Bill Sothern, DrPH, MS, CIH
Microecologies, Inc.
bsothern@microecologies.com

Overcoming the Barriers to Establishing Quantitative Health Guidance Values for Airborne Mold

IAQA

2019 IAQA Annual Meeting

The Association Between Mold and Asthma

Evidence-Based Conclusions from Current Research

- IOM (2004) and WHO (2009) conclude "sufficient evidence of association" between exposure to damp and moldy conditions and asthma, wheeze, rhinitis and HP, but find **insufficient** evidence for establishing quantitative health guidance values to inform risk.
- Mendell et al. 2011 concludes "based on available evidence, the presence of dampness, water damage, visible mold or mold odors or a history of water damage provides more reliable indicators of D/M related health risks than do current quantitative microbiologic assessments" and further concludes "current evidence **does not support (even) measuring** *specific indoor microbiologic factors* to guide health-protective actions."

The Gap Between Research and Practice

- Industrial hygienists and environmental consultants in the U.S. and around the world routinely conduct **indoor air sampling for mold** in their IAQ investigations and use the lab results **together with other findings** to assess risk to occupants and to guide recommendations for health-protective actions and for assessing post-remediation clearance.

AIHA Air Sampling Guidance

- "Airborne culturable and countable fungal data can be used to determine the acceptability of indoor air quality to avoid an exposure that might result in allergy or allergic symptoms." (AIHA Greenbook - 2008 p. 173)
- "Air sampling for viable fungal propagules is a useful tool to detect fungal contamination; however, it should be used in conjunction with…a careful visual inspection…the significant presence of fungi in indoor air not present or as a minor component of the outdoor air mycoflora is taken as unacceptable from a health and building performance point of view" (AIHA Fieldguide - 2005 p. 115)
- "TLV's for culturable or total fungal structures are not scientifically supportable…" (AIHA Greenbook - 2008 p. 173)
- The interpretation of airborne fungal data is therefore left to the **professional judgement** of the industrial hygienist or other qualified environmental practitioner.

Case # 1

Using Air Sampling as a Tool in Guiding Health Protective Advice

Mold growth conditions in PTAC units in high-end residential high rise

Airborne mold (spore trap) with PTAC unit off	*Airborne mold (spore trap) with PTAC unit on*
MBR: *Pen/Asp* 93 structures/m^3 Outdoor: *Pen/Asp* 0 structures/m^3	MBR: *Pen/Asp* 2800 structures/m^3 Outdoor: *Pen/Asp* 110 structures/m^3

Outcome: 1) Resident discontinued occupancy 2) Client's respiratory symptoms resolved

IAQA

Case # 1

Using Air Sampling as a Tool in Guiding Health Protective Advice

Mold growth conditions in PTAC units in high-end residential high rise

Fiberglass insulation (culture)	*Airborne mold with PTAC unit on (spore trap)*
Cladosporium cladosporiodes: 260,000 CFU *Penicillium corylophilum*: 420,000 CFU *Yeasts*: 130,000 CFU	Living room: *Penicillium/Aspergillus* 8900 structures/m^3 Outdoor: *Penicillium/Aspergillus* 110 structures/m^3

Outcome: 1) Resident discontinued occupancy 2) Client's respiratory symptoms resolved

IAQA

Case # 2

Using Air Sampling as a Tool in Guiding Health Protective Advice

Mold growth conditions in supply trunk of HVAC system in landmark church

Airborne mold (spore trap) *HVAC system on*	*Airborne mold (spore trap)* *HVAC system off*
Indoor *Pen/Asp* 11,000 structures/m^3 Outdoor *Pen/Asp* 0 structures/m^3	Indoor *Pen/Asp* 760 structures/m^3 Outdoor *Pen/Asp* 0 structures/m^3

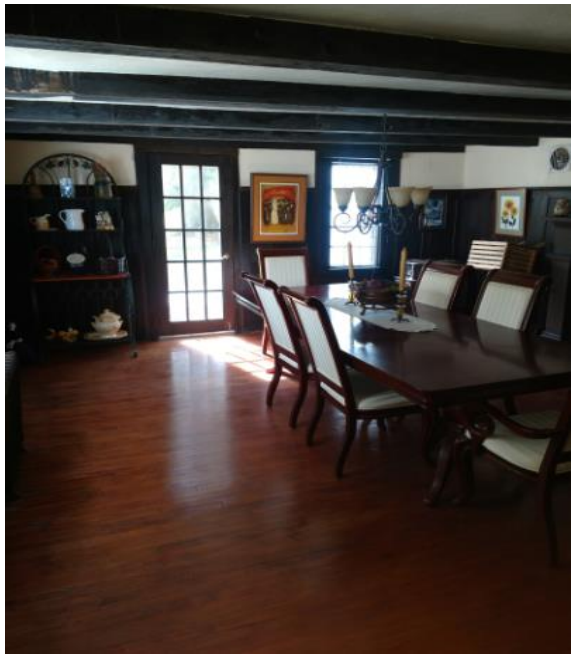
Outcome: 1) Use of rooftop unit discontinued 2) Airborne mold levels declined substantially

IAQA

Case # 3

Can Air Sampling Detect Hidden Mold Growth?

Yes. Sometimes air sampling can detect hidden mold growth and inform risk to occupants.



Dining Room *Pen/Asp* 15,000 structures/m^3
Family Room/Kitchen *Pen/Asp* 13,000 structures/m^3
Master Bedroom *Pen/Asp* 10,000 structures/m^3
Outdoors *Pen/Asp* 1,100 structures/m^3

Outcome: 1) Occupants permanently relocated 2) Significant improvement in client's respiratory condition (no O_2)

IAQA

Common Denominators in IPF/HP Cases: High-End Housing, Hidden Mold

- Air sampling can be a valuable tool in assessing hidden mold growth conditions.
- But, air sampling should never be used as a standalone tool, and there are no authoritative quantitative guidelines for interpreting mold air sampling laboratory results.
- A properly conducted mold inspection should always include the four WHO markers for D/M conditions: 1) visible mold; 2) visible water damage; 3) excessive surface moisture – observed or measured, and; 4) moldy odor
- In addition, an inspection should always include learning the water damage history of the premises and inspecting all components of the HVAC system.
- Finding the hiding places often means conducting minimally invasive inspections.

Case # 4

Air and Surface Sample Results from Initial Inspection

Analysis	Results
Direct microscopic examination (air – spore trap)	
Indoor	*Pen/Asp* 27 spores/m^3, *Stachybotrys*: 36 spores/m^3
Outdoor	*Pen/Asp* 0 spores/m^3, *Stachybotrys*: 0 spores/m^3

Revealed during inspection

Revealed during inspection

Revealed during remediation

Direct microscopic examination (swabs from sheetrock surfaces)	*Stachybotrys* - very high *Ulocladium* - very high *Cladosporium* - very high

Outcome: 1) Occupants temporarily relocated 2) Resumed occupancy post-remediation 3) Client's conditions resolved.

The Gap Between Research and Practice

The Problem Caused by the Absence of HGV/MRL's for Airborne Mold

The interpretation of laboratory results are left to the **professional judgement** of individual practitioners resulting in a **wide range** of interpretation criteria, undermining the credibility of the laboratory results as a risk assessment tool in the eyes of clients, fellow practitioners, physicians and the courts.

Establishing HGV's for Airborne Mold – The 30 Year Quest

Rao, Burge, et al. (1996) cited 15 agencies and organizations that attempted to establish quantitative minimum risk levels (or HGV's) for indoor airborne mold levels, including WHO 1988, ACGIH 1989, AIHA 1989, OSHA 1992, CEC (Europe) 1993, and National Health and Welfare (Canada) 1993. Latest attempt ACGIH and IAQA 1995.

These 15 agencies and organizations set MRL's for indoor air at 150 - 1000 CFUs/m^3. These risk levels were based on personal experiences **(professional judgement)**, not on dose response-based studies, and in each case were withdrawn or allowed to expire.

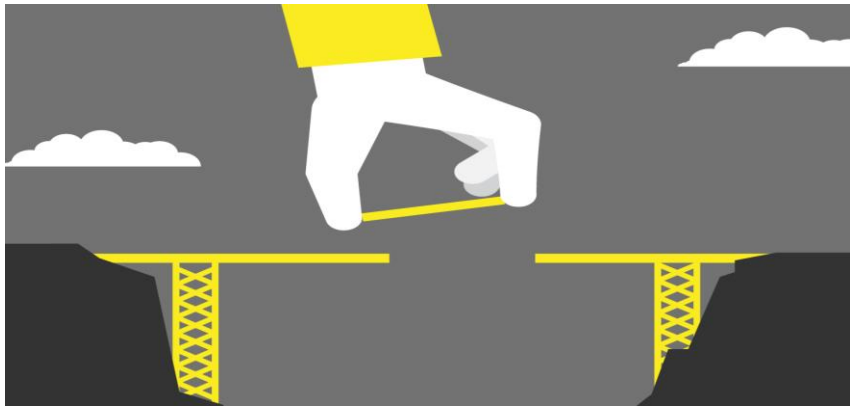
Authors cite **urgent** need for dose response-based studies and for development and widespread use of standard protocols for air sampling.

Overcoming the Barriers to Establishing HGV's for Airborne Mold

- Many barriers to the establishment of PEL's and TLV's cited by the AIHA (Green Book)
  - Variation in individual susceptibility
  - Variations in sampling and analytical methods
  - Temporal variability in airborne mold levels
  - Absence of dose-response based risk assessment data
- Overcoming the barriers
  - Make clear that HGV's are for atopic individuals
  - Make clear that HGV's are for most commonly used method (spore trap) - telephone survey of major labs - spore trap sampling 15-20x more common than culture sampling (>1,000,000/yr). AIHA Field Guide recognizes spore trap sampling as useful tool in assessing indoor air quality.
  - Make clear that HGV's are subject to false negatives but not false positives
  - Assess current scientific evidence; encourage research community to design study methods such that results can be used to inform HGV's; design and conduct dose-response based research studies.

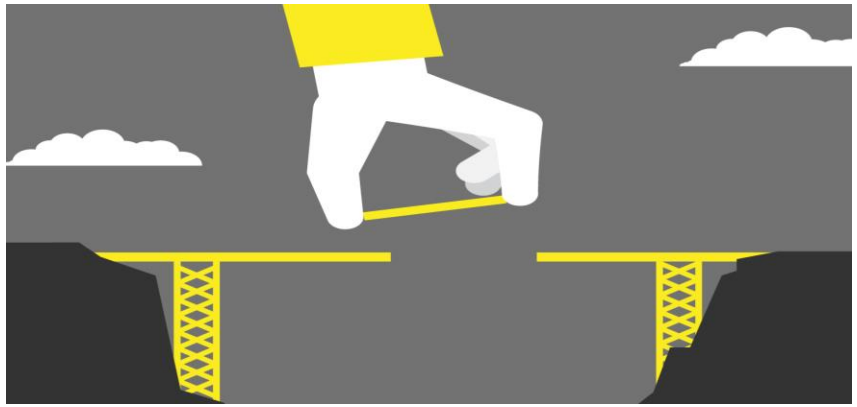
Bridging the Gap between Environmental Research & Practice

Identifying the Research Questions



In 2015, Mendell issued *A Research Agenda on Assessing and Remediating Home Dampness and Mold to Reduce Dampness-Related Health Effects* (supported by HUD) recommending research be conducted that "would increase scientific support for **evidence-based public health policies** on residential D/M" and proposed priority research questions for short-term research to be completed over the **next 2-3 years** for assessing unhealthy levels of indoor D/M.

Bridging the Gap between Environmental Research & Practice



Research Question, Aim and Hypothesis

- Mendell Research Question #1: "What are the best currently reported *quantified microbiological measurements* for indicating increased health risks (in a dose-related manner if possible) that could be used in health-protective guidelines for indoor D/M?... The current evidence has not been systematically mined for this information."
- Specific Aim Study #1: Conduct a systematic review to assess the homogeneity or heterogeneity of findings in studies that examined the associations between exposure to *elevated levels* of mold in indoor air and adverse respiratory health outcomes using evidence-based inclusion criteria, and examine the criteria used in these studies to define *elevated levels*.
- Hypothesis Study #1: The current body of scientific evidence does support the conclusion that there is a significant association between exposure to elevated levels of specific genera of mold in the indoor air and adverse respiratory health outcomes.

IAQA

Study #1

A Systematic Review of Studies Examining the Associations between Exposure to Elevated Levels of Indoor Airborne Mold and Asthma and Other Respiratory Health Outcomes

William M. Sothern[1,2], Chris Mikrut[2], Nasrin Khandaker[2], Franklin E. Mirer[1]

[1]City University of New York School of Public Health, NY, USA
[2]Microecologies, Inc, NY, USA

Critical Processes for Conducting a Systematic Review

Follow the PRISMA Statement: 27 item checklist

- Selective journals require substantial compliance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA Statement)

Define the inclusion/eligibility criteria (PRISMA – Methods #6, #7, #9 and #13)

- Primary inclusion criteria
  - Indoor air samples for mold taken in residences
  - Associations between airborne mold levels and respiratory health outcomes assessed and measures of effect presented as OR, RR, HR or p value.
- Secondary inclusion criteria
  - Exposure to elevated levels of indoor airborne mold defined as a numeric value/cut point or comparison of means/percentiles to define exposed vs unexposed groups
  - Exposure to elevated levels assessed by genus/genera – not by total fungal counts
  - Health outcomes assessed: asthma, rhinitis, wheeze, HP and other respiratory conditions, ER visits or allergic sensitization
  - Susceptibility bias accounted for

Critical Processes for Conducting a Systematic Review

Conduct comprehensive literature search (PRISMA – Methods #7 and #8; Results #17)

- Identify studies that meet primary inclusion criteria
  - Conduct PubMed keyword search through 2017 to identify systematic reviews and meta-analyses (SR/MA) examining the associations of interest using search terms consistent with our exposure and outcome criteria. Search results add one study being added to authors' archived file of 10 SR/MA.
  - Reference lists of 11 SR/MA screened by title for suggestion that article met primary inclusion criteria (N=221), then abstracts of these articles read to assess whether article did meet primary inclusion criteria (N=27) for studies published 1989-2014.
  - Conduct PubMed keyword search (2014-2017) to identify articles assessing associations of interest (N=260), screen for suggestion that article met primary inclusion criteria (N=49), then abstracts of these articles read to assess whether article did meet primary inclusion criteria (N=5), studies meeting inclusion criteria through 2017 (N=32).
  - Conduct in-depth review of articles (by 2 authors) where abstracts met primary inclusion criteria (N=32 – see Table 2) to assess whether article met secondary inclusion criteria (N=21 – see Table 3).

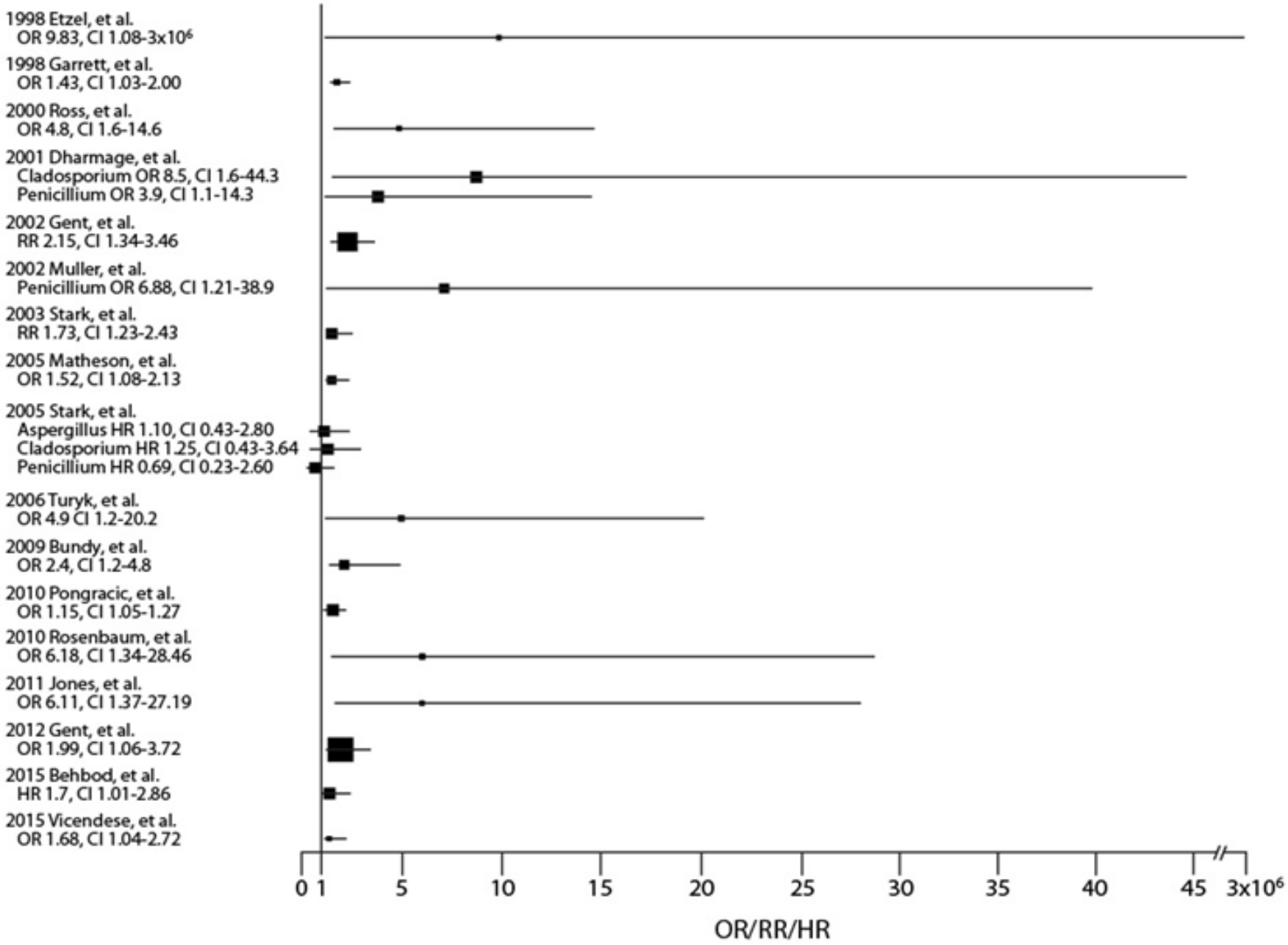
Table 2 Secondary inclusion criteria review and summary for the 32 studies that met initial inclusion criteria (PRISMA – Methods #6, #9 and #16; Results #18 and #19)

Year	Investigator	Country, Study Population & Health Outcome of Interest	Assessed by Genus/ Genera	Elevated Levels of Indoor Airborne Mold Meets Secondary Inclusion Criteria		Log Norm. Expos. Data	Suscept-ibility Accounted for	Meets All Inclusion Criteria
				Outdoor levels	Referent group			
1998	Etzel et al.[24]	U.S.A., Infants (n = 40), Pulmonary hemorrhage	✓		✓		N/A	✓
Reviewed 3/22/18 by WMS & 6/9/18 by WMS and NK. Review confirms that primary inclusion criteria were met. Air sample results analyzed by genus. OR based on increased risk of pulmonary hemorrhage (hemosiderosis) with an increase of 10 CFU/m^3 in mean concentration of *Stachybotrys atra*. Because this outcome is considered a toxic rather than an allergic response, susceptibility criteria are not applicable.								
2003	Belanger et al.[32]	U.S.A., Infants (n = 849) with an asthmatic sibling, Wheeze, persistent cough			✓		✓	
Reviewed 3/22/18 by WMS & 6/23/18 by WMS and NK. Review confirms that primary inclusion criteria were met. Air sample results analyzed for total CFU only. Increased risk assessed for increase per 20 CFU of total fungi. Data analyzed separately for mothers with physician diagnosed asthma and therefore susceptibility criteria were met.								
2012	Gent et al.[46]	U.S.A., Children with asthma or asthma symptoms (n =1,233), Days of wheeze, cough and high asthma severity score	✓		✓	✓	✓	✓
Reviewed 3/23/18 by WMS & 5/31/18 by WMS and NK. Review confirms that primary inclusion criteria were met. Air sample results analyzed by genus. Review finds that exposure data for indoor airborne mold were log-normalized before assessing associations with wheeze, persistent cough, and higher asthma severity score among children exposed to any *Penicillium*. Cohort comprised of children with asthma and/or persistent cough and/or use of rescue medication for asthma and therefore susceptibility criteria were met.								

Table 3 Summary Data for 21 Studies that Meet All Inclusion Criteria (PRISMA– Methods #6, #9 and #16; Results #18, #19, #20 and #23)

Year	Investigator	Sampling Method/ No. Events	Study Design/Population and Health Outcomes	Findings Exposure to Elevated Levels of:	Strength of Association
Studies That Did Not Log Normalize Exposure Data					
1998	Etzel, et al.[24]	Culture/ Single	Case-control (n=40) of infants (U.S.A.) Health Outcome - Pulmonary Hemorrhage	*Stachybotrys atra* - Pulmonary hemorrhage (OR 9.83, 95% CI 1.08 - 3 x 10^6)	Statistically significant
Definition of Elevated Indoor Airborne Mold Levels for Assignment to Exposed Group- OR based on increased risk of pulmonary hemorrhage (hemosiderosis) with an increase of 10 CFU/m^3 in mean concentration of *Stachybotrys atra*.					
2002	Müller, et al.[30]	Culture/ Single	Prospective cohort (n=200) of children (Germany) Health Outcomes – Respiratory tract infections and Atopy	*Penicillium* – Resp. tract infections (OR 6.88, 95% CI 1.21-38.9) *Aspergillus* – Atopy ($p < 0.05$)	Statistically significant
Definition of Elevated Indoor Airborne Mold Levels for Assignment to Exposed Group- OR based on increased risk of respiratory tract infection for children exposed to *Penicillium* > 100 CFU/m^3 higher than outdoor levels. P value based on increased risk of atopy (suppression of Th1 cytokines INF-γ, TNF-α and IL-2) for children exposed to *Aspergillus* (authors hypothesize due to mycotoxins) prejudicing immune response towards Th2/IgE pathway.					
Studies That Did Log Normalize Exposure Data					
2012	Gent, et al.[46]	Culture/ Single	Prospective cohort (n=1,233) of children (U.S.A.) with asthma Health Outcomes – Days of Wheeze, Cough, and High Asthma Severity	*Penicillium* - Wheeze (OR 2.12, 95% CI 1.12-4.04), Persistent cough (OR 2.01, 95% CI 1.05-3.85), Asthma severity score (OR 1.99, 95% CI 1.06-3.72)	Statistically significant
Definition of Elevated Indoor Airborne Mold Levels for Assignment to Exposed Group- OR's based on contrasting health outcomes of children exposed to any *Penicillium* to health outcomes of referent group (no *Penicillium*).					

Forest Plot of OR's, RR's and HR's and CI's for Studies on Table 3 (PRISMA - Results #20)



Additional Subgroup Analyses of Studies (PRISMA – Results #23)

Susceptibility Type Selection Bias

In studies where the outcome variable is an allergic disease such as asthma, susceptibility bias may affect the validity of the findings unless care is taken in the study design to assure that all study participants have similar susceptibility to experiencing an allergic response to the provoking environmental exposure factor.

Impact of Using Log Transformed Exposure Data

Indoor air sampling exposure data from D/M homes is highly right skewed (Sothern et al. 2018) and therefore we hypothesized that studies that log-normalized exposure data may have driven the measures of effect toward the null. To test this hypothesis, we separated studies in Table 3 that did and did not log-normalize exposure data, and the results suggest that we should reject this hypothesis.

Summary of Main Findings (PRISMA – Discussion #24)

- 20 of the 21 studies that met primary and secondary inclusion criteria found significant risk between exposure to elevated levels of indoor mold and asthma or other respiratory outcomes irrespective of criteria used to define *elevated levels*.
- Only 2 of these 21 compared indoor to outdoor levels, and only 1 study provided data that could contribute to the development of HGV's for indoor airborne mold.
- *Penicillium* was the genus most frequently associated with adverse outcomes (10 of 21), followed by *Cladosporium* (5 of 21), *Alternaria* (3 of 21) and *Aspergillus* (2 of 21).

Conclusion and Relevance of Findings in Key Groups (PRISMA – Discussion #24 and #26)

- Results suggest that current scientific evidence **does** support measuring the indoor airborne mold **subset** of *specific indoor microbiologic measurements* in assessing respiratory health risks to occupants of D/M homes.

  This finding validates the practices of environmental consultants who routinely use air sampling results as a tool together with other findings to assess respiratory health risk to occupants.

- These findings do **not** contribute to establishing dose-response based HGV's for indoor airborne mold.

  For research to inform the establishment of dose-response based HGV's, researchers will need to align their study methods with the methods required by the AIHA be followed by environmental practitioners for the collection of airborne mold samples and interpretation of laboratory results.

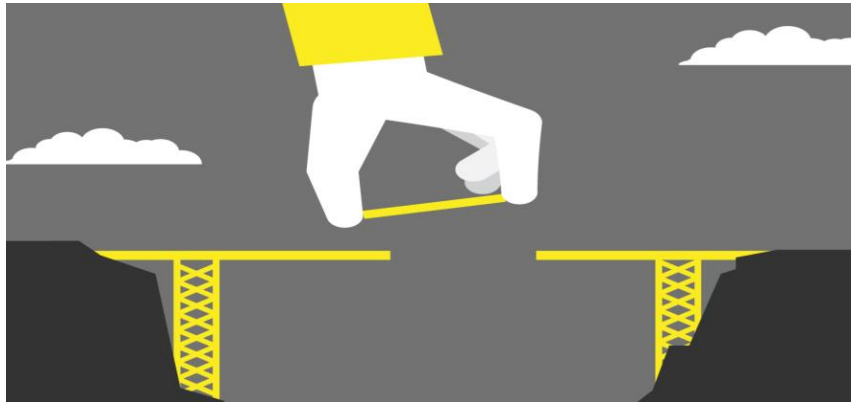
Study #2

A Nested Case-Control Study Examining the Associations between Exposure to Elevated Levels of Mold in Indoor Air and Wheeze Among Atopic Children in Cuba

William M. Sothern[1,2], Silvia-Josefina Venero-Fernández[3], Ramón Suárez-Medina[3], Teresa-Irene Rojas[4], Kenia Sánchez-Espinosa[4], Michel Almager-Chavez[4], Chris Mikrut[2], Ariunaa Jalsrai[5], Marilyn Aguirre-Molina[1]

[1]City University of New York School of Public Health, NY, USA,
[2]Microecologies, Inc., NY, USA,
[3]National Institute of Hygiene, Epidemiology, and Microbiology, Havana, Cuba,
[4]University of Havana, Department of Microbiology and Virology, Havana, Cuba,
[5]EMLab P&K environmental laboratories, NJ, USA

Bridging the Gap between Environmental Research & Practice



Research Question, Aim and Hypothesis

- Mendell Research Question #2: "What standard for combined multi-level D/M (indices) can be constructed, from combinations or expansions of the most strongly health-related D/M (or microbiologic) assessments in current studies, using information easily collected in a building, that have potential for dose-related associations with key health effects that are even stronger than current metrics, and that could be compared in future studies?"
- Specific Aim Study #2: Establish a quantitative dose-response based benchmark for genera-specific airborne mold above which there is a significant respiratory health risk (wheeze) to atopic residents of D/M homes by conducting a nested case-control study in Havana, Cuba.
- Hypothesis Study #2: There is a determinable dose-response based quantitative level that can be expressed in fungal structures per cubic meter for specific genera of indoor airborne mold above which there is a significant respiratory health risk to atopic occupants.

Research in Preparation for Havana Trip

- Literature search conducted to find studies that examine associations between environmental risk factors and asthma in preparation for Cuba preparation for January 2016 trip
- Prevalence of current wheeze in Havana, Cuba – school children 17.5%
- INHEM Infant Wheeze Cohort study (*Risk Factors for Wheezing in Infants Born in Cuba*) – Venero-Fernandez, Suarez-Medina, et al. (2013)

  Primary risk factors identify presence of:
  - eczema (OR 2.09, 95% CI 1.48-2.94)
  - family history of asthma (OR 2.05, 95% CI 1.60-2.62)
  - poor ventilation (OR 1.99, 95% CI 1.48-2.67)
  - male sex (OR 1.52, 95% CI 1.19-1.96)
  - no. smokers in house ($p < 0.03$ for trend)
- Potential research gap identified - water damage, excessive moisture and mold not considered major risk factor in infant wheeze study

Bridging the Gaps – Step 1

Finding the Road to the Bridge

Objective Conduct a nested case-control pilot study with participants selected from the 1956-participant 2010-2011 INHEM Infant Wheeze Cohort to assess the association between exposure to elevated levels of mold in indoor air and wheeze.

Proposal In November/December 2015, we reached out to and established a dialogue with Dr. Venero-Fernandez and Dr. Suarez-Medina who responded favorably to and shared our interest in conducting the pilot study.

Next steps

- Design the study
- Identify the research team members – consider qualifications & training requirements
- Acquire the necessary field instrumentation & air sampling cassettes
- Schedule the meetings to finalize project design, training, data and sample collection, logistics

Pilot Study Design - Methods

Selection of Cases and Controls

- 2010-2011 Infant Wheeze Cohort comprised of 1,956 infants aged 12-15 mo from 17 randomly selected polyclinic catchments in 4 of the 15 municipalities in Havana. Questionnaires (ISAAC) administered annually by family pediatrician to participants' parents. At time of selection for pilot study (2012/2013 questionnaire) cohort comprised of 1,543 children aged 3 - 4. For pilot study, participant pool selected from 2 municipalities - eligible pool 799 children.
- Inclusion criteria for pilot study limited to children whose parents answered "yes" to questions "family history of asthma" (2010/2011 questionnaire) and "visible mold/dampness" (2012/2013 questionnaire), leaving pool of 95 eligible children. Parents of 69 eligible children answered "yes" to "any wheeze in the past 12 months" question and 26 answered "no" (2012/2013 questionnaire).
- From remaining pool, 36 participants randomly selected for pilot study, 18 cases (wheeze) and 18 controls (no wheeze).

Pilot Study Design - Methods

- Air Sample Collection and Laboratory Analysis
  - ❖ Samples collected Feb-Jun 2016 indoors (children's bedroom) and outdoors (directly outside home) onto Air-O-Cell spore trap cassettes using Zefon Bio-Pumps calibrated to 15 LPM for 5 minutes.
  - ❖ Samples retrieved from Cuba and returned to U.S. for analysis at EMLab P&K.
- Laboratory Results Interpretation
  - ❖ Results interpreted by comparing indoor levels to outdoor levels by genera (in accordance with AIHA guidelines) for each home.
- Statistical Analysis
  - ❖ Based on a review of laboratory results and previous research, the exposed group defined as children who lived in homes where the levels of *Pen/Asp* and *Cladosporium* in the indoor air were elevated contrasted to the levels in the outdoor air by >200 str/m^3.

Pilot Study - Results

- Air sampling results show that *Pen/Asp* airborne mold levels in the child's bedroom > 200 str/m^3 higher than outdoor levels in 13 of the 34 homes (11 cases, 2 controls), indicating a significantly increased risk of current wheeze among children exposed to *Pen/Asp* at these levels (OR 11.0; 95% CI, 1.90-63.83).
- Air sampling results show that *Cladosporium* airborne mold levels in the child's bedroom > 200 str/m^3 higher than outdoor levels in 10 of the 34 homes (6 cases, 4 controls) indicating there is not a significantly increased risk of current wheeze among children exposed to *Clad* at these levels (OR 1.5; 95% CI, 0.34-6.70).
- The air sampling results show that there were only four genera representing >1% of the total fungal organisms in both the indoor and outdoor air of the 34 homes, and that the only genera where the mean indoor levels exceeded mean outdoor levels was *Pen/Asp*.
- The outdoor air sampling results comparing mean outdoor levels in New York in June to mean levels outside the 34 homes in the subtropical climate of Cuba (samples taken February through June 2016) show that only four genera represented > 1% of total outdoor fungal organisms in both geographies and climates. This data also shows that levels of *Pen/Asp*, the water damage related fungi most frequently associated with adverse respiratory health outcomes, were within the same range in both geographies and climates.

Pilot Study - Conclusions

- Conclusion #1
  - Children with family history of asthma exposed to *Pen/Asp* in indoor air > **200 str/m^3 higher than outdoor air** are at significant risk for wheeze.
  - The strength of association between exposure to elevated levels of *Pen/Asp* and wheeze in this pilot study supports our hypothesis that air sampling results can be a useful tool in providing health protective advice to occupants and their physicians.
  - Pilot study results suggest defining *elevated levels* of mold as indoor levels of *Pen/Asp* > **200 str/m^3 higher than outdoor levels** may be useful starting point/benchmark for examination in larger similarly designed studies that can test the reliability of this quantitative value.
- Conclusion #2
  - Pilot study results support our conducting larger (229 cases and controls) nested case-control study.
    - Data collection commenced in September 2018.
    - Quantitatively assessed D/M exposure parameters expanded to include 4 WHO markers of D/M conditions (visible mold, visible water damage, moisture measurements and mold odor) associated with adverse respiratory health effects.
    - Statistical analysis will measure the strengths of association between and among each of these parameters and asthma among the now 8 and 9 year old children in the cohort.

Translational Environmental Research Framework (TERF)

Examples of changes in best practice, policy and law:
AIM 1999; NIEHS 2013; NYC Building Code 2014; NYCHA 2018

Questions?

Bill Sothern, DrPH, MS, CIH
bsothern@microecologies.com