

# **Health Implications of Moisture in Homes and What to Do About Them**

## **National Center for Healthy Homes Seminar**

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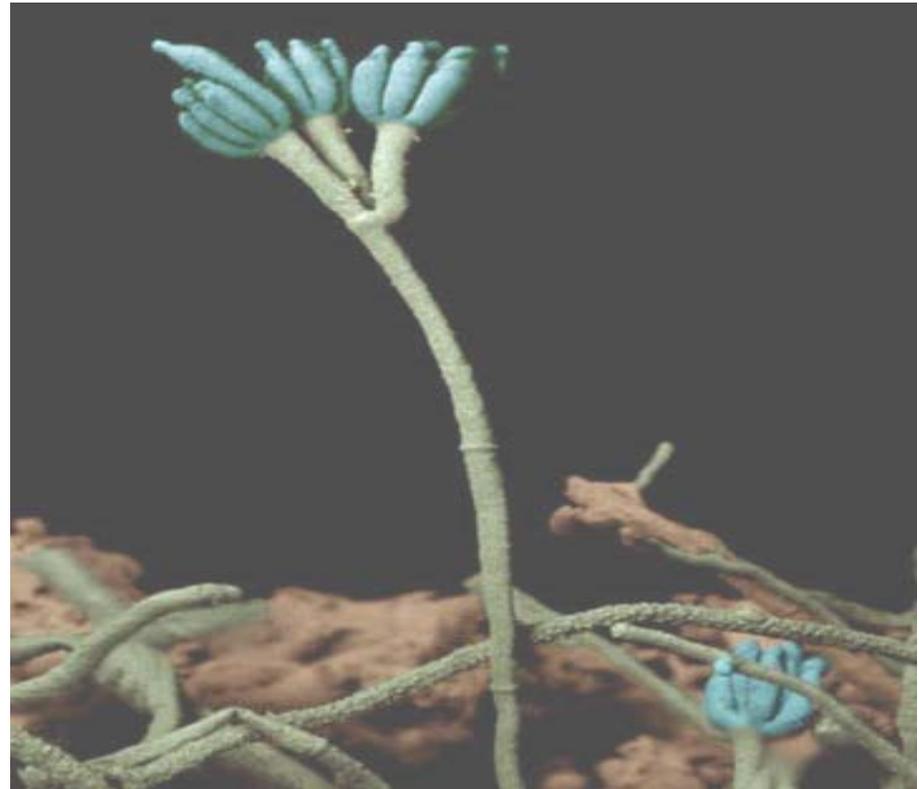
# Early Concerns About Mold

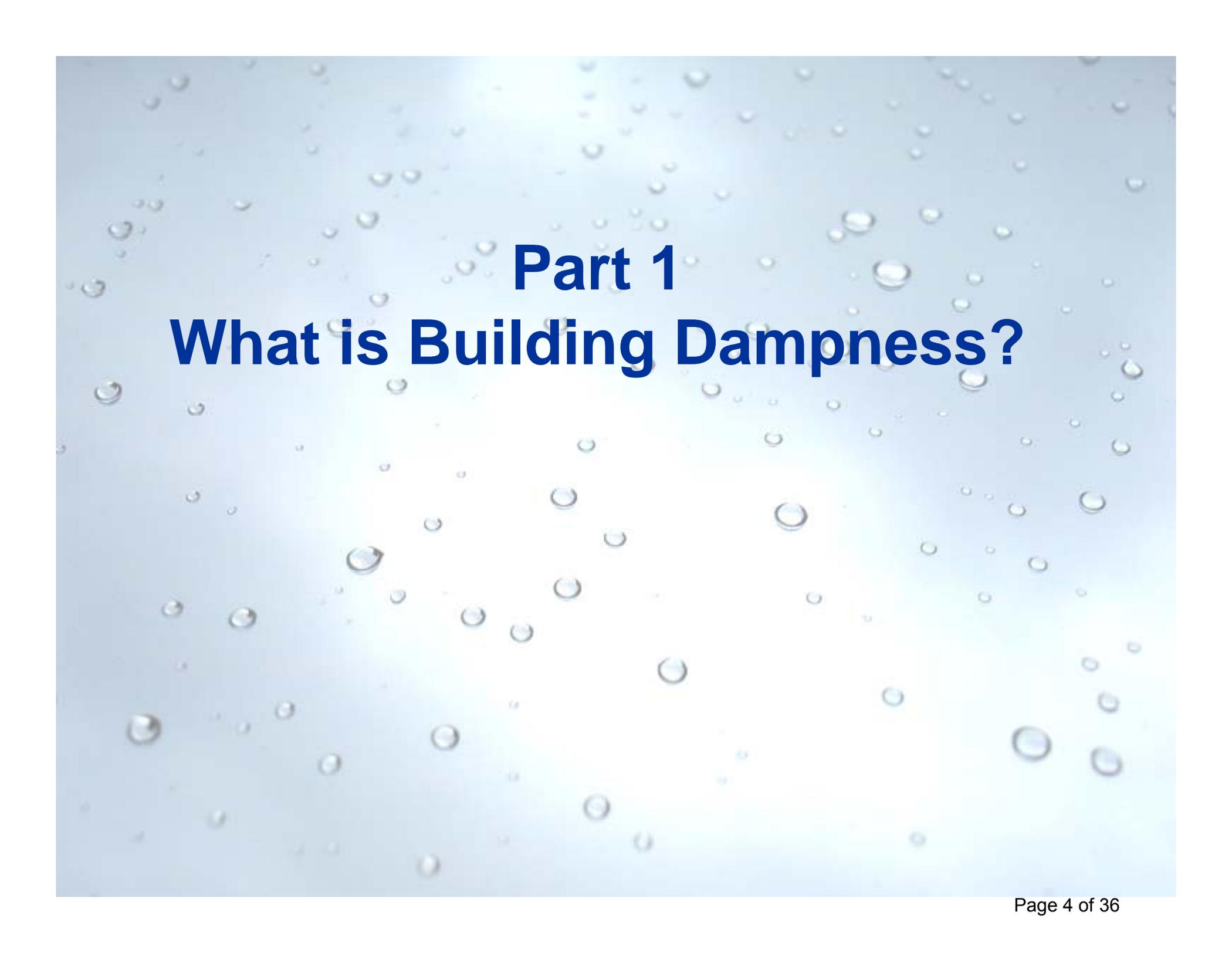
## Leviticus, Chapter 14:

“On the seventh day, the priest shall return to inspect the house. If the mildew has spread on the walls, he is to order that the contaminated stones be torn out and thrown into an unclean place outside of town. If the mildew reappears in the house after the stones have been torn out and the house is scraped and plastered, it is a destructive mildew and the house is unclean. It must be torn down—its stones, timbers and all plaster—and taken out of town.”

# Presentation Overview

- ❑ What is building dampness?
- ❑ What aspects of health are affected by dampness in homes?
- ❑ How large are the effects?
  - ❑ **Health**
  - ❑ **Economics**
- ❑ Are remediations effective?
- ❑ Does dampness at work or at schools affect health?
- ❑ Is dampness in air conditioning systems a risk?
- ❑ Prevention and remediation





# **Part 1**

## **What is Building Dampness?**

# Dampness is Multifaceted

## Signs of dampness

- Standing water, wet surfaces, moisture stains, material damage, visible mold, mold odors, high humidity
- No widely accepted criteria for a problem damp building

## Sources of dampness

- Leaky walls or roofs, plumbing leaks, floods, groundwater entry, capillary water transport, vapor condensation, wet construction materials, indoor evaporation, outdoor air & inadequate dehumidification, air conditioning cooling coils

## Locations of dampness

- Interior surfaces, wall cavities, crawl spaces, attics, HVAC systems

# Exposures Associated With Building Dampness

## Molds and bacteria (many types)

- Spores a few micrometers in size, bacterial cells, microbial fragments sometimes less than one micrometer
  - may carry allergens, inflammatory agents, toxins
  - settling and resuspension → inhalation exposures
- Microbial volatile organic compounds → odors

## Chemicals

- Formaldehyde
- Alcohols and products of degradation of plasticizers
  - Damp concrete and PVC flooring

## House dust mites

- Survival depends on sufficient indoor humidity

## Cockroach

# From Dampness to Microbial Growth

Microbial growth requires a damp substrate

- Moisture at surfaces is key

Surface characteristics are important

- Easily biodegradable materials are more readily colonized
- Almost any damp surface can become sufficiently soiled to support microbial growth

Time is important

- Slow drying → more chance of serious growth



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# Building Dampness is Common

<b>Author</b>	<b>Location</b>	<b>Population</b>	<b>Mold or mildew</b>	<b>Water damage or dampness</b>	<b>Any dampness or mold</b>
Spengler 1994	24 Cities in US & Canada	12,842 homes	36%	24%	50%
Mendell 2002	US Cities	100 offices		43% (current) 85% (past)	
RTI 2003	California	1181 classrooms	11%	43%	



**Part 2**  
**What Are the Health Effects of  
Dampness and Mold?**

**Results of a Review by the  
National Academy of Science,  
Institute of Medicine (IOM)**

# Upper Respiratory Track (URT) Symptoms

## Description

- Nasal congestion, nasal irritation, runny nose
- Throat irritation, sore throat
- Hay fever like symptoms

## IOM Findings

- Increased URT symptoms are associated with dampness
- Increased URT symptoms are associated with mold

What does “associated” mean?

- Correlated in numerous quality studies
- Statistically significant
- Studies controlled for anticipated confounding

# IOM Findings: Other Respiratory Symptoms

## Symptom

- Wheeze → breathing sound often from restricted or labored breathing
- Cough
- Shortness of breath (dyspnea)

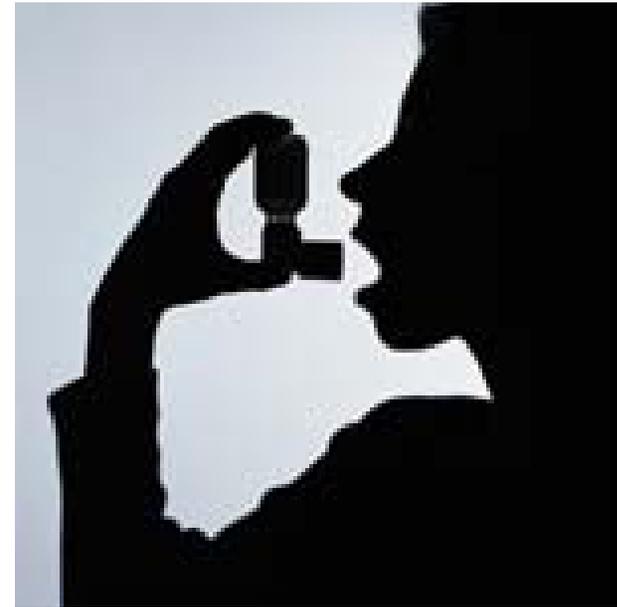
## IOM Findings

- Increased wheeze is associated with dampness
- Increased cough & wheeze are associated with mold
- Limited or suggestive evidence that increased shortness of breath is associated with dampness

# IOM Findings: Asthma

## Description

- ❑ Chronic disease of 6-7% of population, airway inflammation and normally episodic symptoms of wheezing, breathlessness, chest tightness, cough
- ❑ 2 million emergency room visits and 0.5 million hospitalizations per year in US
- ❑ 5000 deaths per year
- ❑ Annual ~\$17 billion annual cost



## IOM Findings

### Asthma exacerbation

- ❑ Increased asthma exacerbation is associated with dampness & with mold

### Asthma development

- ❑ Limited or suggestive evidence that asthma development is associated with dampness

# Hypersensitivity Pneumonitis (HP)

## Description

- Lung disease from exposure to organic dusts
- Cough, shortness of breath, fever several hours after exposure
- Only small portion of population appear to manifest disease after exposure



## IOM Findings

- HP is associated with mold and bacteria in damp buildings – in susceptible individuals

# Respiratory Infections



## Description

- Fungi can infect the respiratory system of immune compromised individuals
- In individuals with normal immune function, prevalence of normal respiratory illnesses might be affected by mold exposures
  - **Animal and cellular studies suggest potential immune system suppression**

## IOM Findings

- In severely immunocompromised persons, exposure to indoor molds (*Aspergillus*) can lead to severe respiratory infections
- In otherwise healthy children, there is limited or suggestive evidence of an association of respiratory illnesses with building dampness or mold

# Pulmonary Hemorrhage or Hemosiderosis

## Description

- ❑ Bleeding or hemorrhage in lungs, mostly in infants
- ❑ In 1993/1994, a cluster of pulmonary hemorrhage in eight infants from Cleveland was initially linked to exposure to the molds (*Stachybotrys chartarum*)
- ❑ Follow up review by CDC found that *Stachybotrys chartarum* was not clearly associated with acute pulmonary hemorrhage in infants

## IOM Findings

- ❑ Available data (very limited), are inadequate to determine whether pulmonary hemorrhage in infants is associated with *Stachybotrys chartarum*, dampness, or other mold

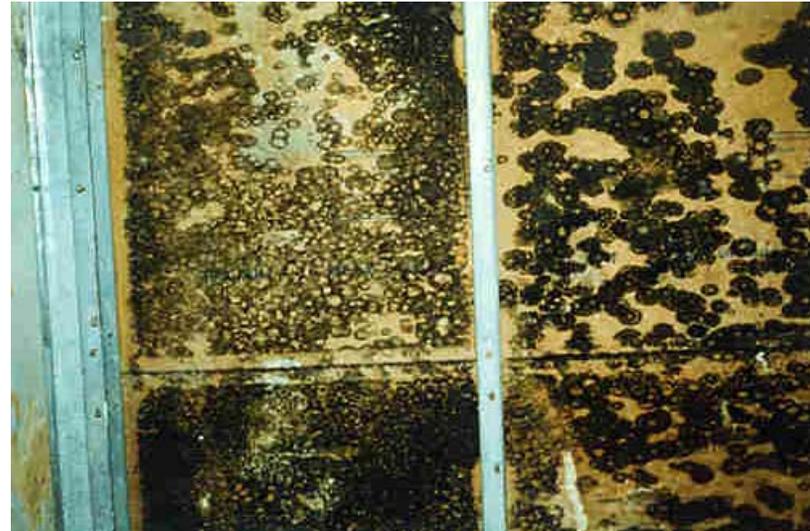
# Other IOM Findings about Health Effects of Indoor Dampness and Mold

There is inadequate evidence to determine whether dampness or mold in buildings is associated with:

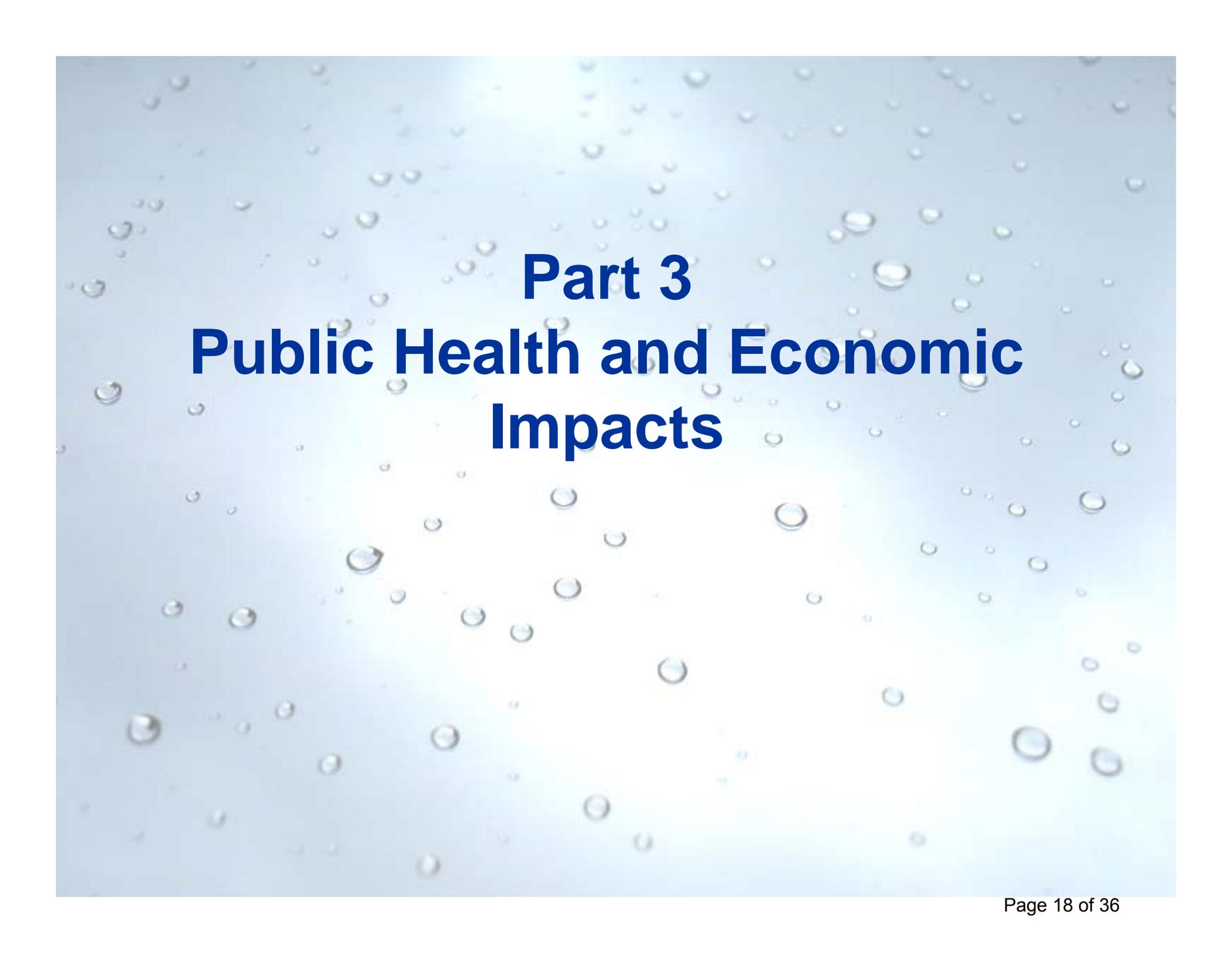
- Skin symptoms
- Gastrointestinal tract problems
- Fatigue
- Cancer
- Reproductive effects
- Rheumatologic and other immune diseases

# Toxic Molds: IOM Conclusions

- Some molds (and bacteria) that grow indoors can produce potent toxins
- Animal and cell studies have demonstrated adverse effects (immunologic, neurologic, respiratory, and dermal)



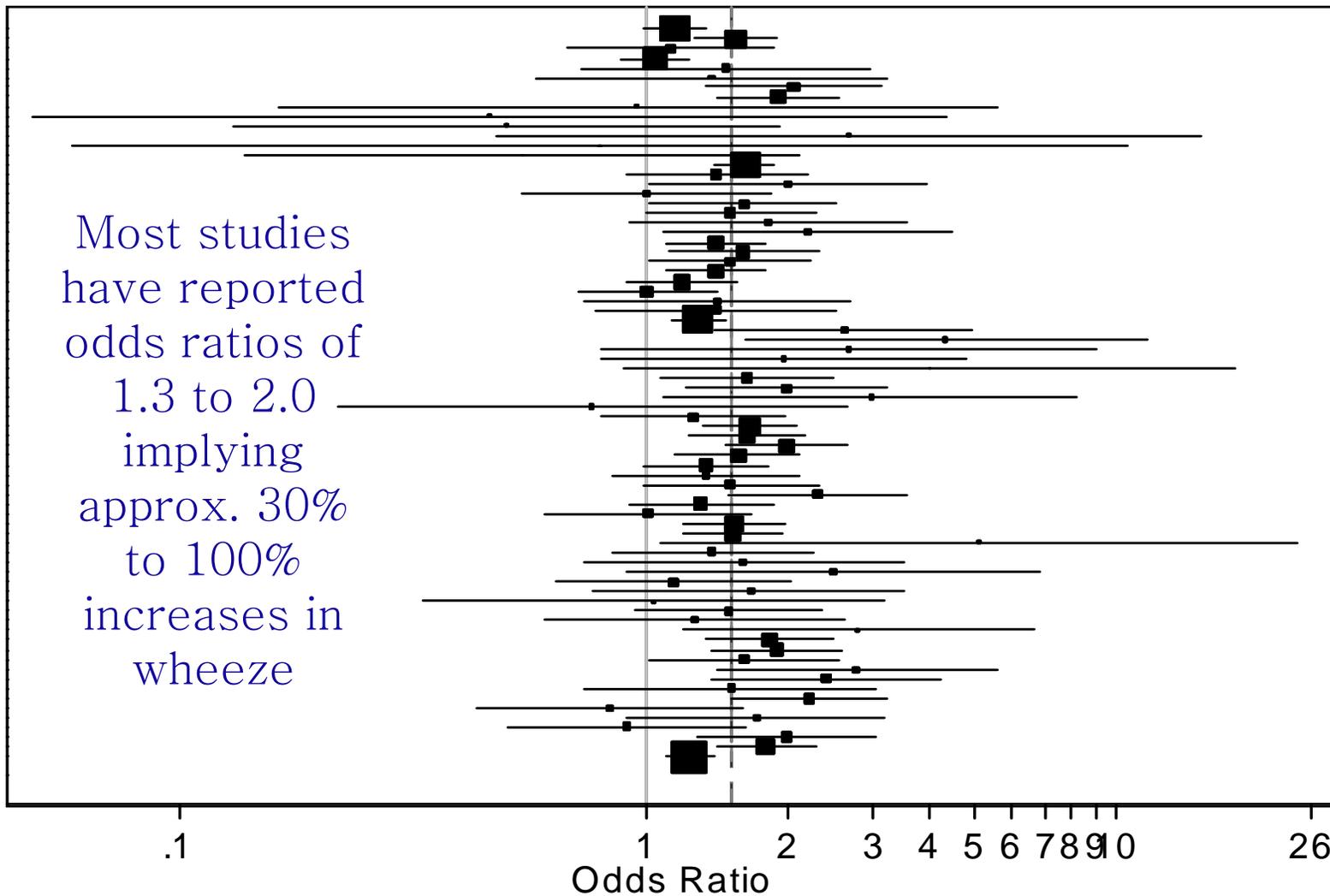
- Magnitude of people's exposures to mold toxins in damp buildings is unknown
- Dose required to cause health effects in people is unknown



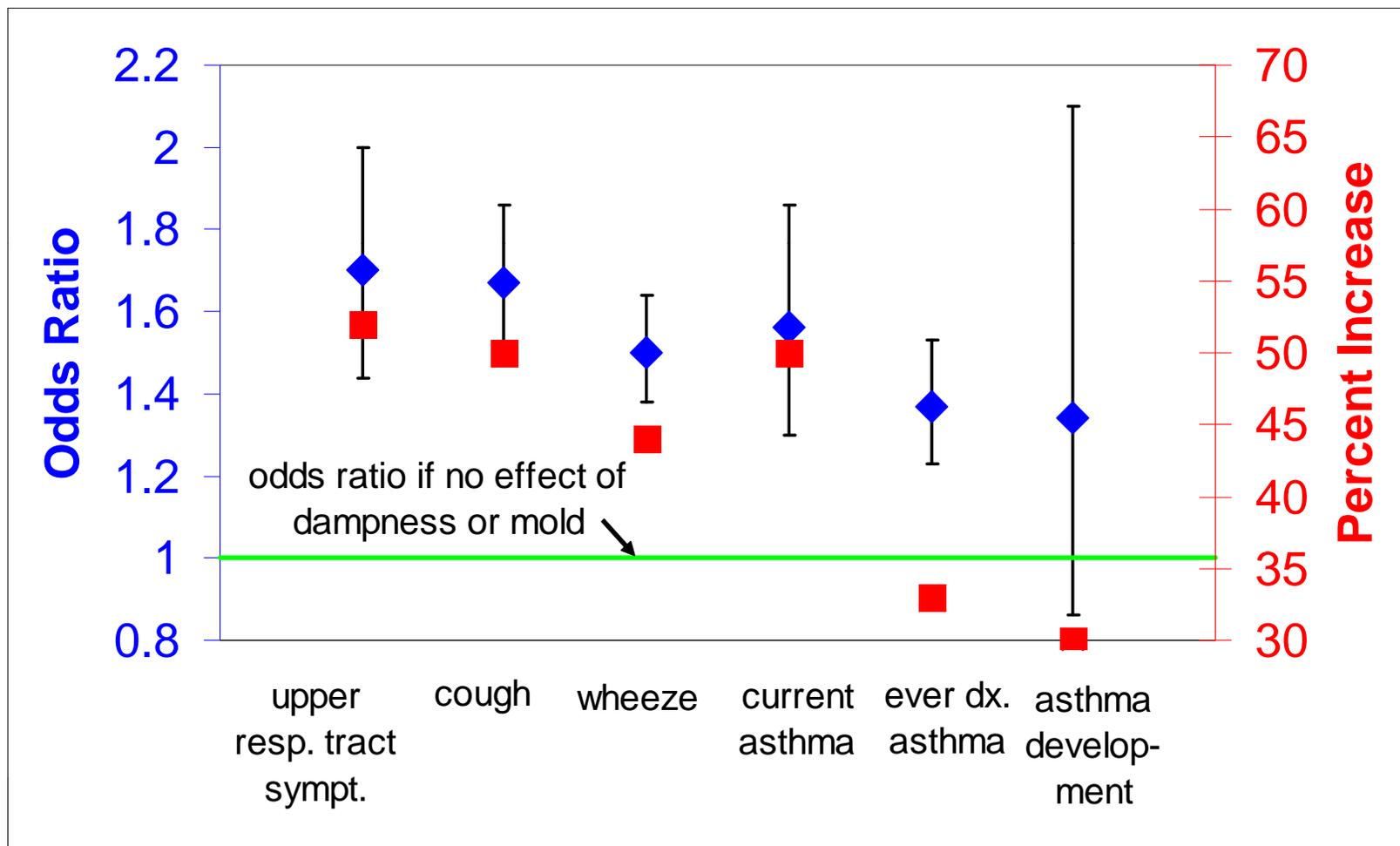
# **Part 3**

## **Public Health and Economic Impacts**

## Example of Available Data -- Associations of wheeze with dampness or mold



# Quantifying the Health Risk – Results: Results of a Meta Analysis\*



\* Fisk et al. (2007) Indoor Air 17: 284-295

# Estimated Public Health Impact of Dampness and Mold in U.S. Houses

4.6 (2.9 – 6.3) million cases  
of current asthma  
12% to 29% of all cases

## Issues

- Additional types of health effects
- Range does not reflect uncertainty in dampness and mold prevalence
- Correlation versus causation

\*Mudarri and Fisk (2007) Indoor Air 17: 226–235

# Estimated Cost of Current Asthma Attributable to Dampness and Mold\*

Fraction of current asthma cases in US attributable to dampness or mold in homes  
0.21 (0.12 – 0.29)

Total annual cost of asthma cases in US (\$16.8 B)

•Health care \$12.2 B

•Productivity loss \$1.0 B

US annual cost of asthma attributable to dampness or mold in homes  
**\$3.5B (\$2.1 – \$4.8B)**

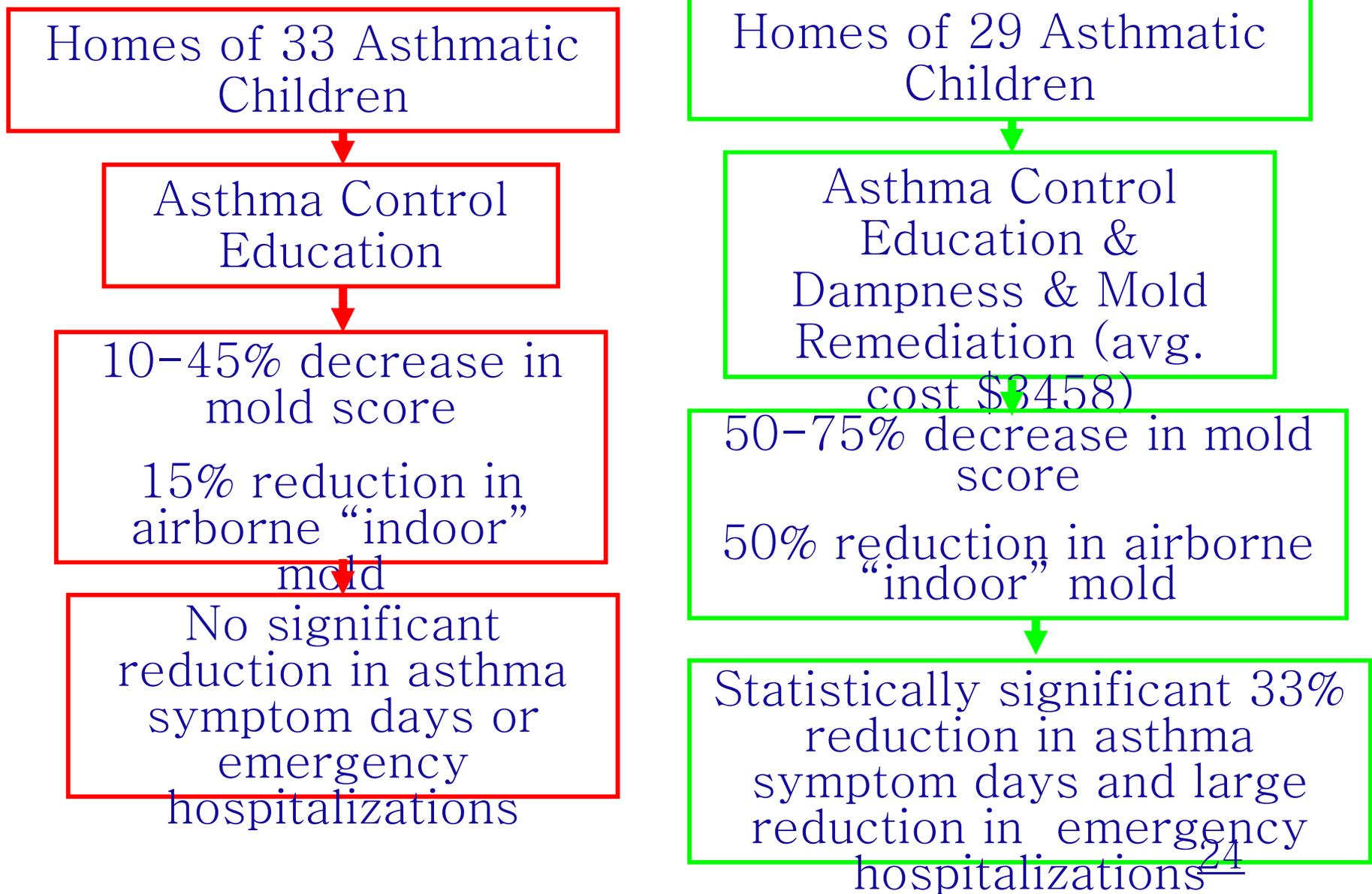
\*Mudarri and Fisk (2007) Indoor Air 17: 226–235



**Part 4**  
**Does Home Dampness and  
Mold Remediation Improve  
Health?**

# Does Dampness & Mold Remediation Help?

Kerscmar et al. (2006) Environmental Health Perspectives 114: 1574-1580



# Does Mold Remediation Help?

Burrr et al. (2007) Thorax 62: 767-772

68 Homes of 95  
Asthmatics

Mold removed,  
Fungicide, Fan installed  
in loft

63 Homes of 87  
Asthmatics

No intervention (for  
12 months)

In Remediated Houses

6 months

Statistically significant 25% larger improvement in wheeze, 52% larger perceived improvement in breathing, 59% perceived reduction in medication, no larger improvement in peak flow

12 months

Larger reduction in medication use, 25% larger improvement in runny nose, 20% larger improvement in runny nose + eye irritation, no larger improvement in peak flow

# Do Residential Indoor Humidity Control Measures Reduce the Risks of House Dust Mites?

## Increased Ventilation (7 studies)

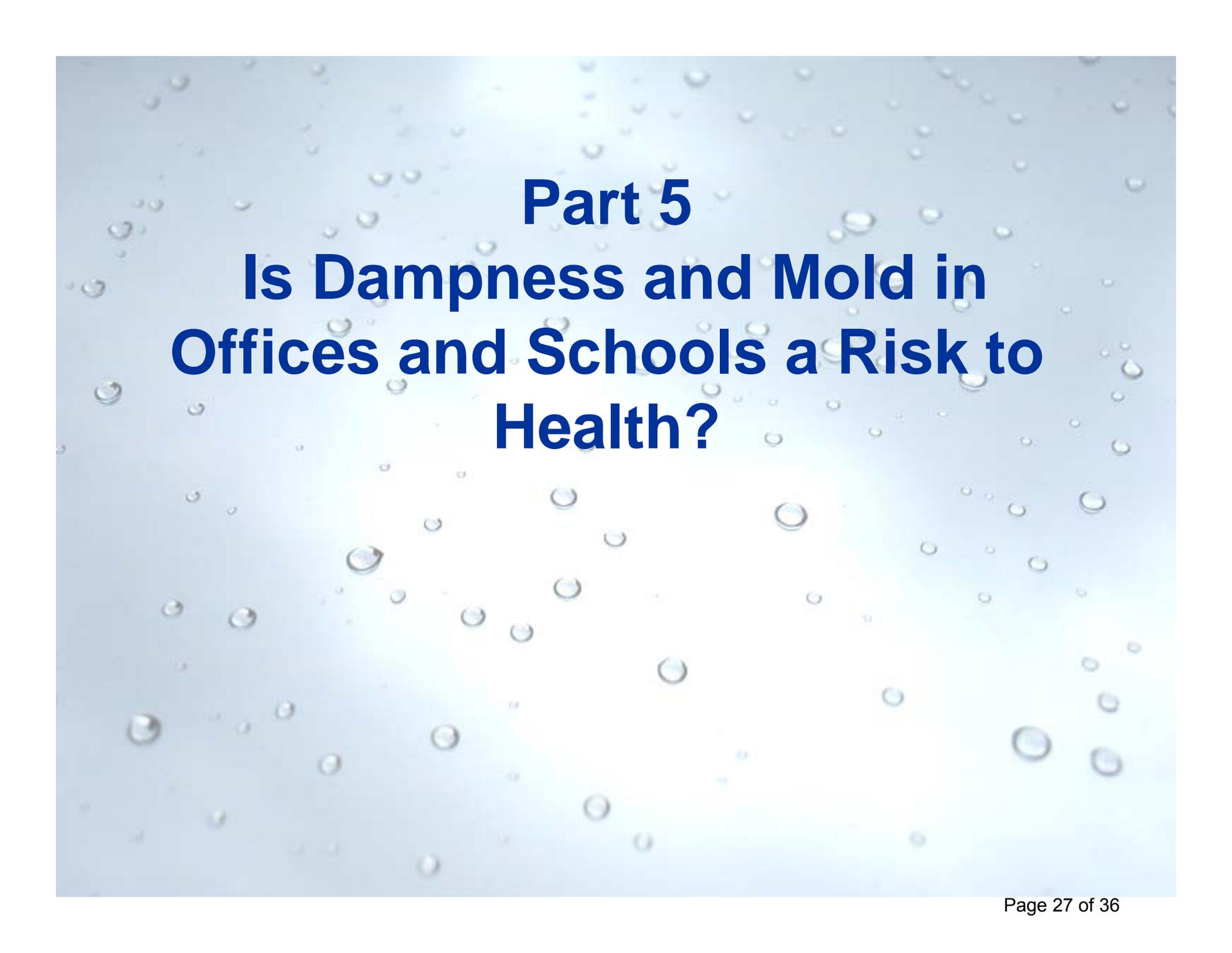
- Decreased mite allergen (3 studies)
- No decrease in mite allergen (4 studies)
- Often failed to keep RH < 50%

## Dehumidifiers (3 studies)

- Decreased mite allergen (1 study)
- No decrease in mite allergen (1 studies)
- Decrease in mite allergen only if RH < 50% (1 study)

## Health Benefits (3 studies)

- Some health benefits (2 studies)
  - But both studies included other mitigation measure
- No health benefits (1 study)



**Part 5**  
**Is Dampness and Mold in  
Offices and Schools a Risk to  
Health?**

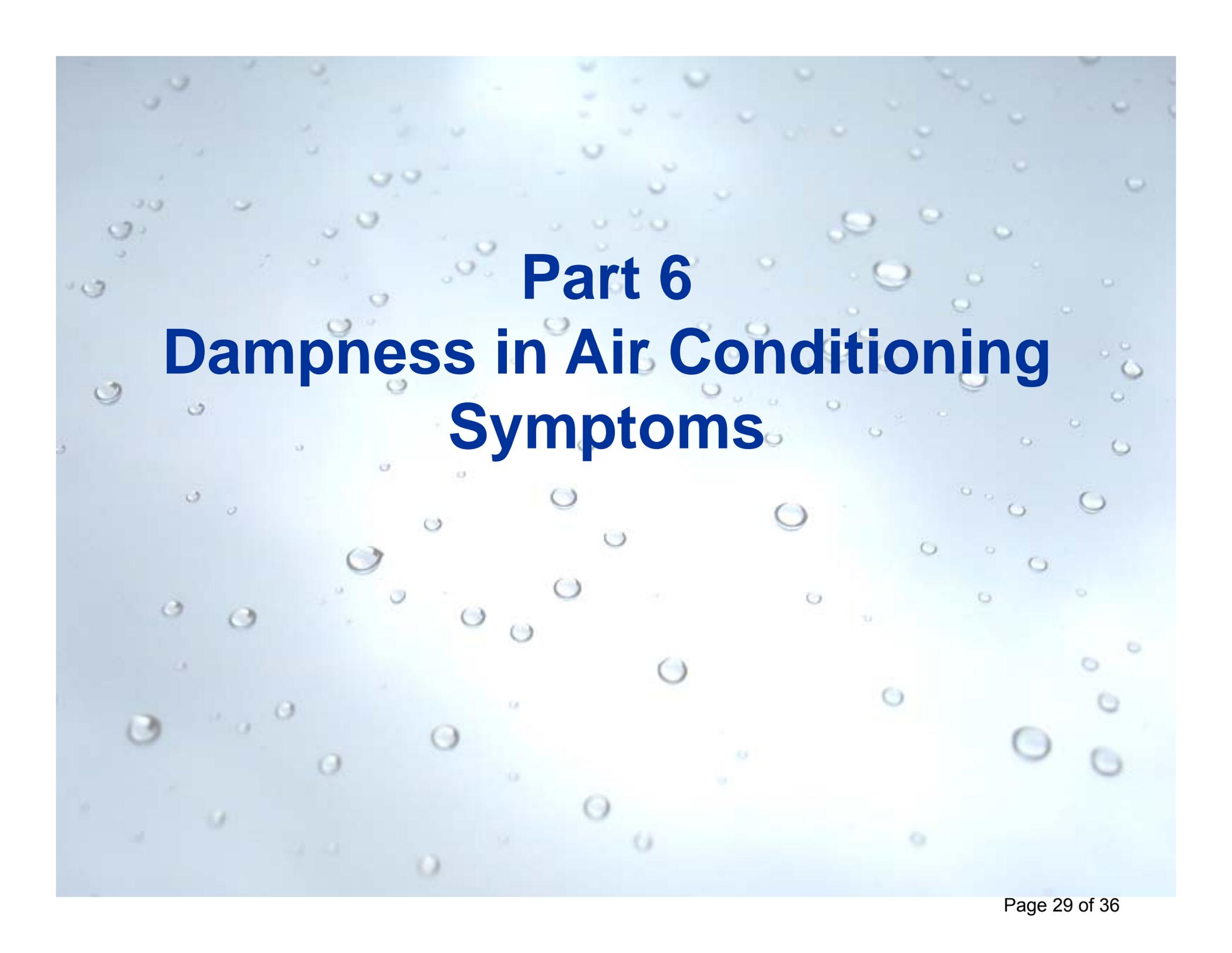
# Offices and Schools: A Synopsis of the Available Literature (as of 2007)

## Offices

- 8 studies published in journals
- Every study found a statistically significant increase in at least 1 health effect
- In several studies, risk increased > 100%

## Schools

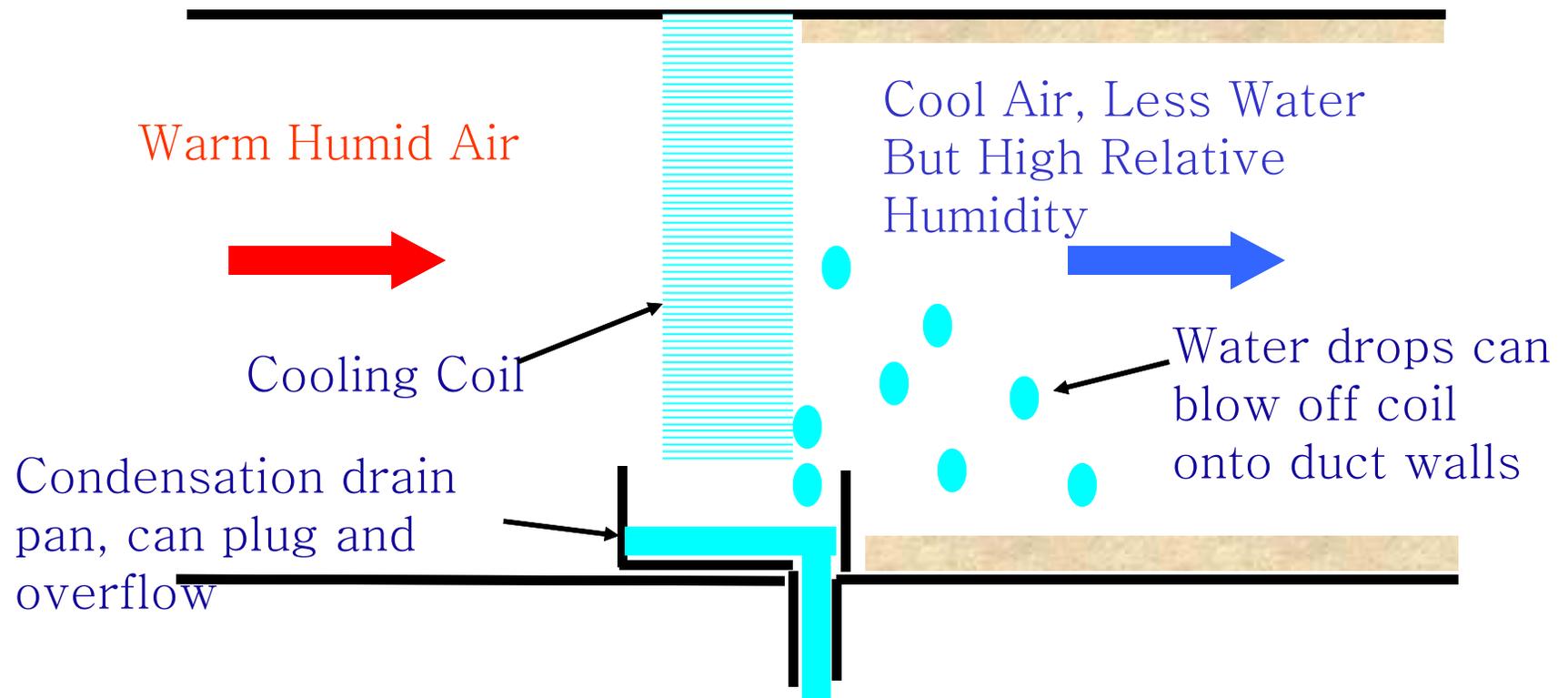
- 14 studies published in journals
- Most studies small in size – some have weak study designs
- Most studies reported statistically significant increases in some health effects



# **Part 6**

## **Dampness in Air Conditioning Symptoms**

# Illustration of Dampness Inside Air Conditioning Systems\*



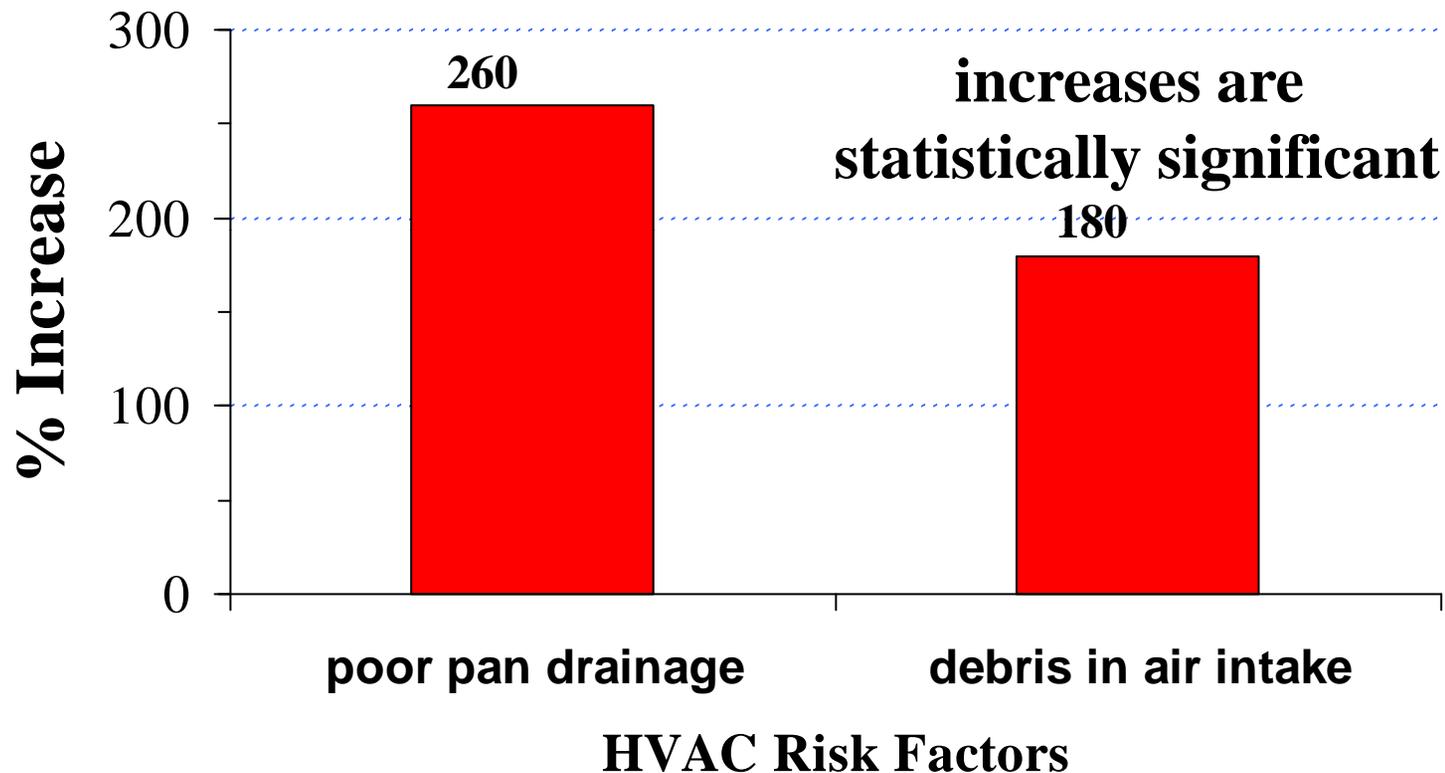
\*Also, rain, fog, or snow can be drawn into AC system with outdoor :

# Dampness in Air Conditioning (AC) Systems: What is Known

- Microbial contamination in AC systems is common
- AC increases risks of respiratory or other health symptoms
  - In 16 of 17 office building studies, typically 30% to 100% increase in symptoms with AC
  - In European study of 19,000 homes, 30% more wheeze, 46% more current asthma
  - In US study of 13,000 homes, 14% more lower respiratory symptoms, 28% more bronchitis symptoms
  - But not certain that dampness and mold causes the increased symptoms



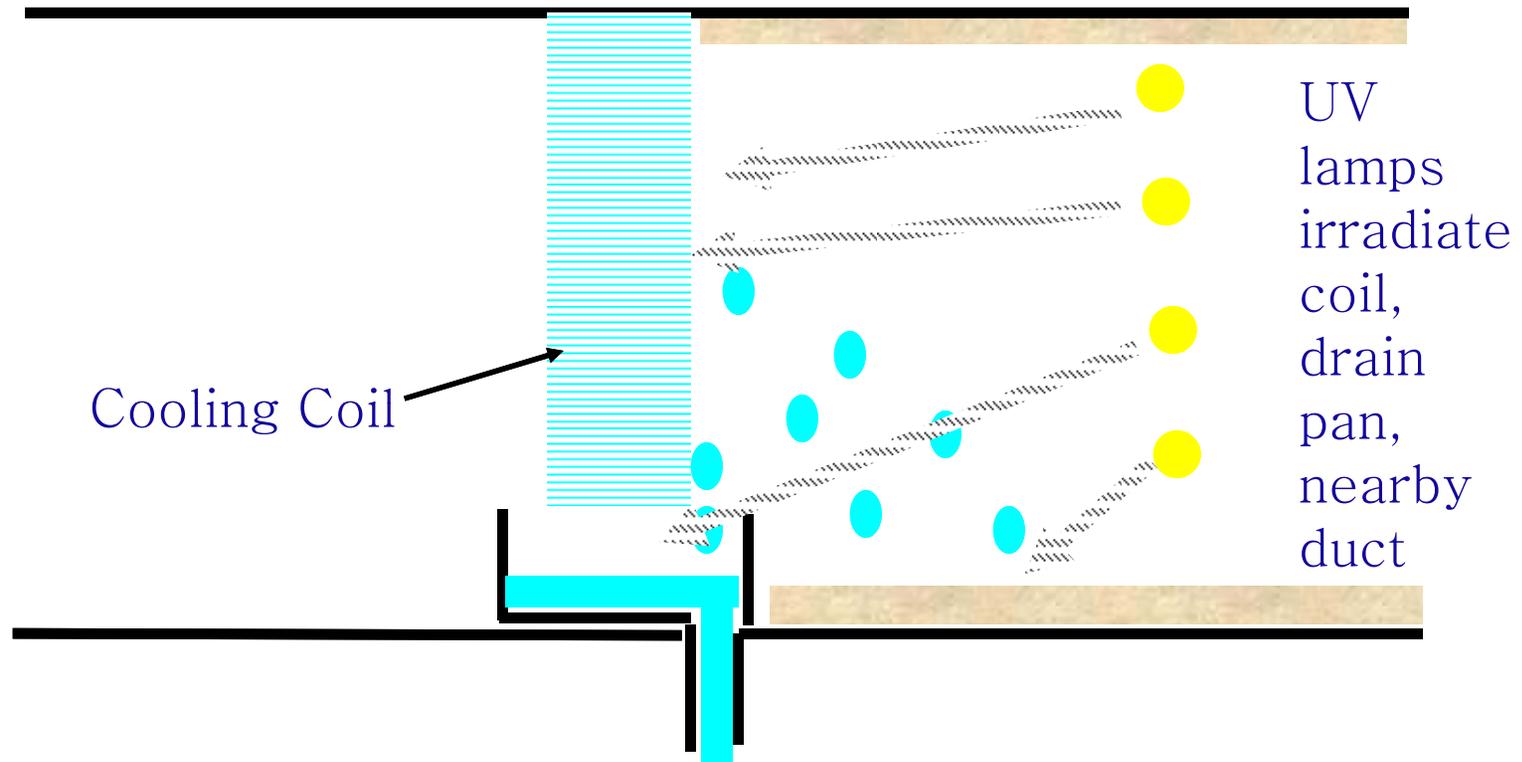
# Increase in Asthma-like Respiratory Symptoms\* with Evidence of HVAC Contamination in 80 Complaint Buildings



\* wheeze, shortness of breath, cough

Source: Mendell et al. 2003

# Ultraviolet Germicidal Irradiation of Cooling Coils and Drain Pans

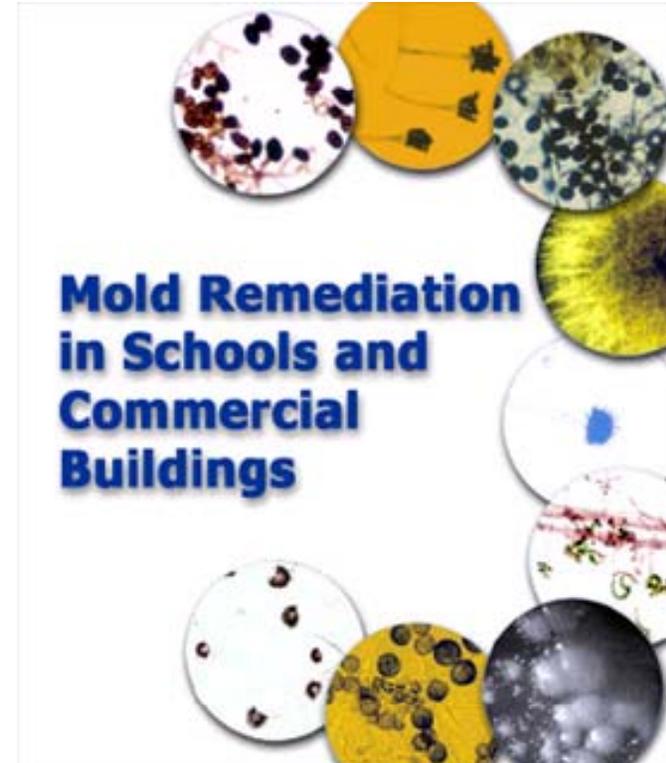


- ❑ UV irradiation can dramatically reduce microbial growth on coils, pans, ducts
- ❑ In single health study performed (Menzies 2003) , UV reduced respiratory symptoms by 40% (10% to 60%), and mucosal symptoms by 30% (10% to 50%)
- ❑ May be energy savings

# Prevention and Remediation

## A Few Key Points

- Better building design, construction, operation, and maintenance is the key long term solution
  - Much existing guidance exists
  - Are many barriers to implementation
- When microbial contamination is present, it should be eliminated
  - Solve the moisture problem
  - Remove or clean contaminated surfaces
  - Use respiratory protection (except with small problems)
  - Apply the widely available remediation guidance



- Other reasons to reduce dampness problems
  - Reduced structural damage
  - Energy savings from dry insulation

# Take Home Messages

- Dampness and mold are common
- Excessive building dampness is a public health problem → substantial morbidity and cost
- When microbial contamination is present, it should be eliminated
  - **must address the source of dampness**
- Better building design, construction, operation and maintenance are the key to reducing dampness
  - **Much existing knowledge is underutilized**

in the  
Bible



Missing  
from  
Bible



# For More Information

- **National Academy of Sciences Review**  
[www.nap.edu](http://www.nap.edu) (search for “damp”)
- **US EPA web site** [www.epa.gov/mold](http://www.epa.gov/mold)
- **IAQ Scientific Findings Resource Bank website**  
[www.iaqscience.lbl.gov](http://www.iaqscience.lbl.gov)
- **Indoor Air Journal: vol 17: 226-235; and vol 17: 285-295**
- **Guidance on residential building envelope design by climate**  
<http://buildingscience.com/designsthatwork/>
- **Guidance for commercial building design at Canadian Mortgage and Housing Corporation “Best Practice Guides”** <http://www.cmhc-schl.gc.ca/en/>