Surveillance and Monitoring for Fungi During Construction

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Introduction

- Fungal spores present a risk of opportunistic infections
  - Both exogenous and endogenous sources

- Control is essential to the safety of immunocompromised patients
  - *Aspergillus* sp. represent greatest “exogenous” risk

Controlling the patient's room

- Room pressurization
- Directional air flow
- Re-filtration or air cleaning
  - Address both endogenous and exogenous sources of contamination

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

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REVIEW

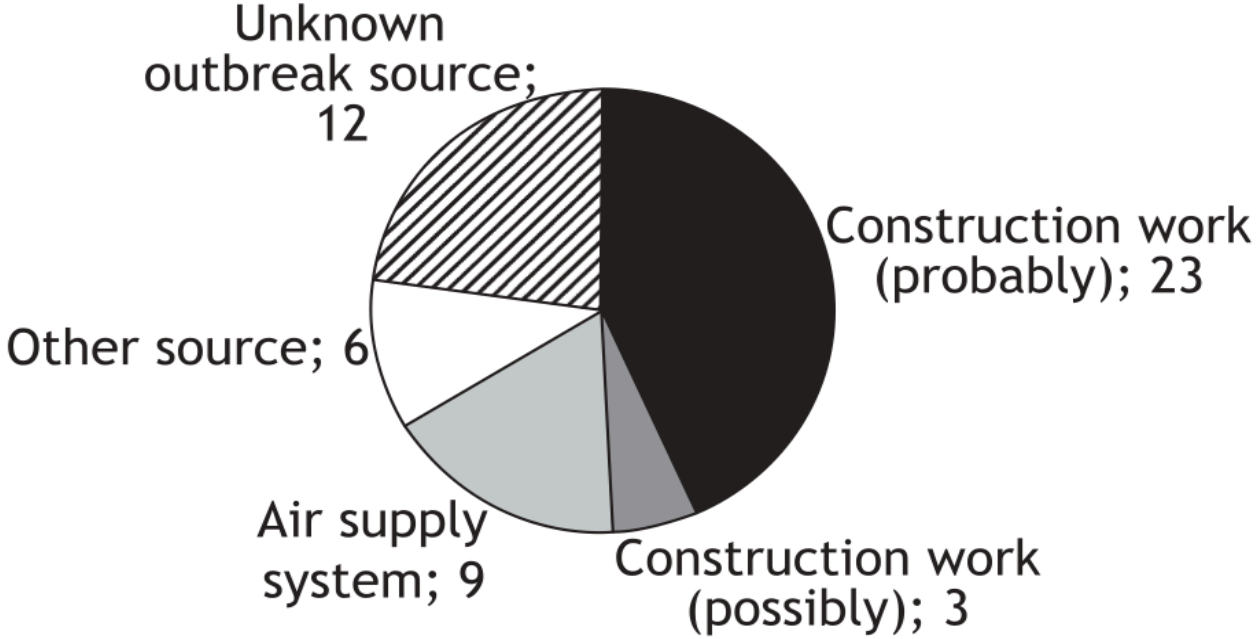
Nosocomial aspergillosis in outbreak settings

R-P. Vonberg*, P. Gastmeier

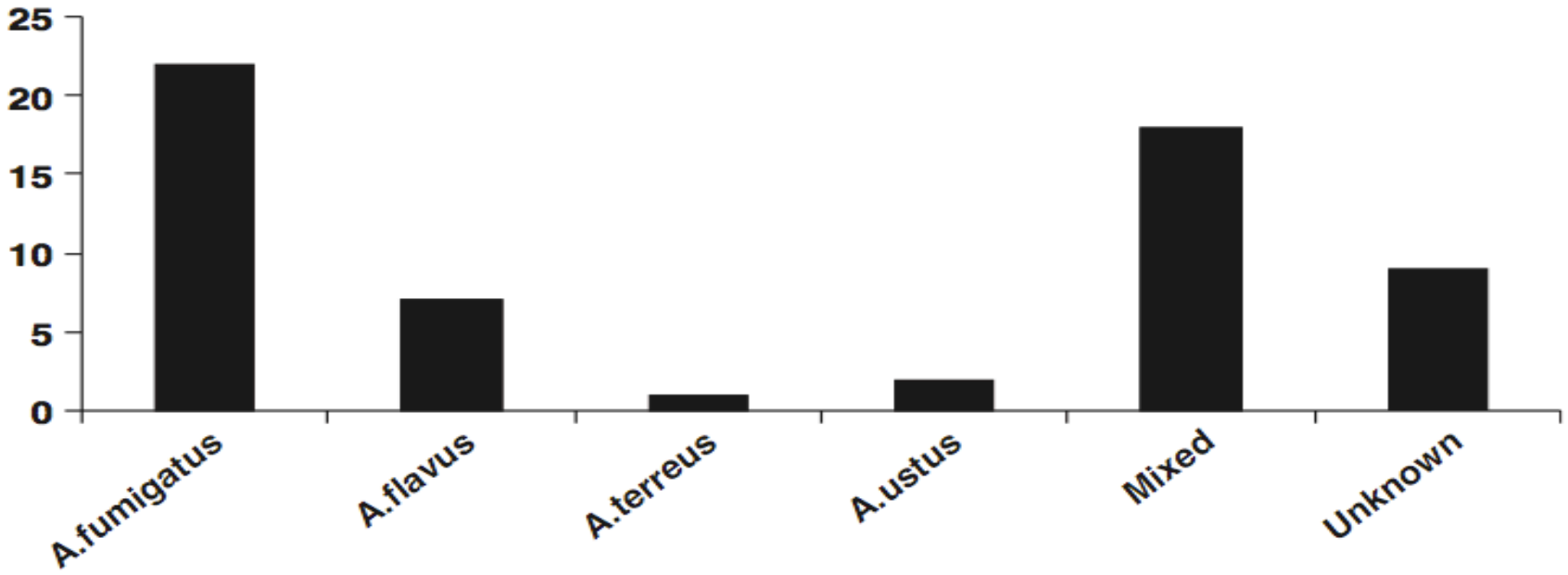
Institute for Medical Microbiology and Hospital Epidemiology, Medical School Hannover, Germany

- 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

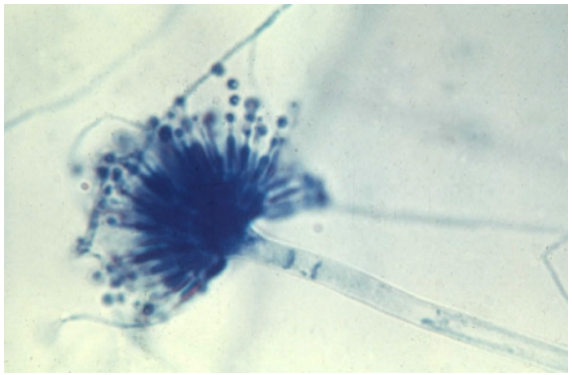


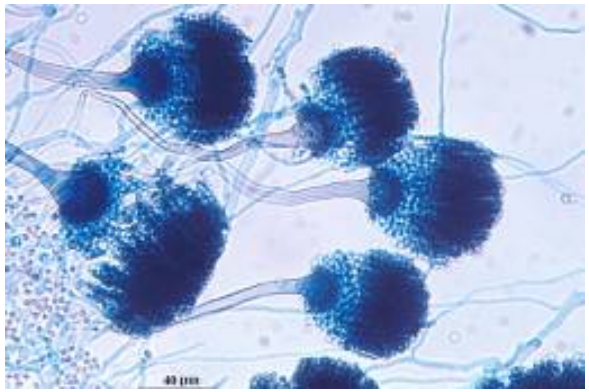
Species isolated

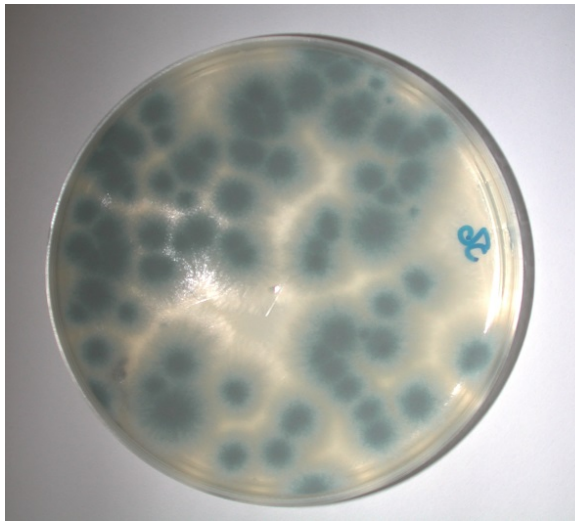


Ventilation as a source

Dust: a perfect home for *Aspergillus*!







Surveillance

- Healthcare associated aspergillus
  - Case
  - Antifungal drug consumption
  - Invasive fungal disease in targeted groups
- Air sampling
- Water sampling

Journal of Hospital Infection (2008) 68, 270–282

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LETTERS TO THE EDITOR

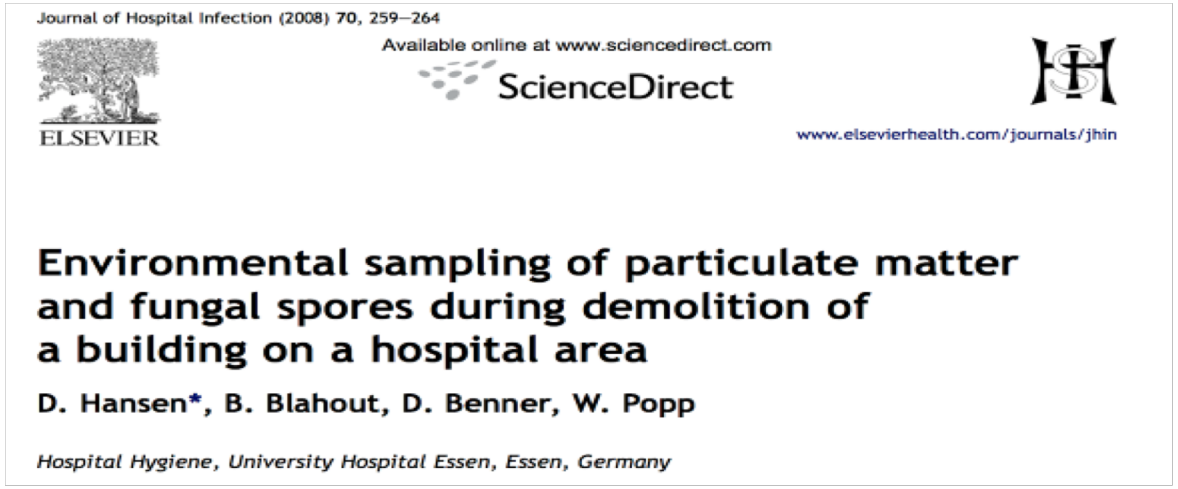
Routine sampling of air for fungi does not predict risk of invasive aspergillosis in immunocompromised patients

- 7-year sampling period: weekly: 978 samples
- *Aspergillus* spp. 16.7%: 1.8 cfu/m^3 - 28.3 cfu/m^3
- 45 cases proven IA (2.29% allo; 0.36% auto HSCT)
- cases of IA analysed 14 and 28-days following high counts
- Conclusion: high counts did not predict risk of developing IA

Rupp et al. JHI 2008.

Particle counting

- IQAir Particle Scan Pro Airborne Laser Counter
- 0.3μm - 5μm



Journal of Hospital Infection (2008) 70, 259–264

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Environmental sampling of particulate matter and fungal spores during demolition of a building on a hospital area

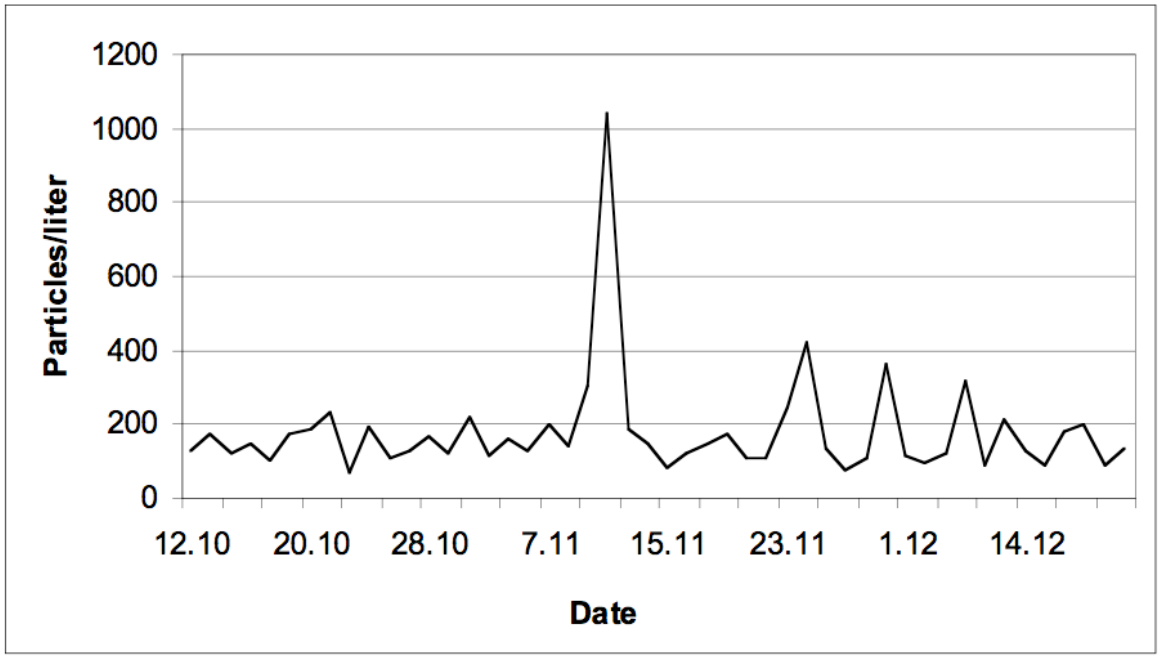
D. Hansen*, B. Blahout, D. Benner, W. Popp

Hospital Hygiene, University Hospital Essen, Essen, Germany

- During demolition building was sealed and water sprayed to minimise dust emission
- Particle and fungal concentrations monitored before and during demolition
- Particle concentrations significantly higher during demolition
- No difference in mould cultured at 37^0C before and during demolition

Air quality monitoring of HEPA-filtered hospital rooms by particulate counting

Median particle counts of the patient rooms during a high risk period in 2005.



Anttila V-J, Nihtinen A, Kuutamo T, Richardson M. 2008.

Air quality monitoring of HEPA-filtered hospital rooms by particulate counting

Particle counts of different locations

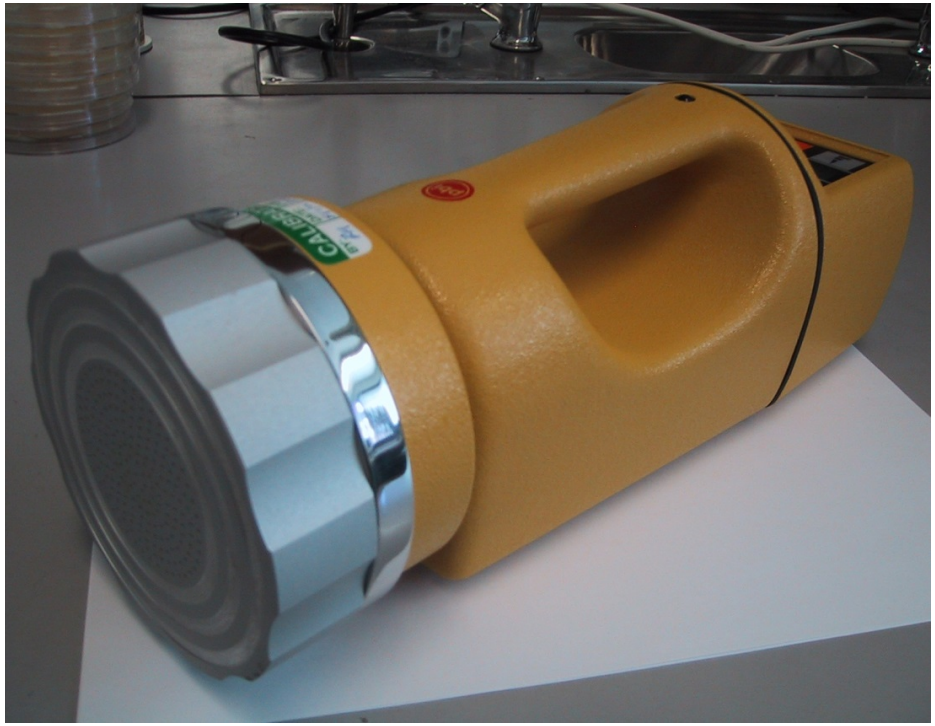
Location	Mean particle count (part/l)	Range	Number of measurements
13 HEPA-filtered patient rooms of adult HSCT ward	174	7-6309	daily for 12 weeks
Intensive care unit (children), 3 patient rooms	5750	1370-21300	6 separate days
Regular adult patient ward - patient room - hallway	 7450 20870	 3200-10600 12000-29000	hourly for one day
Outside air	173659	110806-292624	6 separate days

Anttila V-J, Nihtinen A, Kuutamo T, Richardson M. 2008.

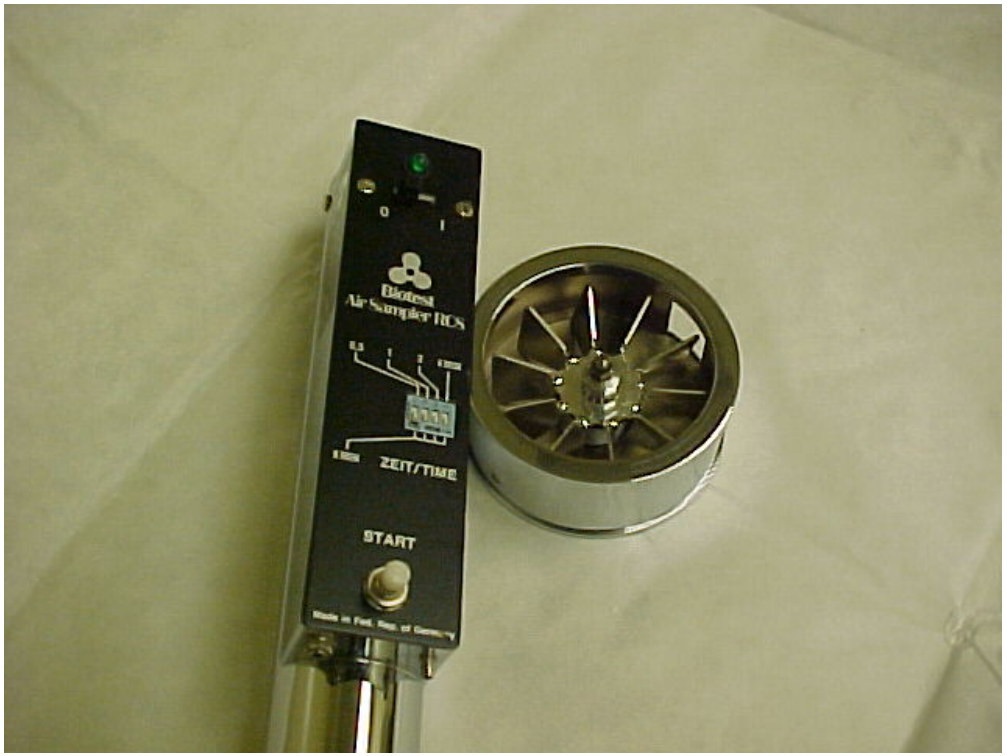
Air sampler for quantitation of viable fungal spores

Sampler type	Principle	Flow rate (litres/min)	Cut-off diameter (d50)(um)
Sieve impactor (Anderson)	Impaction on to agar plate	28·3	0·65–7·0
Slit sampler (e.g. Casella)	Impaction on to rotating agar plate	30–700	~0·5
Centrifugal Impactor (RCS)	Impaction due to centrifugal acceleration	40	4·0
Impingers (e.g. AGI)	Impingement into liquid	12·5	0·3
P.B.I. SAS Sampler (Single stage impaction)	Impaction on to agar plate	90/180	2·0
Settle plates	Gravity	Non-volumetric	N/A
Contact plates	Surface Sampling	Non-volumetric	N/A

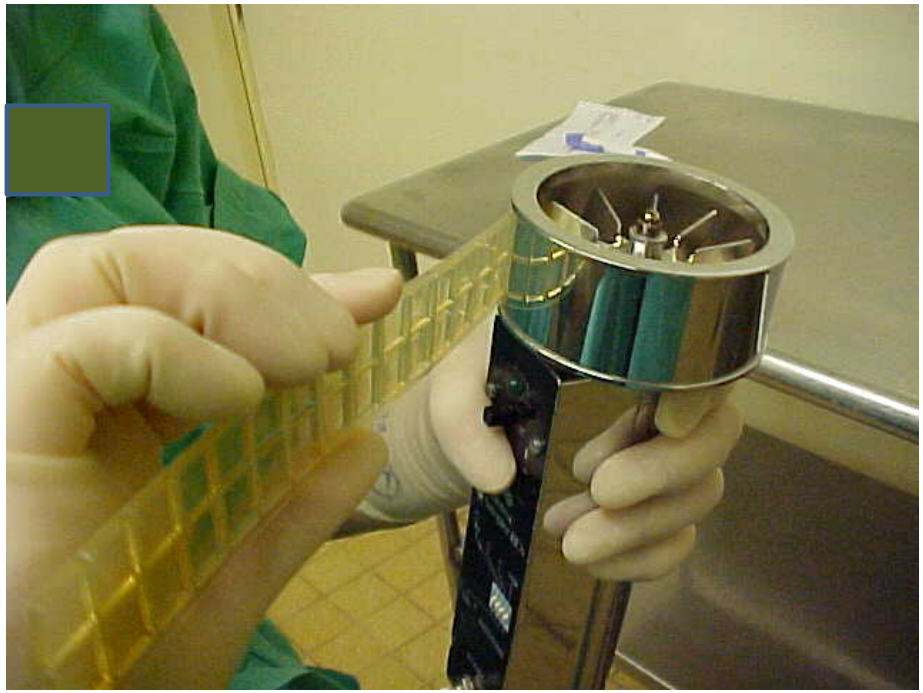
Air sampling: SAS Super 100 and Duo

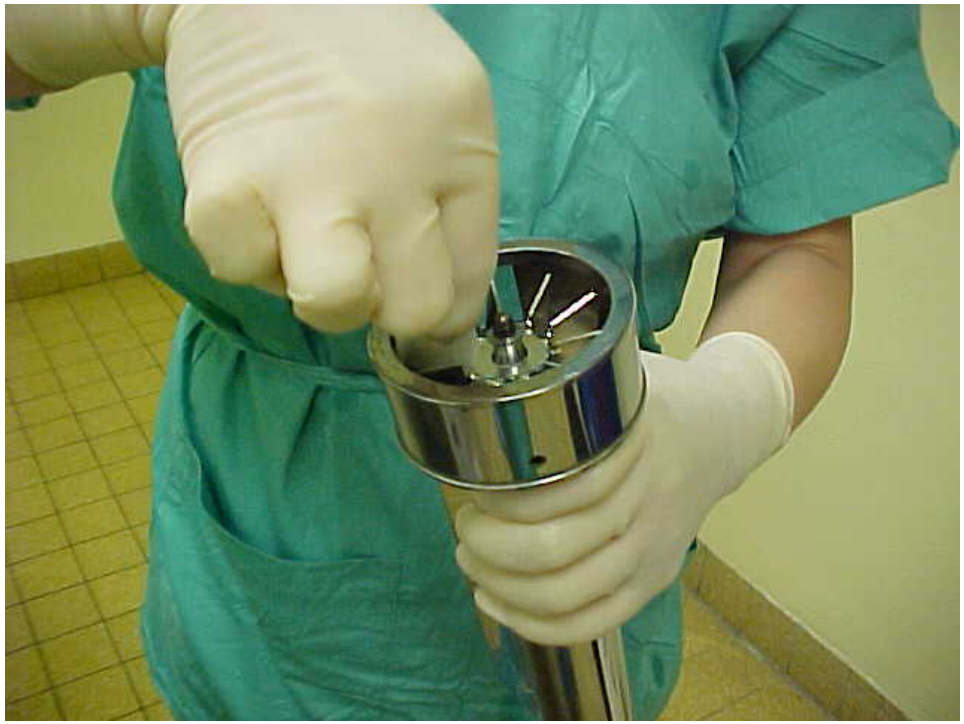


Air sampler



Air sampling





Samplers: Andersen vs RCS

Table 1. Fungal genera most frequently isolated with the two air samplers.

Genera	Number of positive samples (%)	
	Andersen sampler	RCS
Penicillium	35 (83)	39 (92)
Aspergillus	33 (78)	18 (42)
Cladophialophora	31 (73)	20 (47)
Fusarium	21 (50)	–
Trichoderma	21 (50)	–
Rhodotorulla	15 (35)	–
Alternaria	15 (35)	–
Candida	–	14 (33)
Rhizopus	–	9 (21)
Number of samples	42	42

RCS: Reuter centrifugal air sampler.

Brazilian Journal of Medical and Biological Research (2003) 36: 613-616

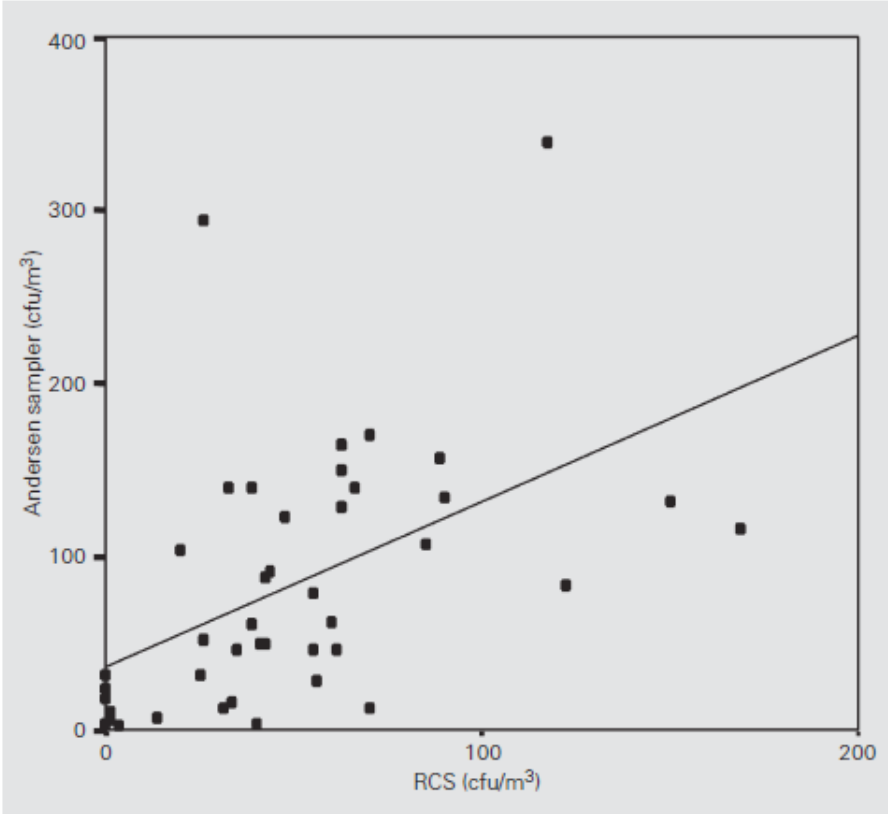


Figure 1. Correlation between fungal spore levels determined by measurement with the N-6 Andersen sampler and the Reuter centrifugal air sampler (RCS).

Indications for sampling

- To monitor levels of contamination prior to occupancy of special controlled environments e.g. to determine efficiency of HEPA filters in laminar flow facilities
- To identify potential sources of nosocomial aspergillosis when a case has been identified
- To predict environmental spore contamination from outside sources
- To identify defects/breakdown in hospital ventilation/filtration systems
- To correlate outbreaks of invasive aspergillosis with hospital construction or demolition work
- To monitor efficiency of procedures to contain hospital building wards where at-risk patients are managed

Method

- The air sample is aspirated through the instrument at a nominal rate of 180 litres/minute for a period of between 20 seconds and 6 minutes giving a volume range between 60 - 1080 litres

- The airflow is directed towards the agar surface of a 50 mm diameter contact plate that contains 12.5 ml of agar

- The plate is then removed for incubation

Location of sampling

- Choice of sampling height is 1.2 metres for room hygiene, with other samples taken for exploratory purposes near suspected or potential sources of contamination.

- Multiple samples are preferable to a single sample
  - For temporal and spatial variation in spore levels within any environment.

Sampling time

- Trial and error

- Not too long in sampling time in a heavily contaminated environment then the colonies
  - confluent growth - the colonies may even be uncountable

Laboratory procedure

- On receipt of the contact plates, these are placed in a pre-heated incubator to 28^0C for 5 days

- Identification of fungal colonies is based on colony characteristics and micro-morphological characteristics ascertained through microscopic examination at 400X magnification

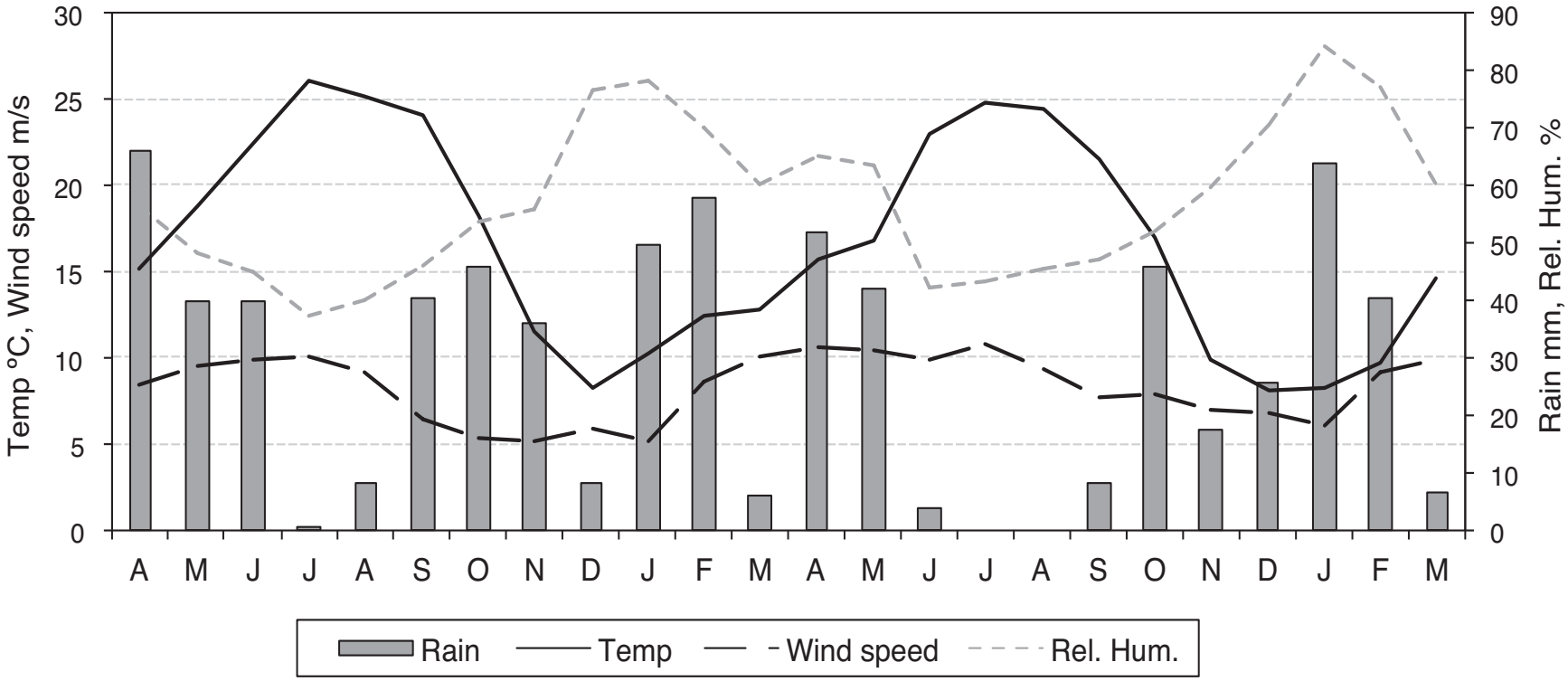
- Specimens for examination should be prepared using a wet needle mount using lactophenol with cotton blue stain (0.75%)

Interpretation

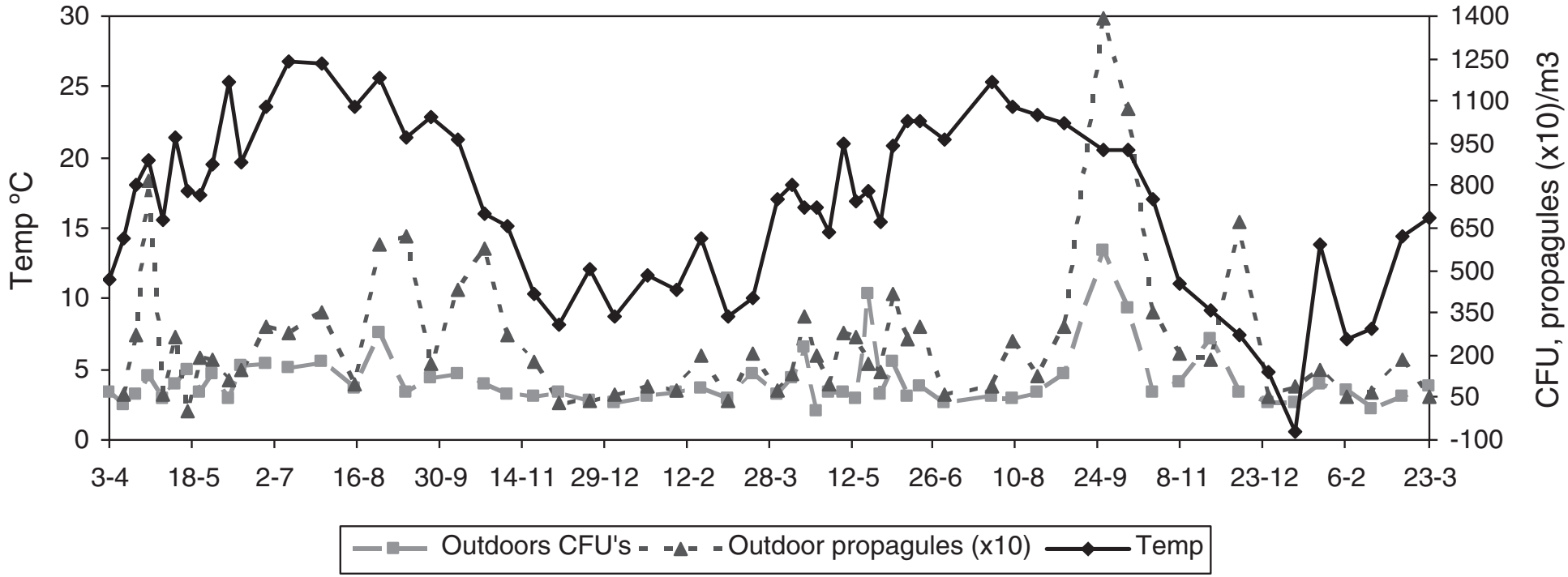
- Levels of fungal spores vary by several orders of magnitude during the course of a day due to:
  - Activity levels in any one particular area
  - Fluctuations in temperature
  - Fluctuations in humidity
  - Fluctuations in air flow
  - Changes in light level

Monthly meteorological data for the period studied, including rain, mean temperature, wind speed and RH (%)

R. Tormo-Molina et al. / Rev Iberoam Micol. 2012;29(4):227–234



Seasonal pattern with peaks in summer



Interpretation

- Outdoor air (Note: seasonal variation recognised):
  - Total fungal count: 10^3 to 10^5 CFU/m^3,
  - Aspergillus: 0.2-3.5 conidia/m^3
- HEPA filtered air (>95% efficiency and >10 air changes per hour)
  - < 0.1 CFU/m^3
- No air filtration: 5.0 conidia/m^3
- Construction/defective ventilation: 2.3-5.9 conidia/m^3
- If total fungal count exceeds 1.0 CFU/m^3 on several occasions the air systems or procedural practice in patent areas requires intensive evaluation

Recommend to do further investigation of sources of contamination

- Total indoor counts > outdoor counts
- Comparison of indoor and outdoor levels of fungal organisms show one of the following:
  - Organisms are present in the indoor sample and not in the outdoor sample
  - The predominant organisms found in the indoor sample is different from the predominant organism in the outdoor sample
- A monoculture of an organism is found in the indoor sample. It may be absent from samples taken in other areas of the building
- Persistently high counts

Air sampling

- Targeted air sampling
- Written, defined, standardised, multidisciplinary protocol for sample collection and culturing
- Analysis and interpretation of results should use scientifically determined or anticipatory baseline values for comparison
- Expected actions, based on the results obtained, should also be defined

Chang CC. Internal Medicine Journal 44 (2014)

Recommended results analysis

- Best to look at performance trend and correlate with activities
- Exposure level of <5 CFU/m^3 of *Aspergillus* spp. in protective isolation areas
- <0.1 CFU/m^3 in HEPA-filtered environments, with limits of 15 CFU/m^3 for total colony counts of all fungal organisms

Guidelines for Environmental Infection Control in Health-Care Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC).

Morris G, Kokki MH, Anderson K, Richardson MD. Sampling of Aspergillus spores in air. J Hosp Infect 2000; 44: 81–92

Munoz P, Burillo A, Bouza E. Environmental surveillance and other control measures in the prevention of nosocomial fungal infections. Clin Microbiol Infect 2001

Further actions

- Start appropriate antifungal prophylaxis or pre-emptive therapy if not already used
- Perform an intensive retrospective review of microbiological, histopathological and post-mortem records for other cases
- Alert clinicians caring for high risk patients to the possibility of infection
- Establish a system for prospective surveillance of patients and their environment for additional cases
- If further cases arise in the absence of a nosocomial source consider monitoring home environments of patients pre-admission

Persistent high counts

- Sample:
  - dust
  - fabrics
  - ventilation ducts/screens/fans
  - ceiling voids
  - kitchen areas
  - excreta of roosting birds in close proximity of windows

Airborne *Aspergillus* contamination during hospital construction works: Efficacy of protective measures

Isabelle Fournel, MD,[a] Marc Sautour, PhD,[b] Ingrid Lafon, MD,[c] Nathalie Sixt, MD,[b] Coralie L'Ollivier, PhD,[b] Frédéric Dalle, PharmD, PhD,[b] Pascal Chavanet, MD, PhD,[d] Gérard Couillaud, MD,[e] Denis Caillot, MD,[c] Karine Astruc, MD,[a] Alain Bonnin, MD, PhD,[b,f] and Ludwid-Serge Aho-Glélé, MD[a]
Dijon, France

	Before work		During work		
Air treatment system	**N**	**%**	**N**	**%**	***P***
None	58/93	62.4	53/95	55.8	.36
HEPA filtration	0/134	0	2/234	0.8	.54
Plasmair	42/248	16.9	85/497	17.1	.95
Aspergillus airborne contamination	100/475	21.1	140/826	16.9	.07

AJIC major articles

The impact of portable high-efficiency particulate air filters on the incidence of invasive aspergillosis in a large acute tertiary-care hospital

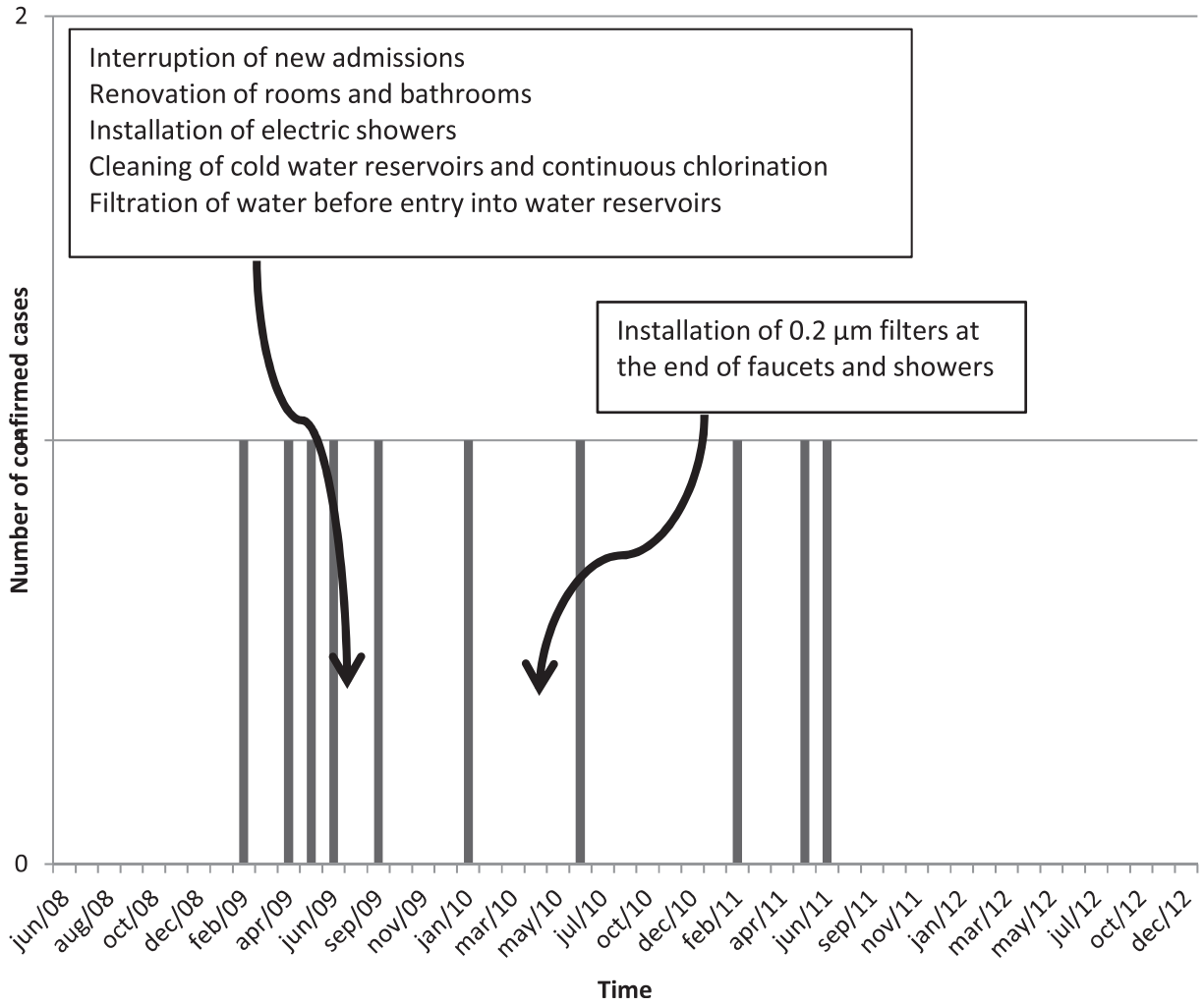
Zakir-Hussain Abdul Salam, MBBS, MS, MPH,[a] Rubiyah Binte Karlin, BHSc,[b] Moi Lin Ling, MBBS, FRCPA,[b] and Kok Soong Yang, MBBS, MMedPH[a]
Singapore *(Am J Infect Control 2010;38:e1-e7.)*

Table 1. Incidence rates and RRs of IA in different ward groups during the study period

Ward group	Ward type	Incidence rate (per 1000 patient-days)		*P* value	RR (95% CI)
		Period I (December 2005 to November 2006)	Period II (December 2006 to June 2008)		
Group I	Wards with portable HEPA filters deployed December 2006	0.35	0.17	.013	1.98 (1.11-3.51)
Group II	Wards with only fixed HEPA filters during the entire study period	0.16	0.31	.061	0.51 (0.28-0.93)
Group III	Wards with no HEPA filtration	0.088	0.075	.623	1.17 (0.44-3.10)

Outbreak lasted 2 years including 10 confirmed cases

Water was defined as the main source



Distribution of confirmed cases of fusariosis that occurred during an outbreak in a children's cancer hospital

Clinical Microbiology and Infection, Volume 21 Number 3, March 2015

Environmental cultures performed during an outbreak of fusariosis in a children's cancer hospital

Room number	Cultures of the water		Cultures of swabs	Air cultures		Cultures of water after hyperchlorination	Cultures			
	June 2009					August 2009	January to March 2010			
	Shower	Tap	Drains and taps	Dry	Humid	Shower	Swabs	Water	Dry air	Humid air
1	+	+	ND	−	−	−	−	−	+	−
2	+	+	+	+	−	−	+	−	−	+
3	+	+	+	+	+	−	−	−	−	−
4	−	−	ND	ND	ND	ND	ND	ND	ND	ND
5	−	−	ND	ND	ND	−	−	−	−	−
6	−	−	ND	ND	ND	−	−	−	ND	ND
7	+	+	+	+	−	−	−	−	+	+
8	+	+	ND	−	−	−	−	−	−	−
9	−	−	ND	ND	ND	−	−	−	−	−
10	−	−	ND	ND	ND	−	−	−	−	−
11	−	−	ND	ND	ND	−	−	−	+	−
12	−	−	ND	ND	ND	−	+	−	−	−
13	−	−	ND	ND	ND	−	+	−	−	−
14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15	−	−	ND	−	−	−	−	−	−	+
Isolation room 1*	ND	ND	ND	ND	ND	−	−	−	+	−
Isolation room 2*	+	+	−	−	−	−	+	−	+	+

+, positive for *Fusarium;* −, negative for *Fusarium*; ND, not done; Humid, air collected during the flow of the shower in the adjacent bathroom; Dry, air collected before the shower was opened in the adjacent bathroom.
*For transplant patients.

Clinical Microbiology and Infection, Volume 21 Number 3, March 2015

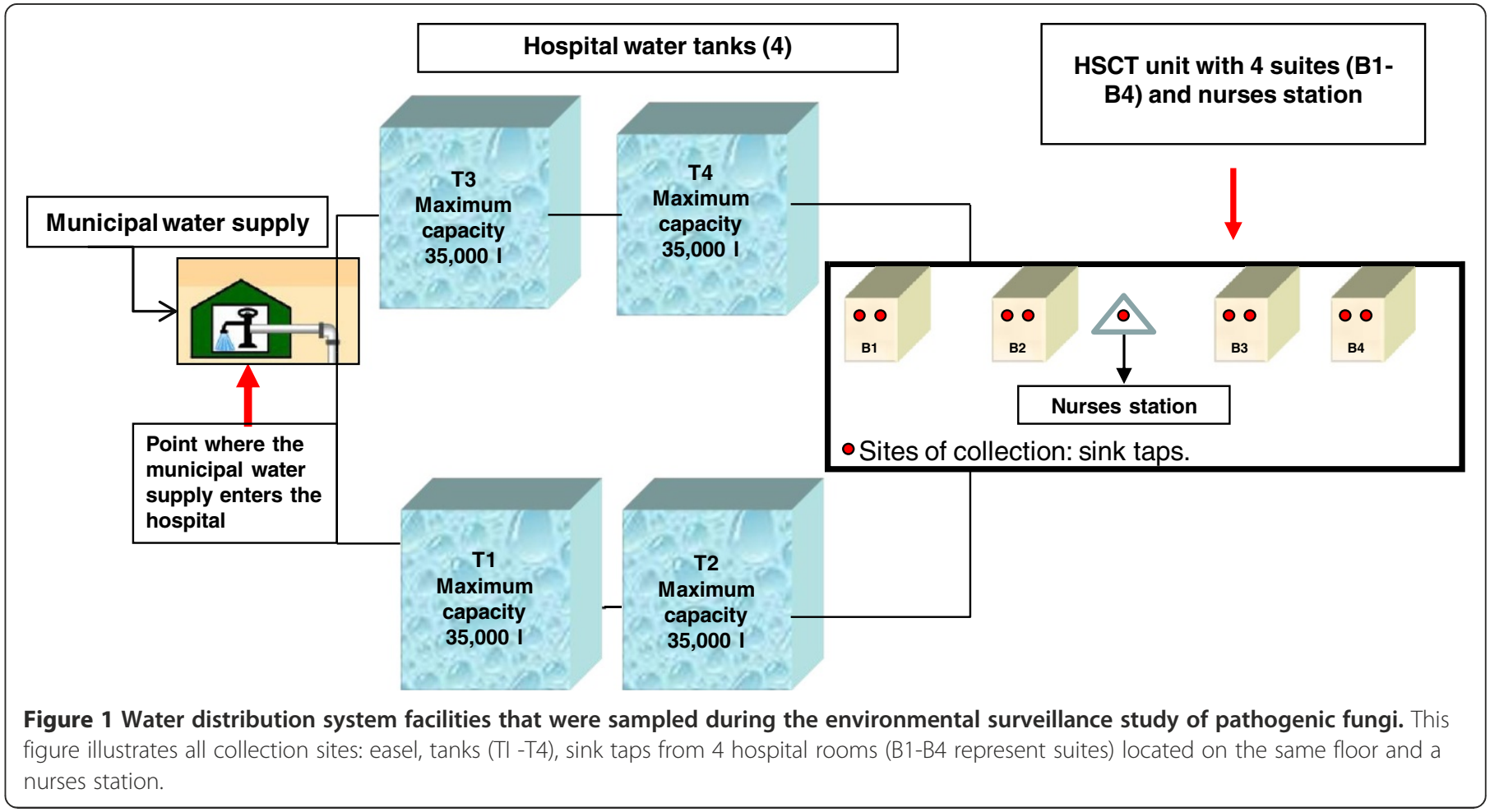


Figure 1 Water distribution system facilities that were sampled during the environmental surveillance study of pathogenic fungi. This figure illustrates all collection sites: easel, tanks (TI -T4), sink taps from 4 hospital rooms (B1-B4 represent suites) located on the same floor and a nurses station.

- 1L samples from water taps and tanks were collected every 30–40 days using sterile one-litre glass containers
- Filtered and cultured on SDA plates for 15 days at 25^0C and 37^0C

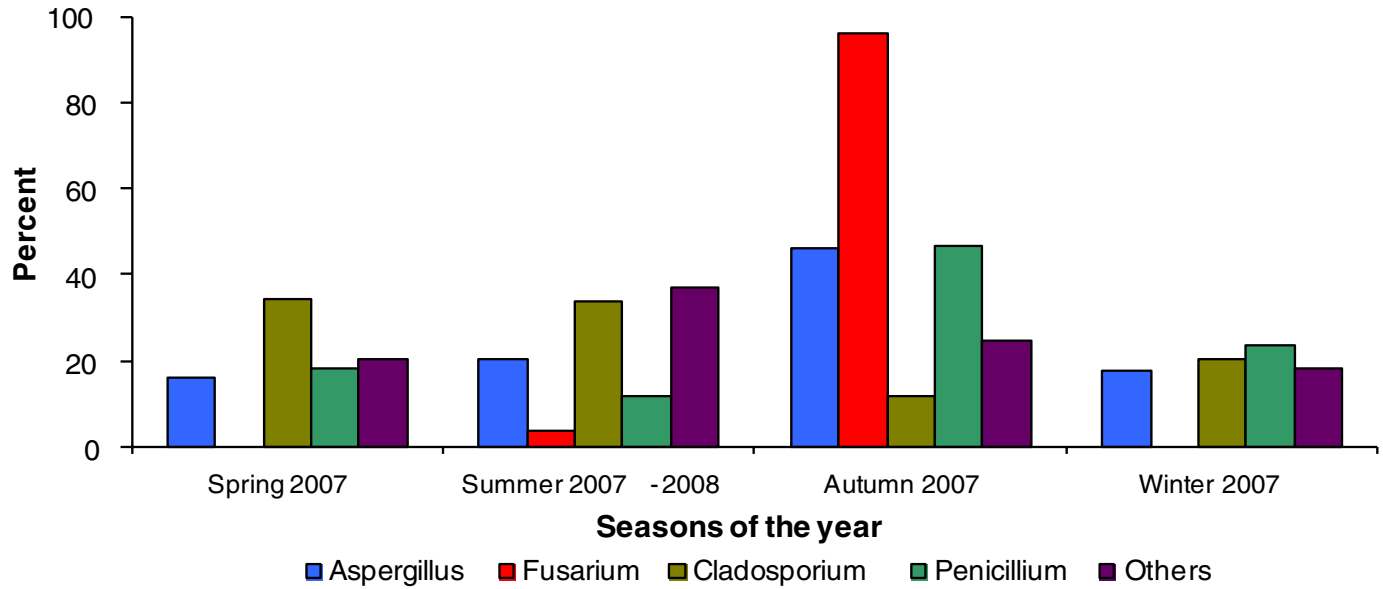


Figure 2 Distribution of fungal propagules in water samples collected from 4 different seasons of the year.

Mould in tap water

- Free residual chorine rate varied from 0.14-0.89 mg/mL, with a mean of 0.38 mg/mL
  - Consistent with those established by the Brazilian Ministry of Health, ordinance no 518/2004, which set the standard for drinking water in Brazil
  - Mould conidia may be more resistant to chlorine (Rosenzweig WD, Minnigh HA, Pipes WO: Chlorine demand and inactivation of fungal propagules. Appl Environ Microbiol 1983, 45:182–186)

Water sampling

- High-risk patients avoid drinking tap water
- Targeted water sampling should be considered in comprehensive investigations of healthcare-associated fungal outbreaks

Conclusion

- Surveillance
- Monitoring
  - Sample as and when required
  - Follow up results over time
  - Use the service of a professional vendor
- Environment hygiene is one of core component of the IPC program
  - Air, water, general environment cleanliness (hygiene)

THANK YOU