Infections associated with hospital construction and renovation: pathogens and risk factors

Dr Ling Moi Lin
Director, Infection Control
Singapore General Hospital

External construction projects

Duke – NUS University

Academia

New NHC

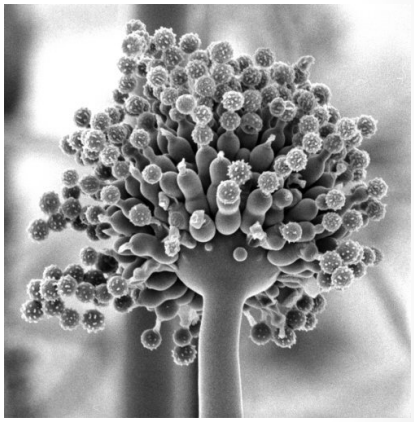
Internal projects – keep the dust *in*

Hospital renovation: the problems

- Construction, renovation or demolition generates vast quantities of dust which contains huge numbers of aerosolized filamentous fungi, such as *Aspergillus*, and sometimes as other potential pathogens, such as *Legionella*
- Moreover, construction can impair air handling systems or contaminate potable water with these pathogens.

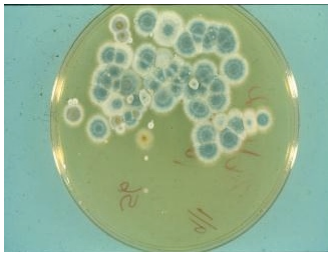
Aspergillus fumigatus

- Most common cause of invasive and non-invasive aspergillosis
- Causes >50% of invasive aspergillosis
- Capable of growth up to 55°C (131°F)



Epidemiology

- *A. fumigatus* is a ubiquitous organism whose primary ecological niche is felt to be decomposing vegetable matter
- Ambient levels in outside air is considerable
  - Typical 1-15 spores/m3 with significant day to day variability
  - May reach tremendous levels near compost heaps and hay barns (106 spores/m3)



Aspergillus – basic life cycle

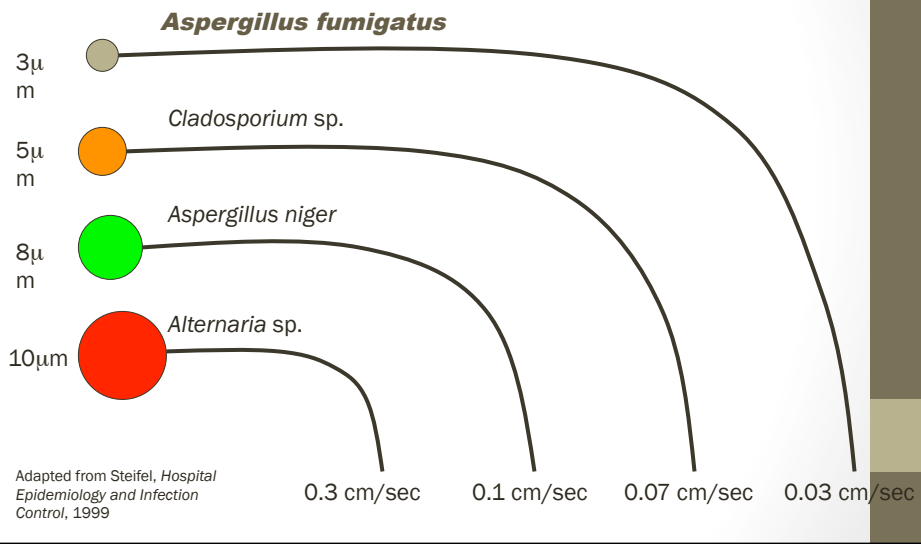
Fungal growth (surfaces)

Spore release (air)

Hospital renovation: the problem

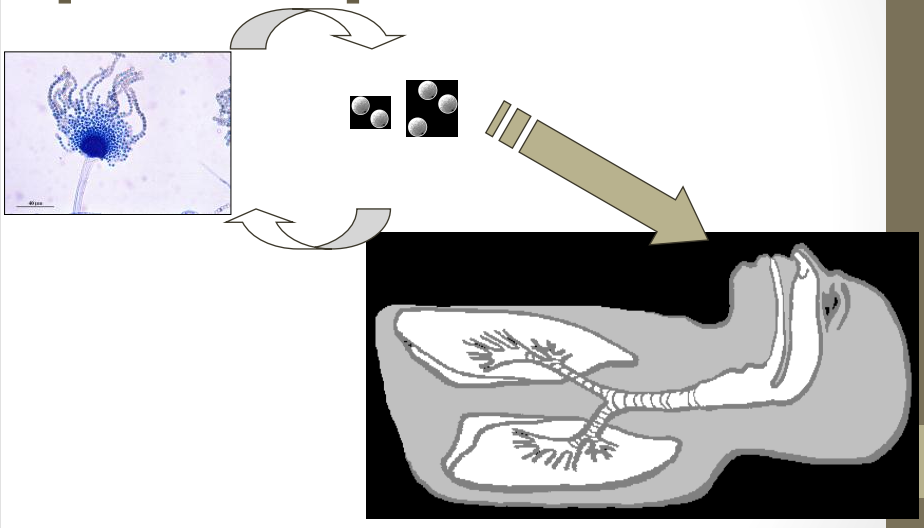
- Hospitals and clinics are filled with patients who are immunocompromised and highly vulnerable to devastating invasive infection with these newly unleashed pathogens

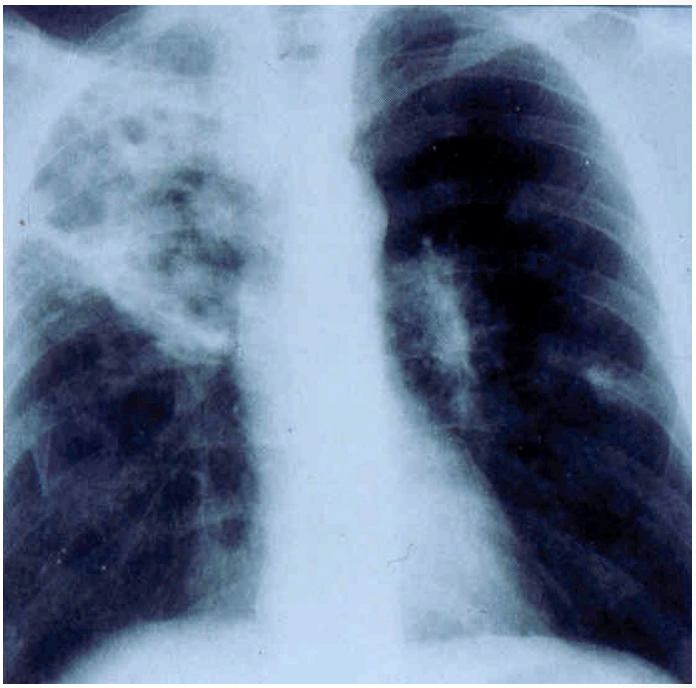
(Particle) size matters

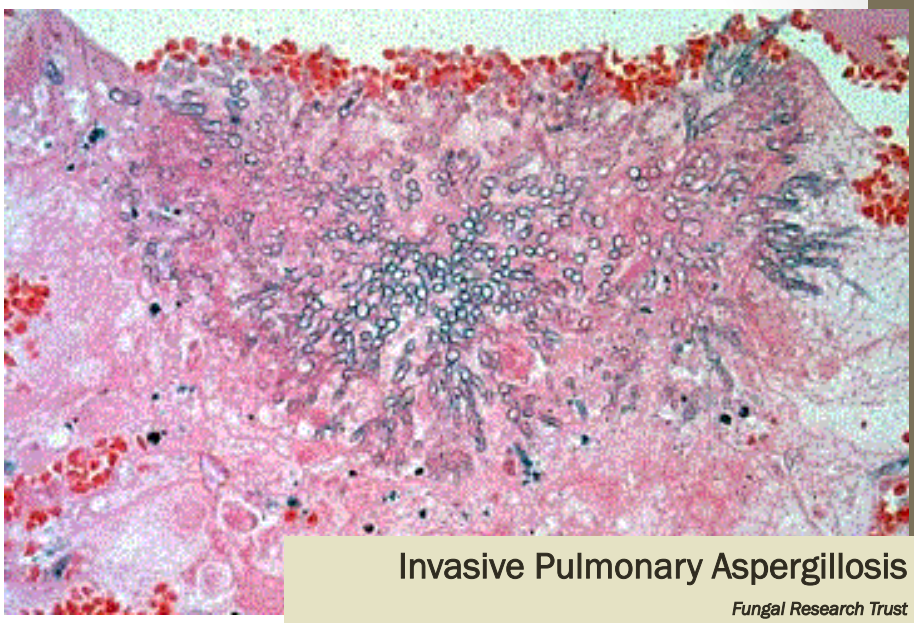


Adapted from Steifel, *Hospital Epidemiology and Infection Control*, 1999

Aspergillus - vulnerable patient exposure

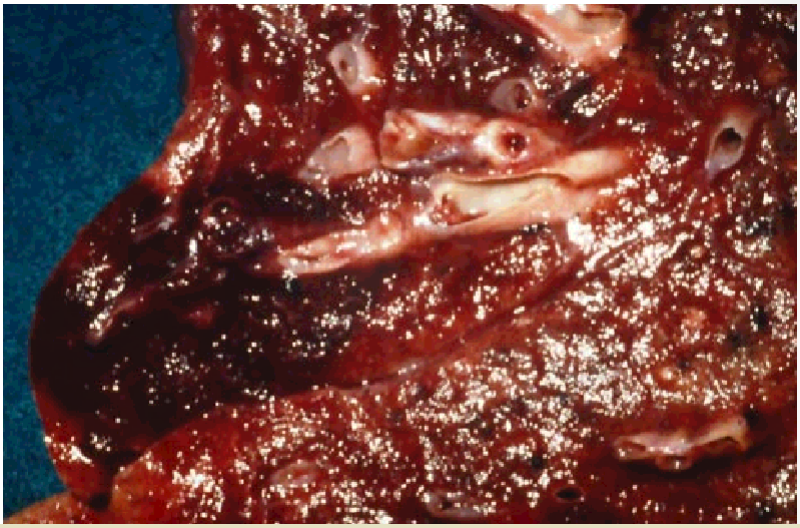






Invasive Pulmonary Aspergillosis

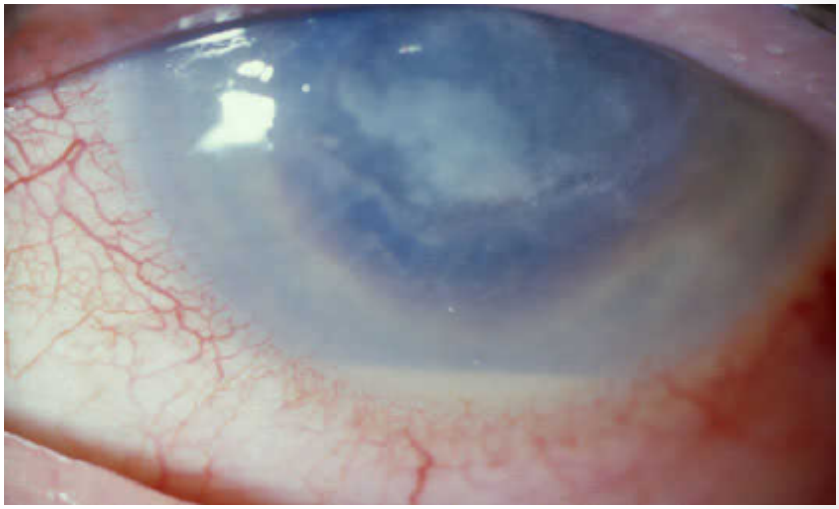
Fungal Research Trust



Invasive Aspergillosis - Pulmonary Infarction

Fungal Research Trust

Aspergillus eye infection



Aspergillus fumigatus

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- Capable of growth up to 55°C (131°F)
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- Ambient levels in outside air is considerable
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Sources of *Aspergillus* sp

- Unfiltered air
- Ventilation systems
- Contaminated dust dislodged during hospital renovation and construction
- Horizontal surfaces


510

How do fungi get in?

- Fresh air intakes of HVAC systems
- Open doors and windows
- Attached to people's clothes, shoes, and skin.
- Attached to new building materials.

What do fungi need to grow?

- Nutrient Sources
- Warm temperature
- Moisture

Ideal conditions for *Aspergillus*

Nutrients

- Gypsum board
- Cellulose ceiling tiles
- Carpets
- Upholstery
- Fibreglass lined ducts
- Dirt on surfaces

Sources of moisture

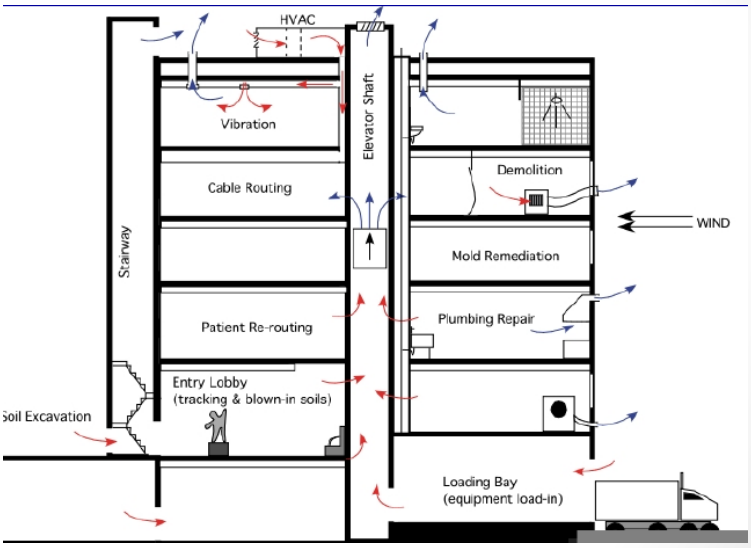
- Roof leaks
- Building envelope cracks
- Condensation on cold Surfaces
- Leaking pipes

Dust mats need to be maintained

Dust is a concern

- All construction generates dust
- Assume all dust contains *Aspergillus* mold spores
- *Aspergillus* spores in dust can kill immunocompromised patients
- These patients are in hospital

Dust moves!

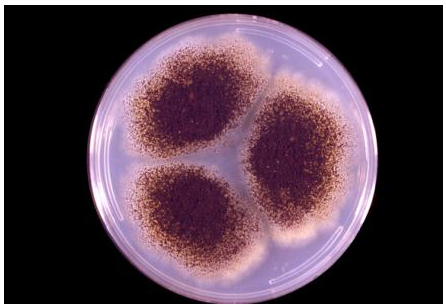


Vibration may move ceiling boards!

- Watch out for dislodged ceiling boards.
- Call 4000 and Infection Control Unit

Water and mold are close allies

- There is mold wherever there is water



Invasive Aspergillosis

- Caused by extremely common mold
- Spread through air easily
- Can be difficult to diagnose in severely immunosuppressed patients
- Mortality over 50%
- Prevention of Exposure is Key

Patients at risk

- Bone marrow transplant patients
- Hematology and oncology patients who develop severe and prolonged neutropenia
- Solid organ transplant patients (intestinal > lung > liver > heart > kidney)
- Patients who receive prolonged high-dose corticosteroids (~1 mg/kg)

Journal of Hospital Infection (2006) 63, 246–254
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REVIEW

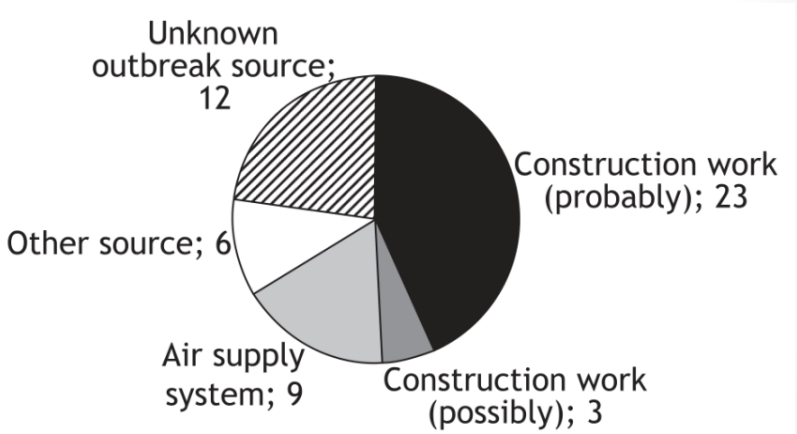
Nosocomial aspergillosis in outbreak settings

R-P. Vonberg*, P. Gastmeier

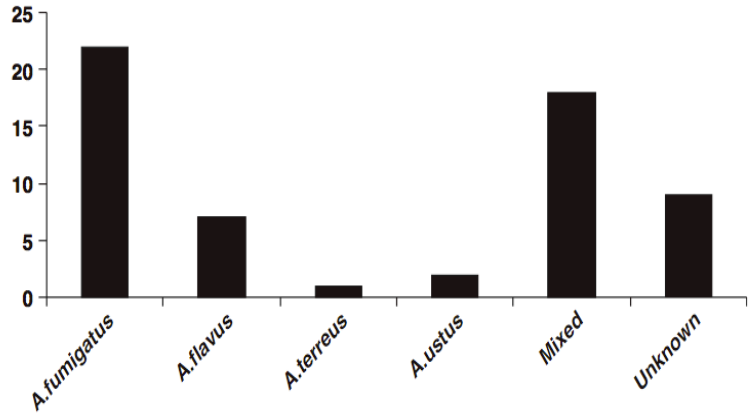
Institute for Medical Microbiology and Hospital Epidemiology, Medical School Hannover, Germany

- 53 outbreaks: 1967-2005
- 458 affected patients:
  - 299 (65.3%) haematological malignancies
  - Route of transmission: air
  - Site of primary infection: lower respiratory tract (356 patients)
  - Surgical site infections (24 patients)
  - Skin infections (24 patients)

Nosocomial aspergillosis



Species isolated



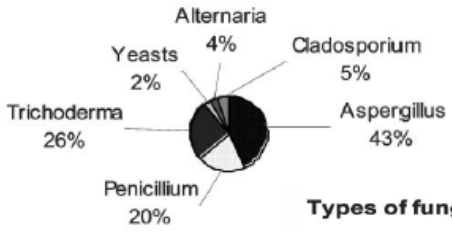
Indoor air quality during renovation actions: a case study

A. A. Abdel Hameed,* I. H. Yasser and I. M. Khoder

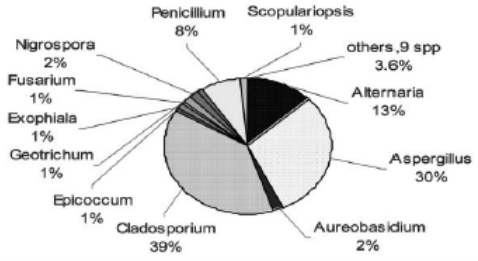
Air Pollution Department, National Research Centre, Dokki, Giza, Egypt.
E-mail: hameed_33@yahoo.com

J. Environ. Monit., 2004, 6, 740–744

Types of fungal genera before renovation



Types of fungal genera during renovation



Healthcare associated outbreaks of Aspergillosis

- Activities that cause increases in counts of airborne *Aspergillus* spores
- Building demolition, construction, renovation, repair
- Bird droppings in air ducts supplying high risk patient care areas
- Contaminated fireproofing material
- Damp wood, sheet rock

Sources of airborne pathogens

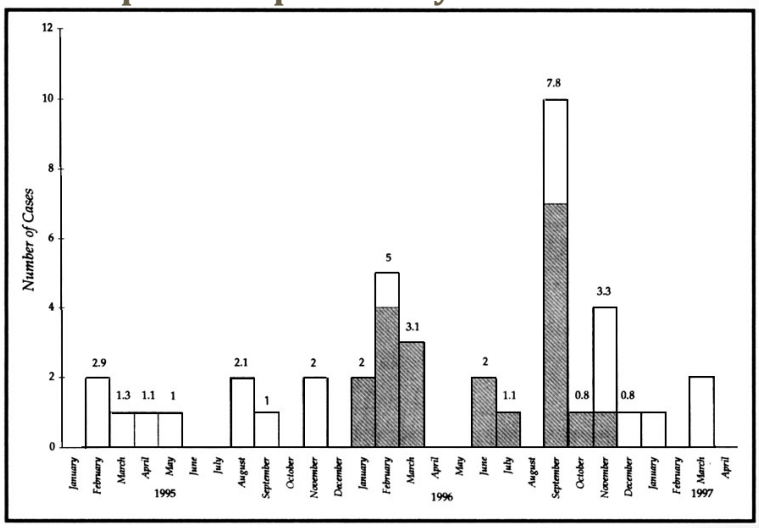
- Construction and renovation activities
- Ventilation system contamination and malfunction
  - Accumulation of dust and moisture in heating, ventilation and air conditioning (HVAC) systems
  - Failure or malfunction of HVAC systems
  - Pigeon droppings

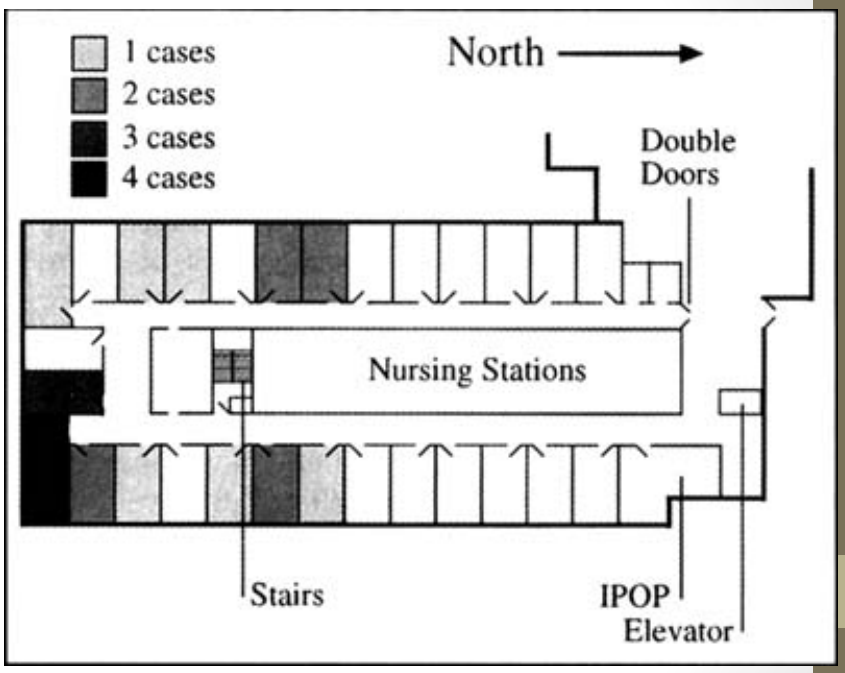
Outbreak case study

Infect Control Hosp Epidemiol 2000; 21:18-23

- February, March 1996 – increase in invasive fungal infections noted in leukaemia and BMT patients at Johns Hopkins Hospital
- September 1996 – 2nd outbreak
- Background
  - 940 bed facility; 63-bed Oncology Center is a 3-storey building connected to the hospital
  - 2 buildings separated by set of double doors
  - Oncology Centre's air went through 3 filters system; each room is HEPA filtered and positive P
  - Pressure differentials, HVAC system checked monthly
- Construction immediately adjacent to the Oncology Center
- *A. flavus* emerges, previously *A. fumigatus*

2 in 1996: Incidence increased from 2.9 and 1.3 per 1000 patient days in Feb and Mar 1995 to 5.0 and 3.1 per 1000 patient days in Feb and Mar 1996





Findings

- 21 of 29 surveillance-identified patients met case definition of "definite" or "probable"
- Housekeeping procedures inadequate
  - Clean "wet" instead of dry buffing
- Univariate analysis
  - Patient's location near the stairwell door
  - They then closed off the stairwell
- Large volume air samplers detected *A. flavus*, while small volume samples were negative

Findings

- Pressure differentials
  - 25 PE rooms, 3 of which were negative relative to the corridor (-0.35 to –3.2 Pa)
  - Air pressure in the central stairwell was positive relative to the corridor of the unit
  - Oncology Center was neutral – negative compared to the adjacent hospital

Environmental control measures March 1996

- Source of outbreak
  - Spores entered Centre through double doors, poorly sealed windows and walls
  - Conveyed through corridors and elevators due to P differentials and human traffic and portable equipment
- Doors engineered to close automatically
  - Doors to individual rooms kept closed at all times
- Re-sealed windows, exterior walls

Environmental control measures March 1996

- Staff entrance near construction was closed; redirected pedestrian traffic away from Oncology Centre
- Construction policy developed
- Air sampling for fungal spores
- N95 respirators for high-risk patients when outside a HEPA filtered area

Additional environmental control measures; September 1996

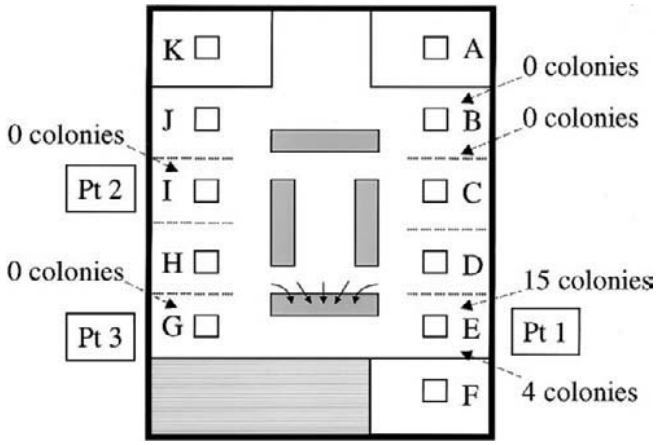
- Closed the stairwell between the HSCT and leukemia units
- Conducted case-control studies
- Additional environmental cultures
- Reviewed housekeeping procedures
- Large volume air sampling
- Supplemental HEPA filtration when structural modification not feasible

Nosocomial transmission
Clinical Infectious Disease 2002;34:412–6

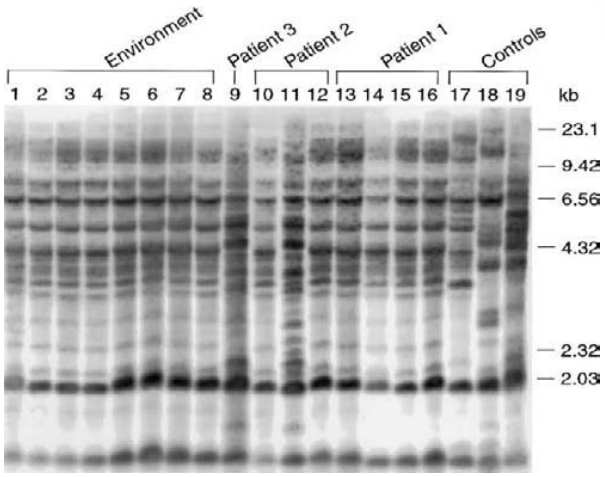
Cluster of Cases of Invasive Aspergillosis in a Transplant Intensive Care Unit: Evidence of Person-to-Person Airborne Transmission

David A. Pegues,[1] Brent A. Lasker,[3] Michael M. McNeil,[3,a] Patricia M. Hamm,[2] Judy L. Lundal,[2] and Bernard M. Kubak[1]

[1]Division of Infectious Diseases and [2]Department of Hospital Epidemiology, University of California Los Angeles Medical Center; and [3]Division of Bacterial and Mycotic Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia



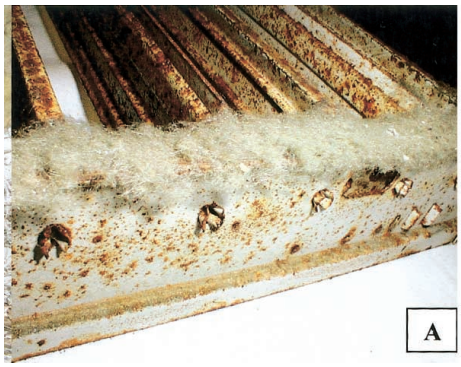
Aspergillus infection in the wound can sporulate in vivo and is potentially transmissible from person to person.



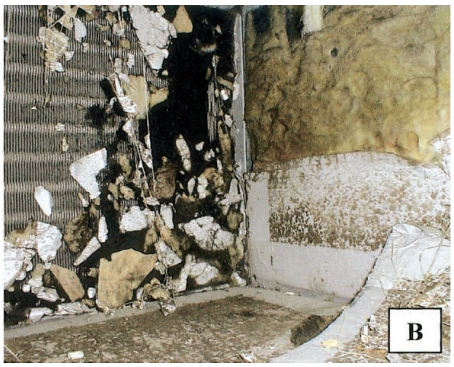
Hospitalized patients with wound or cuta- neous Aspergillus infection should have their lesions covered with a clean dressing and disruption minimized. If this is not feasible, the patient should be placed in a private room with monitored negative room-air pressure. The room door should be closed and high-efficiency filtration of room air considered

Invasive *Aspergillus* infections among post-surgical patients

Lutz et al. Clinical Infectious Diseases 2003;37:786–93

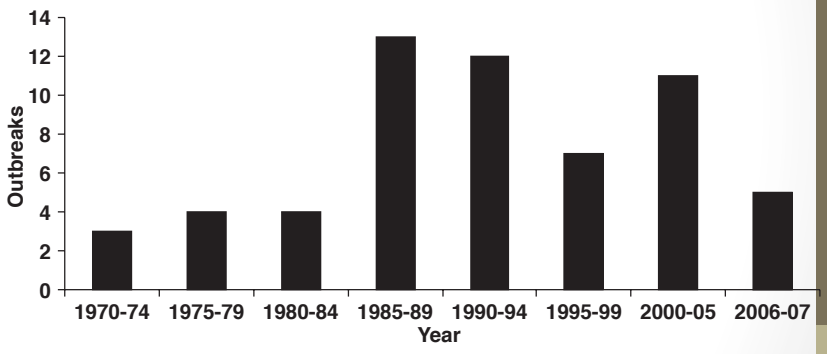


Operating room diffuser showing fiberglass fragments from insulation blown downstream from a variable airflow volume (VAV) unit. Severe rusting is indicative of intermittent or chronic condensation



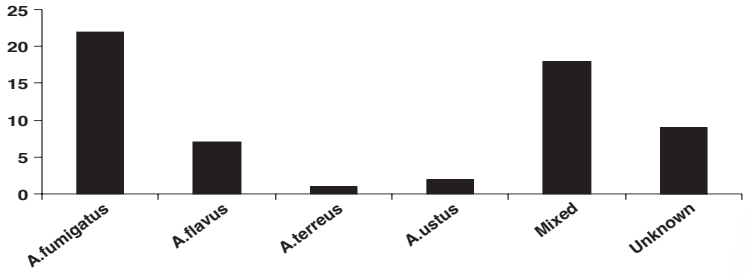
Interior view of a VAV unit showing deterioration of foil-lined fiberglass insulating material.

Aspergillus outbreaks reported in the English literature, 1970 - 2007 based on year of publication



Weber et al. Preventing healthcare-associated *Aspergillus* infections: review of recent CDC/HICPAC recommendations. Medical Mycology 2009, 47 (Supplement 1), S199 - S209

Distribution of *Aspergillus* species reported in outbreaks (1967 – 2007)



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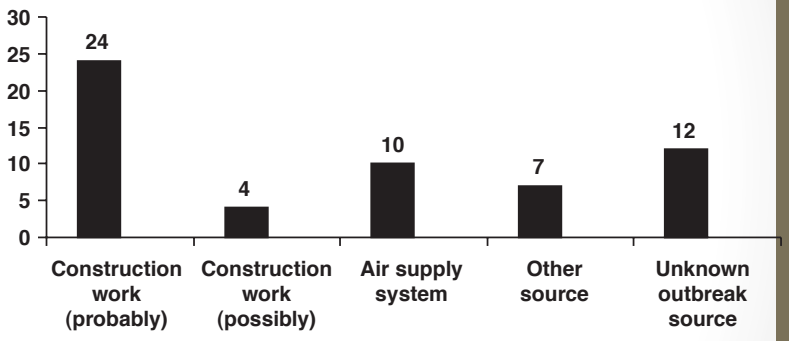
Distribution of sources of nosocomial *Aspergillus* outbreaks



Weber et al. Preventing healthcare-associated *Aspergillus* infections: review of recent CDC/HICPAC recommendations. Medical Mycology 2009, 47 (Supplement 1), S199 - S209

Kuwait's experience

- Kuwait Cancer Control Centre (KCCC); 200 bed hospital
- 4 cases of Aspergillosis identified (23 June - 25 November 2010)
  - Actions taken after identification of 2 cases of pulmonary Aspergillosis
  - 2 deaths – CNS Aspergillosis, multi-organ failure

Water-borne infections

- Plumbing system
  - Leaking water pipes causing damage to false ceiling
  - Dust and mold particles were dispersed
  - Soil contaminated with *Legionella* sp. entered water supply at time of installation of new pipes

Water damaged ceiling tile with fungal growth

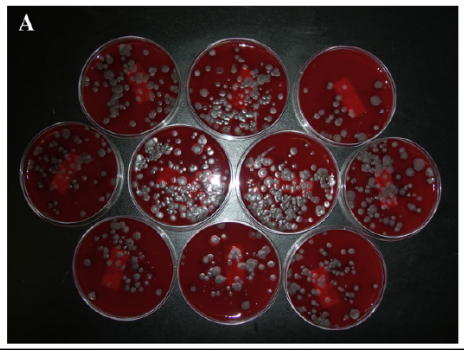
Water-borne infection prevention

- Regular maintenance and inspection of water supply system to minimize stagnation and back flow and for temperature control
- Regular clean and maintain water faucet aerators to prevent and control for Legionella
- Avoid decorative water fountains in high risk patient care areas
- Where fountains are used - regular clean and maintained

It can also affect workers!

- Outbreak of coccidioidomycosis in a 12-person civilian construction crew that excavated soil during an underground pipe installation on Camp Roberts Military Base, California in October 2007
  - Ten (83.3%) workers developed symptoms of coccidioidomycosis
  - Eight (66.7%) had serologically confirmed disease
  - Seven had abnormal chest radiographs,
  - One developed disseminated infection
- None used respiratory protection

Cummins et al *Epidemiol. Infect.* (2010), **138**, 507–511.



Other bugs to look out for

171 patients during a six-month period coinciding with large-scale construction work beside the hospital

Most patients presented with bacteraemia (146/171; 85.4%) with 46/171 (26.9%) requiring extended treatment courses with vancomycin or other interventions

Balm MND et al

Journal of Hospital Infection 81 (2012) 224–230

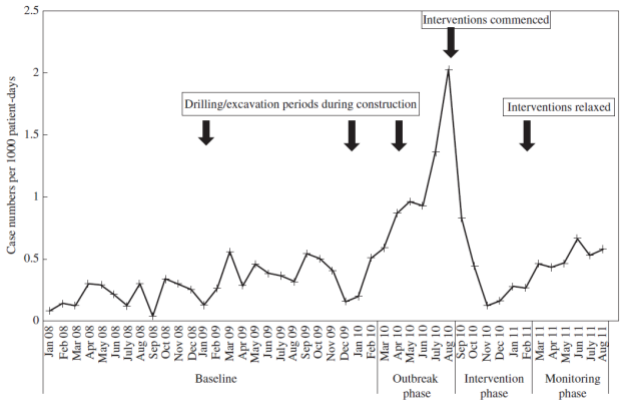


Figure 1. Epidemic curve for new cases of *Bacillus cereus* group per 1000 patient-days, January 2008 to August 2011.

Sampling confirmed extensive airborne dispersal inside the hospital, including isolation rooms and air-conditioned wards. Hospital linen was heavily contaminated [7403 cfu/cm^2; 95% confidence interval (CI): 6349 - 8457; for 30 towels sampled], encouraged by inappropriate storage in airtight plastic bags (4437 cfu/cm^2; CI: 3125 - 5750) compared with storage in porous canvas bags (166 cfu/cm2; CI: 76 - 256; P < 0.001)

Peritoneal Dialysis International, Vol. 21, pp. 296–301
Printed in Canada.

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POLYMICROBIAL OUTBREAK OF INTERMITTENT PERITONEAL DIALYSIS PERITONITIS DURING EXTERNAL WALL RENOVATION AT A DIALYSIS CENTER

Vincent C.C. Cheng,[1] Wai Kei Lo,[2] Patrick C.Y. Woo,[1] Shiu Bing Chan,[2] Suk Wai Cheng,[2] Melissa Ho,[3] and Kwok Yung Yuen[1]

Division of Infectious Disease,[1] Department of Microbiology, Queen Mary Hospital; Division of Nephrology,[2] Department of Medicine, Tung Wah Hospital; and Department of Pathology,[3] Kwong Wah Hospital, Hong Kong

- 4 episodes of peritonitis involved infection by more than one organism
- Air sampling of the environment detected a median of 110 colony forming units of bacteria per cubic meter of air, 10% of which were found to be *Acinetobacter baumanii*
  - The source of this polymicrobial outbreak was attributed to the bamboo scaffolding structure covering the external wall of the hospital during renovation

Design matters!

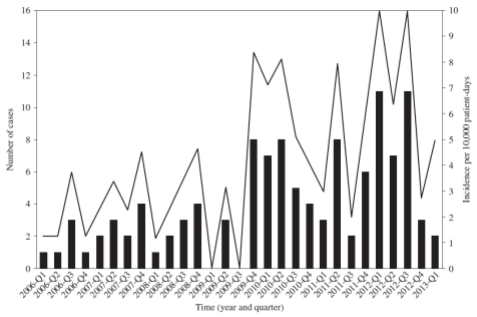

Figure 1. Epidemic curve showing new cases of *Elizabethkingia meningoseptica* infection or colonization from intensive care unit patients, 2006–2013. Bars indicate number of cases, and line indicates incidence.

E. meningoseptica was more likely to be recovered from an aerator in a hand hygiene sink frequently used for rinsing re-usable patient care items or disposal of patient secretions (odds ratio 6.65, 95% confidence interval 2.22 - 19.92; P < 0.001) compared with sinks that were not misused

Balm MND et al Journal of Hospital Infection 85 (2013) 134–140

Sources of concern

- Building / renovation site
- Plumbing system
- Ventilation system

To minimize risk of HAIs

- Proactive risk assessment before construction
  - Infection control risk assessment (ICRA) matrix
- Control measures implemented
- Monitoring to assess efficacy of control measures

Conclusion

- Building / renovation in healthcare IS DIFFERENT from that at other places
- Difference is we have immunocompromised patients in the facility
  - They need good indoor air quality