National Collaborating Centre for Environmental Health

Mould: Health Effects, Exposure Assessment and Remediation

Mona Shum, MSc, CIH
Chrystal Palaty, PhD
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CIPHI Newfoundland and Labrador
Outline

- What is mould?
- What are the health effects ascribed to mould?
- What is the evidence for these health effects?
- How do you know if you have a mould problem?
- What do you do if there is a mould problem?
Mould and Health Effects
Objectives

• To update state of knowledge about mould in indoor environments and health effects since the IOM’s Damp Indoor Spaces and Health (2004)

• To make recommendations for mould testing and remediation
What is mould?

- Eukaryotic, microscopic, spore-bearing (except yeasts)
- Separate phylogeny from plants and animals
- Grows in mat of intertwined filaments (hyphae)
- Relies on dead or decaying organic matter

What does mould need to grow?

- Food (organic matter)
- Right temperature (preferably 18-32°C)
- Water

Only component in indoors that can be controlled is water
What are the components of concern?

- Mycotoxins
- Spores
- Structural components
- Volatile organic compounds

Photo: http://en.wikipedia.org/wiki/Hypha
How can I get exposed?

- Ingestion
- Dermal contact
- Inhalation

Photo: http://commons.wikimedia.org/wiki/File:Heart-and-lungs.jpg
What are the types of ascribed health effects?

- Systemic fungal infections
- Allergic reactions
- Irritant/non-allergic reactions
- Toxic effects

Photo: http://www.flickr.com/photos/haiiroproject/3947206219/
Ascribed Health Effects

Range of health effects blamed on mould exposure:

• Lower, upper respiratory effects
• Asthma
• Respiratory tract disorders
• Pulmonary hemorrhage
• Neurological, reproductive, immune effects
• Cancer

Photo: http://upload.wikimedia.org/wikipedia/commons/d/d3/Aspergillosis.jpg
Methodology for Reviewing Evidence for Health Effects

Looked at guidelines, position papers, reviews and metanalyses where most

- were written by subject area experts or were reviewed by a committee of experts in the field;
- critically evaluated the research that has been done in the field, taking into account limitations;
- were either endorsed by a professional or scientific body, or published in peer-reviewed journals.
<table>
<thead>
<tr>
<th>++</th>
<th>Sufficient evidence of a causal relationship</th>
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</thead>
<tbody>
<tr>
<td>+</td>
<td>Sufficient evidence of an association</td>
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<td>(-)</td>
<td>Limited or suggestive evidence of an association</td>
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<td>0</td>
<td>Inadequate or insufficient evidence to determine whether an association exists</td>
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<td></td>
<td>Association not examined (blank)</td>
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# Evidence for Health Effects

<table>
<thead>
<tr>
<th>Study</th>
<th>Agent of Interest</th>
<th>Asthma symptoms</th>
<th>Asthma development</th>
<th>Allergy/hyper-sensitivity</th>
<th>Upper respiratory</th>
<th>Lower respiratory</th>
<th>General/toxic effects</th>
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<tbody>
<tr>
<td>IOM (2004)</td>
<td>Indoor Mould</td>
<td>+</td>
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<td>Storey et al. (2004)</td>
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<tr>
<td>Curtis (2004)</td>
<td>Indoor mould, mycotoxin</td>
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<tr>
<td>Douwes (2005)</td>
<td>Beta 1,3 glucan</td>
<td>0</td>
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*regarded IOM study as benchmark*
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<tr>
<td>Richardson et al. (2005)</td>
<td>Dust mite allergen</td>
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<tr>
<td>Richardson et al., (2005)</td>
<td>Other agents incl. mould</td>
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<td>AAAAI, Bush et al. (2006)</td>
<td>Indoor mould</td>
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<td>Committee on Environmental Health (2006)</td>
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<tr>
<td>Mazur et al. (2006)</td>
<td>Indoor dampness and mould</td>
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<tr>
<td>Fisk et al. (2007)</td>
<td>Indoor dampness and mould</td>
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<td>(-)</td>
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<tr>
<td>Health Canada (2007)</td>
<td>Indoor mould</td>
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<td>Seltzer and Fedoruk (2007)</td>
<td>Indoor mould</td>
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<td>Hope and Simon (2007)</td>
<td>Indoor dampness and mould</td>
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<tr>
<td>Dales et al. (2008)</td>
<td>Indoor air (many factors)</td>
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<td>Sahakian et al. (2008)</td>
<td>Indoor dampness and mould</td>
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<tr>
<td>NYC (2008)</td>
<td>Indoor damp</td>
<td>+</td>
<td></td>
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<tr>
<td>Portnoy et al. (2008)</td>
<td>Indoor mould</td>
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<tr>
<td>Pestka et al. (2008)</td>
<td>Stachy-botrys &amp; bioactive components</td>
<td>0</td>
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<tr>
<td>Bush (2008)</td>
<td>Indoor allergens including mould</td>
<td>+</td>
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</tbody>
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Summary of Evidence for Health Effects from Indoor Mould Exposure

• Causal relationship
  – None

• Sufficient evidence for association
  – Asthma symptoms (in asthmatics)
  – Upper respiratory symptoms (i.e., sore throat, conjunctivitis, allergic rhinitis, nasal symptoms)
  – Cough, wheeze
  – Hypersensitivity pneumonitis in susceptible people
Summary of Evidence Cont’d

• Limited or suggestive evidence for association
  – Lower respiratory tract symptoms in otherwise healthy children
• Inadequate or insufficient evidence for association
  – Asthma development (although more evidence is accumulating)
  – Other respiratory disease not mentioned above
  – GI tract problems
  – Skin symptoms
  – Non-occupational inhalation fevers
  – Neuropsychiatric symptoms
  – Cancer
  – Rheumatologic and other immune diseases
  – Reproductive effects
  – Acute idiopathic pulmonary hemorrhage in infants.
How do you know if you have a mould problem?

Visual inspection most important
- Signs of water intrusion
- Building envelope
- Sometimes not visual

• Testing can supplement

AIHA “Green Book” – Recognition, Evaluation, and Control of Indoor Mold (2008)

Photo: http://images.google.ca/imgres?imgurl=http://coastalhomeinspections.org/mold_house.jpg&imgrefurl=http://coastalhomeinspections.org/services.html&usg=__e6NGopW6nTFTtN0FbMQU4yCLRE=&h=311&w=400&sz=46&hl=en&start=22&um=1&tbnid=kRd4U8bILXAD_M:&tbnh=96&tbnw=124&prev=/images%3Fq%3Dmold%2Btesting%2Bphotos%26ndsp%3D20%26hl%3Den%26sa%3DN%26start%3D20%26um%3D1
Visible mould or suspicion of mould: odour, water damage, excess moisture or health effects.

**STEP 1  INFORMATION GATHERING & PLANNING BY PHI OR EHO**
Gather information about complaints, space and occupants use.

**STEP 2  VISUAL INSPECTION OF PREMISES BY PHI OR EHO**
Examination of external and internal surfaces for signs of moisture damage and mould growth.

Unclear if mould or moisture is present

No further action required

- Prevention/Awareness initiated

No evidence of mould or moisture

Evidence of mould growth and/or moisture damage

Remediate for moisture and/or mould

Prevention/Awareness initiated
**STEP 3** MOULD SAMPLING BY QUALIFIED ENVIRONMENTAL SPECIALIST/CONSULTANT
Create hypothesis, design and implement sampling protocol with necessary controls.

Do test results provide clear evidence of indoor mould contamination?

- **NO** → No further action required → Prevention/Awareness initiated
- **YES**

**STEP 4** IF NECESSARY, ENVIRONMENTAL SPECIALIST/CONSULTANT INVESTIGATES SUSPECT HIDDEN AREAS
Invasive techniques used only if a strong suspicion or evidence exists.

- Evidence of mould growth and/or moisture damage
  - Prevention/Awareness initiated
- No evidence of mould or moisture
  - No further action required → Prevention/Awareness initiated

REMEDiate FOR MOISTURE AND/OR MOULD
Exposure Assessment

- Indoor mould not directly related to exposure or health effects
  - Mould not the only possible contributor to a health effect (eg., dampness)
  - Different components of mould can be harmful
  - Exposure determined by more than just the quantity of mould present
  - Exposure can occur anywhere
  - Individual susceptibility is a major factor
Visual Inspection: What to look for

- Indicators of past and present water damage
  - Wet spots (moisture meter), actual mould growth
  - Cracks in materials, staining, efflorescence, decayed or warped wood, wrinkled wall paper, bubbled paint
  - Condensation
  - Previous repairs and renovations
Exterior Inspection

• Building deficiencies
• Drainage, grade of soil, clearance between soil and siding
• Sprinklers, landscaping
• Roof (if possible)
• Missing drainage elements
• Penetrations
Interior Inspection

- All occupiable areas – floor, walls, ceiling
- Areas under windows
- Fireplace, penetrations
- Under sinks, toilets, in and around baths/showers, dishwashers
- Hot water heaters
- Refrigerators
- Attics, basements, crawlspaces, storage spaces
Documentation and Tools

Documentation
- Floor plan of the building/residence
- Detailed description of observations (include direction, size)
- Photos, photos, photos

Tools
- Moisture meter
- Bendable mirror
- Multipurpose tool (knife, pliers)
- T/RH meter
- Clipboard
- Multicoloured pen
Testing

- Surface – tape, culture, bulk (material)
- Dust – vacuum, tape
- Air sampling
  - Total spore (onto a slide for microscopy)
  - Culturable (onto agar for culture and speciation)
  - DNA (polymerase chain reaction)
- Destructive
  - Removal of wallboard, cabinetry, carpeting, baseboards
Limitations of Testing

• Snapshot in time
• Doesn’t inform of actual exposure
• Not well-standardized or validated
• Difficult to interpret
  – Most compare indoors with outdoors
  – Johnson et al., 2008 shows that when 30 sets of air sample datasets were sent to 40 IAQ professionals, inconsistent conclusions
  – No prior history or other information provided
• Testing not that useful by itself
What do you do if you have a mould problem?

- Remove source of water
- Remove/replace porous, semiporous materials
- Clean hard surfaces
- Many guidelines
  - NYCDOH, 1993, 2000
  - Health Canada, 1995
  - ACGIH, 1999
  - US EPA, 2001
  - AIHA, 2001

Photo courtesy of Terry Brennan, [http://www.epa.gov/mold/moldcourse/imagegallery7.html](http://www.epa.gov/mold/moldcourse/imagegallery7.html)
<table>
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<tr>
<th>Classification</th>
<th>Description</th>
<th>Necessary Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small / Area 1</td>
<td>Total area: 1 m² of visible mould growth or less.</td>
<td>Most guidelines recommend that occupants can clean up areas less than 1 m². No special training is required. Recommended Personal Protective Equipment (PPE): N-95 mask and rubber gloves. Guidelines disagree about whether containment is required for this size of growth.</td>
</tr>
<tr>
<td>Moderate/ Area II</td>
<td>Total area: between 1–4 m² of visible mould.</td>
<td>Most guidelines recommend that occupants can clean up moderate areas if they have received some training and are using proper procedures. Recommended PPE: N-95 mask, goggles and rubber gloves. Minimal containment is required, including air filtration and barriers.</td>
</tr>
<tr>
<td>Large/ Area III</td>
<td>Total area: 4–10 m² of visible mould.</td>
<td>Professional remediation only* Full PPE, air filtration and full containment required.</td>
</tr>
<tr>
<td>Extensive contamination/ Area IV</td>
<td>Contiguous visible mould growth larger than 10 m² in an area.</td>
<td>Professional remediation only* Full PPE, air filtration and full containment required. Note: only guidelines from the New York City Department of Health and Mental Hygiene and the US Department of Labour include extensive areas of mould growth.</td>
</tr>
</tbody>
</table>
Limitations

- Limited understanding of “dampness”
- Limited dampness and mould exposure assessment methods
- Lack of knowledge of which mould or components in indoor air are problematic
- Lack of biomarkers for assessing exposure
- Reported health effects not standardized
- No dose-response curve established
- Lack of evidence on extent of containment for remediation
- Lack of tools for assessing success of remediation
Conclusions

- Mould in indoor environments associated with asthma and upper respiratory effects
- Visual inspection and information gathering is the most important step in exposure assessment
- Mould growth in indoor environments should be remediated and moisture source stopped
Thank You

Questions?
Comments?

www.ncceh.ca | www.ccnse.ca

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