Do Mold Remediation Chemical Products Provide Long-Term Protection Against Mold Growth?

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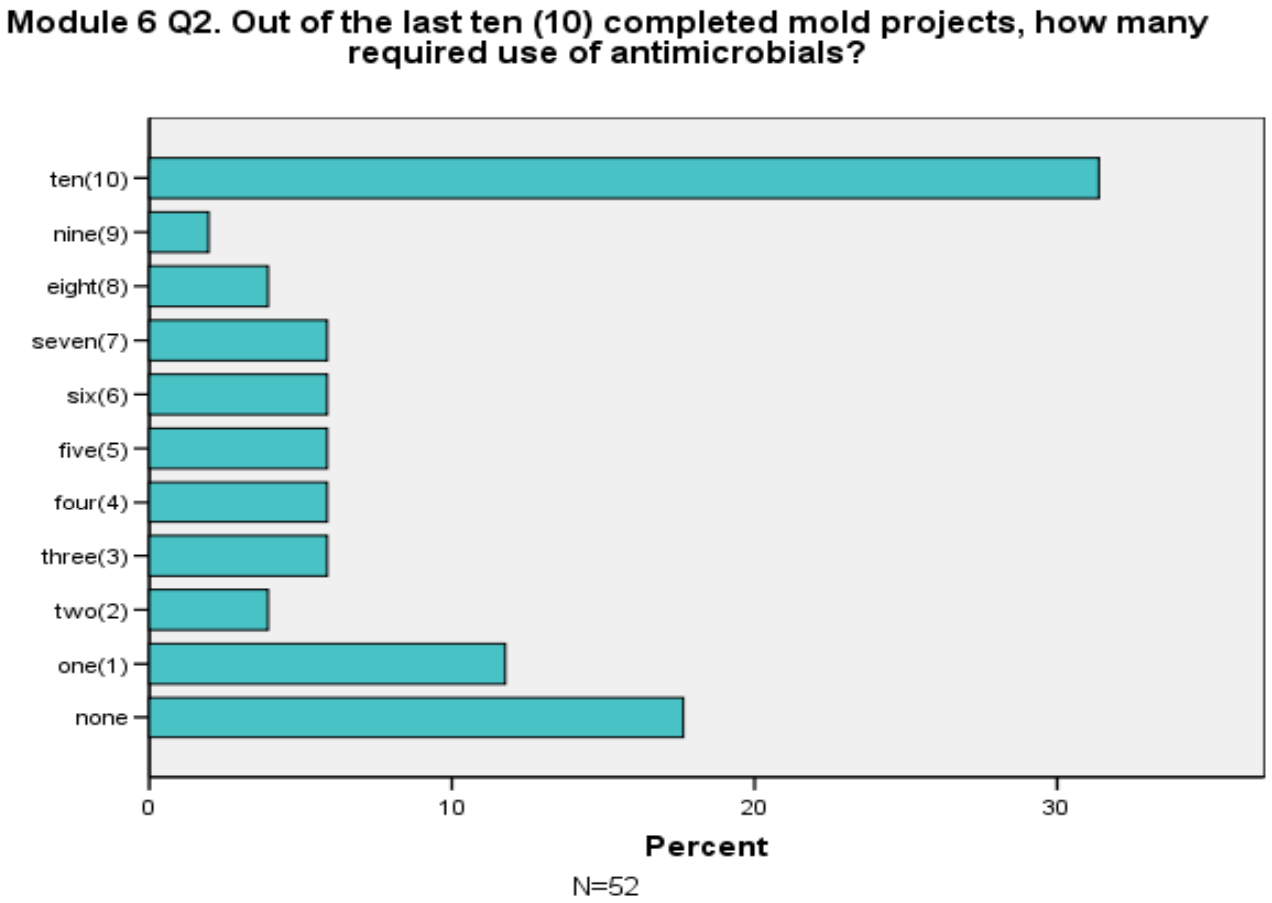
How common is chemical product use in mold remediation industry?

(MOLHH0137-05)



Top 6 Reasons Given for Chemical Application

(MOLHH0137-05)

1. To accommodate client request (80%)
2. To treat inaccessible building spaces (78%)
3. To prevent further microbial growth
4. Incursion of non-potable or contaminated water (65%)
5. To control odor (63%)
6. Response delayed by > 48-72 hrs. (59%)

(N=49)

Antimicrobial Pesticides (EPA) against fungi colonizing moist building substrates

- Expected to work against a variety of fungi
- Mechanism of action not always known or fully understood
- Differences in fungal susceptibility over time

Short and Long-term Fungicidal Activities of Mold Remediation Chemicals

(HUD:MOLHH0167-08)

Outcomes Studied

- Control of existing fungal growth
- Prevention of fungal growth

Test Products

- Antimicrobial formulations - Disinfectant, Sanitizer, Mold Cleaner, Fungicide (10)
- Antimicrobial coatings – fungal growth inhibitors (5)
- Household bleach

Why Test Bleach (Sodium hypochlorite)?

- Recommended "*to clean visible mold on walls, floors and ceiling as directed.…*" by American College of Allergy, Asthma, and Immunology http://www.acaai.org/allergist/liv_man/home/Pages/mold_spores.aspx)

- Commercially recommended for disinfection/sanitization of hard non-porous surfaces

- Updated guidelines from government agencies do not promote use of bleach for mold mitigation (OSHA, EPA)

Why Test Bleach?

Residential cleaning with bleach

- Lowers incidence of asthma & eczema in children (Nickmilder et al. Pediatr Allergy Immunology 2007; 18:27-35)
- Increases quality of life (Barnes et al., Allergy Asthma Proc 2008; 29; 197-204) and improved asthma-related health outcomes (Barnes et al., Ann Allergy Asthma and Immunol. 2008; 101; 551-552)

AND

- Bleach denatures fungal, cat, mouse, and cedar pollen allergens

Selection of Test Formulations

- EPA-registered
- Available for use in mold remediation and/or water damage restoration situations
- Recommended for use on a variety of interior surfaces

  based on information available at the manufacturers' and/or distributers' website, product label, and/or technical data sheet

Today's Presentation

Formulations

- Quaternary Ammonium Compounds vs. household bleach
- Antimicrobial Coatings

Methods

1. Suspension test
2. Carrier Tests

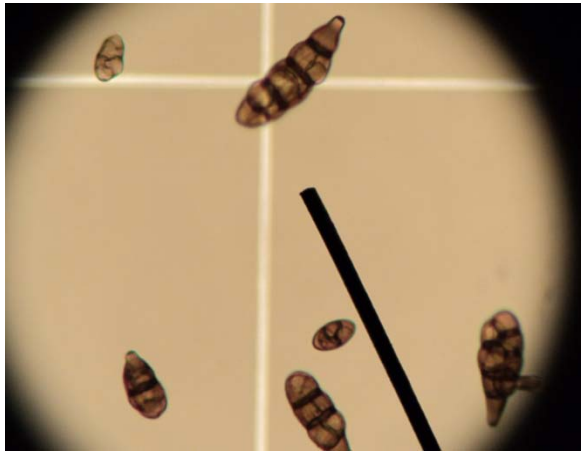
Quaternary Ammonium Compounds (QUATs)

Product	Stated Function	Target Surfaces (MSDS,TDS or PDS)
QUAT 1	Disinfectant	Mold and microbial contaminated impacted materials of varied permeability
QUAT 2	Disinfectant, Sanitizer, Cleaner, Fungicide	Disinfectant for hard surfaces but a sanitizer for semi-porous and porous materials
QUAT 3	Disinfectant, Sanitizer, Cleaner, Fungicide	Hard nonporous or washable surfaces

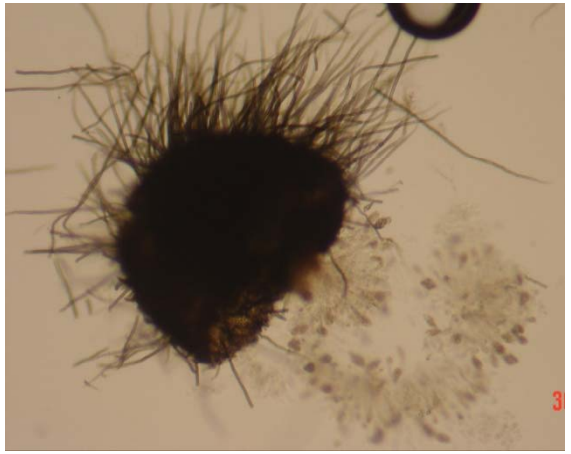
Test Formulations

Product	Active Ingredients	Concentration
QUAT 1	Octyl Decyl Dimethyl Ammonium Chloride (0.025%) Dioctyl Dimethyl Ammonium Chloride (0.01%) Didecyl Dimethyl Ammonium Chloride (0.015%) Alkyl Dimethyl Benzyl Benzyl Ammonium Chloride (0.034%)	Ready to Use
QUAT 2	Dimethyl Benzyl Ammonium Chloride (<2.25%) Dimethyl Ethyl Benzyl Ammonium Chloride (<2.25%)	1:64 Dilution
QUAT 3	Dimethyl Benzyl Ammonium Chloride (3.3%) Alkyl Dimethyl Benzyl Ammonium Chloride (2.2%)	1:4 Dilution
Bleach	Sodium hypochlorite (6%)	1:10 Dilution

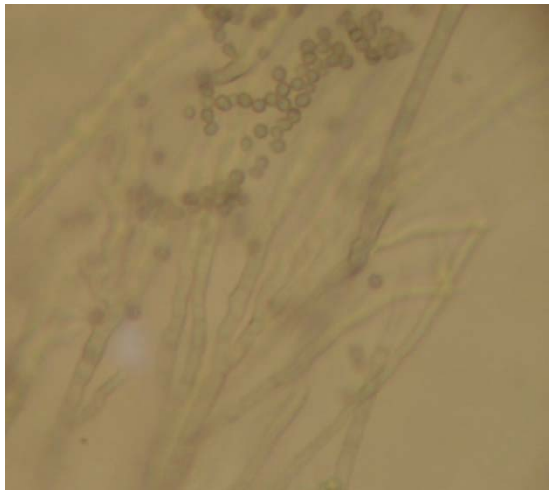
Experimental Fungi



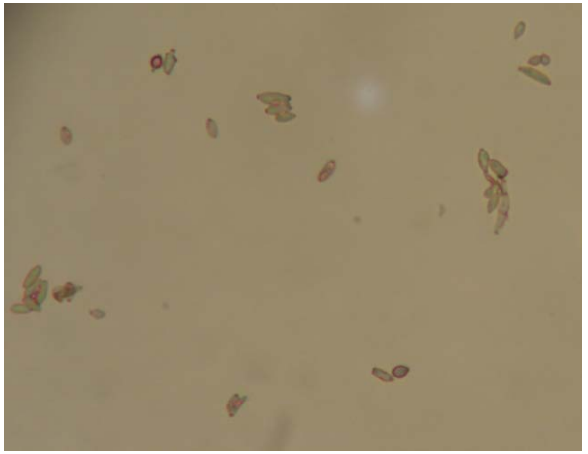
Alternaria alternata



Chaetomium globosum



Penicillium brevicompactum



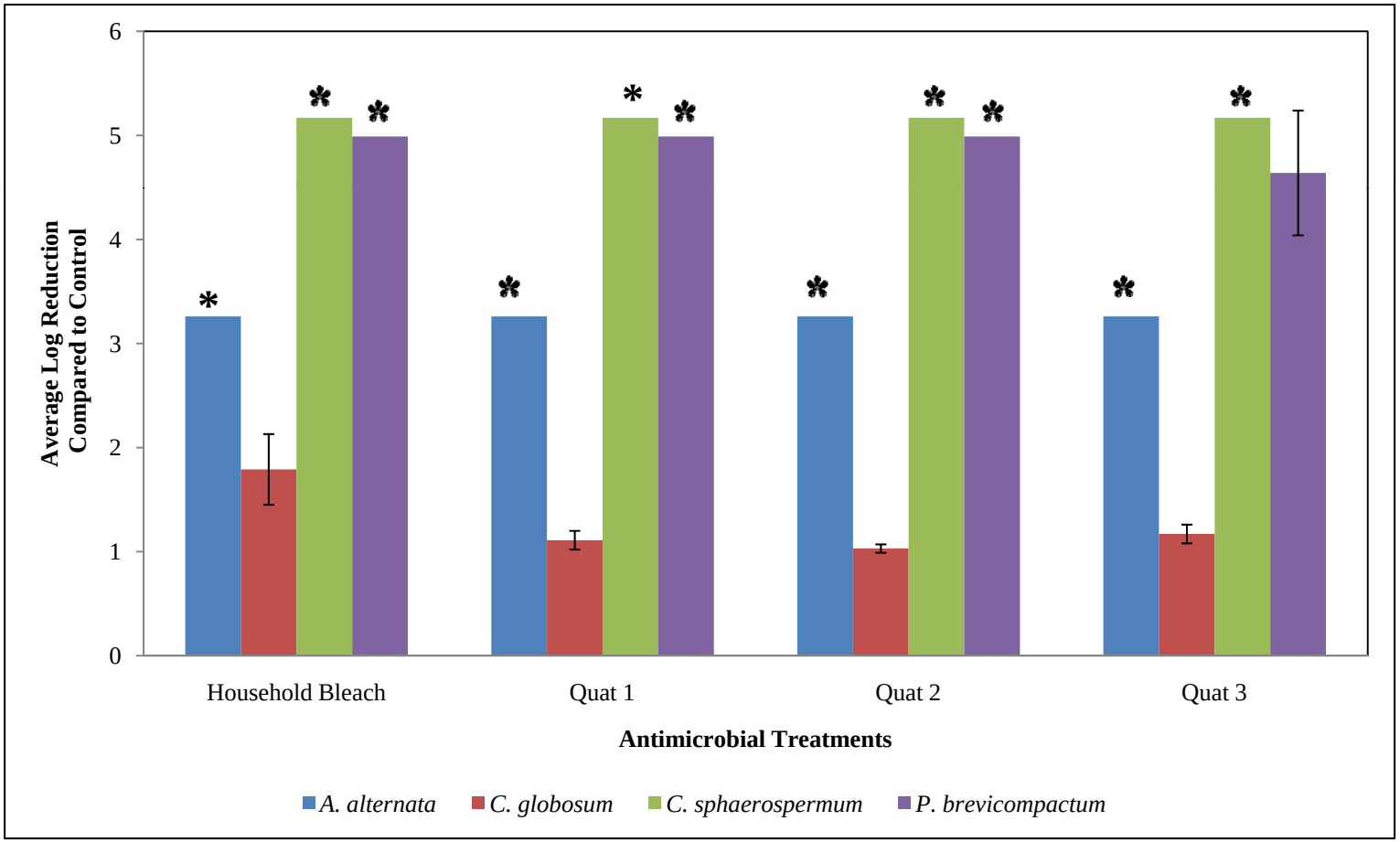
Cladosporium sphaerospermum

Short-Term Efficacy

Spore Suspension Test

Short-Term Efficacy

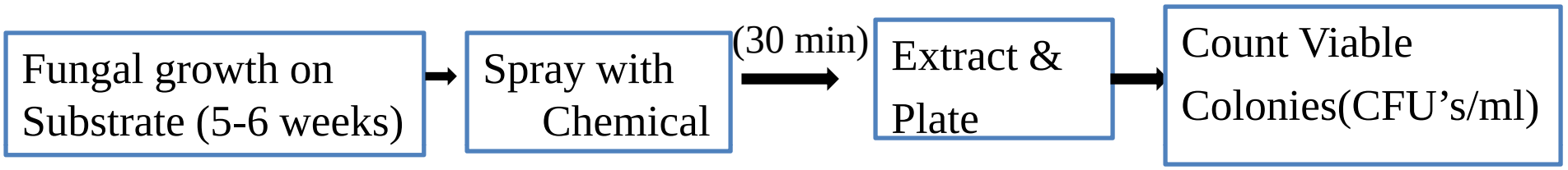
Viability of Spore Suspensions: Household Bleach vs. Quaternary Ammonium Compounds



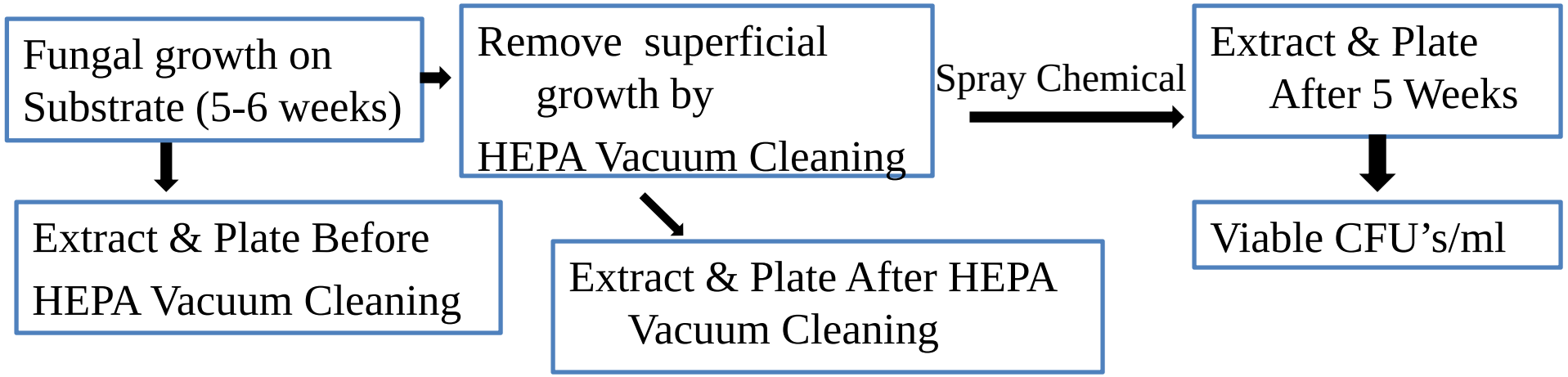
* Shows 100% reduction in viability

Carrier Tests

Method 1: Direct spray on fungal growth and extract (Short-term efficacy)

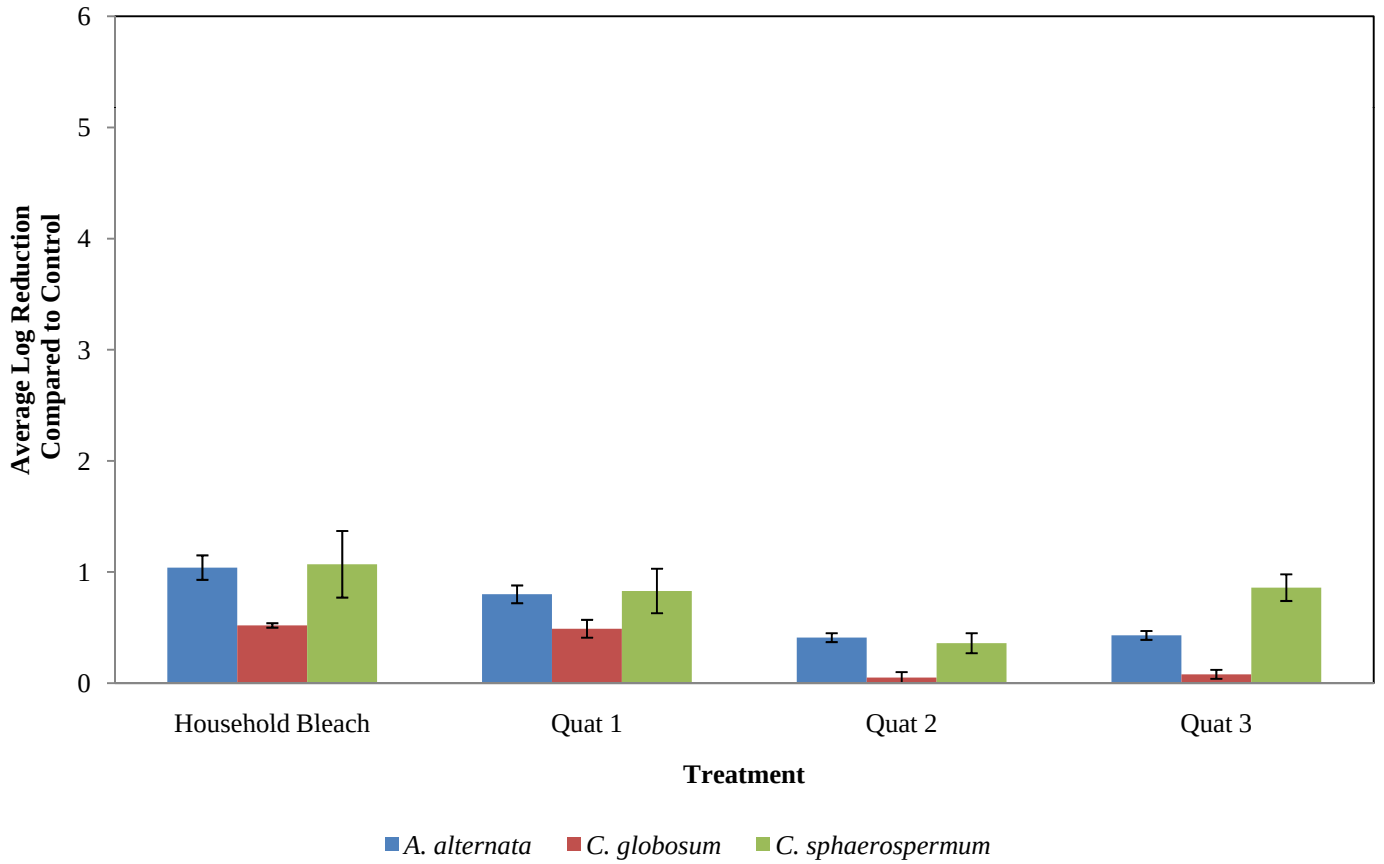


Method 2: Spray after superficial fungal growth removal by HEPA vacuum cleaning (Long-term efficacy)

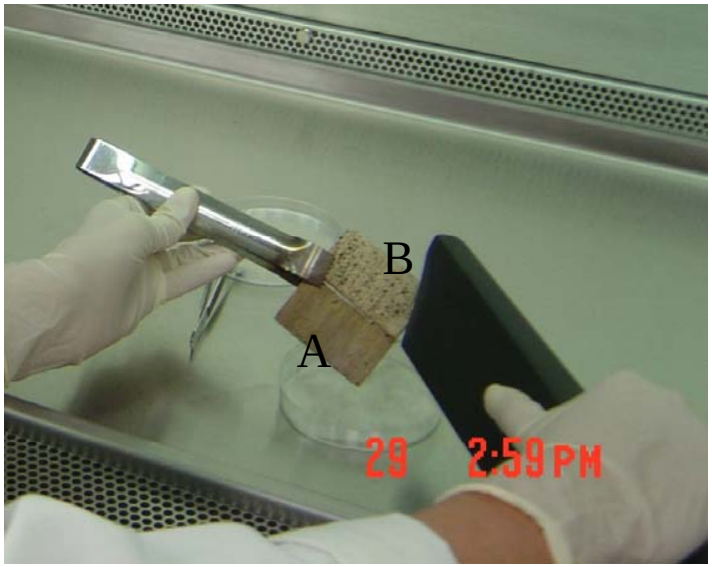


Short-Term Efficacy

Viability After Direct Spray Treatment of Fungal Growth on Drywall: Household Bleach vs. Quaternary Ammonium Compounds



HEPA Vacuum Cleaning*



"**A**" shows HEPA vacuum cleaned compressed wood sample with fungal growth

"**B**" shows fungal growth on compressed wood samples

***Dustless HEPA vacuum cleaner (Model 16006 16 Gallon), Dustless Technologies**

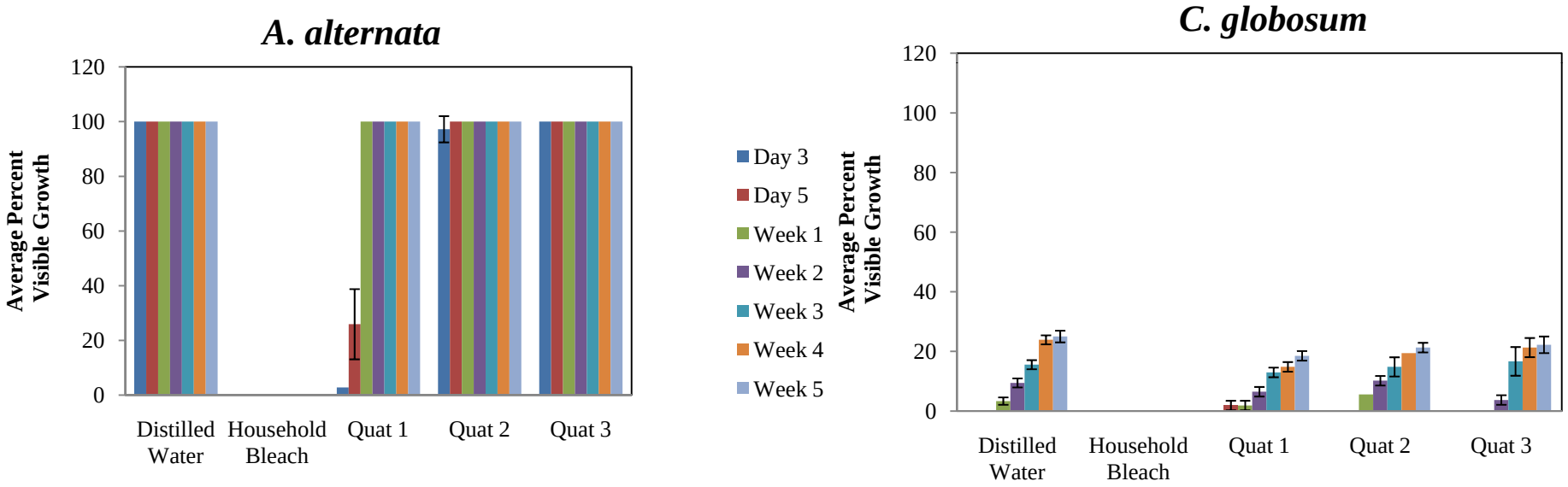
Carrier Tests

Reduction in Viability of Fungi After Just HEPA Vacuum Cleaning

- *Alternaria alternata* = 0.64
- *Chaetomium globosum* = 1.01
- *Cladosporium sphaerospermum* = 0.20
- *Penicillium brevicompactum* = 0.70

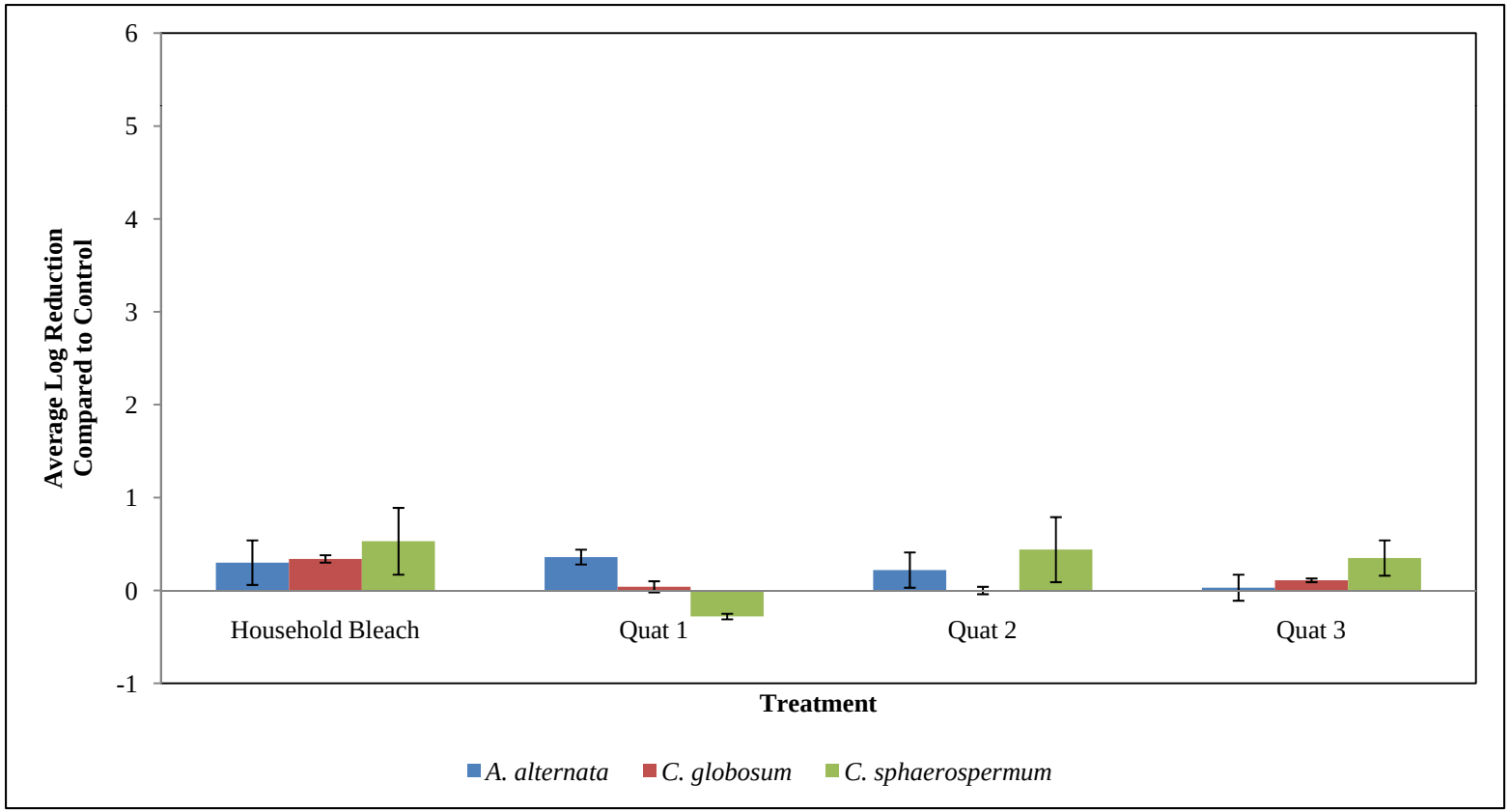
Long-Term Efficacy

Visible Change in Appearance of Substrate After HEPA Vacuum Cleaning and Treatment with Chemicals: Household Bleach vs. Quaternary Ammonium Compounds



Long-Term Efficacy

Residual Viability 5 Weeks After HEPA Vacuum Cleaning and Chemical Treatment: Household Bleach vs. Quaternary Ammonium Compounds

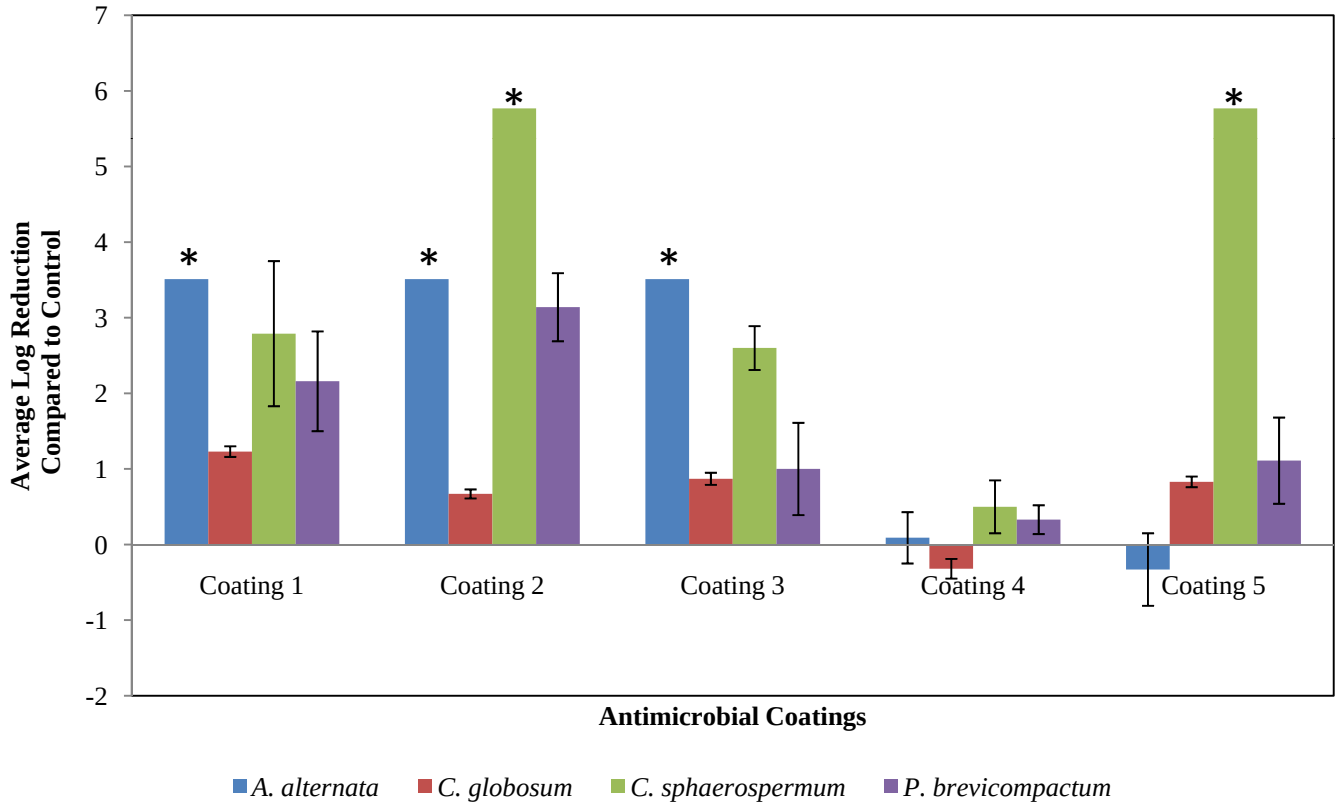


Antimicrobial Coatings

Test Products	Active Ingredients
Coating 1	Titanium dioxide[< 25%] 2–Tetrachloroisophthalonitrile [0.49%]
Coating 2	Barium compound (15%) with Propynyl Butyl Carbamate (17%)
Coating 3	Barium compound [5-10%] Titanium dioxide [1-5%] Zinc oxide [1-5%] Amorphous Silica [1-5%] Propylene glycol [0.1-1%]
Coating 4	3-lodo-2 Propynyl Butyl Carbamate (1%)
Coating 5	Organosilane (nanotechnology based product)

Antimicrobial Coatings

Residual Viability 5 Weeks After HEPA Vacuum Cleaning and Treatment with Antimicrobial Coatings



* Shows 100% reduction in viability

Do Mold Remediation Chemical Products Provide Long-Term Protection Against Mold Growth?

- **Fungicidal effectiveness of a chemical product depends on**
  - Active ingredients
  - Method of testing
  - Fungal species

- **Short-term efficacy does not always represent long-term effectiveness**

Do Mold Remediation Chemical Products Provide Long-Term Protection Against Mold Growth?

- **Discrimination of fungicidal effectiveness**

1. Carrier test is superior to suspension test for discerning differences in activity
2. Carrier tests allow comparison of both short-term and long-term fungicidal efficacies

- **HEPA vacuum cleaning**

1. Can be very effective against some fungi
2. Visible change in appearance is only a qualitative estimate of outcome
3. Viability data gives a quantitative assessment of long-term efficacy of fungicides
4. Re-growth on substrate subsequent to HEPA vacuum cleaning and chemical treatment varies with fungus and the chemical product

Acknowledgments

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DAMPNESS, MOLD AND RESPIRATORY INFECTIONS

William Fisk, Ekaterina Eliseeva and Mark Mendell

Indoor Environment Department
Lawrence Berkeley National Laboratory

Supported by the U.S. EPA

Introduction

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."

Building Dampness

Signs of dampness

- Standing water, wet surfaces, moisture stains, material damage, visible mold, mold odors

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, air conditioning systems

Exposures from Dampness

Molds and bacteria (many types)

- Spores, cells, fragments
  - allergens, inflammatory agents, toxins
- Microbial volatile organic compounds→ odors

Chemicals

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

House dust mites

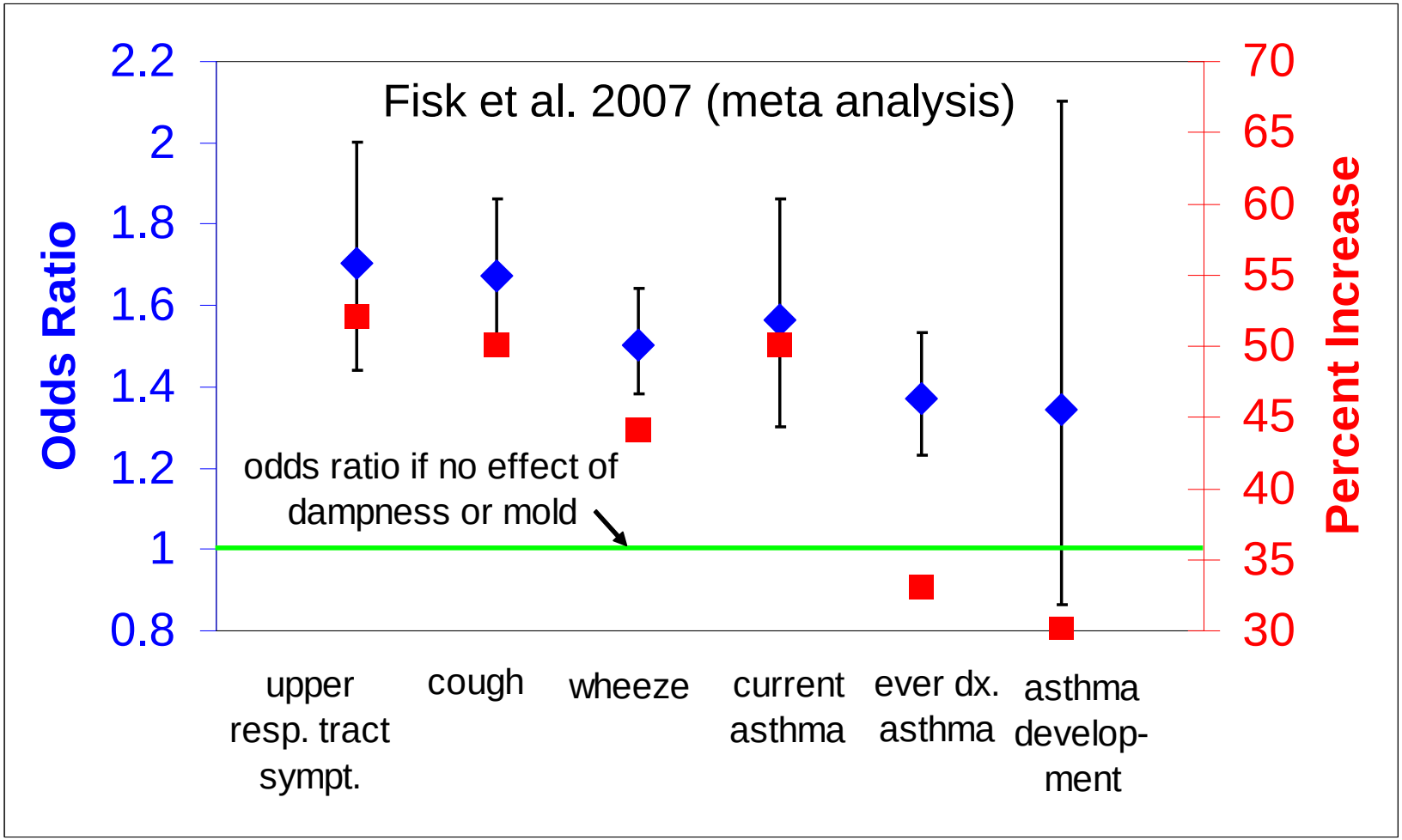
- Survival depends on sufficient indoor humidity

Cockroaches

Building Dampness is Common

Author	Location	Population	Mold or mildew	Water damage or dampness	Any dampness or mold
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%	

Increases in Respiratory Symptoms in Damp or Moldy Homes



Implication: 4.6 (2.9 – 6.3) million cases of current asthma costing $3.5B/yr ($2.1 – $4.8B) attributed to dampness and mold

A New Meta-Analysis

Do Dampness and Mold Increase Bronchitis & Respiratory Infections?

Types of Respiratory Infections Considered in Analyses

Normal respiratory infections in individuals with normal immune function

–Animal and cellular studies suggest potential immune system suppression

Considered

Fungi can infect the respiratory system of immune compromised individuals

Not Considered

Methods

Select 23 Studies

In archival journals

Homes

Dampness and/or mold vs. Bronchitis or Infections

Select Categories of Respiratory Infections

Bronchitis

Respiratory infection group (RIG)

Specific infections

Common cold

Compile Existing Results

Perform Statistical Meta-Analyses

Random effects model

All studies &

Studies with control for age, gender, smoking, socio-economic status

Central Estimates of Risks

Respiratory Infections Considered

Bronchitis → **Acute bronchitis, chronic bronchitis*, unspecified type of bronchitis***

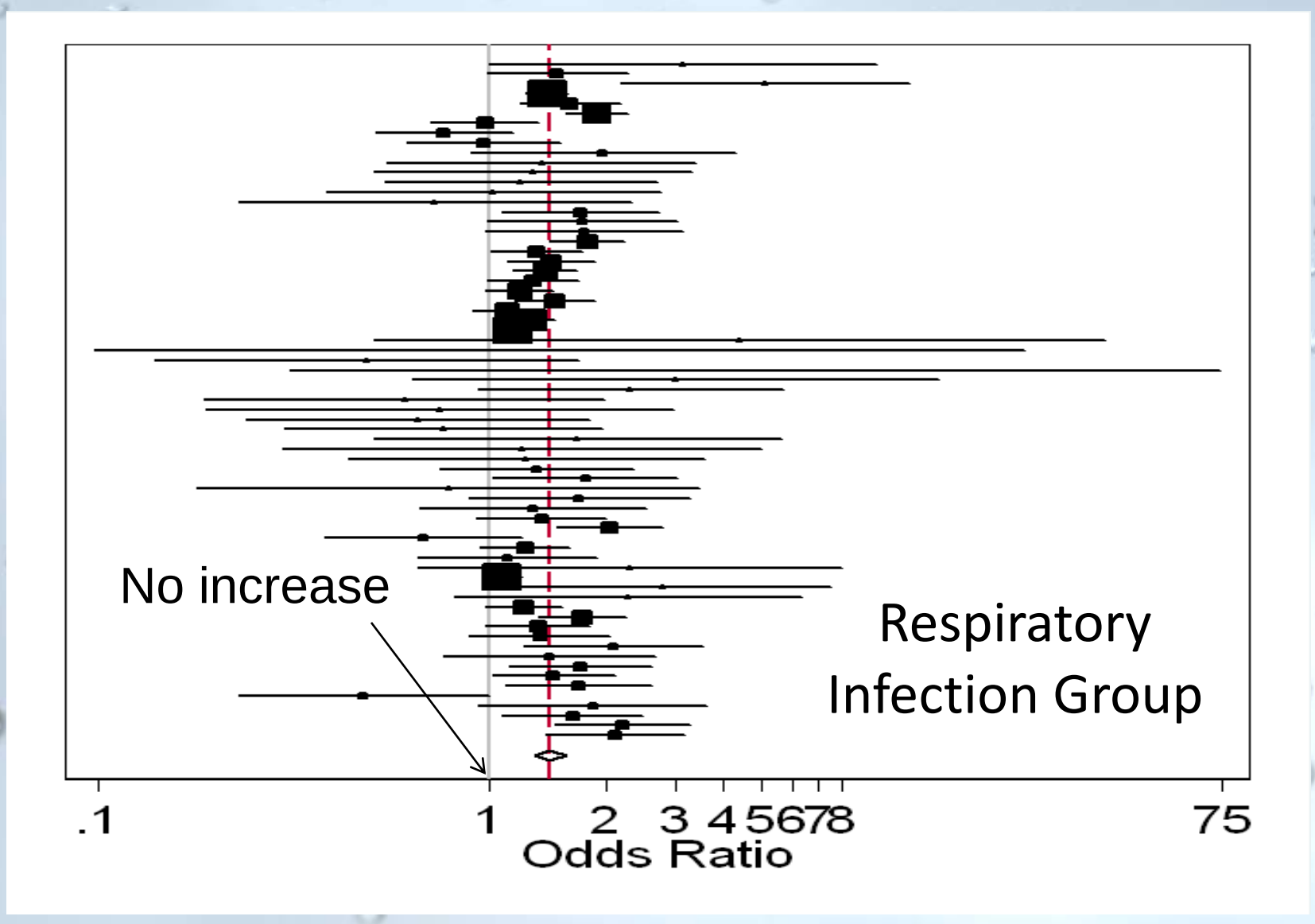
Respiratory Infection Group (RIG) → **Non-specific: Airway infection last month, common cold, acute upper respiratory tract infection, chest cold**

Specific Respiratory Infections → **Specific: Sinus or ear infection with antibiotic use, sinusitis, tonsillitis, croup, acute bronchitis, otitis media, pneumonia**

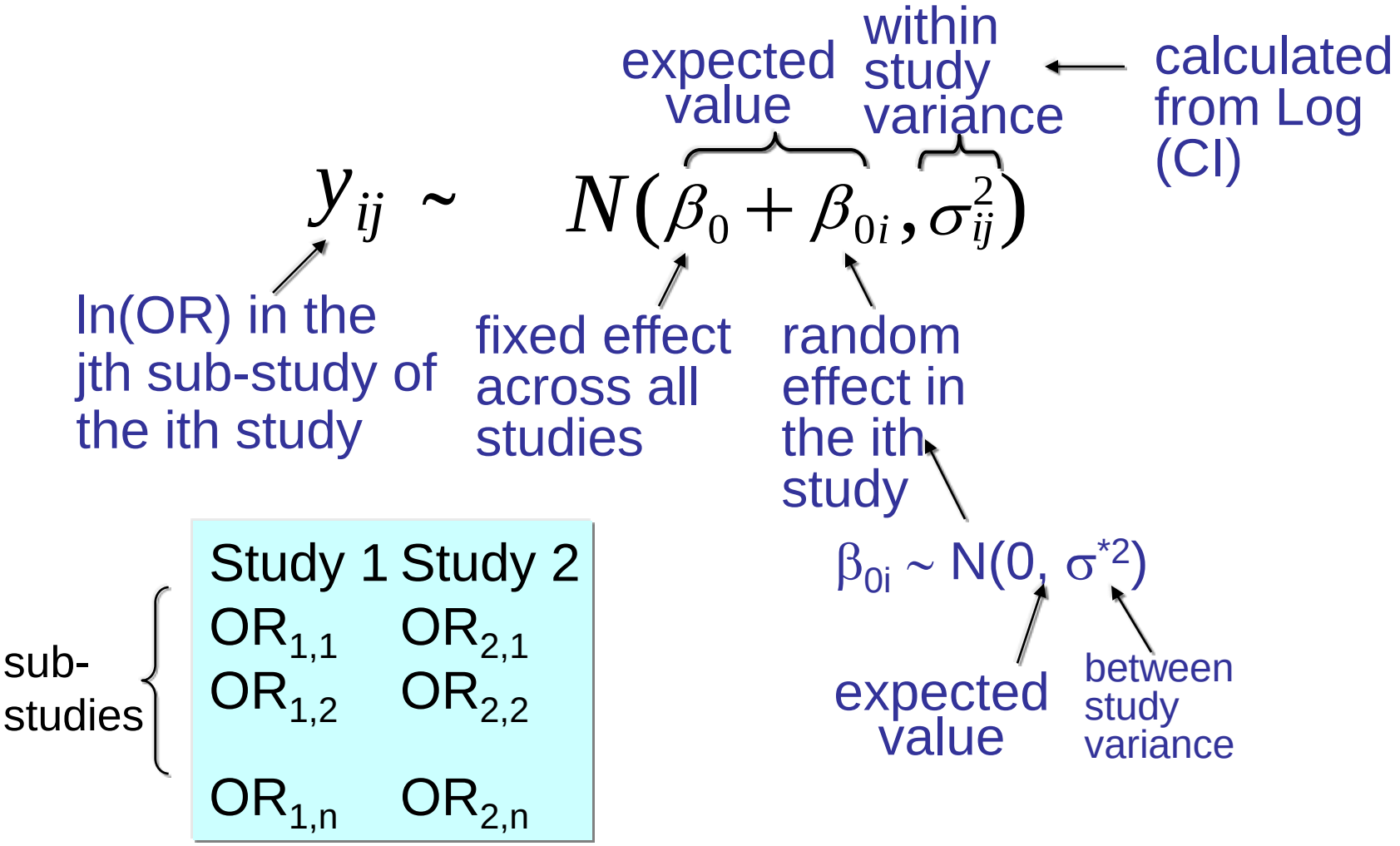
Common Cold → **Common cold, acute upper respiratory infection**

*potentially non infectious

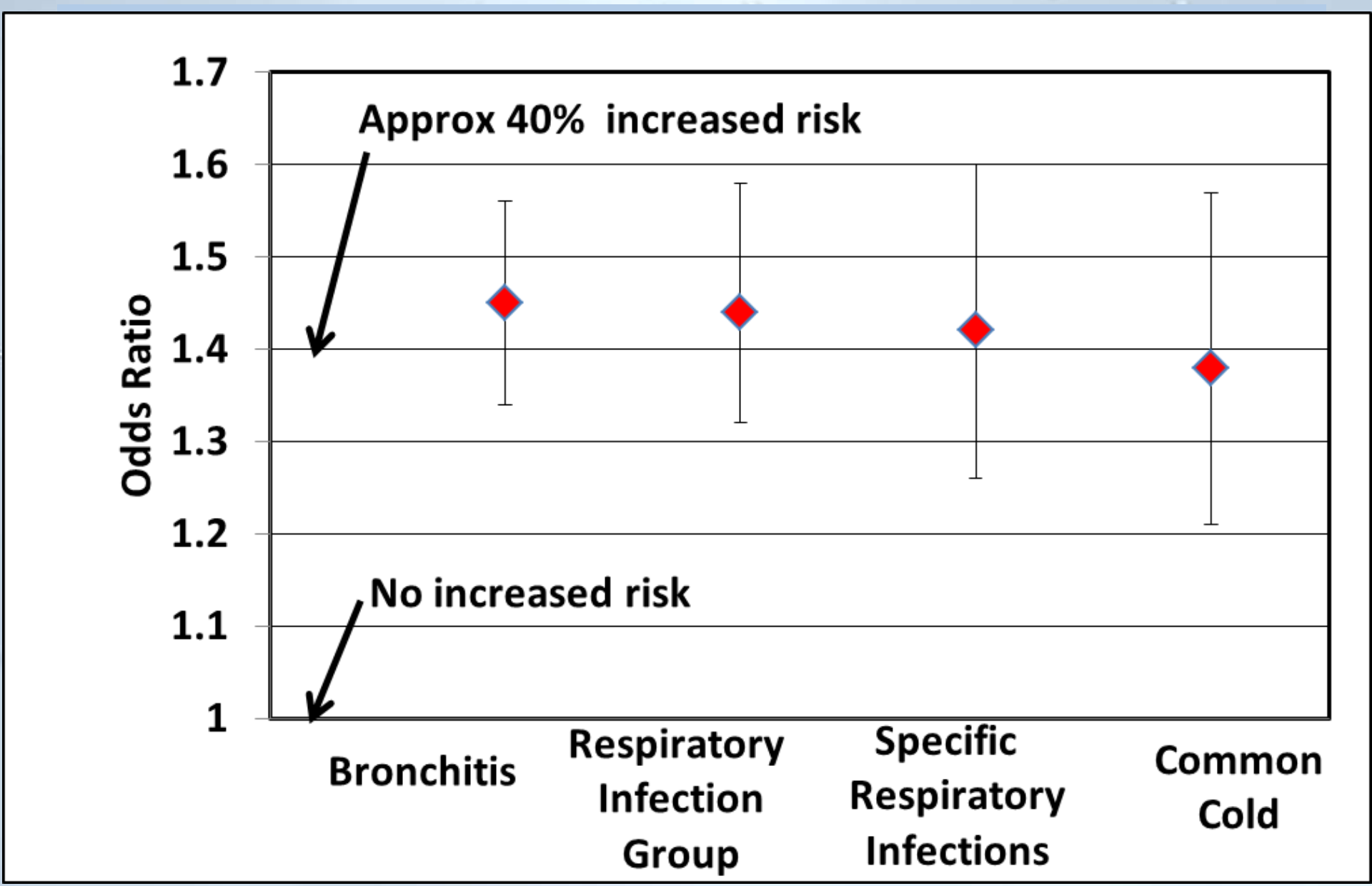
Example of Meta-Analysis Inputs and Result



Dampness and Respiratory Infection
Meta Analysis : Model



Results: Increased Risk in Damp or Moldy Homes



Estimated % of Health Effects Attributable to Dampness and Mold

Health Effect	Percentage	
	20% of Houses Damp or Moldy	50% of Houses Damp or Moldy
Bronchitis	8	18
Specific Respiratory Infections	9	20

ISSUES

Limitations

- Not proof that dampness and mold **causes** the observed impacts on health
- Mechanisms unknown (hypothesis available)

Strengths

- Numerous studies, generally with good control for confounding and moderately strong findings
- Different analysis models give similar results
- Little impact of publication bias

Significance

- Opportunity to significantly reduce respiratory infections?
  - Very common
  - High costs
    - ~$40 B /yr in US excluding cost of influenza*
  - Few other prevention strategies available
- Other simultaneous benefits of reducing dampness and mold
  - Decreased asthma and respiratory symptoms
  - Decreased damage to buildings

*Fendrick et al. Archives Internal Med, vol 163

Take Home Message

Prevention and Remediation of Dampness and Mold in Homes is a High Priority

More Information

- National Academy of Sciences Review www.nap.edu (search for “damp”)
- World Health Organization Review **http://www.euro.who.int/__data/assets/pdf_file/0017/43325/E92645.pdf**
- US EPA web site www.epa.gov/mold
- Indoor Air Journal: vol 17: 226-235; vol 17: 285-295
- Environmental Health Journal: vol 9:72
- Environmental Health Perspectives 2011 Jan 26 [Epub]
- Guidance on residential building envelope design by climate http://buildingscience.com/designsthatwork/
- Guidance for commercial building design **http://www.cmhc-schl.gc.ca/en/**

Infants in High ERMI Homes More likely to Develop Asthma

Steve Vesper

US EPA Cincinnati

The U.S. Environmental Protection Agency (EPA) through its Office of Research and Development, funded and collaborated in the research described here. It has been subjected to the Agency's peer review and has been approved as an EPA publication. Mention of trade names or commercial products does not constitute endorsement or recommendation by the EPA for use. Commercial use of the ERMI technology can provide royalties to the EPA.

Cincinnati Childhood Allergy and Air Pollution Study (CCAAPS) TEAM

Department of Environmental Health, University of Cincinnati, Cincinnati, OH, USA

- **Grace LeMasters, Tiina Reponen, Umesh Singh, Elisabet Johansson, Atin Adhikari, Patrick Ryan, Linda Levin, Shu Zheng, Jeff Burkle, Sergey A. Grinshpun, Chris Schaffer**

Department of Internal Medicine, University of Cincinnati, OH

- **David I. Bernstein MD, James Lockey MD, Manuel Villareal MD**

Division of Allergy and Immunology, Cincinnati Children's Hospital Medical Center, Cincinnati, OH

- **Gurjit K. Khurana Hershey MD**

Agenda

1. Asthma problem in US today.
2. Explain Environmental Relative Moldiness Index (ERMI).
3. Describe Cincinnati Childhood Allergy and Air Pollution Study (CCAAPS) Prospective study.
4. Describe Possible Mechanism for Development of Some Asthma Cases

Asthma Facts*

*from Allergy and Asthma Foundation

Every day in America:

- **40,000 people miss school or work due to asthma.**
- **30,000 people have an asthma attack.**
- **5,000 people visit the emergency room due to asthma.**
- **1,000 people are admitted to the hospital due to asthma.**
- **11 people die from asthma.**

Asthma Costs

Most common chronic disease of children.

- **Overall, the total lifetime economic impact of a single case of asthma in 1999 (year data was available for) was $49K for an average asthma patient and $202K for a more severe case.**
- **In addition, about 212 children born in 1999 died from asthma.** Cost of Illness Handbook at http://www.epa.gov/opptintr/coi/pubs/toc.html

Result: Each year Medical Costs alone for asthma about $12.7-19.7 billion each year in US.

Corso and Fertig. The Long-term Economic Costs of Asthma. Partnership for America's Economic Success. www.PartnershipforSuccess.org

Relationship Between Molds and Asthma

*from 2009 WHO Guidelines for Indoor Air Quality: Dampness and Mould

- **Occupants of moldy buildings are at increased health risk**
- **Causative agents have not been identified conclusively**
- **Exposures to mold should be “avoided or minimized”**

When and Why do we Need to Analyze for Molds?

- **Every environment contains mold.**
- **Mold is not always obvious. We found that 50% of the time occupants were unaware of and inspectors failed to find mold problems.** Vesper et al. Journal of Urban Health 2009:86:850-860.

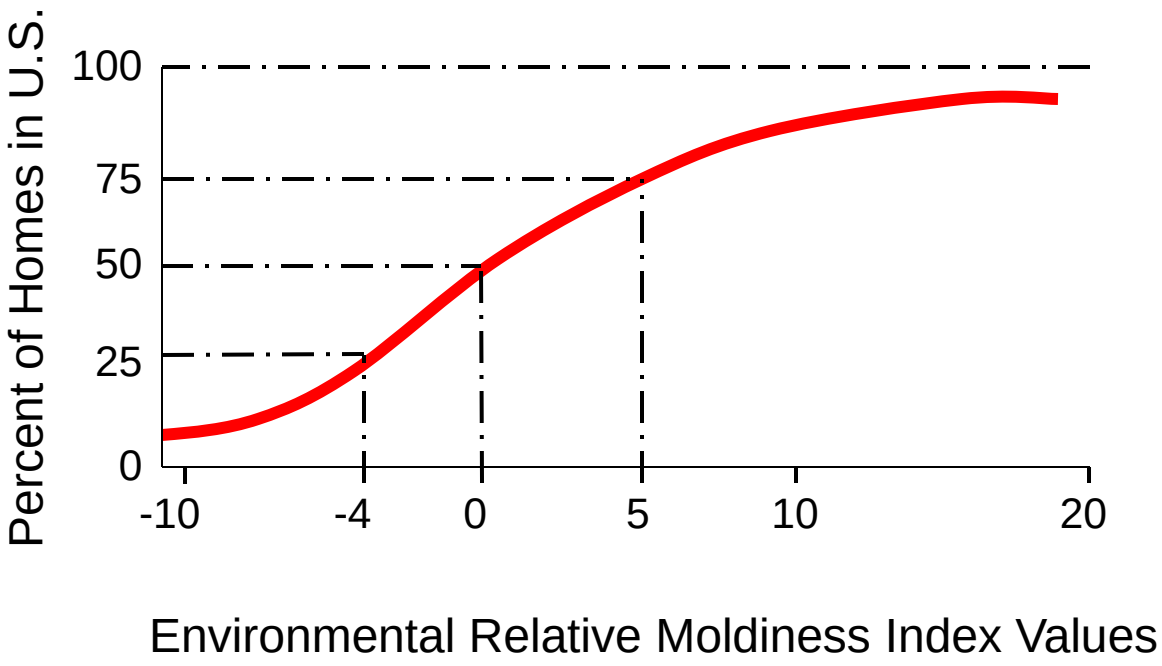
Mold Analysis

Vesper SJ, McKinstry C, Haugland RA, Wymer L, Ashley P, Cox D, DeWalt G, Friedman W.
Development of an environmental relative moldiness index for homes in the U.S. Journal of Occupational and Environmental Medicine. 2007;49:829-833.

- **Combined dust sample collected in living room and bedroom.**
- **Analyze for 36 species; 26 Group 1 indicators of water-damage and 10 Group 2 which come from the outside.**
- **Used the analysis in conjunction with HUD to evaluate US homes in the 2006 American Health Homes Survey**

HUD American Healthy Homes Survey – 1096 Random Homes Analyzed

The Environmental Relative Moldiness Index (ERMI)



CCAAPS Prospective Study of Asthma Development in Cincinnati Infants

Methods:

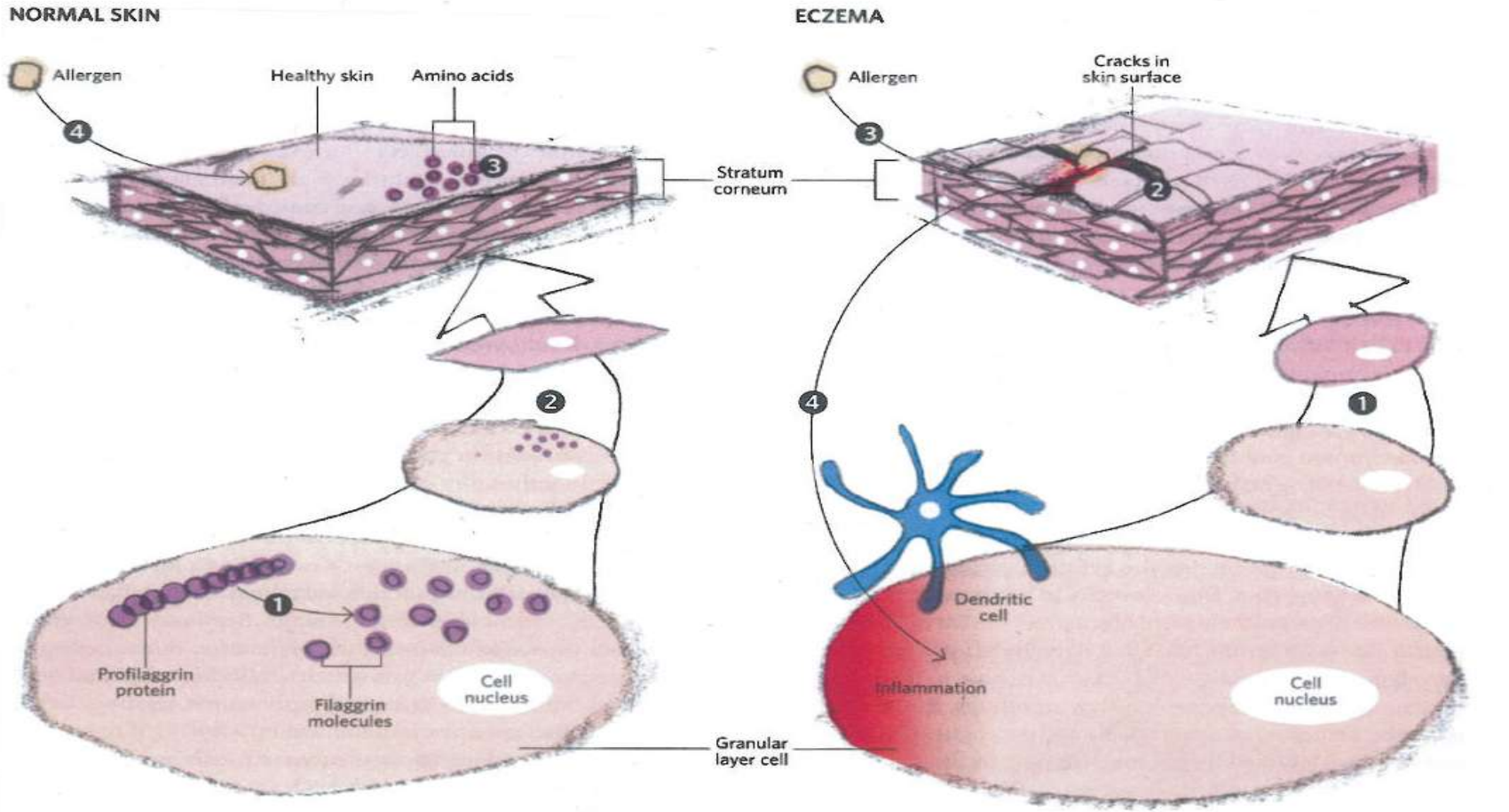
- Infant, family and home characteristics were prospectively evaluated for 289 infants in greater Cincinnati, OH. These characteristics included history of parental asthma, race, gender, cigarette smoking, skin prick test, season of birth, family income, air conditioning, dehumidifier, carpeting and age of home.
- In addition, dust samples were collected from each infant's home and analyzed for the concentration of the 36 ERMI molds, (1-3)-β-D-glucan endotoxin and dust mite, cat, dog and roach allergens.

Results

- **At age seven, 18% of children were found to be asthmatic.**
- **Parental asthma was a risk factor for asthma development (aOR=3.7, 95% CI=1.58, 8.61).**
- **In this study, children living in a high ERMI value (≥ 5.2) home at age one had over twice the risk of developing asthma than those in low ERMI value home (< 5.2) (adjusted odds ratio, aOR=2.4; 95% confidence interval, 95% CI=1.04, 5.73).**
- **In this study, a high ERMI value at age seven did not increase asthma risk.**

Possible Mechanism

Mutations in the Filaggrin Gene



Dermal Exposures of Infants may be Key

Conclusions

- **The odds of developing asthma if a child lived in a high ERMI value (≥ 5) home at age one were 2.4 times greater than the odds for a child who lived in low ERMI value (<5) home.**
- **The study results provide impetus to focus on reducing mold in infant's homes.**

Possible Asthma Prevention?

Applying the Final Multivariate Model:

If ERMI Values were	then Possible Reduction in Asthma
<10	6.2%
<5	14.5%
<0	29.1%

ACKNOWLEDGEMENTS

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