Quantitative assessment of the environmental fungal risk and implementation of management precautions

Focus on construction works

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AGENDA

Environmental fungal risk
I. Defining the risks
II. Analysis of the relationship between the environmental fungal pollution and the risk of fungal infection
III. Quantitative assessment of the environmental fungal risk

Implementation of management precautions: focus on construction and renovation works in hospitals
IV. Risk characterization
V. Implementation of management precautions
VI. Proposed indicators for the determination of the impact of management precautions on the risk of fungal infection
I. Defining the risks

- **The environmental fungal risk**: the identified and quantified presence and persistence of potentially harmful filamentous fungi, likely to be transferred to a patient during treatment

  = biocontamination or pollution

*Aspergillus*
Molds present in the environment and involved in infections:

Aspergillus, Fusarium, Penicillium, Scedosporium, Scopulariopsis, Lichtemia, Mucor, Rhizopus, Rhizomucor, Alternaria, Cladosporium, Exophiala, etc…
How to avoid biocontamination or pollution?
I. Defining the risks

- **The risk of infection**: results from exposure of the host to a microorganism. It can be defined as the likelihood of infection following exposure to a potentially pathogenic microorganism.

\[
\text{Risk of infection} = \text{Inoculum} \times \text{microorganism's virulence} \times \text{host's resistance}
\]

- **Risk of nosocomial fungal infection** associated with fungi during hospitalisation
The relationship between *Aspergillus* exposure and the risk of infection is well established,
- qualitatively
- and descriptively

⇒ However, it is difficult to establish it in *quantifiable* terms

- highly fluctuating nature of fungal contamination
- influence of measurement uncertainties
- statistical demonstration (low incidence/rare events of invasive aspergillosis)
- etc...

Risk threshold : a hard question?
II. Analysis of the relationship between the environmental fungal pollution and the risk of fungal infection

=> 3 approaches could help characterize this relationship and attempt to define a level of contamination above which the risk of aspergillosis would be increased

1. COMPREHENSIVE STUDY OF EPIDEMICS

2. STUDY OF THE IMPACT OF AIR TREATMENT MEASURES

3. A PROSPECTIVE APPROACH
Both clinical and mycological data obtained on a continuous basis are needed

- 24 outbreaks
- during which measurements were made of airborne contamination

=> measured values varied significantly $0 \rightarrow 235 \text{ CFU/m}^3$
depending on the outbreak and the sampled sites

[VONBERG 2006]
1. COMPREHENSIVE STUDY OF EPIDEMICS

ARNOW et al. [JID 1991]
⇒ a six-year clinical and mycological follow-up
⇒ during which one aspergillosis outbreak occurred during the epidemic outbreak

<table>
<thead>
<tr>
<th>Airborne concentration of Aspergillus</th>
<th>Pre- and post-epidemic periods</th>
<th>Epidemic outbreak</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.2 CFU/m³</td>
<td></td>
<td>1.1 to 2.2 CFU/m³</td>
</tr>
</tbody>
</table>

Risk threshold : 1-2 CFU/m³ ?
2. STUDY OF THE IMPACT OF AIR TREATMENT MEASURES

<table>
<thead>
<tr>
<th>Nb IFI/Nb high risk patients</th>
<th>Before laminar air flow</th>
<th>After laminar air flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHAME 1984</td>
<td>12/67</td>
<td>9/167</td>
</tr>
<tr>
<td>SHERERTZ 1987</td>
<td>14/73</td>
<td>0/40</td>
</tr>
<tr>
<td>BARNES 1989</td>
<td>6/19</td>
<td>0/19</td>
</tr>
<tr>
<td>ARAUJO 2008</td>
<td>6/198</td>
<td>0/205</td>
</tr>
</tbody>
</table>
### 3. A PROSPECTIVE APPROACH

Summary of protocols for the study of the relationship between environmental fungal contamination and the rate of invasive aspergillosis

<table>
<thead>
<tr>
<th>Authors</th>
<th>Follow-up duration (months)</th>
<th>Clinical department</th>
<th>Measurement of airborne contamination</th>
<th>Number of invasive aspergillosis cases</th>
<th>Correlation between contamination rate and IA*</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOSPENTHAL 1998</td>
<td>13</td>
<td>Oncology</td>
<td>Yes</td>
<td>6</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>MAHIEU 2000</td>
<td>11</td>
<td>Neonatal (3 departments)</td>
<td>Yes</td>
<td>0 cases of IA Measurement of pharyngeal carriage</td>
<td>No</td>
<td>Efficacy of HEPA air purifier</td>
</tr>
<tr>
<td>ALBERTI 2011</td>
<td>48</td>
<td>Hematology (3 departments)</td>
<td>Yes</td>
<td>64</td>
<td>Yes</td>
<td>Correlation between IA risk and use of conventional rooms</td>
</tr>
<tr>
<td>LAI 2001</td>
<td>6</td>
<td>Hematology</td>
<td>Yes</td>
<td>6</td>
<td>No</td>
<td>Efficacy of HEPA air filtration</td>
</tr>
<tr>
<td>FALVEY 2007</td>
<td>120</td>
<td>Hospital</td>
<td>Yes</td>
<td>1</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>PINI 2008</td>
<td>14</td>
<td>Hematology</td>
<td>Yes twice/month i.e. 270 samples</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Yes During construction</td>
<td>3 cases of IA during construction / High rate of Aspergillus</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>RUPP 2008</td>
<td>84</td>
<td>Hematology</td>
<td>Yes</td>
<td>45</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

**Risk threshold**: 2 CFU/m³
III. Monitoring of environmental fungal contamination in hospitals
Indoor fungal contamination: Health risks and measurement methods in hospitals, homes and workplaces

Delphine Méheust\textsuperscript{1,2}, Pierre Le Cann\textsuperscript{1,2}, Gabriel Reboux\textsuperscript{3}, Laurence Millon\textsuperscript{3}, and Jean-Pierre Ganegueux\textsuperscript{1,4}
1. Why monitoring the environmental fungal contamination in hospitals?

2. When/where?

3. How?
1. **Why monitoring the environmental fungal contamination in hospitals?**
   - to detect increases in conidia density
   - to assess air filtration efficiency

2. **When/where?**
   - in hospital units which benefit from air control measures
   - in case of *Aspergillus* infection
   - In case of construction and renovation works

3. **How?**
   - Air and surface sampling
Comparison of biocollectors for air sampling

Methods: impaction, filtration, centrifugation
Reference impactor: Andersen device

New generation impactors: > Andersen / other methods

Nesa, JHI 2001

Gangneux, ICHE 2006
Sampl’Air (AES Chemunex)

Air Ideal (bioMérieux)

BACTair - Airport MD8 (Sartorius)

100 L/min

Classical Petri dish (90 mm)

Special BACTair™ dish and sieve (110 mm)

125 L/min

Méheust et al., J Occup Environ Hyg. 2013;10(8):455-9
Culture vs. cytometry for fungal quantification in hospitals

**Combination of two technologies**

**Liquid cyclone high-volume air sampler**
- Air flow rate: 100 to 300L/min
- Sampling time: 1 to 10 min
- Particle size: > 0.5µm

**ChemScan system (AES Chemunex)**

**Solid-phase cytometry**
Enzymatic ‘viability’ staining procedure
A double discrimination key:
viability and cell membrane integrity

\[
\text{Esterase} = \text{Enzyme} \rightarrow \text{Viability substrate} \\
\rightarrow \text{Free fluorochrome} = \text{Fluorescein}
\]
Comparison of 2 samplers

Coriolis (Bertin Technologies)

Saml’Air (AES)

Cultural analysis
Comparison of 2 analytical methods

Coriolis (Bertin Technologies)

Solid-phase cytometry

Cultural analysis
Cultural analyses
- Samp’Air: incubation of MEA plates at 25°C
- Coriolis: 1/3 liquid volume (~1m3 air) spread plate method on MEA dishes at 25°C
Fungal enumeration at days 3 and 5

Solid-phase cytometry
- Coriolis: 1/3 liquid volume (~1m3 air)

1. Filtration
2. Pre-Labeling (3h)
3. Labeling (1h)
4. Microscopic validation
## Air sampling protocol in the Teaching Hospital of Rennes (France)

<table>
<thead>
<tr>
<th>Presumed level of fungal contamination</th>
<th>Site sampled (hospital)</th>
<th>No. of samples per sampler</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Office</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Medium</td>
<td>Conventional room</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Low</td>
<td>Corridor in hematology unit</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Negative</td>
<td>Room with laminar air flow&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

<sup>a</sup> Provided with high efficiency particulate air filtration

### Air sampling conditions

- **Sampl’Air:** 2 * 500L on Malt Extract Agar plates – 100L/min → 10min
- **Coriolis:** 3m<sup>3</sup> in 15mL liquid sample – 300L/min → 10min
Quantification of viable fungi

One-way ANOVA on the fungal concentrations obtained after air samplings with Coriolis bar heights represent mean of 10 samples ± 1 standard deviation. * indicates a statistically significant difference between the measurements by the two analytical methods ($p < 0.05$).

One-way ANOVA on the fungal concentrations obtained after air samplings with Coriolis bar heights represent mean of 10 samples ± 1 standard deviation. * indicates a statistically significant difference between the measurements by the two analytical methods ($p < 0.05$).
A rapid quantification of viable fungi…

**Culture-based method**

- Sampling
- Culture plate seeding
- First counting

**Solid-phase cytometry**

- Sampling
- Filtration + Activation medium
- Laser scanning

**Action Decision**
- Cleaning measures
- Reopening of high risk areas
- Patients’ return to their room

… but requiring complementary methods for identification

Culture-based methods: a non-costly and easy identification of the cultivable fungal diversity

*Méheust et al., J Hosp Infect. 2013 Feb;83(2):122-6*
Surface sampling

Contact Petri dishes

Humidified and non-humidified swabs
Fungal counts on Malt and Tryptic Soy Agar
(mean ± sd of 12 measures)

Conventional room
(200 L)

(P > 0.05)

Archive room
(100 L)

* TS < Malt (P < 0.05)

Gangneux, ICHE 2006,
Rhythm of the surveillance (French study Group, *Presse Med* 2002)

- Rooms equipped with LAF system: 1X/trimestre
- Shared rooms of the ward/corridors: 1X/month

1-2 air samples + 5-10 surface samples

**Under the air flow**
- 1 air sample
- Surface samples: bedside table, telephone, television, technical block...

**Outside the air flow**
- 1 air sample
- Surface samples: floor, extraction grid, window sill...
Mycological analysis

- *Aspergillus* sp.

- Total fungal flora ++
  \[\Rightarrow\] marker of risk for the presence of *Aspergillus* sp.

*Alberti, J Hosp Infect 2000*

- Phenotyping and genotyping of human/environmental isolates ?
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Implementation of management precautions: focus on construction and renovation works in hospitals

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VI. Proposed indicators for the determination of the impact of management precautions on the risk of fungal infection
Risk of fungal infections, and construction work in hospitals
Identification of risks and implementation of management precautions
Practical approach to the development of an impact study in the hospital sector.

**Putting the construction site into context**

**Partners:** Nosocomial Infection Control Committee - Infection Control Team - aspergillus task force – clinicians – mycologists - construction manager or his/her representative...

**Description of the project**
- Location
- Description of technique
- Consequences for:
  - the air: particulate and fungal contamination
  - hot and cold water networks
- Start / Duration of the construction work

**Description of the receiving environment**
- Determining the zone at risk
- Description of the relevant components
- Consequences for:
  - patients at risk
  - services at risk
  - working areas (operating room ...) at risk

**Analysis of the project's impacts**
- Impact determination and quantification, according to the type of construction work
  - Air: evaluation of particulate and fungal contamination
- Impact determination and quantification within the hospital
- Global quantification of risk

**Propose preventative measures**
- Recommendations to intervening firms and/or the technical maintenance service
- Recommendations to the relevant healthcare services

**Monitoring and follow-up**
- Planning a follow-up of the recommended precautions
- Proposal for the surveillance:
IV. Risk characterization during construction and renovation works

⇒ Combination of 3 risk analysis

1. Identification of the environmental fungal risk according to the type of construction work

2. Identification and quantification of populations at risk of invasive fungal infection

3. Identification and quantification of hospital wards or units at risk of fungal infection
# Classification of construction works according to the volume of dust they produce

## Types of construction work

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Type A** | Non-invasive control work / internal work with minimum production of dust.  
Non-exhaustive list  
- Removal of suspended ceiling panels for inspection, limited to 1 plate/m²,  
- painting without sanding,  
- paperhanging,  
- minor electrical work,  
- minor plumbing with water cutoff in the room lasting <15 minutes,  
- other inspection work requiring neither recesses in the walls, nor more extensive interventions on suspended ceilings. |
| **Type B** | Short-duration, minor construction work producing small quantities of dust  
Non-exhaustive list  
- Wire recesses in the walls or ceilings, with controlled production of dust for minor electrical installations or repairs on ventilation components, telephone or computer cabling,  
- removal of floor covering (limited area)  
- minor construction work on suspended ceilings,  
- sanding/grinding of the walls for paint removal or wallpapering involving the repair of only a small area,  
- plumbing work with water cutoff affecting ≥ 2 rooms for less than 30 minutes,  
- any construction work that can be performed by a single building trade. |
| **Type C** | Any construction work producing moderate to high levels of dust, or requiring the demolition or removal of any fixed item (e.g. sinks, boards...)  
Non-exhaustive list  
- Sand blasting / sanding of walls for painting or wallpapering; any construction work with plaster elements,  
- minor demolition,  
- removal of floor coverings and suspended ceilings,  
- construction of new walls; installation of new partitions,  
- minor construction,  
- minor piping or electrical wiring work in the ceilings,  
- minor excavation,  
- major wiring activities,  
- any activity that requires several building trades,  
- any plumbing work with water cutoff affecting > 2 rooms for > 30 minutes, but <1 hour. |
| **Type D** | Major demolition, renovation, construction work / Major external construction work with significant dust production  
Non-exhaustive list  
- demolition or renovation of an entire wiring system,  
- new construction involving several building trades,  
- plumbing with water cutoff affecting > two rooms, for > 1 hour,  
- major excavations |
2. Identification and quantification of populations at risk of invasive fungal infection

<table>
<thead>
<tr>
<th>Very high-risk populations</th>
<th>High-risk populations</th>
<th>Lower-risk populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Allograft of hematopoietic stem cells, especially in the case of old age, disease relapse, second allograft, pheno-versus geno-identical graft, HLA incompatibility, total body irradiation (TBI) during conditioning, according to the type of graft (placental blood versus other cellular sources, T-depleted graft), presence of a graft versus host disease, of a cytomegalovirus (CMV) disease, of iron overload; - autografting of hematopoietic medullary stem cells; - severe combined immunodeficiencies; - post-chemotherapy neutropenia (with neutrophil counts [ANC] of &lt; 500/mm$^3$) 14 d or &lt; 100/mm$^3$ regardless of duration; - Severe bone marrow failure</td>
<td>- High-dose corticosteroid therapy in the treatment of acute lymphoblastic leukemia; - post-chemotherapy neutropenia (with an ANC of &lt; 500/mm$^3$) lasting less than fourteen days; - solid organ transplant: pulmonary, liver kidney, heart, pancreas, intestine; - chronic pulmonary diseases treated with corticosteroids or other immunosuppressants: obstructive pulmonary disease, emphysema, bronchiectasis, uncontrolled asthma, cystic fibrosis; - chronic granulomatous septic disease; - newborns in neonatal resuscitation; relapsed or refractory acute myeloblastic leukemia</td>
<td>- Repeated and/or prolonged high-dose corticosteroid therapy; - HIV positive patients with AIDS, with CD4 T lymphocytes + of &lt;50/mm$^3$; - patients on mechanical ventilation; - patients on dialysis; - patients on chemotherapy; - diabetic ketoacidosis; - burned persons (&gt; 50% body surface area); - systemic disease.</td>
</tr>
</tbody>
</table>
3. Classification of hospital wards or units with a risk of fungal infection

<table>
<thead>
<tr>
<th>Groups of wards</th>
<th>Wards or departments concerned</th>
</tr>
</thead>
</table>
| **Area 1** | • Offices  
  • Unoccupied rooms  
  • Public areas | • Cardiology  
  • Echocardiology  
  • Nuclear Medicine  
  • Endoscopy  
  • Radiology/NMR  
  • Pneumology  
  • Functional rehabilitation |
| **Small RFI** | • All other healthcare departments (unless they are in groups 3 and 4)  
  • Outpatient clinics (except for oncology and surgery)  
  • Admission units | |
| **Area 2** | • Emergency rooms  
  • Conventional radiology  
  • Recovery rooms (PACU)  
  • Labor and delivery rooms (except the operating room)  
  • Nurseries  
  • Ambulatory surgery  
  • Nuclear medicine  
  • Spa pools or physiotherapy facilities  
  • Echocardiology  
  • Laboratories  
  • General medicine and surgery rooms (unless they are in group 4)  
  • Pediatrics  
  • Geriatrics  
  • Extended or long-term care | • Emergency room  
  • Labor and delivery rooms (except operating room)  
  • Nurseries  
  • Laboratories  
  • Ambulatory surgery  
  • Pediatrics  
  • Pharmacy  
  • Recovery rooms (PACU)  
  • Surgical departments |
| **High RFI** | • Intensive care units  
  • Operating rooms  
  • Anesthesia facilities  
  • Oncology units and outpatient consultation services for cancer patients  
  • Transplant and outpatient units for patients having received a hematopoietic stem cell or solid organ transplant  
  • Rooms and outpatient consultation services for patients with AIDS or any other immune deficiency  
  • Dialysis  
  • Neonatology  
  • All cardiac catheterization and angiography facilities  
  • Cardiovascular/Cardiology departments  
  • Endoscopy facilities  
  • Drugs preparation facilities  
  • Sterile preparation rooms  
  • Central treatment (sterilization, endoscopes) | • Intensive care units  
  • Operating rooms  
  • Positive pressure isolation rooms  
  • Medical departments  
  • Oncology units and outpatient consultation services for cancer patients  
  • Transplant and outpatient consultation units for patients having received a hematopoietic stem cell or solid organ transplant  
  • **Burn patients** unit  
  • Central sterilization |
V. Implementation of management precautions

⇒ 4 steps

1. Implementation of an impact study

2. Identification of risk management precautions

3. Indicators for the determination of the impact of management precautions on the risk of fungal infection

4. Areas of responsibility for the fungal risk management
Phases* of fungal infectious risk evaluation to be managed according to the organizational resources of the establishment

<table>
<thead>
<tr>
<th>Evaluation of the particulate contamination risk</th>
<th>Evaluation of the risks related to the patients and to the construction site location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Qualitative:</strong> High, Moderate, Low,</td>
<td><strong>Qualitative:</strong> ++++, ++, +</td>
</tr>
<tr>
<td>(see table III)</td>
<td>(see table V)</td>
</tr>
<tr>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td><strong>Quantitative:</strong> score/81</td>
<td><strong>Quantitative:</strong> from 0 to 10</td>
</tr>
<tr>
<td>(see table IV)</td>
<td>(see table V)</td>
</tr>
</tbody>
</table>

**Global risk quantification**

<table>
<thead>
<tr>
<th>Qualitative:</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td><strong>Quantitative:</strong> High (index &gt; 100)</td>
<td>Moderate (index between 25 and 100)</td>
</tr>
<tr>
<td>Low (index &lt; 25)</td>
<td></td>
</tr>
<tr>
<td>(see table VI)</td>
<td></td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
</tbody>
</table>

Deciding on preventative measures
Commitment from the relevant stakeholders
Monitoring of measures put into place
Qualitative tool for the evaluation of risks, according to the type of construction work [AP-HP Guide 1994, Anonyme Canada 2001, South-West CCLIN, 2006].

<table>
<thead>
<tr>
<th>Contamination</th>
<th>Typology of construction work</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Demolition</td>
</tr>
<tr>
<td></td>
<td>Sandblasting of walls</td>
</tr>
<tr>
<td></td>
<td>Ventilation system interventions</td>
</tr>
<tr>
<td></td>
<td>Plastering (plasterboard, insulation ducts)</td>
</tr>
<tr>
<td></td>
<td>Heavy work on roads, utilities and miscellaneous</td>
</tr>
<tr>
<td></td>
<td>Plumbing</td>
</tr>
<tr>
<td>Moderate</td>
<td>Timber frame</td>
</tr>
<tr>
<td></td>
<td>Suspended ceiling (+/- dismantling of existing ceiling)</td>
</tr>
<tr>
<td></td>
<td>Interventions on roller blind casings</td>
</tr>
<tr>
<td></td>
<td>Flooring (resilient, tiles or resin-based)</td>
</tr>
<tr>
<td></td>
<td>Indoor joinery</td>
</tr>
<tr>
<td></td>
<td>Ventilation - Air conditioning</td>
</tr>
<tr>
<td>Low</td>
<td>Light work on roads, utilities and miscellaneous (buried networks, earthwork)</td>
</tr>
<tr>
<td></td>
<td>Structural masonry</td>
</tr>
<tr>
<td></td>
<td>Landscaping</td>
</tr>
<tr>
<td></td>
<td>Roofing (with or without tiles)</td>
</tr>
<tr>
<td></td>
<td>Outdoor joinery (facade, outer cladding, coating)</td>
</tr>
<tr>
<td></td>
<td>Metal frame, fitting</td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
</tr>
<tr>
<td></td>
<td>Wall covering</td>
</tr>
</tbody>
</table>
Quantitative risk evaluation tool according to the nature of the construction work [South-West CCLIN, 2006]

<table>
<thead>
<tr>
<th>Type of work</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demolition</td>
<td>10</td>
</tr>
<tr>
<td>Roads, utilities &amp; miscellaneous (heavy)</td>
<td>10</td>
</tr>
<tr>
<td>Roads, utilities &amp; miscellaneous (light)</td>
<td>3</td>
</tr>
<tr>
<td>Foundations</td>
<td>2</td>
</tr>
<tr>
<td>Structural masonry</td>
<td>3</td>
</tr>
<tr>
<td>Timber frame</td>
<td>5</td>
</tr>
<tr>
<td>Covering (with or without tiles)</td>
<td>1</td>
</tr>
<tr>
<td>Outdoor joinery (façade, outer cladding, coating)</td>
<td>1</td>
</tr>
<tr>
<td>Metal frame / locks</td>
<td>1</td>
</tr>
<tr>
<td>Electricity / heating, ventilation and air conditioning (+/- reconnection to existing ducts)</td>
<td>1</td>
</tr>
<tr>
<td><strong>Suspended ceiling (+/− dismantling of the existing)</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Intervention on the ventilation system</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>Intervention on the ducts for the rolling blinds</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Wall covering (+/− dismantling of the existing)</strong></td>
<td>1</td>
</tr>
<tr>
<td>Floor covering (resilient, tiles or resin-based floor covering)</td>
<td>5</td>
</tr>
<tr>
<td>Plastering (plasterboards, insulating ducts)</td>
<td>10</td>
</tr>
<tr>
<td>Indoor joinery (timber, PVC, aluminum, glass)</td>
<td>5</td>
</tr>
<tr>
<td>Landscaping</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>81</td>
</tr>
</tbody>
</table>
Measures to be implemented for the containment of bioaerosols on the construction site, and to avoid their scattering towards areas in which RFI patients are housed.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Indication</th>
<th>Feasibility</th>
<th>Level of evidence</th>
<th>Importance and/or usefulness</th>
<th>Comments</th>
<th>Relevant literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close the ward in which RFI patients are housed</td>
<td>- Protect RFI patients</td>
<td>4</td>
<td>II</td>
<td>A</td>
<td>Transfer RFI patients to another sector or hospital in which the level of environmental pollution is guaranteed and controlled. As this is not always possible, planning and/or phasing of the construction work should be envisaged.</td>
<td>[BOCUET 1993, Anonymous Canada 2001, Anonymous Ireland 2001, APIC 2005, South-West CCLIN 2006, HAIDVEN 2009]</td>
</tr>
<tr>
<td>Place the area under construction under lower air pressure than the adjacent sectors</td>
<td>- Avoid the scattering of bioaerosols towards adjacent sectors</td>
<td>3</td>
<td>II</td>
<td>B</td>
<td>Use efficient air extractors equipped with a highly efficient filtration system.</td>
<td></td>
</tr>
<tr>
<td>Erect rigid, waterproof barriers or dust-proof screens, from floor to ceiling, between the area of activity and that under construction</td>
<td>- Isolate the construction site</td>
<td>2</td>
<td>II</td>
<td>A</td>
<td>Use materials which do not release dust which could be contaminated by filamentary fungal spores.</td>
<td></td>
</tr>
<tr>
<td>Minimize the re-suspension of bioaerosols in the area under construction</td>
<td>- Implement containment of construction site bioaerosols</td>
<td>2</td>
<td>II</td>
<td>A</td>
<td>Ensure that the environment remains damp, in order to avoid the re-suspension of dust.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Implement in the case of a low, average or high level of risk</td>
<td></td>
<td></td>
<td></td>
<td>- Clean access roads on a regular basis.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Isolation of the construction site using plasterboard panels screwed onto metal structures (advantages: rapidly put into place and panels can be cut with a Stanley knife), together with a doordset for access to the construction site.</td>
<td></td>
<td></td>
<td></td>
<td>- Empty waste from closed containers and/or tarpaulin covered bins.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Installation of a 120 micron polyane film on the outside of the partition, to ensure its air-tightness.</td>
<td></td>
<td></td>
<td></td>
<td>- Work with closed doors.</td>
<td></td>
</tr>
<tr>
<td>Practical application</td>
<td>- Use of 3-cm orange or gray duct tape (to be visually checked every day) To be over-lapped every 50 cm.</td>
<td></td>
<td></td>
<td></td>
<td>- Reduc dust produced during drilling, through the use of machines and equipment fitted with a very high efficiency vacuum filtering system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Installation of one or several construction site air extractors, in accordance with its surface area, if it is possible to have an external casement.</td>
<td></td>
<td></td>
<td></td>
<td>- During the dust-removal phase, install a high efficiency air purifier (permanently, or for the duration of construction work in the case of a limited construction area). Foresee</td>
<td></td>
</tr>
</tbody>
</table>
VI. Proposed indicators for the determination of the impact of management precautions on the risk of fungal infection

1. Visual checks

- doors tightly sealed (using adhesive tape for example)
- windows closed
- ground dust collection mat checked and replaced (at least daily, and whenever it is clearly saturated)
- obvious presence of dust (clouds, footprints, dusty surfaces ...)
## Quick Audit Sheet

### Ongoing construction work:

<table>
<thead>
<tr>
<th>Department</th>
<th>Date</th>
</tr>
</thead>
</table>

### Barriers put in place

<table>
<thead>
<tr>
<th>Sign displayed?</th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doors</td>
<td>Yes</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Common premises: properly closed</td>
<td>Yes</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Rooms: properly closed</td>
<td>Yes</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Clean floor surface, no conspicuous dust</td>
<td>Yes</td>
<td>No</td>
<td>NA</td>
</tr>
</tbody>
</table>

### Air conditioning

<table>
<thead>
<tr>
<th>Windows shut in the construction area</th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative pressure functional</td>
<td>Yes</td>
<td>No</td>
<td>NA</td>
</tr>
</tbody>
</table>

### Construction area

<table>
<thead>
<tr>
<th>Rubble removed in covered containers</th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning of construction site</td>
<td>Yes</td>
<td>No</td>
<td>NA</td>
</tr>
</tbody>
</table>

### Movement

<table>
<thead>
<tr>
<th>Restricted to workers</th>
<th>Yes</th>
<th>No</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted to required care staff</td>
<td>Yes</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>Waste disposal duly performed</td>
<td>Yes</td>
<td>No</td>
<td>NA</td>
</tr>
</tbody>
</table>

| Persons outside the department (visitors…) are informed of precautions to be observed | Yes | No | NA |

### Clothing

| Compliant with regulations in areas providing access to the construction site (e.g. operating rooms, high-risk units…) | Yes | No | NA |

<table>
<thead>
<tr>
<th>If not compliant, by whom: care staff □, technical staff □, other □</th>
</tr>
</thead>
</table>

| Specify: ………………………………………………………………………….. |

| NA: Not Adapted to the situation |
2. Checking the negative pressure in the construction zone

3. Particulate checks
4. Fungal biocontamination checks of the air and surfaces

• in protected areas where immunosuppressed patients reside for prolonged periods
• in other areas under construction, at least at the end of the construction work, following bio-cleaning of the premises
## Proposed interpretation of the results of fungus-oriented environmental monitoring

<table>
<thead>
<tr>
<th>Area</th>
<th>Local</th>
<th>Air sampling</th>
<th>Surface Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protected (with air conditioning)</td>
<td>Patient's room</td>
<td>No fungal spores</td>
<td>Under laminar flow: no fungal spores</td>
</tr>
<tr>
<td></td>
<td>Common areas</td>
<td>Tolerance for very rare CFUs per sample with no <em>Aspergillus</em></td>
<td>Other areas: tolerance for very rare Colony Forming Units (CFUs) of fungal spores per sample with no <em>Aspergillus</em></td>
</tr>
</tbody>
</table>

By way of indication, in a normal situation in the absence of construction work,

* A tolerance of 2 CFUs/sample is accepted for a 25 cm² surface sample,

** A tolerance of 2 CFUs/sample is accepted for a one m³ air sample,

*** A tolerance of 5 CFUs/sample is accepted for a 25 cm² surface sample.

Gangneux et al., J Mycol Med. 2012 ;22(1):64-71
Monitoring and areas of responsibility

Proposed frequency of environmental monitoring to be implemented, and responsibilities.

<table>
<thead>
<tr>
<th>Overall quantification of risk</th>
<th>Visual Healthcare Unit</th>
<th>Pressure Technical Staff</th>
<th>Particulates ICT</th>
<th>Airborne contamination ICT/Laboratories</th>
<th>Surfaces ICT/Laboratories</th>
</tr>
</thead>
<tbody>
<tr>
<td>High &quot;Protected&quot; area</td>
<td>Once daily</td>
<td>Once daily</td>
<td>End of construction</td>
<td>Once weekly and at the end of construction work</td>
<td>Once weekly and end of construction work</td>
</tr>
<tr>
<td>High Other areas</td>
<td>Once daily</td>
<td>Once daily</td>
<td>—</td>
<td>Period to be defined by the CLIN** and end of construction work</td>
<td>End of construction work</td>
</tr>
<tr>
<td>Average</td>
<td>Once daily</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>End of construction work</td>
</tr>
<tr>
<td>Low</td>
<td>Once weekly</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

ICT: Infection Control Team (or internal or external sampler)

*Technical Department or Biomedical Department (Work Supervisor)

**For information and according to the duration of construction work, once or twice monthly.
5. Epidemiological surveillance of invasive fungal infections

a/ Creation of a local structure for epidemiological surveillance

b/ The investigation of clusters of cases or epidemics

⇒ The final indicator for the beneficial effects of preventive measures
⇒ a tool for the detection of grouped cases and/or epidemics, allowing corrective measures to be considered
Comparison of Epidemiological, Clinical, and Biological Features of Invasive Aspergillosis in Neutropenic and Nonneutropenic Patients: A 6-Year Survey


Table 2. Outcome of invasive aspergillosis (IA), according to the patient’s underlying disease and case classification.

<table>
<thead>
<tr>
<th>Primary disease/underlying condition and case classification</th>
<th>Death (n = 63)</th>
<th>Recovery (n = 19)</th>
<th>Unknown (n = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary disease/underlying condition</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hematological malignancy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (n = 49)</td>
<td>29 (59)</td>
<td>16 (33)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Acute leukemia (n = 19)</td>
<td>8 (42)</td>
<td>11 (58)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Other hematopathy (n = 30)</td>
<td>21 (70)</td>
<td>5 (17)</td>
<td>4 (13)</td>
</tr>
<tr>
<td>Solid-organ transplantation (n = 10)</td>
<td>9 (90)</td>
<td>1 (10)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Chronic pulmonary disease (n = 18)</td>
<td>16 (89)</td>
<td>1 (5.5)</td>
<td>1 (5.5)</td>
</tr>
<tr>
<td>Vasculitis disease (n = 5)</td>
<td>5 (100)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Solid tumor (n = 3)</td>
<td>2 (67)</td>
<td>0 (0)</td>
<td>1 (33)</td>
</tr>
<tr>
<td>AIDS (n = 1)</td>
<td>1 (100)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Unknown (n = 2)</td>
<td>1 (50)</td>
<td>1 (50)</td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>Case classification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proven IA (n = 12)</td>
<td>10 (83)</td>
<td>2 (17)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Probable IA (n = 52)</td>
<td>37 (71)</td>
<td>10 (19)</td>
<td>5 (10)</td>
</tr>
<tr>
<td>Possible IA (n = 24)</td>
<td>16 (67)</td>
<td>7 (29)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>All cases of IA (n = 88)</td>
<td>63 (71.5)</td>
<td>19 (21.5)</td>
<td>6 (7)</td>
</tr>
</tbody>
</table>

Figure 2. Underlying diseases and risk factors present in patients with invasive aspergillosis.
Organizing committee

**Project coordinators:** Jean-Pierre Gangneux and Raoul Baron

In alphabetical order: Serge Alfandari, Bertrand Dupont, Joseph Hajjar, Bruno Grandbastien, Odile Roucoules, Anne Thiebaut

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**Coordinators:** Francis Derouin, Olivier Castel, Louis Bernard

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Learned societies

**Promotion:** Société française de mycologie médicale (SFMM) and Société française d’hygiène hospitalière (SF2H)

**Collaborations:** Société française d’hématologie (SFH), Société française de greffe de moelle et de thérapie cellulaire (SFGM-TC), Société de pathologie infectieuse de langue française (SPILF), Association française des infirmières de thérapie cellulaire (AFITCH)

With the methodological support of the French National Authority for Health [HAS]:

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Société Française de Mycologie médicale

Société Française d’Hygiène Hospitalière
Thank you for your attention

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