact with the surfaces. *A*, Percentage of positive *C. difficile* cultures; *B*, mean number of *C. difficile* colony-forming units acquired; *C*, percentage of positive MRSA cultures; *D*, mean number of MRSA colony-forming units acquired.

Disinfection of Noncritical Surfaces Bundle

NL Havill AJIC 2013;41:S26-30

- Develop policies and procedures
- Select cleaning and disinfecting products
- Educate staff to environmental services and nursing
- Monitor compliance (thoroughness of cleaning, product use) and feedback
- Implement “no touch” room decontamination technology and monitor compliance



Disinfection of Noncritical Surfaces Bundle

- Develop policies and procedures
  - Environmental cleaning and disinfection is an integral part of preventing transmission of pathogens
  - In addition to identifying products and procedures, ensure standardization of cleaning throughout the hospital
    - **Some units utilize ES to clean pieces of equipment (e.g., vital sign machines, IV pumps); some units use patient equipment, and some units utilize nursing staff.**
    - **Multidisciplinary group to create a standardized plan for cleaning patient rooms and pieces of patient equipment throughout the hospital**

Surface Disinfection

Noncritical Patient Care

Rutala, Weber, HICPAC. CDC 2008. www.cdc.gov

- Disinfecting Noncritical Patient-Care Items
  - Process noncritical patient-care equipment with a EPA-registered disinfectant at the proper use dilution and a contact time of at least 1 min. *Category IB*
  - Ensure that the frequency for disinfecting noncritical patient-care surfaces be done minimally when visibly soiled and on a regular basis (such as after each patient use or once daily or once weekly). *Category IB*

Surface Disinfection

Environmental Surfaces

Rutala, Weber, HICPAC. CDC 2008. www.cdc.gov

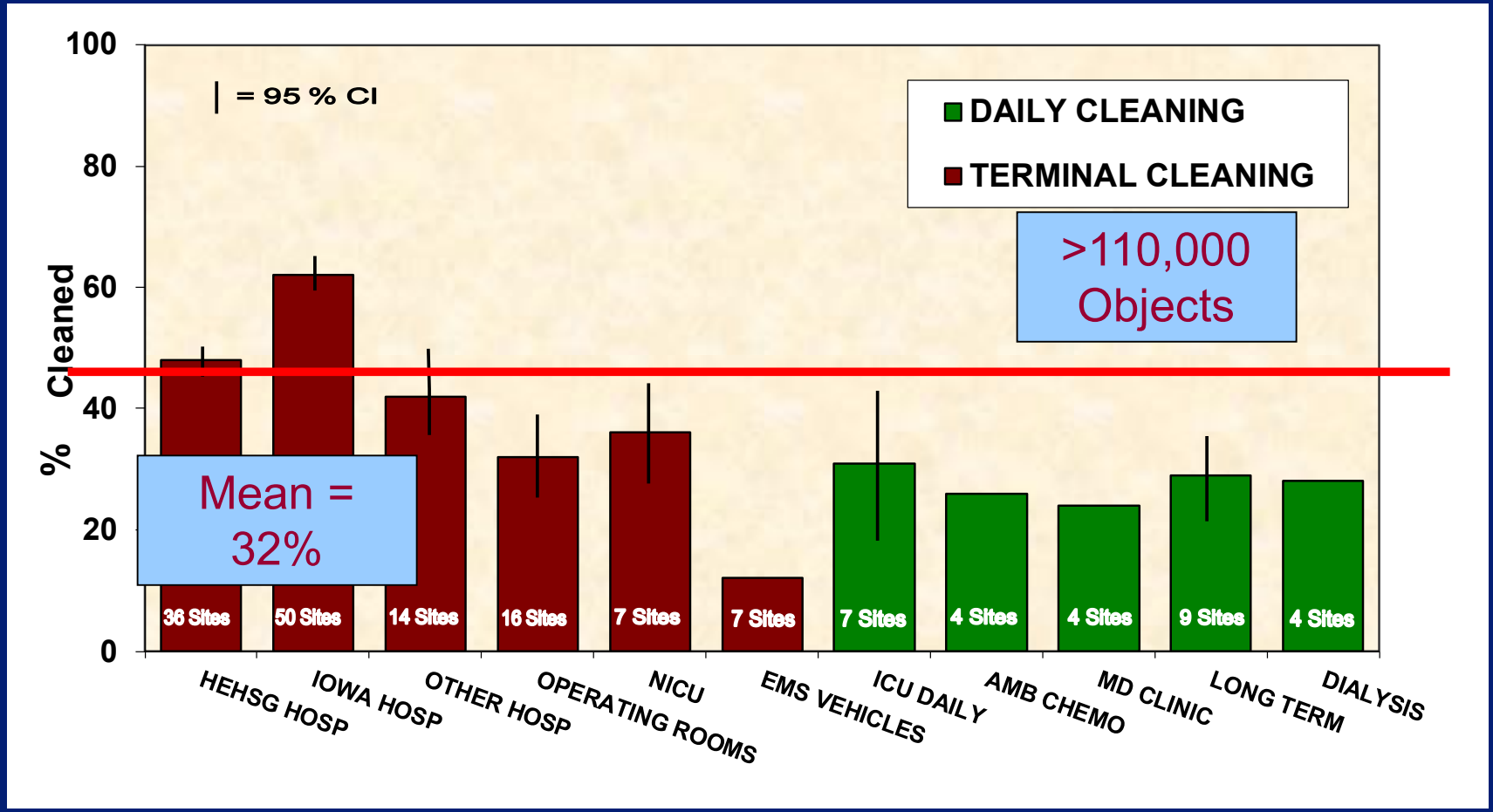
- Disinfecting Environmental Surfaces in HCF
  - Disinfect (or clean) housekeeping surfaces (e.g., floors, tabletops) on a regular basis (e.g., daily, three times per week), when spills occur, and when these surfaces are visibly soiled. *Category IB*
  - Use disinfectant for housekeeping purposes where: uncertainty exists as to the nature of the soil on the surfaces (blood vs dirt); or where uncertainty exists regarding the presence of multi-drug resistant organisms on such surfaces. *Category II*

Effective Surface Decontamination

Product and Practice = Perfection

Thoroughness of Environmental Cleaning

Carling P. AJIC 2013;41:S20-S25



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/cm^2-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 IP unbeknown to EVS, after EVS cleaning, markings are reassessed)

These interventions (effective surface disinfection, thoroughness indicators) not enough to achieve consistent and high rates of cleaning/disinfection

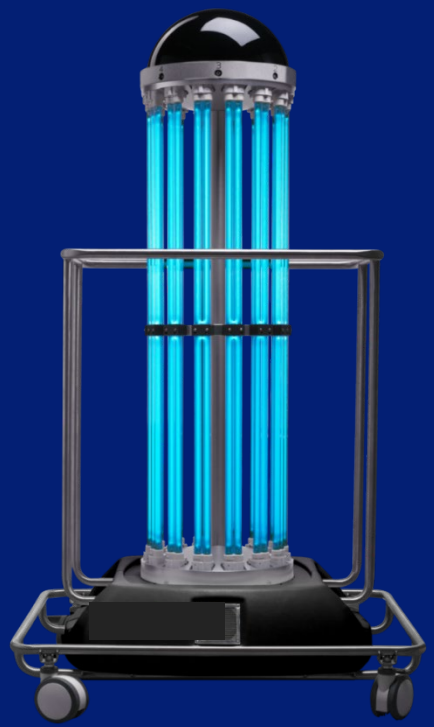
No Touch

(supplements but do not replace surface cleaning/disinfection)

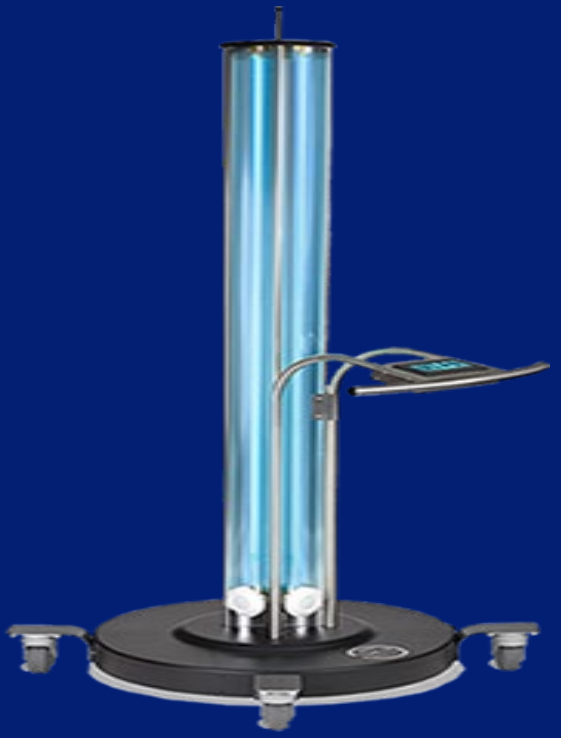
“NO TOUCH” APPROACHES TO ROOM DECONTAMINATION

(UV/VHP~20 microbicidal studies, 12 HAI reduction studies; will not discuss technology with limited data)

Weber, Kanamori, Rutala. Curr Op Infect Dis 2016;29:424-431; Weber, Rutala et al. AJIC; 2016:44: e77-e84; Anderson et al. Lancet 2017;389:805-14; Anderson et al. Lancet Infect Dis 2018;June 2018.







Enhanced Disinfection Leading to Reduction of Microbial Contamination and a Decrease in Patient Col/Infection

Anderson et al. Lancet 2017;289:805; Rutala et al. ICHE 2018;38:1118-1121

	Standard Method		Enhanced method	
	Quat	Quat/UV	Bleach	Bleach/UV
EIP (mean CFU per room)[a]	60.8	3.4	11.7	6.3
Reduction (%)		94	81	90
Colonization/Infection (rate)[a]	2.3	1.5	1.9	2.2
Reduction (%)		35	17	4

Comparing the best strategy with the worst strategy (i.e., Quat vs Quat/UV) revealed that a reduction of 94% in EIP (60.8 vs 3.4) led to a 35% decrease in colonization/infection (2.3% vs 1.5%). Our data demonstrated that a decrease in room contamination was associated with a decrease in patient colonization/infection.

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NL Havill AJIC 2013;41:S26-30

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Water As A Source of Nosocomial Outbreaks





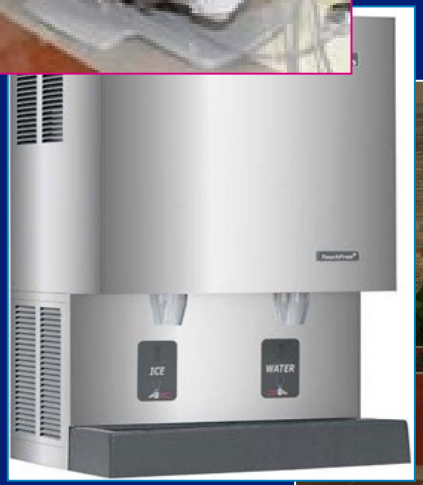














WATER RESERVOIRS

- Potable water
- Sinks
- Faucet aerators
- Showers
- Tub immersion
- Toilets
- Decorative fountains
- Dialysis water
- Ice and ice machines
- Water baths
- Flowers
- Eye wash stations
- Water walls

Healthcare Outbreaks Associated with Water Reservoir

Kanamori, Weber, Rutala. Clin Infect Dis 2016;62:1423

Clinical Infectious Diseases

INVITED ARTICLE

HEALTHCARE EPIDEMIOLOGY: Robert A. Weinstein, Section Editor

Healthcare Outbreaks Associated With a Water Reservoir and Infection Prevention Strategies

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Hospital water may serve as a reservoir of healthcare-associated pathogens, and contaminated water can lead to outbreaks and severe infections. The clinical features of waterborne outbreaks and infections as well as prevention strategies and control measures are reviewed. The common waterborne pathogens were bacteria, including *Legionella* and other gram-negative bacteria, and nontuberculous mycobacteria, although fungi and viruses were occasionally described. These pathogens caused a variety of infections, including bacteremia and invasive and disseminated diseases, particularly among immunocompromised hosts and critically ill adults as well as neonates. Waterborne outbreaks occurred in healthcare settings with emergence of new reported reservoirs, including electronic faucets (*Pseudomonas aeruginosa* and *Legionella*), decorative water wall fountains (*Legionella*), and heater-cooler devices used in cardiac surgery (*Mycobacterium chimaera*). Advanced molecular techniques are useful for achieving a better understanding of reservoirs and transmission pathways of waterborne pathogens. Developing prevention strategies based on water reservoirs provides a practical approach for healthcare personnel.

Keywords. waterborne outbreaks; healthcare-associated infections; water; outbreaks.

CLASSIFICATION OF HEALTHCARE-ASSOCIATED INFECTIONS LINKED TO WATER

Kanamori H, Weber DJ, Rutala WA. Clin Infect Dis 2016;62:1423-35

- Key pathogens
  - Bacteria: *Legionella* spp., non-tuberculous mycobacteria (NTM), *Pseudomonas spp. (especially, P. aeruginosa*), *S. maltophilia, Burkholderia cepacia, Ralstonia pickettii, Serratia marcescens, Acinetobacter* spp., *Enterobacter* spp.
  - Other: Fungi (*Aspergillus, Fusarium, Rhizomucor*), norovirus, *Cryptosporidium*
- Key water sources
  - Potable water (contamination may occur anywhere along the distribution track): Sinks, showers, faucets, tubs, ice, eyewash stations, flower vases
  - Other: Fish tanks, water walls, dialysis water, internal fluid channels of medical equipment
- Transmission mechanisms
  - Inhalation of aerosols, direct or indirect contact with contamination source, ingestion, aspiration of contaminated water

Water supply +
Use +
Patient susceptibility

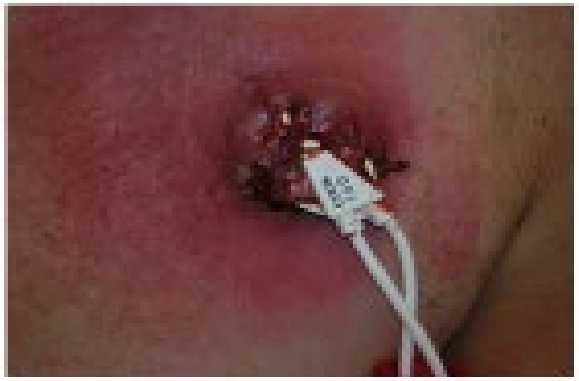








Reddy S. CDC, 2018





Healthcare Outbreaks Associated with Water Reservoir

Kanamori, Weber, Rutala. Clin Infect Dis 2016;62:1423

Table 2. Summary of Key Issues and Infection Prevention Strategies Against Waterborne Outbreaks by Major Water Reservoir in Healthcare Settings

Reservoir	Key Issues	Infection Prevention Strategies
Potable water, tap water, and hospital water systems	Potable water is not sterile, and pathogenic waterborne organisms may exist in potable water at acceptable levels of coliform bacteria (<1 coliform bacterium/100 mL). Healthcare-associated outbreaks have been linked to contaminated potable water. Semicritical devices are often rinsed with potable water, which may lead to contamination of the equipment and subsequent healthcare-associated infections. Common pathogens include nonenteric gram-negative bacilli (eg, *Pseudomonas aeruginosa*), *Legionella*, NTM.	Follow public health guidelines. Hot water temperature at the outlet at the highest temperature allowable, preferably >51°C. Water disruptions: post signs and do not drink tap water. Maintain standards for potable water (<1 coliform bacterium/100 mL). Rinse semicritical equipment with sterile water, filtered water, or tap water followed by alcohol rinse. Some experts have recommended periodic monitoring of water samples for growth of *Legionella*. *Legionella* eradication can be technically difficult, temporary, and expensive. Potential methods of eradication include filtration, ultraviolet, ozonization, heat inactivation (>60°C), hyperchlorination, and copper-silver ionization (>0.4 ppm and >0.04 ppm, respectively).
Sinks	Colonization of sinks with gram-negative bacilli has been reported. Some studies demonstrate a transmission link between a colonized sink and infected patients. Some studies describe that multidrug-resistant gram-negative bacilli are associated with contaminated sinks. Gram-negative bacilli can survive wet environments, including sinks, for a long time (>250 d) Transmission can be caused by splashing of water droplet from contaminated sinks to hands of healthcare personnel, followed by transient colonization of hands. Common pathogens include gram-negative bacilli (eg, *Pseudomonas, Acinetobacter, Serratia*).	Use separate sinks for handwashing and disposal of contaminated fluids. Decontaminate or eliminate sinks as a reservoir if epidemic spread of gram-negative bacteria via sinks is suspected.
Faucet aerators	Faucet aerators may serve as a platform for accumulation of waterborne pathogens. Potential pathogens include *Pseudomonas, Stenotrophomonas,* and *Legionella*.	Routine screening and disinfection or permanent removal of all aerators are not warranted at present. No precautions necessary at present. For *Legionella* outbreaks, clean and disinfect faucet aerators in high-risk patient areas periodically, or consider removing them in the case of additional infections.
Showers	Some outbreaks are linked to contaminated shower heads or inhalation of aerosols. Potential pathogens include *Legionella, Pseudomonas,* NTM, group A *Streptococcus*, and *Aspergillus*.	Prohibit use of showers in neutropenic patients. Control *Legionella* colonization of potable water.
Ice and ice machines	Patients can acquire pathogens by sucking on ice, ingesting iced drinks, or use of contaminated ices for cooling medical procedure and patients' skin. Large outbreaks occurred when ice machines have become contaminated and ice used for cooling drinking water. Common pathogens include *Pseudomonas, Enterobacter,*	Do not handle ice by hand. Do not store pharmaceuticals or medical solutions on ice for consumption. Use automatic dispenser rather than open chest storage compartments in patient areas. Clean and disinfect ice-storage chests regularly.

Healthcare Outbreaks Associated with Water Reservoir

Kanamori, Weber, Rutala. Clin Infect Dis 2016;62:1423

Eyewash stations	Stationary and portable eyewash stations may not be used for months or years. The water source may stand in the incoming pipes at room temperature for a long period. Pathogens, including *Pseudomonas*, *Legionella*, amoebae, and fungi, could be transmitted.	Use sterile water for eye flush or regularly (eg, monthly) flush eyewash stations.
Dental-unit water systems	Potable water usually supplies dental units. Water delivered to dental devices (eg, dental handpieces and air/water syringes) as well as dental unit water lines may be contaminated. Immunocompromised patients may be at risk for infection. Pathogens, including *Sphingomonas*, *Pseudomonas*, *Acinetobacter*, *Legionella*, and NTM, have been recovered from water supplies in dental units.	Clean dental water systems. Flush with water and disinfectant solution, or use of clean-water systems that put sterile water into the dental unit. Flush dental instruments with water and air for 20–30 sec from any dental device connected to the dental water system that enters the patient's mouth (eg, handpieces). Ensure that water in dental unit meets standards (<500 CFU/mL).
Dialysis water	Excessive levels of gram-negative bacilli in the dialysate were responsible for pyrogenic reactions in patients or bacteremia, which was caused by bacteria or endotoxin entry into the blood from the contaminated dialysate.	Follow AAMI standards for quality assurance performance of dialysis devices. Disinfect water distribution system on a regular basis. Perform microbiological testing and endotoxin testing for water in dialysis settings regularly. Maintain dialysis water (input) <200 CFU/mL and dialysate (output) <200 CFU/mL per CMS.
Water and ice baths	Contaminated water baths were used to thaw or warm blood products (fresh plasma, cryoprecipitate) or peritoneal dialysate bottles, followed by contamination of the infusates occurred during preparation. Contaminated ice baths were used to cool syringes or bottles of saline in measuring cardiac output. Potential pathogens include *Pseudomonas*, *Acinetobacter*, *Burkholderia*, *Staphylococcus*, and *Ewingella*.	Consider routine cleaning, disinfection, and changing of water in water baths. Add germicide to water bath or use plastic overwrap of blood products and keep the surfaces dry. Use sterile water in ice baths (or at room temperature) used for thermodilution catheters.

Healthcare Outbreaks Associated with Water Reservoir

Kanamori, Weber, Rutala. Clin Infect Dis 2016;62:1423

Reservoir	Key Issues	Infection Prevention Strategies
Bathing, tub immersion, and hydrotherapy	Tub immersion used in hospitals for physical hydrotherapy and for cleaning of burn wounds can cause cross-transmission, transmission from environmental reservoirs, or autotransmission. Skin infections such as folliculitis and cellulitis occurred related to water immersion. Water contamination of central venous catheters during bathing was related to bloodstream infection. Potential pathogens include *Pseudomonas*, *Enterobacter*, *Citrobacter*, *Acinetobacter*, *Legionella*, *Alcaligenes*, and NTM.	Adhere strictly to proper disinfection of tub between patients. Drain and clean tanks and tubs after use of each patient, and disinfect surfaces and components according to the manufacturer's instructions. Add disinfectant to the water: 15 ppm in small hydrotherapy tanks and 2–5 ppm in whirlpools per CDC. Disinfect after using tub liners. Cover catheter sites with transparent occlusive dressing.
Toilets	Transmission can be caused by aerosolization of fecal bacteria via flushing or surface contamination by fecal bacteria. Transmission could happen in healthcare facilities caring for mentally or neurologically impaired patients, or children. Potential pathogens include enteric bacteria, *Pseudomonas*, *Clostridium difficile*, and norovirus.	Facilitate good handwashing practices. Maintain clean surfaces with disinfectants. Clean bowl with a scouring powder and a brush. No reason to pour disinfectant into bowl. Separate toilet bowl from clean hospital surfaces.
Flowers and vases	Flower vases and potted plants are heavily colonized with potential pathogens, including *Acinetobacter*, *Klebsiella*, *Enterobacter*, *Pseudomonas*, *Serratia*, *Burkholderia cepacia*, *Aeromonas hydrophila*, and *Flavobacterium*. No healthcare-associated outbreaks directly linked to flower vases or potted plants have been reported.	Prohibit fresh flowers and potted plants in the rooms of immunocompromised and ICU patients. Or add antimicrobial agent to vase water and disinfect vases after use.
Electronic faucets	Electronic faucets were likely to be contaminated by several waterborne pathogens than handle-operated faucets. Issues associated with electronic faucets include 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 of *P. aeruginosa*).	Electronic faucets need to be designed so that they do not promote the growth of microorganisms. No guideline (but some authors have recommended) to remove electronic faucets from high-risk patient care areas [eg, BMTU]). Some have recommended periodic monitoring of water samples for growth of *Legionella*.
Decorative water wall fountains	*Legionella* pneumonia cases associated with decorative water fountain were reported. There is an unacceptable risk in hospitals serving immunocompromised patients (even with standard maintenance and sanitizing methods).	Avoid installation, especially in healthcare facilities serving immunocompromised patients or in areas caring for high-risk patients. Perform maintenance regularly and monitor water safety strictly unless removed.
Heater-cooler units	Healthcare-associated *Mycobacterium chimaera* outbreak due to heater-cooler units during cardiac surgeries as a water source has been recently reported. Airborne transmission from contaminated heater-cooler unit water tanks.	Ensure that heater-cooler units are safe and properly maintained according to the manufacturer's instructions. Enhance vigilance for NTM infections in patients after cardiac surgeries using heater-cooler devices. If NTM infections are suspected, review microbiology database (NTM-positive cultures) and medical records of surgical procedures within several years after cardiac surgeries.
Miscellaneous	Potential reservoirs include distilled water or containers (outbreaks with *Enterobacter cloacae* and *B. cepacia*), wash basins (*Salmonella urbana* infection, *Trichosporon asahii* infection, *Legionella* pneumonia), intraaortic balloon pump (*B. cepacia* bacteremia), humidifier water in ventilator systems (*Acremonium kiliense* postoperative endophthalmitis), water cooler (gastrointestinal illness), holy water (*Acinetobacter baumannii* infection), deionized water (*Exophiala jeanselmei* fungemia), water-damaged plaster (mucormycosis), water birth (*Legionella* pneumonia), water-saving device (*P. aeruginosa* infection), rinse water during endoscope reprocessing (gram-negative bacteria).	Consider control measures based on risk assessment by each reservoir when available.

Water Wall Fountains



Water Walls Linked to Legionnaires'

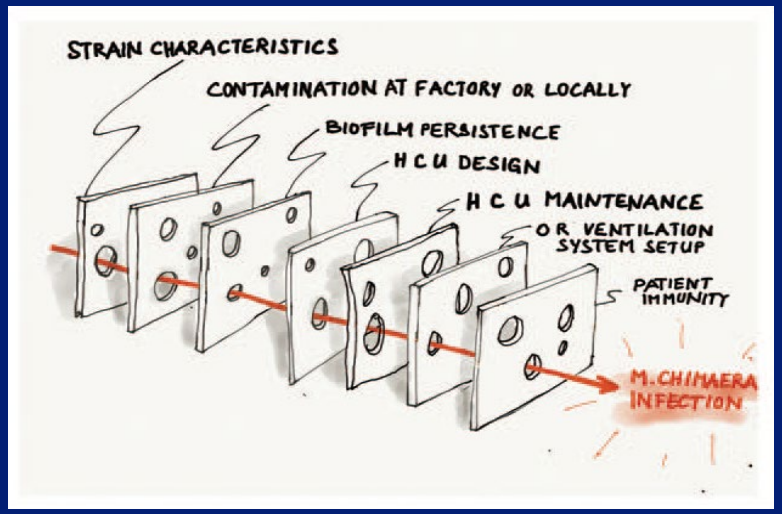
- Palmore et al. ICHE 2009;30:764
  - 2 immunocompromised patients exposed to decorative fountain in radiation oncology; isolates from patients and fountain identical; disinfection with ozone, filter and weekly cleaning
- Houpt et al. ICHE 2012;33:185
  - Lab-confirmed Legionnaires disease was dx in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

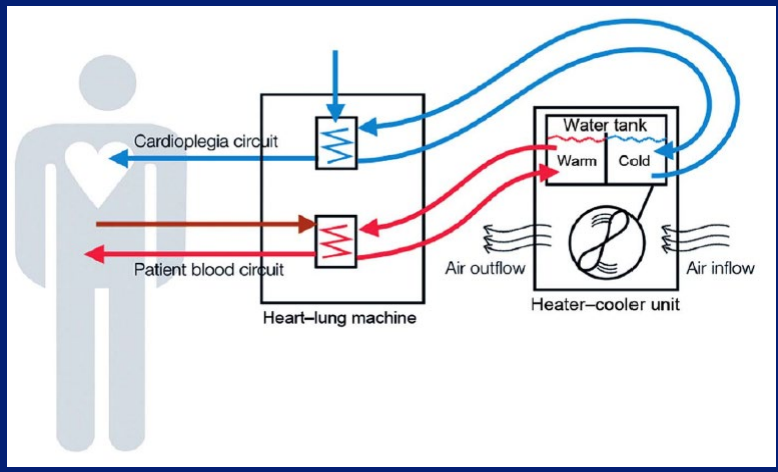
Water Walls and Decorative Water Fountains

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

WORLDWIDE OUTBREAK OF *M. chimaera* DUE TO CONTAMINATED HCUs

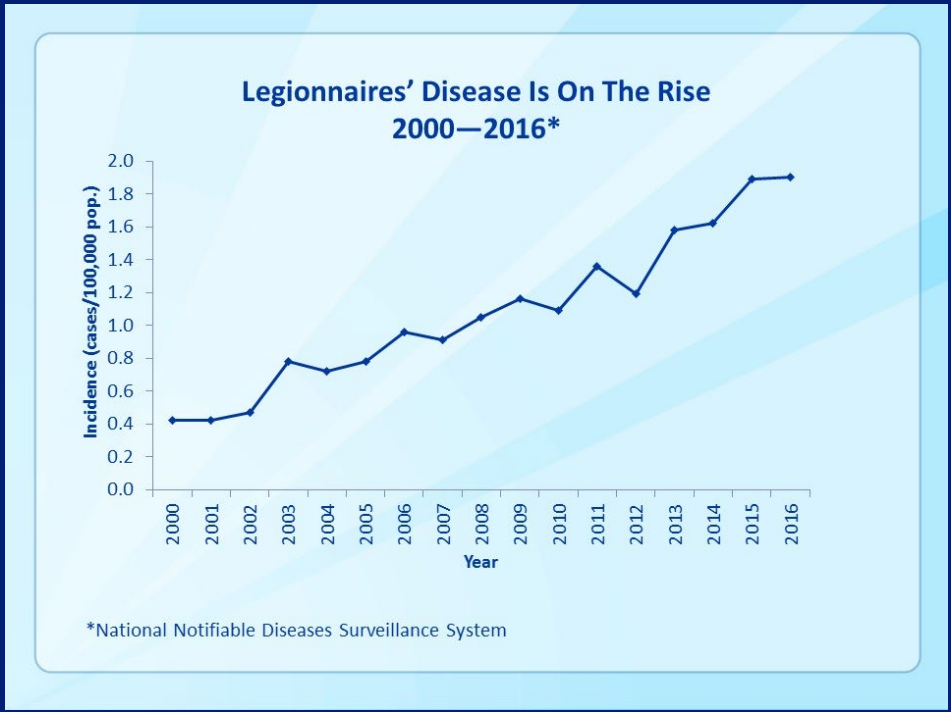
- Since 2003, >200 cases of *M. chimaera* prosthetic valve endocarditis and disseminated disease reported
- Outbreak linked to intrinsically contaminated heater-cooler unit (HCU) – Stockert 3T HCU (Sorin)
- Internal water channels/tanks intrinsically contaminated; transmission from device to patients via aerosols
- Error = Failure to use disposable channels/tanks and/or inability to disinfect/sterilize internal water tanks
- Problem = Presence of biofilm
- Risk = 0.4-16 per 10,000 Pt-years





Sommerstein R, et al. ICHE 2017;38:103;
Schreiber PW, Sax H. Curr Opin ID 2017;30:388

LEGIONELLA INCIDENCE OVER TIME, US, CDC



Potential reasons (per CDC) for 4.5-fold increase in Legionnaires' disease since 2000

- Artifact (increased awareness and testing)
- Increased susceptibility of population
- Increased *Legionella* in environment
- Combination of factors

400 cases of legionellosis in Australia each year

https://www.cdc.gov/legionella/surv-reporting.html

LEGIONELLA: EPIDEMIOLOGY

- 10,000 - 40,000 cases/yr (1-5% of adult pneumonia)
- Reservoir: Ubiquitous in aquatic environments
- Associated with devices that produce potable or non-potable water aerosols (e.g., cooling towers, evaporative condensers, showers, faucets, decorative water fountains, whirlpool baths, ice machines, medication nebulizers, nasogastric feedings diluted in tap water)
- Transmission: Inhalation of aerosols (no person-to-person transmission)

CONTROLLING WATERBORNE MICROORGANISMS

- Water Systems in HCF
  - Hot water temp at the outlet at the highest temp allowable, preferable >124^{o}F (IC)
  - When state regulations do not allow hot water temp >120^{o}F, chlorinate the water or periodically increase >150^{o}F (II)
  - Water disruptions: post signs and do not drink tap water (IB, IC)

LEGIONELLA: CONTROL MEASURES

- Establish surveillance system to detect Legionnaires disease (IB); provide clinicians with lab tests (e.g., urine antigen, DFA, culture)
- No recommendation on culturing water in HCF that do not have patients at high-risk for *Legionella* (transplant)(unresolved issue)
- One laboratory-confirmed case of *Legionella,* or two cases suspected in 6 mo in facility that does not treat IC patients, conduct epidemiological investigation (IB).

LEGIONELLA: CONTROL MEASURES

- One case in IC patient, conduct a combined epidemiological and environmental investigation (IB)
- If evidence of HA transmission, conduct environmental investigation to determine source: collect water samples from potential source of aerosolized water and subtype isolates of *Legionella* from patients and environment (IB)
- If source identified, institute water system decontamination (IB) and assess the efficacy of implementing control measures (IB)
- Culturing for *Legionella* in water from transplant units can be performed as part of comprehensive strategy (II)

LEGIONELLA: CONTROL MEASURES

- If *Legionella* spp are detected in water of a transplant unit, do the following:
  - Decontaminate the water supply (IB)
  - Restrict immunocompromised patients from showers (IB)
  - Use non-contaminated water for sponge baths (IB)
  - Provide sterile water for drinking, tooth brushing (IB)
  - Do not use water from faucets in patient rooms (IB)

Best Practices for Environmental Infection Control: Surfaces, Water and Air

- Identify the infection risks associated with surfaces, water and air
- Identify the infection prevention strategies to reduce the risk of surfaces
- Review the healthcare outbreaks associated with water reservoirs and discuss control strategies
- Explain what infection prevention measures should be implemented to prevent patient exposure to fungal pathogens

Air Control in Healthcare Facilities

- Fungal outbreaks associated with construction and renovation
- Air handling systems in healthcare facilities

AIRBORNE FUNGAL OUTBREAKS

Requirements

- Susceptible host
- Reservoir
- Source
- Infecting dose inhaled (most dependent on concentration of fungi in the air)

MOST COMMON PATHOGENS ASSOCIATED WITH CONSTRUCTION OR RENOVATION OUTBREAKS

- *Aspergillus* spp. (by far most important)
- Zygomycetes
- Other fungi
- Miscellaneous

INVITED ARTICLE HEALTHCARE EPIDEMIOLOGY

Robert A. Weinstein, Section Editor

Review of Fungal Outbreaks and Infection Prevention in Healthcare Settings During Construction and Renovation

Hajime Kanamori,[1,2] William A. Rutala,[1,2] Emily E. Sickbert-Bennett,[1,2] and David J. Weber[1,2]

[1]Hospital Epidemiology, University of North Carolina Health Care, and [2]Division of Infectious Diseases, University of North Carolina School of Medicine, Chapel Hill

Hospital construction and renovation activities are an ever-constant phenomenon in healthcare facilities, causing dust contamination and possible dispersal of fungal spores. We reviewed fungal outbreaks that occurred during construction and renovation over the last 4 decades as well as current infection prevention strategies and control measures. Fungal outbreaks still occur in healthcare settings, especially among patients with hematological malignancies and those who are immunocompromised. The causative pathogens of these outbreaks were usually *Aspergillus* species, but Zygomycetes and other fungi were occasionally reported. *Aspergillus* most commonly caused pulmonary infection. The overall mortality of construction/renovation-associated fungal infection was approximately 50%. The minimal concentration of fungal spores by air sampling for acquisition of fungal infections remains to be determined. Performing infection control risk assessments and implementing the recommended control measures is essential to prevent healthcare-associated fungal outbreaks during construction and renovation.

Review of Fungal Outbreaks

Kanamori, Rutala, Sickbert-Bennett, Weber. CID. 2015;61:433

Table 2. Fungal Infections and Associated Mortality by Each Underlying Disease During Construction, Renovation, or Demolition

Underlying Diseases	No. of Articles Published	No. of Patients Infected	No. of Patients Died	Mortality, No.[a] (%)
Hematologic malignancies or bone marrow transplant	26	414	148	131/288 (45.5)
Other malignancies, transplant, and/or immunosuppressed patients	13	105	38	38/60 (63.3)
Patients in intensive care unit	3	8	2	2/4 (50)
Rheumatology patients	2	6	4	4/6 (66.7)
After surgery	2	8	1	1/8 (12.5)
Premature infant	2	3	2	2/3 (66.7)
Nephrology and dialysis patients	1	3	2	2/3 (66.7)
Total	49	547	197	180/372 (48.4)

[a] Articles in which the number of patients infected or died was unknown were excluded for mortality calculation.

Review of Fungal Outbreaks

Kanamori, Rutala, Sickbert-Bennett, Weber. CID. 2015;61:433

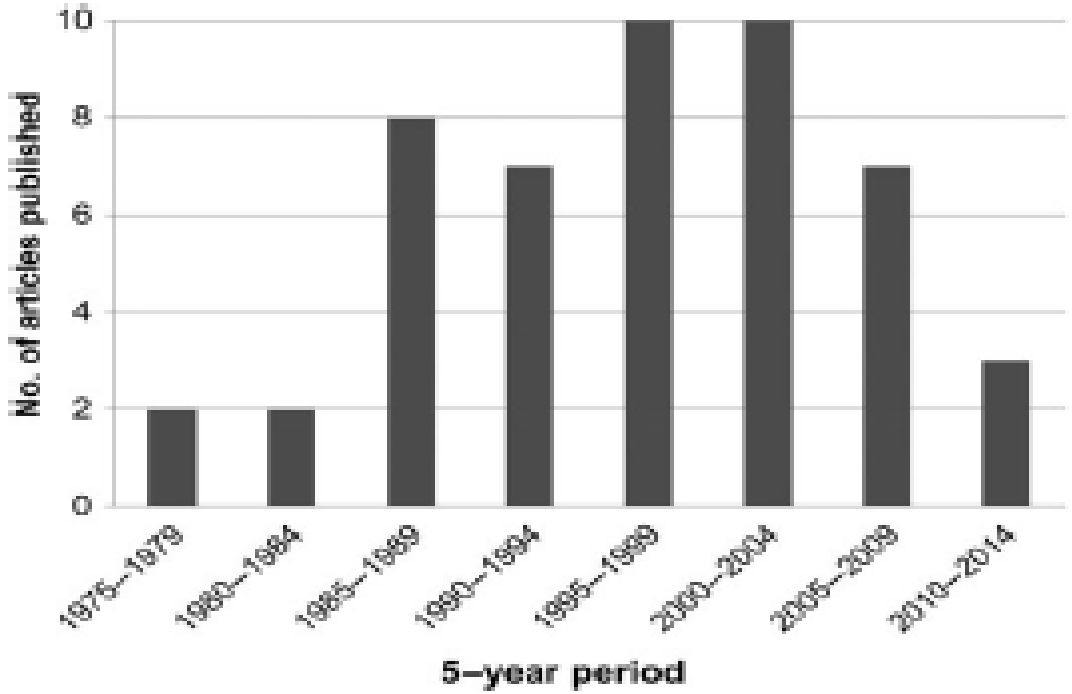


Figure 1. Trend of fungal outbreaks and infections associated with construction, renovation, and demolition.

Review of Fungal Outbreaks

Kanamori, Rutala, Sickbert-Bennett, Weber. Clin Inf Dis. 2015;61:433

Table 1. Characteristics of Fungal Outbreaks and Infections Associated With Construction, Renovation, and Demolition

Author, Year	Patient Population	No. of Patient Infected	No. of Patient Deaths	Type of Infection (Site)	Type of Fungi	Reservoir or Source	Airborne Fungal Level(s)	Molecular Typing	Control Measures
Aisner, 1976 [5]	Cancer patients	8	Unknown	*Aspergillus* infection (lung, pharyngeal, or maxillary sinus)	*Aspergillus* spp. (predominantly *A. niger*, *A. flavus*, *A. fumigatus*)	Fireproofing material sprayed wet during construction	Unknown	Unknown	Unknown
Arnow, 1978 [6]	Immunosuppression (renal transplant)	3	1	*Aspergillus* infection (lung)	*A. fumigatus*, *Aspergillus* sp.	Renovation, spores on dust from false ceiling tiles above transplant unit	Airborne spores >200 cfu below renovation	Unknown	Impermeable plastic barriers, immunosuppressed patients moved to other floors, horizontal surfaces, vacuumed, damp mopped, and dusted
Sarubbi, 1982 [8]	Hospitalized patients (acute nonlymphocytic leukemia for 1 infected)	1	1	Invasive *Aspergillus* infection (lung)	*A. flavus*	Construction, defective ventilation and air filtration	8 *A. flavus*/positive room, control 1 *A. flavus*/positive room-settle plates	Unknown	Pre-filters and filters in ventilation system replaced
Lentino, 1982 [7]	Immunosuppressed patients with renal allograft recipients or hematologic malignancy	10	4	Invasive *Aspergillus* infection (lung)	*Aspergillus* sp.	Road construction for access to the new hospital, contaminated window air conditioners in renal transplantation ward	400–2800 *Aspergillus* spores/cm^2 from air conditioner filter	Unknown	Unknown
Kasinski, 1985 [9]	Premature infants	2	2	Fungal infection (lung)	*Aspergillus* sp., Zygomycetes, *Rhizopus indicus*	Renovation of adjacent special care unit and demolition of wall, mold in dust above a false ceiling	0.88 fungi per hour per settle plate compared to 0.22 fungi per hour per settle plate in construction free area	Unknown	Patients moved from area of construction, additional dampers placed in air ducts, impervious dust barriers erected, area above false ceiling and ventilation ducts vacuumed, replaced HEPA filters, air ducts and environmental surfaces disinfected
Opal, 1986 [10]	Immunocompromised (lymphoreticular malignancy, high-dose corticosteroid therapy or disseminated carcinoma)	11	11	*Aspergillus* infection (disseminated)	*A. flavus*, *A. fumigatus*, *A. niger*, *Aspergillus* sp.	Hospital renovation and construction	5.9 ± 0.7 *Aspergillus*/m^3 inside construction site compared to 1.2 *Aspergillus*/m^3 outside construction site	Unknown	Copper-8 quinolinolate, airtight plastic and dry wall barriers about the construction site, HEPA filters in patients room, and negative pressure in construction area
Barnes, 1989 [14]	Children undergoing BMT	6	6	Invasive *Aspergillus* infection (lung)	Unknown	Building work installing a laminar air flow system to the unit	133 cfu/m^3 of *A. fumigatus* in the BMT unit during building work	Unknown	Laminar air flow isolation
Humphreys,	Source patients in	2	2	Invasive	*A. fumigatus*	Building work in an area	Sampling after	Unknown	Improved hospital design

NOSOCOMIAL ASPERGILLOSIS IN OUTBREAK SETTINIGS

Vonberg, Gastmeier. JHI 2006. 63:245

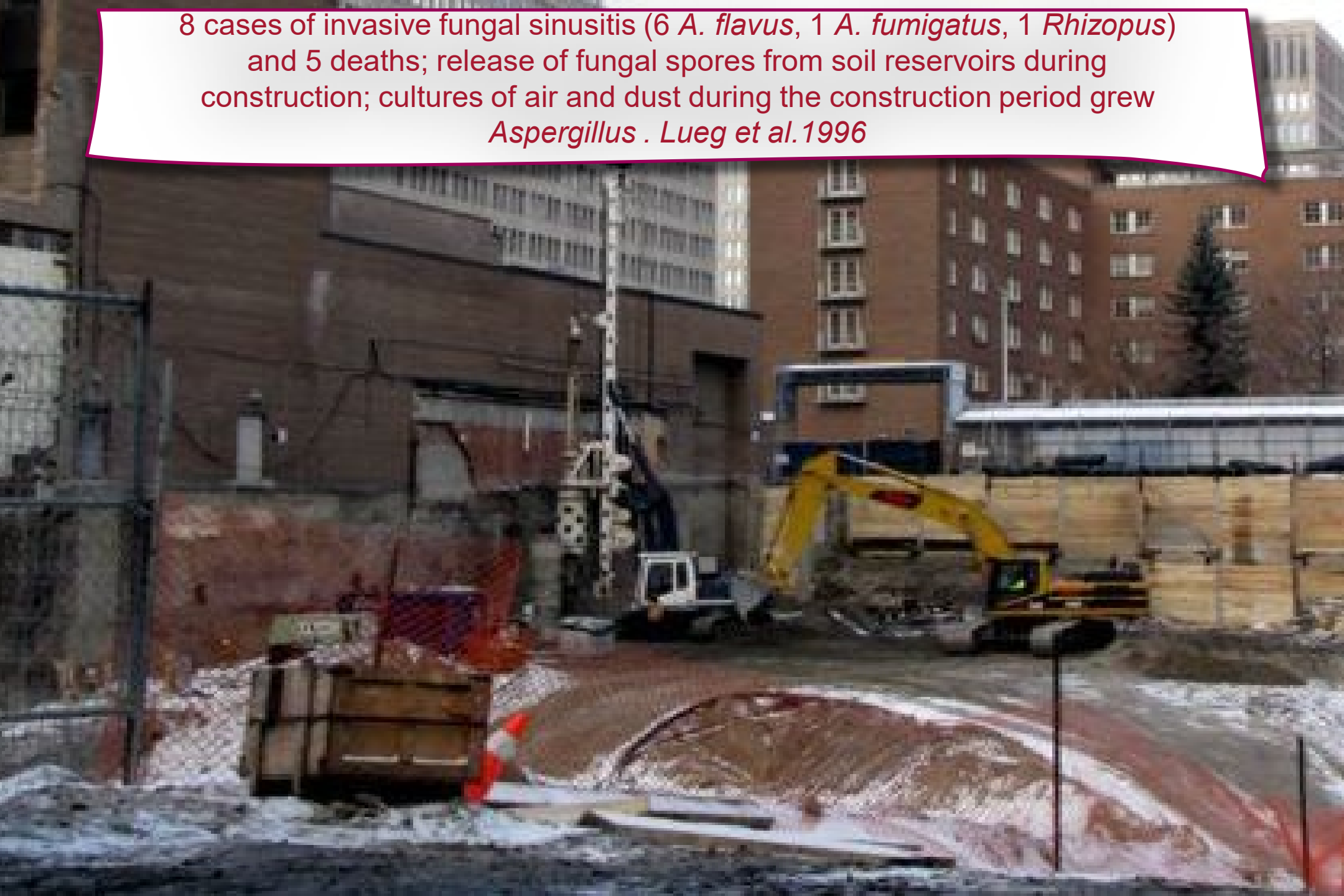
- 53 studies with 458 patients
- 356 patients (78%) were lower respiratory tract
- *Aspergillus fumigatus* (154) and *A. flavus* (101)
- Underlying disease-hemotologic malignancies 299 (65%)
- Overall fatality rate in these 299 patients (57.6%)
- Construction or demolition probable/possible source-49%; virtually all outbreaks attributable to airborne source, usually construction
- Patients at risk should not be exposed to *Aspergillus*

Medically-Important Mycotic Agents

Aspergillus fumigatus






8 cases of invasive fungal sinusitis (6 *A. flavus*, 1 *A. fumigatus*, 1 *Rhizopus*) and 5 deaths; release of fungal spores from soil reservoirs during construction; cultures of air and dust during the construction period grew *Aspergillus* . Lueg et al.1996


NOT AN EXIT
CONSTRUCTION SITE
DO NOT ENTER

Aspergillus

- *Aspergillus* spores are ubiquitous (soil, fruits, vegetables, dust, decaying organic matter) in the environment
- Conidia may travel long distances as airborne particles and are inhaled by humans (several hundred spores each day)
- In most healthy persons, spores are removed by innate defense mechanisms (macrophages)
- Severely immunocompromised (IC) hosts (hematologic, solid organ transplant) a serious complication
- Air is normally the route of fungal spore transmission

AIRBORNE FUNGAL OUTBREAKS

Portal of Entry	Number of Outbreaks
Respiratory tract	27
Skin	7
Operative site	3
Peritoneal dialysis catheter	1
Mixed	1
Not stated	2

AIRBORNE FUNGAL OUTBREAKS

- Activities shown to increase the amount of airborne fungal spores dramatically (and in consequence increases the risk of *Aspergillus* infection in susceptible patients)
  - Internal/External renovation/construction/excavation-construction is a never-ending phenomenon
  - Ceiling access
  - Contaminated or defective air supply
- Minimal airborne concentration of *Aspergillus* necessary to cause infection in IC patients remains unknown






NOT AN EXIT
CONSTRUCTION SITE
DO NOT ENTER


CONSTRUCTION
AREA
DO NOT ENTER
CHECK WITH
SUPERINTENDENT
BEFORE ENTERING

CONSTRUCTION OR RENOVATION[1]

- When planning construction, demolition, and renovation activities in and around the facility, assess whether patients at high-risk for aspergillosis are likely to be exposed to high ambient-air spore counts of *Aspergillus* spp., and if so develop a plan to prevent such exposure (IA)
- During construction, demolition, or renovation activities construct impermeable barriers between patient-care and construction areas to prevent dust from entering the patient-care areas (IB)
- Direct pedestrian traffic that come from construction areas away from patient-care areas to limit the opening and closing of doors or other barriers that might cause dust dispersion (IB)
- IP must participate at all levels of a construction project (CBIC)

[1]Tablan OC, et al. Guidelines for preventing health-care-associated pneumonia, 2003

CONSTRUCTION OR RENOVATION[1]

- Establish a multidisciplinary team that includes infection-control staff to coordinate demolition, construction and renovation (IB, IC)
- Educate construction and healthcare staff in immunocompromised patient-care areas regarding airborne infection risks associated with construction and preventive measures (IB)
- Incorporate mandatory adherence agreements for infection control into construction contracts (IC)
- Establish and maintain surveillance for airborne environmental disease (e.g., aspergillosis) as appropriate during construction (IB)

[1]Guideline for environmental infection control in health-care facilities, 2003

CONSTRUCTION OR RENOVATION[1]

- Implement infection-control measures during construction, renovation, maintenance, demolition, and repair (IB, IC)
  - Before the project gets underway, perform an ICRA to define the scope of the project and need for barrier measures (IB, IC)
    - **Determine if immunocompromised patients may be at risk for exposure and develop a contingency plan to prevent exposures**
  - Implement infection-control measures for external demolition and construction (IB)
    - **Determine if facility can operate on recirculated air; if feasible, seal off adjacent air intakes**
    - **If not feasible, check and replace low-efficiency filters as needed**
    - **Seal windows and reduce outside air intrusion**

[1]Guideline for environmental infection control in health-care facilities, 2003

Windows Closed



CONSTRUCTION OR RENOVATION[1]

- Implement infection-control measures during construction, renovation, maintenance, demolition, and repair (IB, IC)
  - Implement infection-control measure for internal construction (IB, IC)
    - **Construct barriers to prevent dust from entering patient-care areas**
    - **Block and seal off return air vents (if needed)**
    - **Implement dust control measures; divert pedestrian traffic**
    - **Relocate patients adjacent to work zone (depending on their immune status)**

[1] CDC Guideline for environmental infection control in health-care facilities, 2003

CONSTRUCTION OR RENOVATION[1]

- Implement infection-control measures during construction, renovation, maintenance, demolition, and repair (IB, IC)
  - Perform engineering and work-site related infection control measures as needed for internal construction and renovations
    - **Ensure proper operation of the air-handling system**
    - **Create and maintain negative pressure in work zones**
    - **Monitor negative air flow inside of rigid barriers**
    - **Monitor barriers; repair gaps and breaks in barriers**
    - **Direct pedestrian traffic away from work zones**
    - **Provide designated travel routes for construction crew**
    - **Clean work zones daily**
    - **Clean and replace air filters**

[1]Guideline for environmental infection control in health-care facilities, 2003



CONSTRUCTION OR RENOVATION[1]

- No recommendation is offered on routine microbiologic air sampling, before, during, or after construction (unresolved)
- If a case of healthcare-acquired aspergillus airborne fungal infection occurs during construction, implement appropriate measures (IB)
- If there is epidemiologic evidence of ongoing transmission of fungal disease, conduct an environmental assessment to determine and eliminate the source (IB)
- If air-supply systems to high-risk areas are not optimal use portable, industrial-grade HEPA filters on temporary basis (II)

INFECTION CONTROL RISK ASSESSMENT (ICRA)

- ICRA is an multidisciplinary, organizational, documented process that after considering the facility's patient population and type of construction project (non-invasive to major demolition):
  - Focuses on reduction of risk from infection
  - Acts through phases of facility planning, design, construction, renovation, facility maintenance and
  - Coordinates and weights knowledge about infection, infectious agents, type of construction project and care environment permitting the organization to anticipate potential impact

STEP 1:
IDENTIFY TYPE OF CONSTRUCTION PROJECT

TYPE A	**Inspection and Non-Invasive Activities.** Includes, but is not limited to: ▪ removal of ceiling tiles for visual inspection only, e.g., limited to 1 tile per 50 square feet ▪ painting (but not sanding) ▪ wallcovering, electrical trim work, minor plumbing, and activities which do not generate dust or require cutting of walls or access to ceilings other than for visual inspection.
TYPE B	**Small scale, short duration activities which create minimal dust** Includes, but is not limited to: ▪ installation of telephone and computer cabling ▪ access to chase spaces ▪ cutting of walls or ceiling where dust migration can be controlled.

http://www.premierinc.com/quality-safety/tools-services/safety/topics/construction/downloads/ICRA-MatrixColorRevised-091109.pdf

STEP 1:
IDENTIFY TYPE OF CONSTRUCTION PROJECT

TYPE C	**Work that generates a moderate to high level of dust or requires demolition or removal of any fixed building components or assemblies** Includes, but is not limited to: ▪ sanding of walls for painting or wall covering ▪ removal of floorcoverings, ceiling tiles and casework ▪ new wall construction ▪ minor duct work or electrical work above ceilings ▪ major cabling activities ▪ any activity which cannot be completed within a single workshift.
TYPE D	**Major demolition and construction projects** Includes, but is not limited to: ▪ activities which require consecutive work shifts ▪ requires heavy demolition or removal of a complete cabling system ▪ new construction.

STEP 2:
IDENTIFY PATIENT RISK

Low Risk	Medium Risk	High Risk	Highest Risk
▪ Office areas	▪ Cardiology ▪ Echocardiography ▪ Endoscopy ▪ Nuclear Medicine ▪ Physical Therapy ▪ Radiology/MRI ▪ Respiratory Therapy	▪ CCU ▪ Emergency Room ▪ Labor & Delivery ▪ Laboratories (specimen) ▪ Medical Units ▪ Newborn Nursery ▪ Outpatient Surgery ▪ Pediatrics ▪ Pharmacy ▪ Post Anesthesia Care Unit ▪ Surgical Units	▪ Any area caring for immunocompromised patients ▪ Burn Unit ▪ Cardiac Cath Lab ▪ Central Sterile Supply ▪ Intensive Care Units ▪ Negative pressure isolation rooms ▪ Oncology ▪ Operating rooms including C-section rooms

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STEP 3:
MATCH RISK GROUP WITH CONSTRUCTION TYPE

Patient Risk Group	Construction Project Type			
	TYPE A	TYPE B	TYPE C	TYPE D
LOW Risk Group	I	II	II	III/IV
MEDIUM Risk Group	I	II	III	IV
HIGH Risk Group	I	II	III/IV	IV
HIGHEST Risk Group	II	III/IV	III/IV	IV

Note: Infection Control approval will be required when the Construction Activity and Risk Level indicate that Class III or Class IV control procedures are necessary.

INFECTION CONTROL BY CLASS

	During Construction Project	Upon Completion of Project
CLASS I	1. Execute work by methods to minimize raising dust from construction operations. 2. Immediately replace a ceiling tile displaced for visual inspection	1. Clean work area upon completion of task.
CLASS II	1. Provide active means to prevent airborne dust from dispersing into atmosphere. 2. Water mist work surfaces to control dust while cutting. 3. Seal unused doors with duct tape. 4. Block off and seal air vents. 5. Place dust mat at entrance and exit of work area 6. Remove or isolate HVAC system in areas where work is being performed.	1. Wipe work surfaces with cleaner/disinfectant. 2. Contain construction waste before transport in tightly covered containers. 3. Wet mop and/or vacuum with HEPA filtered vacuum before leaving work area. 4. Upon completion, restore HVAC system where work was performed.

INFECTION CONTROL BY CLASS

	Before Construction	After Construction
CLASS III	1. Remove or Isolate HVAC system in area where work is being done to prevent contamination of duct system. 2. Complete all critical barriers i.e. sheetrock, plywood, plastic, to seal area from non work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins. 3. Maintain negative air pressure within work site utilizing HEPA equipped air filtration units. 4. Contain construction waste before transport in tightly covered containers. 5. Cover transport receptacles or carts. Tape covering unless solid lid.	1. Do not remove barriers from work area until completed project is inspected by the owner's Safety Department and Infection Prevention & Control Department and thoroughly cleaned by the owner's Environmental Services Department. 2. Remove barrier materials carefully to minimize spreading of dirt and debris associated with construction. 3. Vacuum work area with HEPA filtered vacuums. 4. Wet mop area with cleaner/disinfectant. 5. Upon completion, restore HVAC system where work was performed.

INFECTION CONTROL BY CLASS

CLASS IV

During Construction

1. Isolate HVAC system in area where work is being done to prevent contamination of duct system.
2. Complete all critical barriers i.e. sheetrock, plywood, plastic, to seal area from non work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins.
3. Maintain negative air pressure within work site utilizing HEPA equipped air filtration units.
4. Seal holes, pipes, conduits, and punctures.
5. Construct anteroom and require all personnel to pass through this room so they can be vacuumed using a HEPA vacuum cleaner before leaving work site or they can wear cloth or paper coveralls that are removed each time they leave work site.
6. All personnel entering work site are required to wear shoe covers. Shoe covers must be changed each time the worker exits the work area.

After Construction

1. Do not remove barriers from work area until completed project is inspected by the owner's Safety Department and Infection Prevention & Control Department and thoroughly cleaned by the owner's Environmental Services Dept.
2. Remove barrier material carefully to minimize spreading of dirt and debris associated with construction.
3. Contain construction waste before transport in tightly covered containers.
4. Cover transport receptacles or carts. Tape covering unless solid lid.
5. Vacuum work area with HEPA filtered vacuums.
6. Wet mop area with cleaner/disinfectant.
7. Upon completion, restore HVAC system where work was performed.

PREVENTION

- Procedures during construction and renovations
  - **Seal hospital construction areas** behind impervious barriers
  - **Clean construction area daily** (i.e., remove dust)
  - **Assure that ventilation system does not transport dust** from inside construction area to other locations
  - **Move immunocompromised patients** from adjacent areas
  - **Thoroughly clean construction area** prior to patient use
  - **Conduct surveillance** for airborne fungal infections
  - **Avoid transporting construction material through patient areas**

Air Control in Healthcare Facilities

- Fungal outbreaks associated with construction and renovation
- Air handling systems in healthcare facilities

AIR-HANDLING SYSTEMS IN HCF

- Ensure HVAC filters are properly installed and maintained (IB)
- Monitor areas with special ventilation (Airborne infection Isolation-AII, Protective Environment-PE) for air changes per hour-ACH and pressure differentials (IB)
- Inspect filters periodically (IC)
- Ensure intakes (>6 ft above ground) and exhaust outlets (>25 ft from intake) are located properly (IC)

Heating, Ventilation and Air Conditioning

Filter Bank of MERV 8

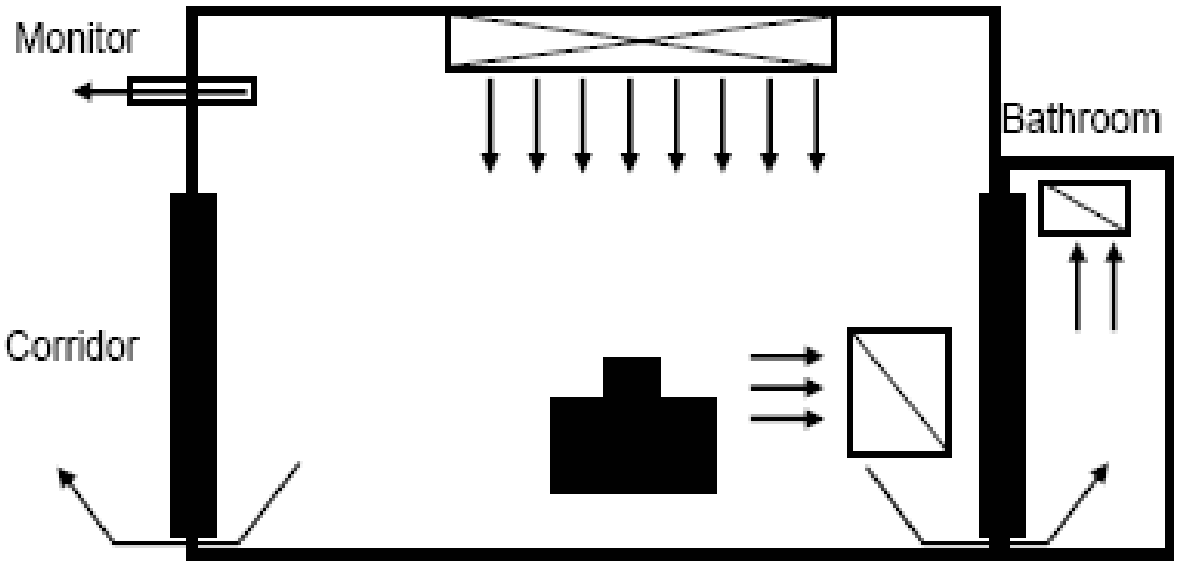


AIR-HANDLING SYSTEMS IN HCF

- Do not use through-the-wall ventilation units (air induction ventilation) for protective environment (IC)
- Seal windows with centralized HVAC, especially protective environment areas (IB, IC)
- Do not shut down HVAC for other than required maintenance, filter changes, and construction (IB, IC); coordinate to allow relocation of immunocompromised (IC)
- Keep emergency doors and exits in protective environments closed (II)

Environmental Infection Control for Special Health Care Settings

Figure 2. Example of positive-pressure room control for protection from airborne environmental microbes (PE)* + §



* Stacked black boxes represent patient's bed. Long open box with cross-hatch represents supply air. Open boxes with single, diagonal slashes represent air exhaust registers. Arrows indicate directions of air flow.

\+ Possible uses include immunocompromised patient rooms (e.g., hematopoietic stem cell transplant or solid organ transplant procedure rooms) and orthopedic operating rooms.



SPECIAL HEALTHCARE SETTINGS

High Risk Patients (PE, Solid Organ Transplants, Neutropenic)

- Planning new units for high-risk patients
  - **Air-filtration:** Install HEPA filters (99.97% efficient in filtering 0.3µ-sized particles) either centrally or point of use (IB)
  - **Directed airflow:** Place air-intake and exhaust ports so that room air flows across patient's bed and exits on opposite side of the room (IC)
  - **Well-sealed room** (IB)
  - **Room-air pressure:** Maintain room at positive pressure with respect to corridor (IB)
  - **Room-air changes:** Maintain at ≥12 per hour (IC)

SPECIAL HEALTHCARE SETTINGS
(Operating Rooms)

- Infection control measures for operating rooms
  - **Room-air pressure:** Maintain positive-pressure ventilation with respect to corridors and adjacent areas (IC)
  - **Room-air changes:** Maintain at ≥15 per hour (IC) with at least 3 ACH of fresh air (20 AC/hr per FGI)
  - **Directed Airflow:** Introduce air at the ceiling and exhaust air near the floor (IC)
  - **Doors:** Keep room doors closed except for essential personnel, patients, equipment; limit entry to essential personnel (IB)



SPECIAL HEALTHCARE SETTINGS

(Airborne Infection Isolation-AII)

- Planning new or renovating AII units
  - **Directed airflow:** exhaust air to the outside, away from air-intake and populated areas (IC)
  - **Well-sealed room** (IB)
  - **Room-air pressure:** Maintain continuous negative room with respect to corridor; monitor air pressure periodically (IB).; install self-closing doors (IC)
  - **Room-air changes:** Maintain at ≥12 per hour (IB)
  - Ante room and audible alarm not required (12 AC/hr, negative airflow-CBIC)

SUMMARY

- Outbreaks of aspergillosis and other fungi continue to occur in US healthcare facilities
- Highly immunocompromised patients are at highest risk
- Most outbreaks are related to construction and renovation
- Appropriate implementation of CDC/HICPAC guidelines can prevent healthcare-associated infection
- Use of ICRA is a logical method to plan for construction and renovation projects

SUMMARY

- Airborne fungal infections cause significant morbidity and mortality for immunocompromised patients
- Despite understanding of the usual sources and reservoirs of these pathogens outbreaks continue to occur
- Well-designed and maintained ventilation systems and use of proper infection control techniques during construction will prevent most fungal outbreaks

SUMMARY

- Surveillance is key to early detection of outbreaks
  - Maintain a high index of suspicion for healthcare-associated pulmonary aspergillosis in severely immunocompromised patients (ANC <500/mm^3 for 2 weeks or <100/mm^3 for 1 week)(IA)
- In the event of an outbreak careful evaluation of cases and an environmental evaluation will usually uncover a correctable cause
- New tools of molecular epidemiology may prove useful to link specific reservoirs with outbreaks

Best Practices for Environmental Infection Control: Surfaces, Water and Air

- Identify the infection risks associated with surfaces, water and air
- Identify the infection prevention strategies to reduce the risk of surfaces
- Review the healthcare outbreaks associated with water reservoirs and discuss control strategies
- Explain what infection prevention measures should be implemented to prevent patient exposure to fungal pathogens

THANK YOU!

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SPECIAL HEALTHCARE SETTINGS

(Airborne Infection Isolation-AII, CDC Guideline 2003)

- Planning new or renovating AII units
  - **Directed airflow:** exhaust air to the outside, away from air-intake and populated areas (IC)
  - **Well-sealed room** (IB)
  - **Room-air pressure:** Maintain continuous negative room with respect to corridor; monitor air pressure periodically (IB).; install self-closing doors (IC)
  - **Room-air changes:** Maintain at ≥12 per hour (IB)