What Are the Risks Associated with Construction and Renovation in Healthcare Settings?

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DISCLOSURES

2018-2019

- **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)

Environment of Care: Air
Learning Objectives

- Identify the infection risks associated with construction and renovation
- Explain what infection prevention measures should be implemented to prevent patient exposure to fungal pathogens

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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

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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.

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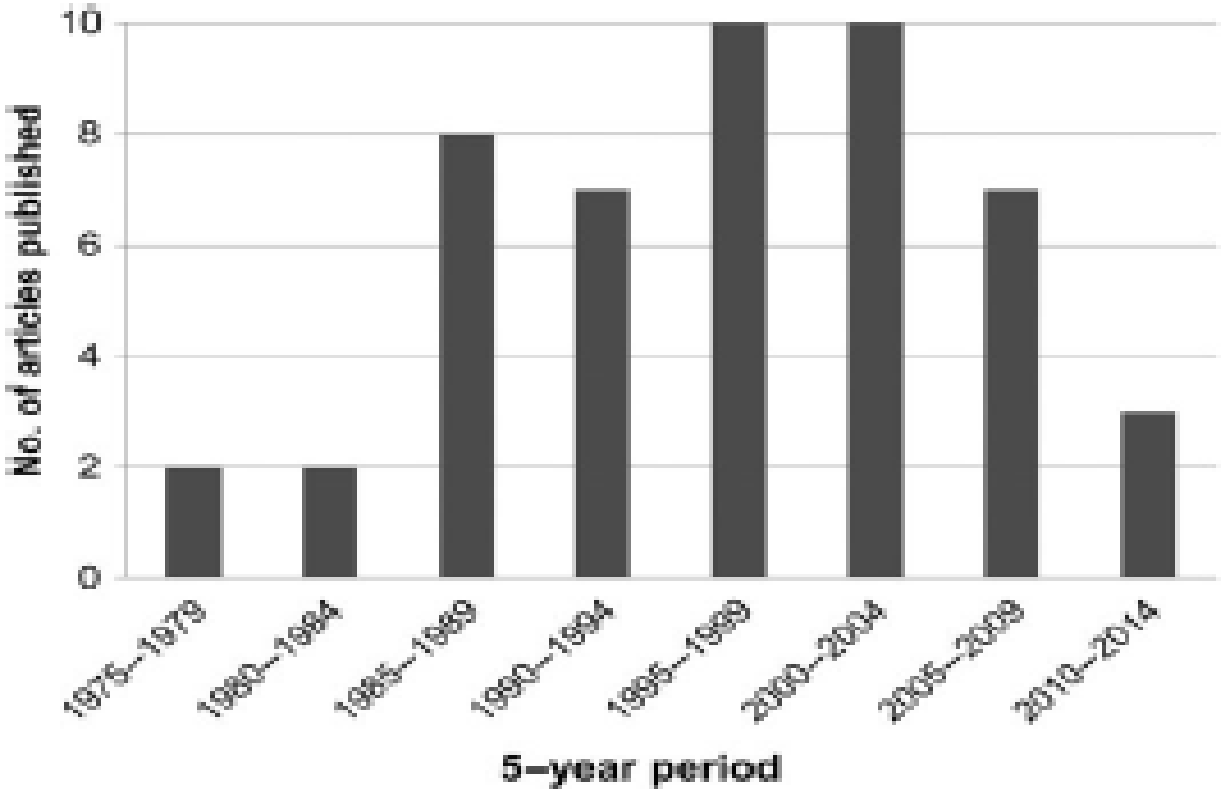


Figure 1. Trend of fungal outbreaks and infections associated with construction, renovation, and demolition.

Review of Fungal Outbreaks

Kanamori, Rutala, Sickbert-Bennett, Weber. CID. 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

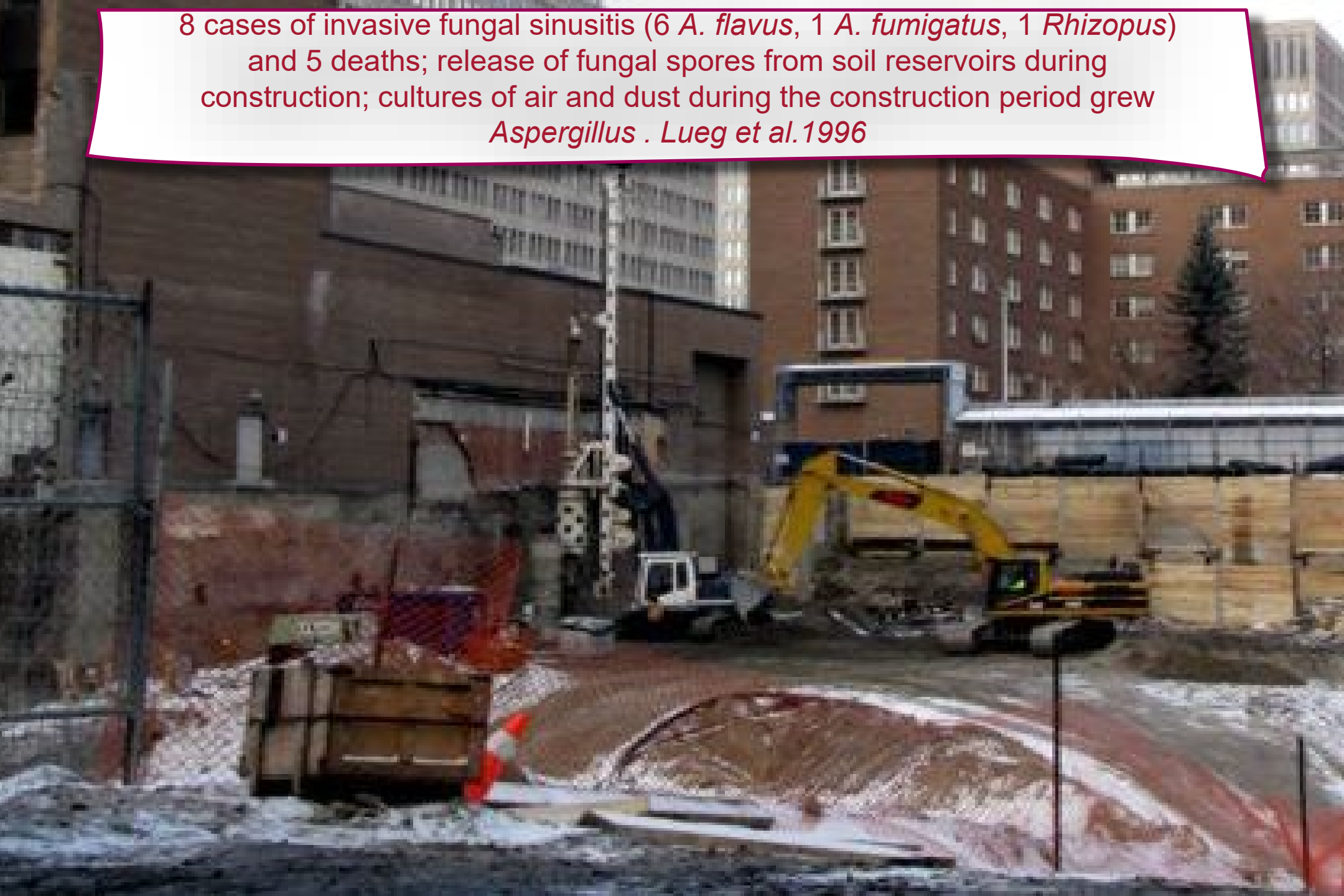
NOSOCOMIAL ASPERGILLOSIS IN OUTBREAK SETTINIGS

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

- Shown to increase the amount of airborne fungal spores dramatically (and in consequence increases the risk of *Aspergillus* infection in susceptible patients)
  - Internal 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 immunocompromised patients remains unknown


NOT AN EXIT
CONSTRUCTION SITE
DO NOT ENTER


CONSTRUCTION
AREA
DO NOT ENTER
CHECK WITH
SUPERINTENDENT
BEFORE ENTERING

Environment of Care: Air
Learning Objectives

- Identify the infection risks associated with construction and renovation
- Explain what infection prevention measures should be implemented to prevent patient exposure to fungal pathogens

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

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	After 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.	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

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

THANK YOU!

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CONSTRUCTION, RENOVATION, REPAIR

- Using active surveillance, monitor for airborne infections in IC patients (IB)
- Implement infection control measures: define the need for barriers (IB), ensure proper operation of the HVAC system (IB), implement dust control measures (IB), relocate IC patients as needed (IB), clean work zones daily (IB), create negative pressure in work areas relative to adjacent patient-care areas (IB), provide crews with designated entrances, corridors, elevators (IB)

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