NIOSH FIELD STUDIES ON DAMPNESS AND MOLD AND RELATED HEALTH EFFECTS

Jean Cox-Ganser, Ph.D.
Division of Respiratory Disease Studies

The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.
Community college study, 2000
Community college study, 2000

- 40 buildings built in 1920s, 1970s, and 1990s
- 1,200 full-time faculty and staff
- Health complaints: Asthma, sinusitis, hypersensitivity pneumonitis
- Observational check sheet for water stains, visible mold, mold odor, dampness
Community college study

- 13 buildings studied
  - 7 buildings had a history of recurrent water incursion
  - 6 buildings had little problem with water incursion

- Self-administered questionnaire survey offered to 554 fulltime employees from the 13 buildings
  - Participation 71% (393/554)
Work-related symptoms by building age group
Community college study

- Wheeze
- Chest tightness
- Shortness of breath
- Attack of cough
- Nasal symptoms
- Sinus symptoms
- Throat irritation

Prevalence (%)
<table>
<thead>
<tr>
<th>Current Moisture</th>
<th>Stain</th>
<th>Visible Mold Density</th>
<th>Mold Odor</th>
</tr>
</thead>
<tbody>
<tr>
<td>XNA</td>
<td>XNA</td>
<td>XNA</td>
<td>XNA</td>
</tr>
</tbody>
</table>

Observational assessment for dampness/mold
Associations between dampness index and work-related symptoms - Community college study

Models adjusted for age, gender, smoking, job, year of hire, allergies, and latex gloves
Conclusions

Community college study

• Observational exposure indices are associated with work-related symptoms and can guide remediation

• Visual and olfactory observation of water stains, visible mold, mold odors and dampness justifies action to control water damage
Hospital study, 2000
Hospital study, 2000

- Six asthma cases among 50 staff on top (8th) floor of a hospital
  - Onset between 1997 and 1999
  - Methacholine challenge positive
  - Peak flow diaries show work-related changes
  - Latex asthma excluded by negative tests for latex-specific IgE antibodies

- History of water incursions and evidence of fungal contamination in the walls and ceiling of top floors of the hospital
Work-related asthma case – Hospital study

**At work**
Methacholine challenge: 10/1999 - $PC_{20}$ 0.23 mg/ml (asthma)

**Work restricted**
Methacholine challenge: 06/2000 - $PC_{20} >25$ mg/ml (normal) (after about 2 months of removal from the hospital)
# Symptom and asthma prevalences

*Hospital study*

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest symptoms in past 12 months</td>
<td>34%</td>
</tr>
<tr>
<td>Proportion with work-related pattern</td>
<td>34%</td>
</tr>
<tr>
<td>≥ 3 lower respiratory symptoms in past 4 weeks</td>
<td>15%</td>
</tr>
<tr>
<td>Proportion with work-related pattern</td>
<td>37%</td>
</tr>
<tr>
<td>Physician-diagnosed asthma</td>
<td>17%</td>
</tr>
<tr>
<td>Physician-diagnosed asthma with post-hire onset</td>
<td>7%</td>
</tr>
</tbody>
</table>

* 1171/1834 (64%) participation
Work-related lower respiratory symptoms and asthma in relation to dampness score
Hospital study

Models adjusted for age, gender, smoking status, and reported mold or dampness at home.
## Floor dust measures and lower respiratory symptoms

Hospital study

<table>
<thead>
<tr>
<th>Floor dust measures (continuous)</th>
<th>Symptom time frame</th>
<th>Work-related lower respiratory symptoms Odds Ratios</th>
</tr>
</thead>
</table>
| Ergosterol                      | 12 months 4 weeks | 1.65 (1.16-2.37)  
                               |                   | 2.08 (1.31-3.32)  |
| EPS-Pen/Asp                     | 12 months 4 weeks | 1.53 (0.99-2.38)  
                               |                   | 1.90 (1.05-3.44)  |
| Cat allergen                    | 12 months 4 weeks | 1.57 (1.01-2.45)  
                               |                   | NS                 |
| Culturable Fungi                | 12 months 4 weeks |                   | NS                 |
| (1→3)-β-D-glucan                | 12 months 4 weeks |                   | NS                 |
| Culturable Bacteria             | 12 months 4 weeks |                   | NS                 |
| Endotoxin                       | 12 months 4 weeks |                   | NS                 |
| Latex allergen                  | 12 months 4 weeks |                   | NS                 |
Work-related respiratory symptoms in relation to ergosterol levels in floor dust

Hospital study

Models adjusted for age, gender, smoking status, and reported mold or dampness at home
Conclusions
Hospital study

• Follow up sentinel cases of building-related asthma to identify risk to co-workers

• Results imply causation of building-related asthma in relation to dampness

• Work-related symptoms related to a number of biological exposures, including ergosterol, EPS Pen/Asp, and cat allergen
Comparison of observational dampness/mold evaluation to environmental sampling in 3 schools
Association between observational score and environmental measurements

- Rooms with scores above the median had significantly higher floor dust levels of:
  - Total culturable fungi
  - Total culturable bacteria
  - \( \beta \)-D-Glucan
  - Ergosterol
- Moisture content of walls and flooring higher in rooms with scores above the median.
Observational scores and measurements of moisture content

Moisture Meter Measurements within a Room

Minimum Mean Maximum

Moisture Content Relative to Dry Material

- Observational Score <= Median
- Observational Score > Median

p=0.04

p<0.01

p=0.01

Moisture Meter Measurements within a Room
Current research-to-practice project

- Practical application of a dampness/mold tool in schools
  - Development of simplified version of assessment sheet for dampness and mold
  - Development of software for data entry and producing summary reports
Purpose of the dampness and mold assessment tool

• **Identify and record** areas of dampness and mold throughout your building

• **Trigger early repair and remediation** to avoid potential health effects and more costly repair and remediation

• **Create awareness** of potential problem areas

• **Track** past and present problem areas by repeating the use of this tool
### NIOSH Dampness & Mold Assessment Form (One sheet per room)

**Date:** __________  **Observer:** __________  **Building:** __________  **Wing:** __________  **Floor:** __________  **Room Number:** __________

**Room Type:** Fill in the bubble for the type of room you are assessing.

- Classroom
- Office
- Hallway
- Conference room
- Bathroom
- Custodial closet
- Mechanical room
- Storage
- Library
- Cafeteria
- Gym
- Auditorium
- Kitchen
- Locker room
- Entrance area
- Stairwell
- Other __________

**MOLD ODOR:** Be sure to smell for mold odor when you first walk into the room/area. Fill in the appropriate bubble.

- NONE
- MILD
- MODERATE
- HEAVY

**Source of MOLD ODOR?** __________  **Source Unknown** __________

<table>
<thead>
<tr>
<th>Fill in bubbles for each column and row.</th>
<th>&quot;NA Mark &quot;X&quot;</th>
<th>DAMAGE or STAINS</th>
<th>VISIBLE MOLD</th>
<th>WET or DAMP</th>
<th>Row Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 1 2 3</td>
<td>0 1 2 3</td>
<td>0 1 2 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walls</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Floors</td>
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<tr>
<td>HVAC systems</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Pipes</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Furnishings</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Supplies &amp; Materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Column Totals**

**Column Averages**

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Size based scores ➔ 0 = NONE  1 = size of this form or smaller  2 = larger than this form, smaller than the size of a standard interior door  3 = larger than the size of a standard interior door

*NA = Not Applicable*
Office building study, 2001-2007
Health concerns
- Asthma
- Hypersensitivity pneumonitis (8)
- Sarcoidosis (6)

Cross-sectional studies of health and exposure

Natural history of building-related respiratory disease
Excess lung disease
Office building study

- Compared to U.S. adults, prevalence ratios were:
  - 2.2 (95% CI 1.9–2.6) for lifetime asthma
  - 2.4 (95% CI 2.0–3.0) for current asthma
  - 2.5 (95% CI 2.2–2.8) for wheezing

- Compared to the state adults, prevalence ratios were:
  - 1.4 (95% CI 1.2–1.6) for lifetime asthma
  - 1.5 (95% CI 1.3–1.9) for current asthma

- 7.5-fold increase in asthma incidence since building occupancy
Breathing test results  
Office building study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Respiratory case group n = 140</th>
<th>Fewer symptoms group n = 63</th>
<th>Comparison group n = 44</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spirometry testing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal</td>
<td>24%</td>
<td>13%</td>
<td>7%</td>
</tr>
<tr>
<td>Obstructed or mixed</td>
<td>15%</td>
<td>6%</td>
<td>7%</td>
</tr>
<tr>
<td>Restriction (low FVC)</td>
<td>8%</td>
<td>6%</td>
<td>0%</td>
</tr>
<tr>
<td>Methacholine challenge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abnormal (PC_{20} \leq 16 mg/ml)</td>
<td>19%</td>
<td>20%</td>
<td>6%</td>
</tr>
<tr>
<td>Any abnormal lung function test</td>
<td>39%</td>
<td>29%</td>
<td>11%</td>
</tr>
</tbody>
</table>
Breathing test results
Office building study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Respiratory case group</th>
<th>Fewer symptoms group</th>
<th>Comparison group</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Predicted FEV$_1$ (Mean ± SD)</td>
<td>92% ± 16</td>
<td>96% ± 17</td>
<td>103% ± 12</td>
</tr>
<tr>
<td>% Predicted FVC (Mean ± SD)</td>
<td>94% ± 14</td>
<td>97% ± 16</td>
<td>103% ± 11</td>
</tr>
</tbody>
</table>
### Medication use and medication use/abnormal lung function
#### Office building study

<table>
<thead>
<tr>
<th></th>
<th>Respiratory cases group</th>
<th>Fewer symptoms group</th>
<th>Comparison group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any medication for breathing problems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral steroids</td>
<td>21%</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>Inhaled steroids</td>
<td>19%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Beta-agonists</td>
<td>28%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Any medication or an abnormal lung function test</td>
<td>67%</td>
<td>38%</td>
<td>11%</td>
</tr>
</tbody>
</table>
Poorer quality of life in respiratory cases
Office building study

- General health fair to poor
- Emotional health has limited kind of activity
- Emotional health has limited accomplishment
- Physical health has limited kind of activities
- Physical health has limited accomplishment
- Limited in climbing stairs
- Limited in moderate activity

- Respiratory cases
- Fewer symptoms group
- Comparison group
Allergy skin reactivity
Office building study

Post-occupancy asthma
Pre-occupancy asthma
No reported asthma

Percent skin-prick positive

Grasses
Trees
Ragweed
Roach
Weeds
Dust Mites
Cat
Atopic
Molds

Molds
Ragweed
Weeds
Atopic
Cat
Roach
Dust Mites
Weeds
Trees
Grasses

0 20 40 60 80 100

0 20 40 60 70 80 90 100

Percent skin-prick positive
Fungi and lower respiratory symptoms
Office building study

Odds Ratio (Log Odds Ratio)

-0.14 (-2)  0.37 (-1)  1.00 (0)  2.72 (1)  7.39 (2)  20.09 (3)

- AB_HIGH
- AB_MEDIUM
- Awaken diff. breathing (AB)_LOW
- CP_HIGH
- CP_MEDIUM
- Cough with phlegm (AP)_LOW
- CA_HIGH
- CA_MEDIUM
- Cough attack (CA)_LOW
- SOB_HIGH
- SOB_MEDIUM
- SOB attack (SOB)_LOW
- CT_HIGH
- CT_MEDIUM
- Chest tightness (CT)_LOW
- WZ_HIGH
- WZ_MEDIUM
- Wheeze (WZ)_LOW

Low exposure
Medium exposure
High exposure

(LOWER RESPIRATORY SX)
Endotoxin and lower respiratory symptoms
Office building study

(OFFICE BUILDING)

Wheeze_LOW
MEDIUM
HIGH

Chest tightness_LOW
MEDIUM
HIGH

SOB attacks_LOW
MEDIUM
HIGH

Cough attacks_LOW
MEDIUM
HIGH

Cough with phlegm_LOW
MEDIUM
HIGH

Awaken diff. breathing_LOW
MEDIUM
HIGH

Low exposure
Medium exposure
High exposure

Odds Ratio (Log Odds Ratio)

0.14 (-2) 0.37 (-1) 1.00 (0) 2.72 (1) 7.39 (2) 20.09 (3)
Combined effect of fungal and endotoxin exposures
Office building study

- Symptom: Wheeze, Chest Tightness, Shortness of breath, SOB on Hurrying, Cough with Phlegm

- Odds Ratio:
  - Low fungi/High endotoxin
  - High fungi/Low endotoxin
  - High fungi/High endotoxin

- Combined effect of fungal and endotoxin exposures

- Office building study

- Ratio
## Fungal load (cfu/m² or chair) and lower respiratory illnesses – Office building study

<table>
<thead>
<tr>
<th>Environmental variable</th>
<th>Odd Ratios (95% CI) for different outcome models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Respiratory cases (n=200)</td>
</tr>
<tr>
<td></td>
<td>Floor dust</td>
</tr>
<tr>
<td>Total culturable fungi</td>
<td>1.66** (1.19–2.33)</td>
</tr>
<tr>
<td>Hydrophilic fungi</td>
<td>1.73** (1.20–2.51)</td>
</tr>
<tr>
<td>Fungi not classified as hydrophilic</td>
<td>1.08 (0.79–1.50)</td>
</tr>
<tr>
<td>Yeasts only</td>
<td>1.37* (0.97–1.93)</td>
</tr>
<tr>
<td>Hydrophilic fungi</td>
<td>1.50** (1.18–1.91)</td>
</tr>
<tr>
<td>without yeasts</td>
<td></td>
</tr>
<tr>
<td>Ergosterol</td>
<td>1.56** (1.13–2.16)</td>
</tr>
</tbody>
</table>

** Odds ratios are statistically significant at α=0.05. * Odds ratios are statistically significant at α=0.1.
Post-occupancy asthma reported 2001 – 2007
Office building study

*based on all participants from all surveys (n=1,494)
Lack of respiratory improvement following remediation efforts – Office building study

• Paired pulmonary function and questionnaire data from 2002 and 2005 for 97 employees

• No overall improvement in respiratory health
  – Symptom scores
  – Medication
  – Lung function
  – Sick leave
Some improvement with relocation
Office building study

- Respiratory cases relocated in the building had a decrease in medication use and sick leave in 2005
Conclusions
Office building study

• This water-damaged building associated with new-onset asthma
• Personal, social, and economic burden on both employees and employers
• Evidence suggests that adverse health outcomes may not reverse at all after remediation (or reverse slowly)
• Increased public health and policy attention warranted for building-related respiratory disease
Conclusions (continued)
Office building study

• Assessing exposure to both fungi and endotoxin appears important

• Ergosterol and hydrophilic (water-loving) fungi are useful markers of health risk in damp buildings
Water-damaged homes six months after hurricane Katrina – New Orleans, 2006
Health effects of exposure to water-damaged homes six months after hurricane Katrina – New Orleans, March 2006
Aims – New Orleans study

• Determine the relationship between exposure to water-damaged homes and respiratory symptoms
• Assess the effect of use of respiratory protection on respiratory symptoms
Respiratory symptom prevalence
New Orleans study

- Nasal
- Sinus
- Throat
- Wheezing
- Chest tightness
- Shortness of breath
- Cough

Moderate/severe
Mild
Symptom scores by exposure
New Orleans study

Upper Respiratory
Lower Respiratory
Overall Respiratory

Exposure 0
Exposure 1
Exposure 2
Exposure 3
Exposure 4

*p < 0.05 for test of linear effect
### Odds ratios for lower respiratory exacerbation
#### New Orleans study

<table>
<thead>
<tr>
<th>Protection Type</th>
<th>Mild</th>
<th>Mod/Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mask only (vs. no protection)</td>
<td>1.51</td>
<td>0.52</td>
</tr>
<tr>
<td>Any respirator (vs. no respirator)</td>
<td>0.42*</td>
<td>0.47*</td>
</tr>
<tr>
<td>N95 respirator only (vs. no respirator)</td>
<td>0.57</td>
<td>0.33*</td>
</tr>
</tbody>
</table>

* *p < 0.05

Adjusted for age, sex, race, smoking, atopy, still participating in clean-up, exposure
Recommendations
New Orleans study

• Educate the public that:
  – Exposure to water-damaged homes is associated with respiratory symptoms, regardless of activity
  – Respirators, but not masks, have a protective effect against symptoms

• Encourage the distribution of respirators rather than masks
Visual contrast sensitivity
Visual contrast sensitivity

• Visual contrast sensitivity testing has been used in studies of exposure to neurotoxins (e.g., mercury, organic solvents).

• Currently, its usefulness in investigations of mold-exposed populations in indoor environments is not well understood.
**Visual contrast sensitivity chart**

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Functional Acuity Contrast Test**

- **A**
- **B**
- **C**
- **D**
- **E**

**Right** **Up** **Left**

---

F.A.C.T. STEREO OPTICAL CO., INC.
2030 North Avenue
Chicago, Illinois 60641
1-800-346-0000
T LI: 773-777-9880
FAX: 773-777-4385

Contrast Vision Test
Developed by Arthur P. Ginsburg, Ph.D.
Licensed under U.S. Patent #4,585,873
and #5,414,475 by Viametro Corp.
Copyright 1993, Viametro Corp.
Visual contrast sensitivity testing
Visual contrast sensitivity testing result
Water-damaged and comparison schools, 2005 and 2006

• Health Hazard Evaluation
  – Water-damaged school in New Orleans
  – Comparison school in Ohio

• Staff at water-damaged school
  – higher symptoms prevalences
  – lower visual contrast sensitivity across all spatial frequencies

Ongoing water-damaged and comparison school study, 2010

• 2 schools in New England
  – Suburban district, about 1 mile apart
  – High socio-economic area

• May and August 2010
  – Questionnaire survey
  – Lung function testing
  – Visual acuity testing
  – Visual contrast sensitivity testing
Take-home messages
Take-home messages

- Building-related lung disease exists
- Cases are sentinels for co-worker risk
- Physicians should explore patient history for exposure to indoor damp environments
- There are consistent associations between health effects and markers of dampness and mold
- Public health actions might best rely on signs of dampness
- There is reason to prevent adverse health effects by early remediation of dampness
I know there's water here somewhere.