

Findings from HUD's Allergen QC Sample Program

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Sponsored by: HUD's Office of Healthy
Homes and Lead Hazard Control
(OHHLHC)

The Allergen QC Sample Program

- HUD recognized early that the ability to properly assess the quality of allergen test results from their grantees and in their other projects was hampered by lack of readily available quality control (QC) samples (dust samples having known levels of allergens).

The Allergen QC Sample Program

- To address this need, HUD developed QC samples for their programs to use as blind samples to the laboratories generating aeroallergen results from submitted settled dust samples collected in housing units under investigation.

The Allergen QC Sample Program

- Results from these QC samples were reported by the grantees to OHHLHC for evaluation.
- Feedback on their performance was used to complete this monitoring process, dubbed the Allergen QC Sample Program.

The Good News (1)

- HUD has a good supply of (2nd round) Allergen QC samples for future use. Out of 750 made, 514 sent out and 236 are still available. In addition, more of the same can be made if needed.
- Allergen QC Samples are made from real world dust sources (not artificially spiked).

The Good News (2)

- Allergen QC Samples are characterized for 7 aeroallergens:
 - dust mite (*Der f 1, Der p 1*)
 - cockroach (*Bla g 1, Bla g 2*)
 - cat (*Fel d 1*)
 - dog (*Can f 1*)
 - mouse (*Mus m 1*)

The Good News (3)

- An investigation of the impact of sample sieve size and extraction time shows that the generally used extraction procedure of 100 mg of dust sieved to 300 μ m in 2mL buffer using a 1-hour extraction time appears to be optimal.
- Use of an overnight extraction is only marginally better and probably not material.

The Not So Good News (1)

- Results variability for both within-lab and across-labs is overly high.
- Comparability issues resulting from differences in calibration standards exist.
- Comparisons between ELISA and MARIA™ results may be very poor for some dust samples.

The Not So Good News (2)

- Evaluation of the allergen QC sample data obtained from multiple laboratories revealed a number of questionable analytical practices that are likely significant causes of overall variability
- In general, there appears to be a lack of consensus among the laboratories on the conduct of ELISA measurements for aeroallergens in house dust samples.

Initially Reported Results Variability

Allergen	Individual Lab Results (Within Lab Variability)			All Results Combined (Across-Lab Variability)	
	Number of Labs	Range of CVs	Mean CV among all Labs	Number of Individual Results	CV
Bla g 1	7	5% - 54%	26%	20	68%
Bla g 2	4	2% - 36%	22%	14	51%
Can f 1	8	2% - 99%	41%	24	115%
Der f 1	8	2% - 19%	11%	24	97%
Der p 1	8	2% - 24%	11%	24	40%
Fel d 1	8	2% - 31%	11%	24	73%
Mus m 1	8	2% - 86%	48%	24	60%

Why is the Across-Lab Variability So High? (1)

- Some variability due to use of different calibration standards.
- InDoor Biotechnology Inc. has been improving their standards over last few years.
- Improvements included collapsing individual allergen standards into single solutions containing >1 allergen; called Universal Allergen Standards (UAS).

Why is the Across-Lab Variability So High? (2)

- Newer standards have more accurate concentration values than older ones.
- Direct comparisons of allergen data generated using different standards **cannot** be made without correcting data sets for known differences between standards used (**analytical results generated using the different standards may not be directly comparable**).
- Technical Bulletin on this was issued to HUD grantees – contained correction factors.

Partial List: Correction Factors (denominators) From Older Stds to 8-Plex UAS (Lot 31012)

Allergen	Lot Number	Description of Lot	Correction Factors
Can f 1	30006	UAS 5-plex	4.5
Can f 1	2832	Individual for Can f 1	5.9
Der f 1	30065	Individual for Der f 1	13
Der f 1	2762	Individual for Der f 1	7.3
Fel d 1	30006	UAS 5-plex	2.2
Fel d 1	2853	Individual for Fel d 1	4
Fel d 1	30002	Individual for Fel d 1	2.6

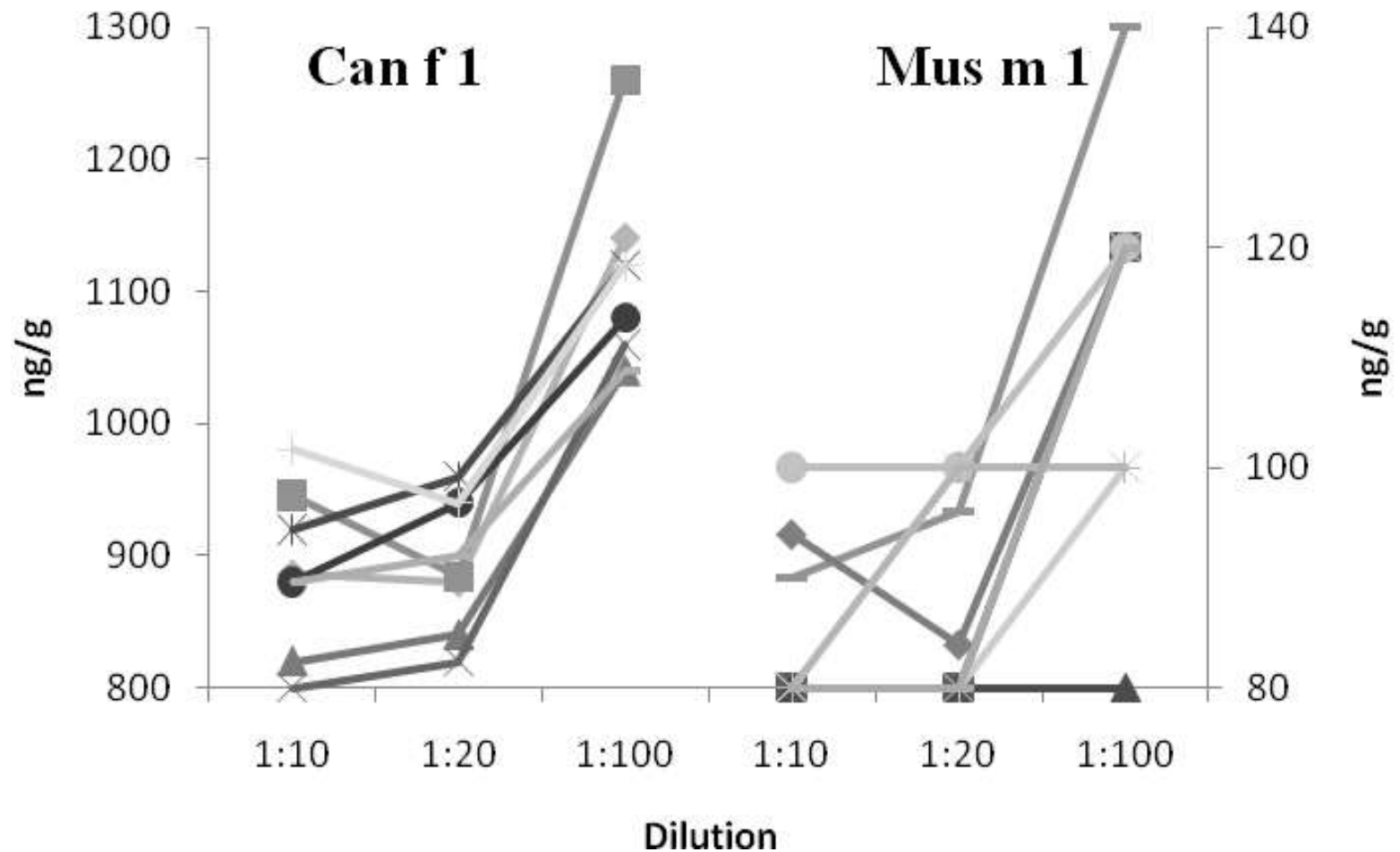
Comparison of Within-Lab and Across-Labs Results

Allergen	Within Lab Results [Not Corrected]	Across Lab Results [Not Corrected]	Across Lab Results [Corrected Data]
	Coefficient of Variation (CV)		
Bla g 1	26%	68%	nc
Bla g 2	22%	51%	46%
Can f 1	41%	115%	77%
Der f 1	11%	97%	81%
Der p 1	11%	40%	28%
Fel d 1	11%	73%	49%
Mus m 1	48%	60%	63%

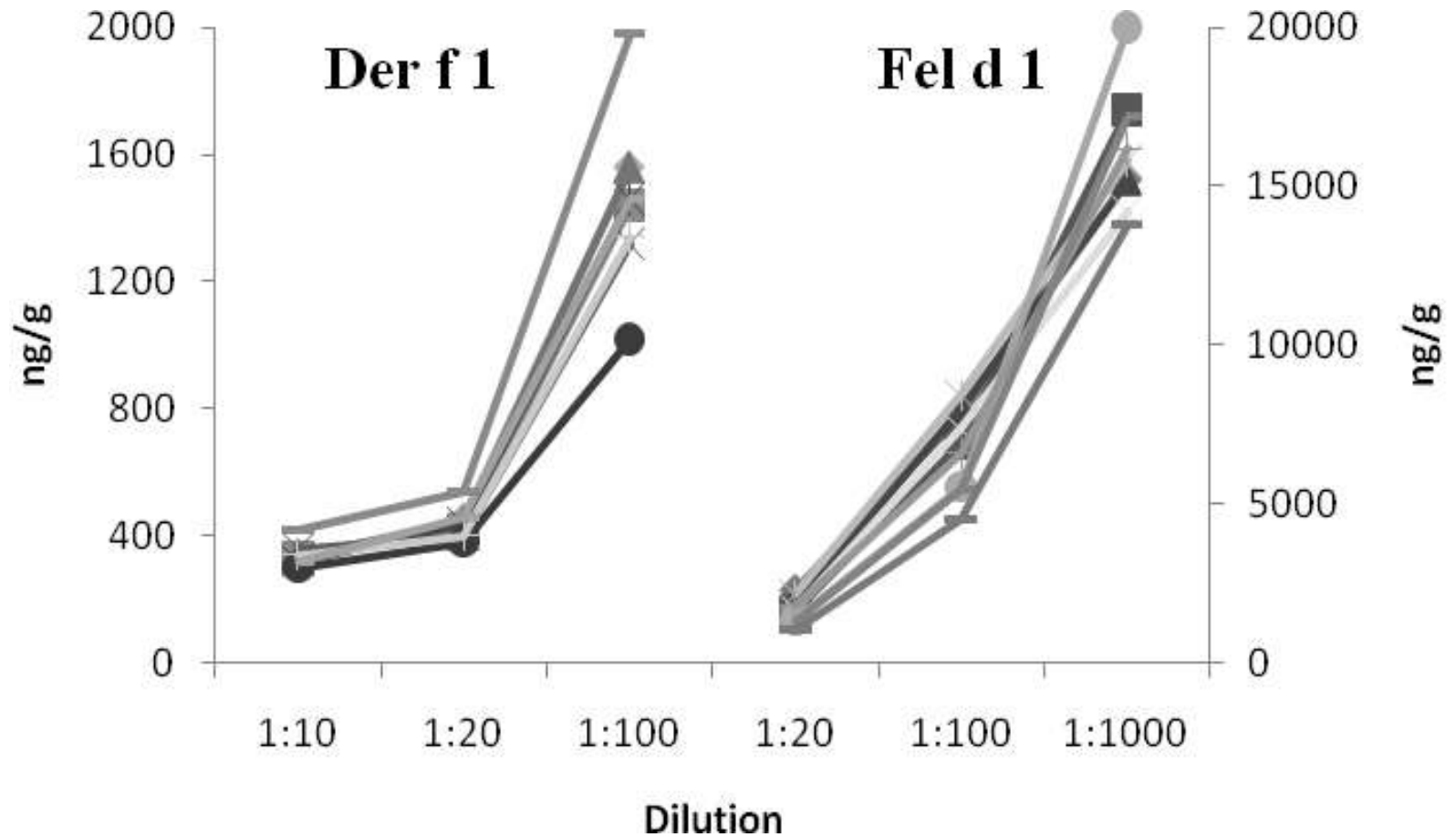
ELISA/MARIA™ Comparisons

Allergen	Ratio of ELISA/MARIA™ Results		
	Lab 1	Lab 2	Lab3
Bla g 2	81%	3.1% - 15%	na
Can f 1	319%	94%	120%
Der f 1	291%	20%	75%
Der p 1	188%	124%	105%
Fel d 1	471%	233%	89%
Mus m 1	207%	114%	168%

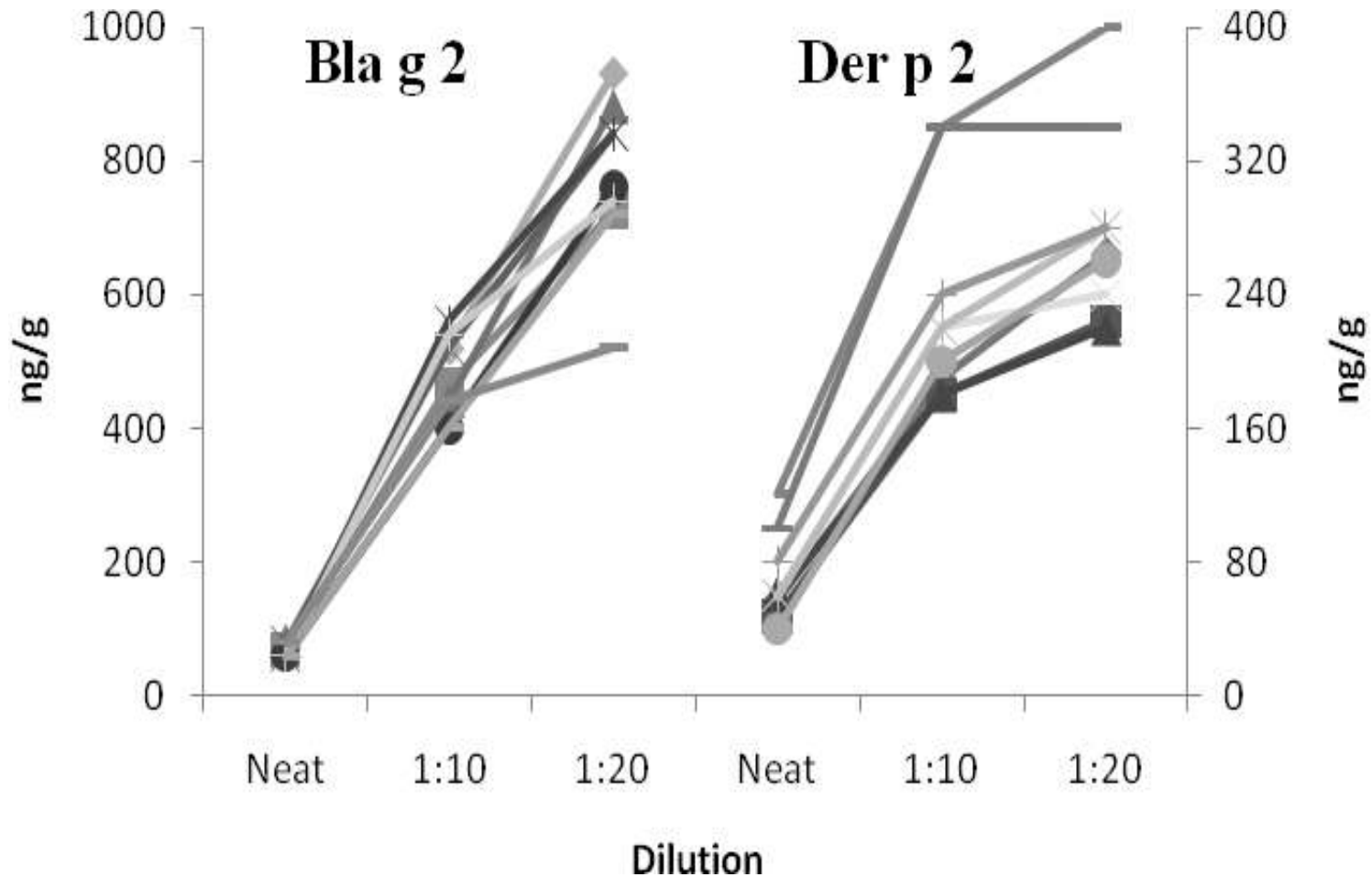
The Effect of Dilution on Reported MARIA™ Results (1)



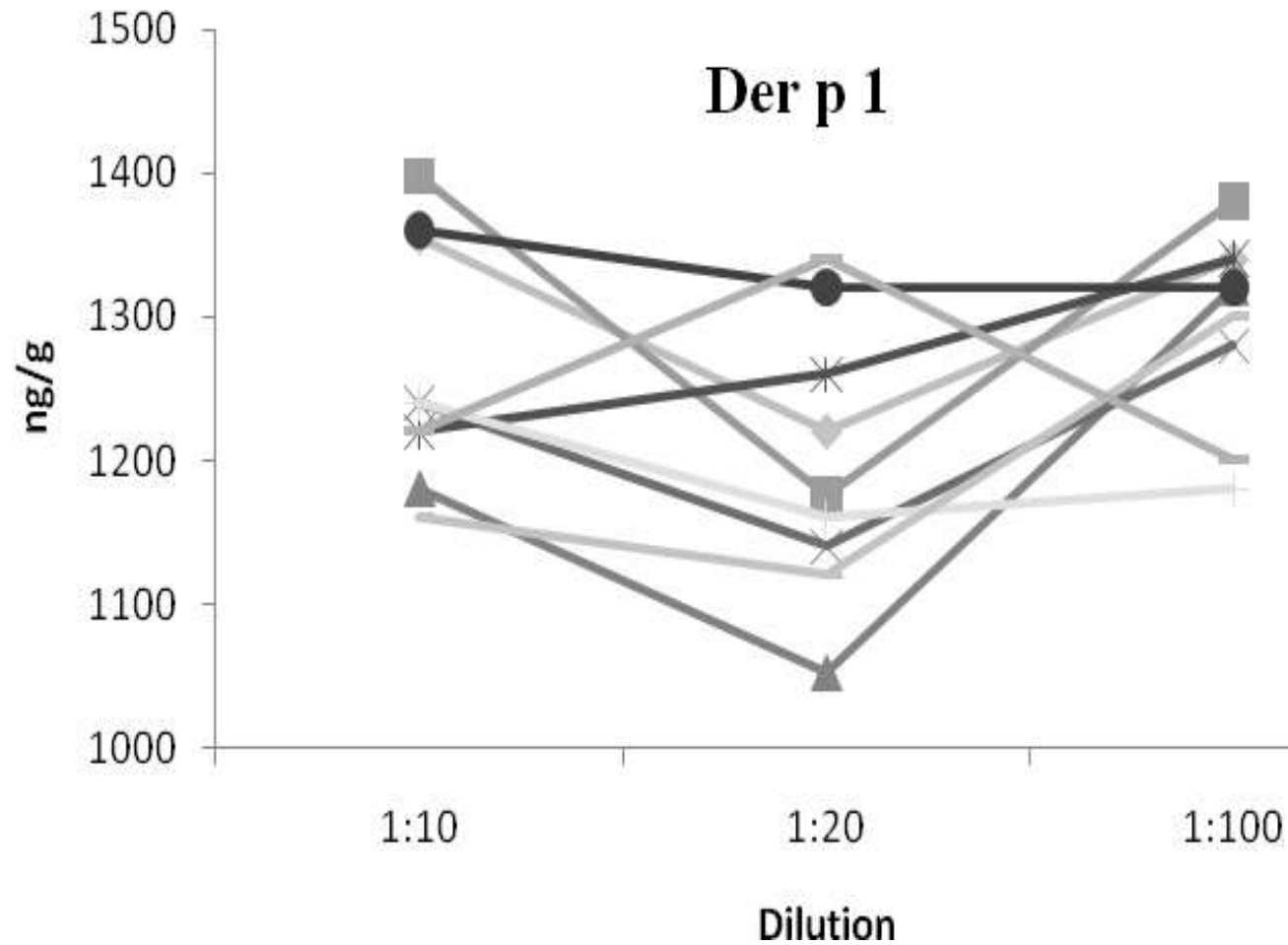
The Effect of Dilution on Reported MARIA™ Results (2)



The Effect of Dilution on Reported MARIA™ Results (3)



The Effect of Dilution on Reported MARIA™ Results (4)



Lab Practice Issues (1)

(1) Detection limits disagreements (ELISA)

Reported ELISA DLs from Participating Labs							
Lab	Bla g 1 (U/g)	Bla g 2 (ng/g)	Can f 1 (ng/g)	Der f 1 (ng/g)	Der p 1 (ng/g)	Fel d 1 (ng/g)	Mus m 1 (ng/g)
Lab1	0.18	16	50	25	50	30	16
Lab2	0.2	20	41	82	71	151	7
Lab3	0.078	na	200	98	98	51	10
Lab4	0.6	na	800	400	400	120	40
Lab5	0.4	60	100	400	400	120	20
Lab6	0.4	100	100	100	100	40	10
Lab7	0.04	100	100	100	100	40	10
Lab8	0.4	200	200	200	200	80	20

Lab Practice Issues (1c)

(1) DL disagreements (cont.)

- Labs use inconsistent definitions and procedures for DLs.
- ELISA DL Methods quoted by Labs:
 - Lowest calibrator on standard curve for DL
 - Lowest calibrator on standard curve after masking those not on linear part of curve.
 - Low concentration replicate approach similar to standard EPA method
 - 2x mean value of negative control

Lab Practice Issues (2-4)

- (2) Indiscriminate masking of standards to improve calibration curve fits.** (Specs quoted by labs stating they will achieve a correlation coefficient (r) of standard curve fit to the data ≥ 0.980 do not mean much if lab masks off offending data points)
- (3) Lack replicate analysis.** Each dilution of sample should be run in duplicate.
- (4) Lack of positive controls.** Calling one of the calibration points a positive control is bad science....use a real sample extract!

Lab Practice Issues (5)

(5) Lack of negative controls; poor acceptance/rejection criteria for results obtained from multiple serial dilutions.

You need the negative control data on every plate to decide which sample dilutions are used to report sample results...

The Industry needs to settle upon a common set of acceptance/rejection criteria.

Suggested Acceptance/Rejection Criteria (1-3)

- 1. Upper Calibration Limits.** Use only responses (optical density) $<10\%$ of the highest calibration standard.
- 2. Replicate criterion.** CVs must be $<25\%$. If not, re-analyze!
- 3. Lower Calibration Limits criterion.** Use only responses $\geq 2x$ negative control. If all dilutions $< 2x$, use the least dilute-mark as not detected.

Suggested Acceptance/Rejection Criteria (4-5)

4. Acceptable Dilution Response criterion.

Verify, if possible, that responses on different dilutions are dropping as dilutions increase. If not, re-run sample at larger dilutions.

5. Multiple Within Calibration Range

Responses criterion. Average results obtained from all dilutions with a response $\geq 2x$ negative control and $< 10\%$ of the highest calibration standard.

Suggested Lab Directives (1)

Ask the Lab to:

- Report all std lot numbers used (distinguish between lot #s for the test kits and lot #s for the calibration standards)
- Use 300um (50 mesh) sieve; report total mass on collected samples.
- Analyze all sample extracts in duplicate.
- Run a negative and a positive control as a samples on every plate and REPORT it.

Suggested Lab Directives (2)

Ask the Lab to:

- Specify analysis parameters being used and acceptance/rejection criteria for analysis responses.
- Specify the DLs and RLs (if used) and how these were derived.
- Provide to you at least some of the optical density (instrument) printouts.

Suggested Lab Directives (3)

Ask the Lab to:

- For MARIA, specify a method for verifying that results provided are comparable to ELISA results such as acceptable replicate results at different dilutions.

Conclusions

- **Measurement variability is high. Be cautious in attributing changes in aeroallergen levels to cause and effect relationships.**
- **Use established correction factors to correct data for differences caused by use of different standards**
- **For more information contact:
fgdewalt@quantech.com or
peter.j.ashley@hud.gov.**

How Much is Too Much Too Wheeze?: Asthma Clinical Assessment and Standardized Allergen Sampling

Megan Sandel, MD, MPH, Boston Medical Center

Sherry Dixon, PhD, National Center for Healthy Housing

David Jacobs, PhD, CIH, National Center for Healthy Housing

John Adgate, PhD, University of Colorado

Outline

- Laboratory Study-John Adgate, PhD
- Field Study-Johnna Murphy
- Asthma Assessment-Megan Sandel, MD, MPH
- Current Data-Sherry Dixon, PhD
- Conclusion-David Jacobs, PhD, CIH

Objectives

To define the strengths and weaknesses of three allergen sampling methods and their relationship to asthma morbidity by:

- Assessing the performance of three common allergen samplers in a laboratory setting
- Making evidence-based recommendations for field use of allergen samplers;
- Providing an overview on allergen loadings and concentrations in different rooms, on different surface types and with different sampling methods
- Identifying the allergen sampling locations and methods that best predict asthma morbidity. (not yet analyzed)

Standardization of Allergen Sampling in Indoor Environments: Performance of Three Commonly Used Samplers

John Adgate

Colorado School of Public Health, Denver, CO

This research was funded by Healthy Homes Technical Study Grant MNLHH0153-06 from the Department of Housing and Urban Development (HUD).

Context: Asthma and Allergen Exposure

- Asthma prevalence rising worldwide
- A classic “gene-environment” interaction
- Indoor air contaminants almost certainly a factor
 - Tighter construction trapping pollutants
 - Children spend more time indoors
 - Allergens implicated: dust mites, cockroach, cat, dog, mouse, fungi
 - **Epidemiological Studies and National Surveys have used varying methods to characterize exposure in homes**



Experimental Design

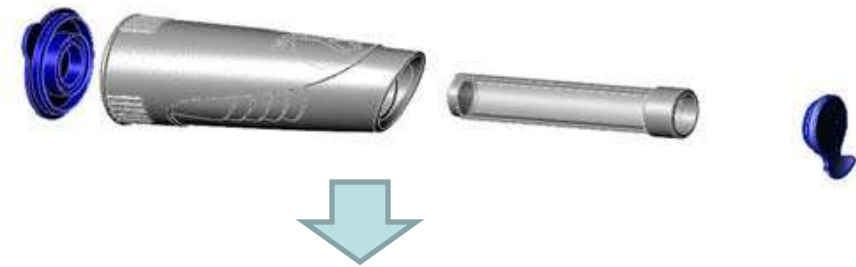
- Randomized Factorial
- Size fractionated test dust:
 - 212-90, 90-45, and <45 microns
- Treatment variables:
 - Sampler (AIHA, EMM (Eureka Mighty Mite), HVS (HVS3))
 - Carpet Properties (pile height, pile density, denier, 6 carpets)
 - Relative Humidity (20, 50, or 80%)



Methods

- Controlled environment
 - Dust embedded using ASTM method F608-9
 - Covariates monitored: RH, electrostatic intensity
- Dust mass obtained by gravimetry (fiber adjusted)
- Allergen quantification: Total dust mites (Der p 1 and Der f 1), cat (Fel d 1) and cockroach allergens (Bla g 1) using ELISA methods at AQS
- QC samples provided by HUD
- Stats: calculated fiber adjusted Collection Efficiency (CE) and Concentration Ratio (CR =Allergen concentration in sample/Allergen concentration in test dust); ANOVA and Regression analysis

Samplers and Media



Methods: Samplers/Carpets





Results I

- 138 experiments, with 29 replicates
 - AIHA=49
 - EMM=50
 - HVS=39
- Collection efficiency varies by sampler and particle size fraction
- Test Dust results: more between than within batch variability for all allergens
 - Concentration ratios calculated within batch

Collection Efficiency (CE)

Sampler	Part. Size	Mean \pm SD	%CV
AIHA	Large	0.9% \pm 2.2%	252%
	Medium	10% \pm 9.1%	95%
	Small	17% \pm 15%	93%
EMM	Large	47% \pm 14%	29%
	Medium	63% \pm 10%	15%
	Small	44% \pm 17%	39%
HVS	Large	24% \pm 13%	54%
	Medium	41% \pm 12%	29%
	Small	42% \pm 18%	44%

Conc. Ratios: Dust Mites

Sampler	Part. Size	Mean \pm SD	%CV
AIHA	Large	NA	NA
	Medium	126% \pm 32%	25%
	Small	79% \pm 19%	24%
EMM	Large	52% \pm 33%	64%
	Medium	77% \pm 31%	40%
	Small	92% \pm 54%	58%
HVS	Large	69% \pm 78%	113%
	Medium	84% \pm 20%	24%
	Small	76% \pm 22%	29%

Conc. Ratios: Cat

Sampler	Part. Size	Mean \pm SD	%CV
AIHA	Large	NA	NA
	Medium	119% \pm 80%	67%
	Small	106% \pm 52%	49%
EMM	Large	52% \pm 42%	80%
	Medium	101% \pm 41%	40%
	Small	114% \pm 73%	64%
HVS	Large	45% \pm 49%	110%
	Medium	49% \pm 38%	78%
	Small	126% \pm 169%	134%

Conc. Ratios: Cockroach

Sampler	Part. Size	Mean \pm SD	%CV
AIHA	Large	NA	NA
	Medium	115% \pm 42%	37%
	Small	85% \pm 24%	28%
EMM	Large	180% \pm 182%	101%
	Medium	65% \pm 29%	44%
	Small	98% \pm 29%	30%
HVS	Large	130% \pm 84%	65%
	Medium	73% \pm 42%	58%
	Small	86% \pm 25%	29%

Discussion

- Collection efficiency for medium and small dust size fractions EMM>HVS>AIHA
- Concentration ratio results: mean and %CV (collection volume)
 - Total Dust Mites: AIHA and HVS appear better than EMM
 - Cat: AIHA and EMM appear better than HVS
 - Cockroach: AIHA > HVS > EMM
- Regression and ANOVA show that for these allergens sampler and PS effects dwarf all other experimental variables
 - Effects were independent of the allergens tested for the most part, though carpet properties were important for cockroach allergen

Conclusions/Future Work

- AIHA has much lower CE, but is relatively easy to use and may provide more representative concentrations
- EMM has highest CE, but this increased efficiency decreases concentration and increases variability
- HVS provides a middle ground between these two, but in these experiments performs closer to AIHA
- Ease of use: EMM and AIHA win out, though carpets and smooth surfaces offer different challenges
- Which sampler to use for standard setting if concentration is the metric of interest?

From the Lab...



To the Real World.

Boston Allergen Sampling Study

- “Real World” Equivalent to Lab study
- Utilizes same three sampling methods
- Conducted in the homes of doctor diagnosed asthmatics
- Alongside clinical and environmental assessment



Rule of Three:



- **3 Rooms:** Living Room, Kitchen, Bed
- **3 Methods:** AIHA, HVS, EMM
- **3 Areas:** 2 square feet sampled from 3 areas of the room for a total of 6 square feet each method (Living Room and Kitchen)

Floor Sampling

- Technicians use templates to measure exactly six square feet of sampling space
- If possible, sample inside doorway, middle of room, and near furniture.
- Avoid cross contamination- gloves, stepping in sampling area, disinfect equipment after every visit
- Timed but not time limited



Bed Sampling

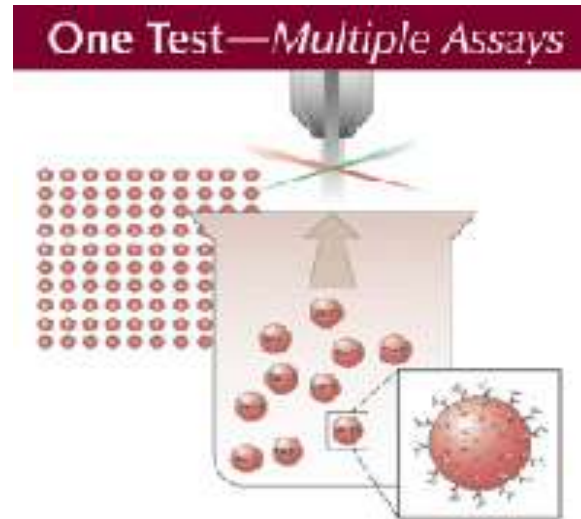


- Measure bed of child with asthma and up to two Pillows
- Divide into three parts for each method
- Sample from fitted sheet or surface closest to body

Back in the lab...

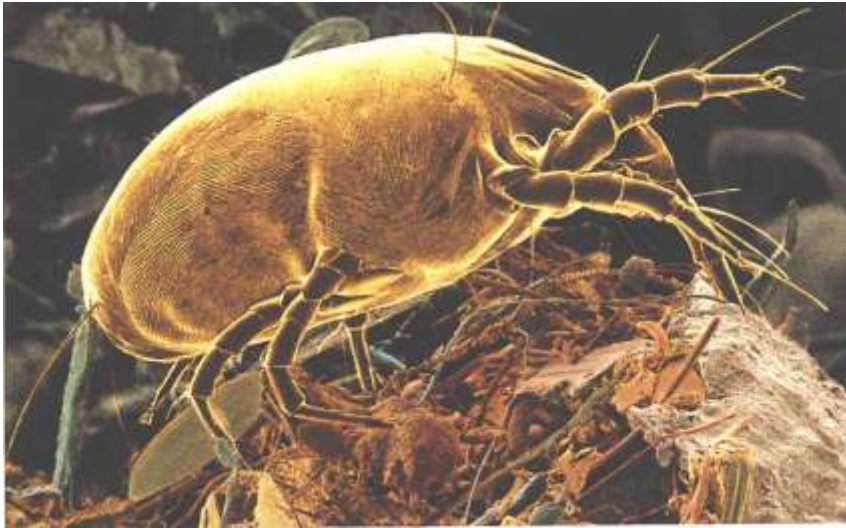
- Before dust is collected, media is dessicated and weighed
- Samples are dessicated and weighed after collection
- Send to Indoor Biotechnologies for MARIA analysis

The MARIA method



The Multiplex Array for Indoor Allergens (MARIA™). MARIA™ technology uses polystyrene microspheres that are internally dyed with distinct fluorophores to create as many as 100 distinctly coded bead sets. Capture antibodies are covalently coupled to different bead sets and then used to develop quantitative immunoassays using biotinylated detector antibodies and a reporting fluorophore (<http://www.indoorbio.com>).

The MARIA method



- One advantage is it requires much less dust than ELISA (only 30mg)
- Another advantage is it can look at up to 11 allergens at once



8 Allergens looked at:

- Dust mite (Der p 1, Der f 1, mite group 2)
- Mouse (Mus m 1)
- Cockroach (Bla g 2)
- Cat (Fel d 1)
- Dog (Can f 1)
- Rat (Rat n 1)





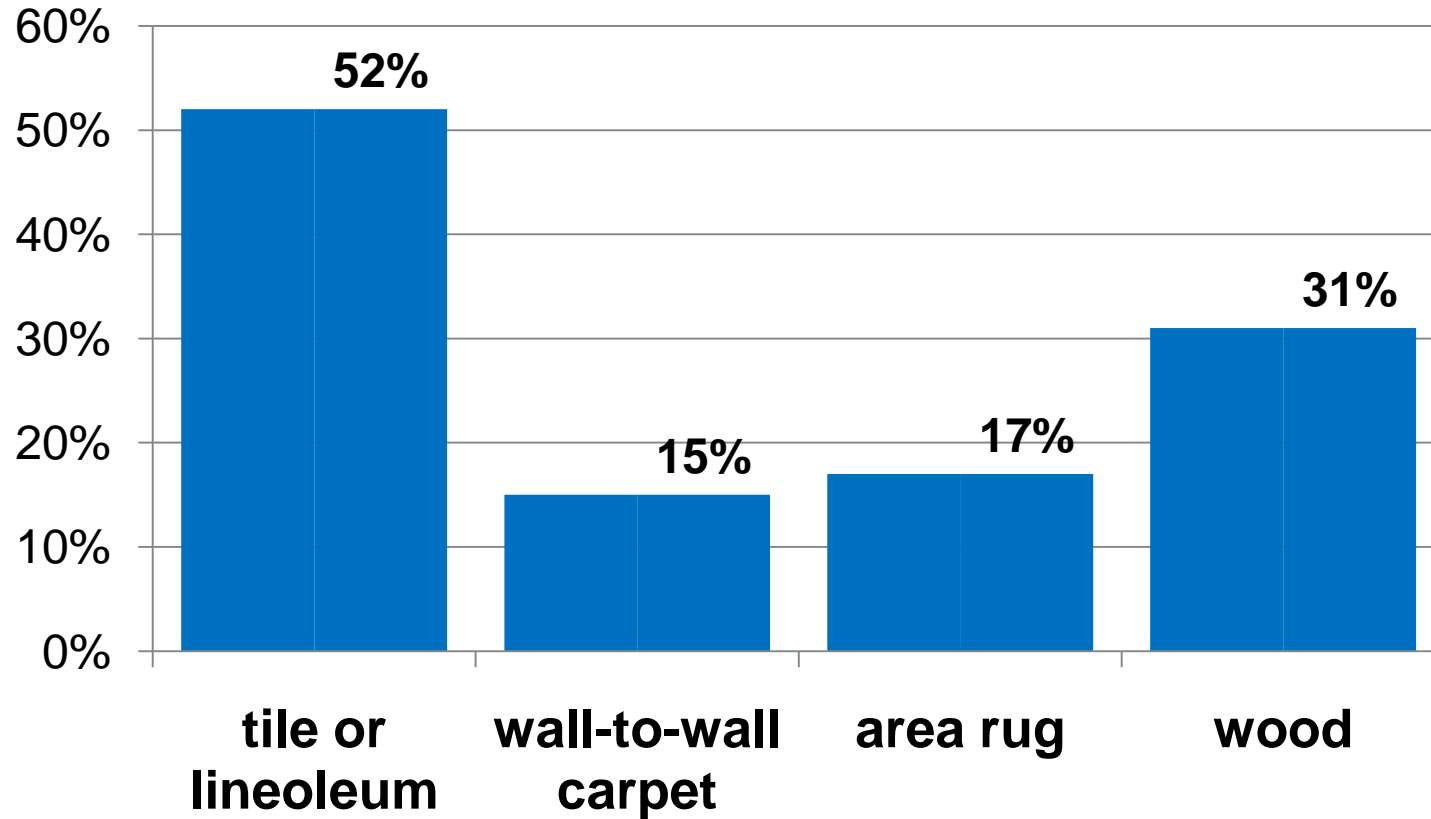
How did we define asthma control?

- Asthma Control Test (score-5-25)
- Two Week Recall of Symptoms (day and night limited activity)
- Rate severity and control based on NAEPP guidelines (use two week recall data to rate severity and control)

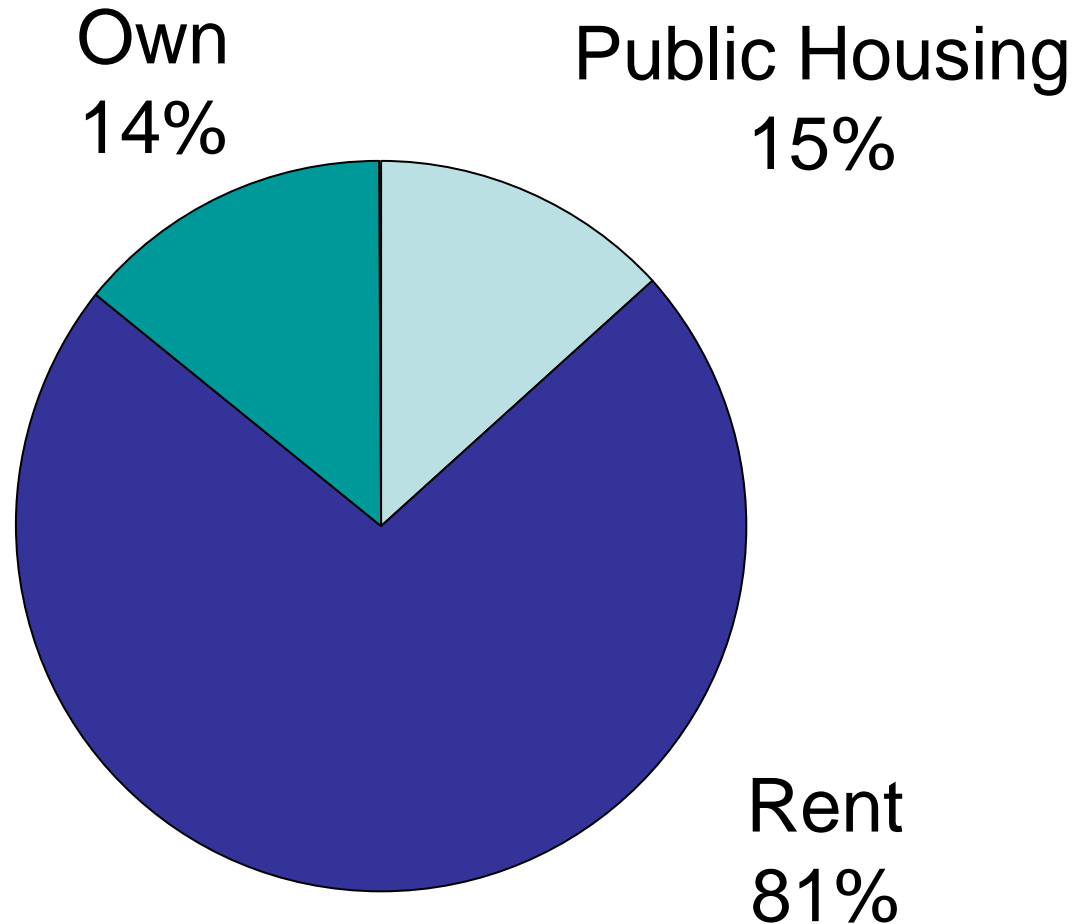
Results thus Far

- 180 homes completed out of 200 as of March
- 164 homes analyzed to date
- 80% children, 20% adult (ages 4-65)
- Average child age: 9 years

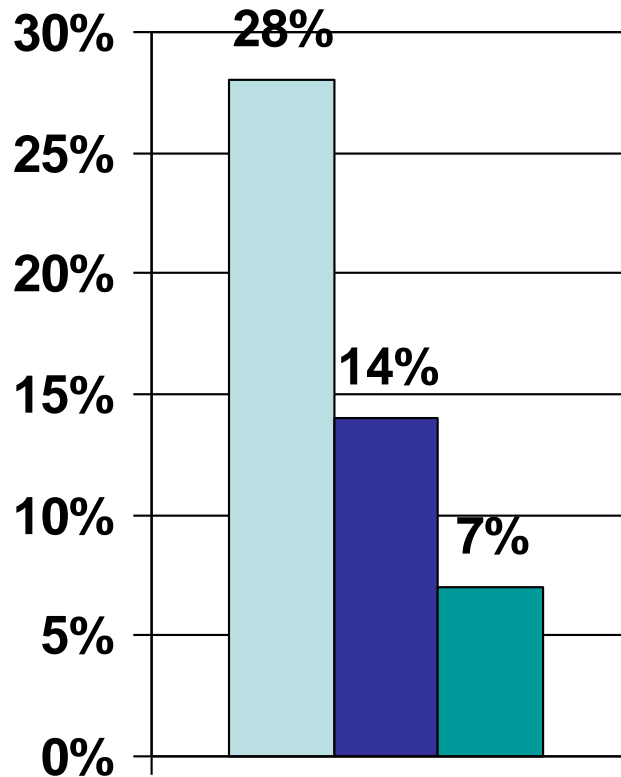
Type of Flooring



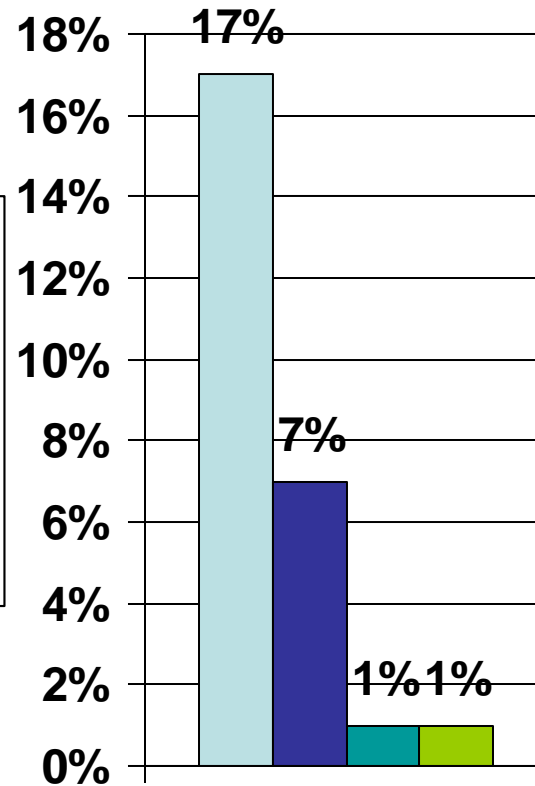
Type of Housing



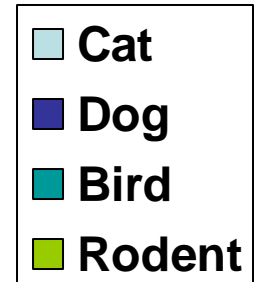
Allergen Sources



Pests Observed in last month



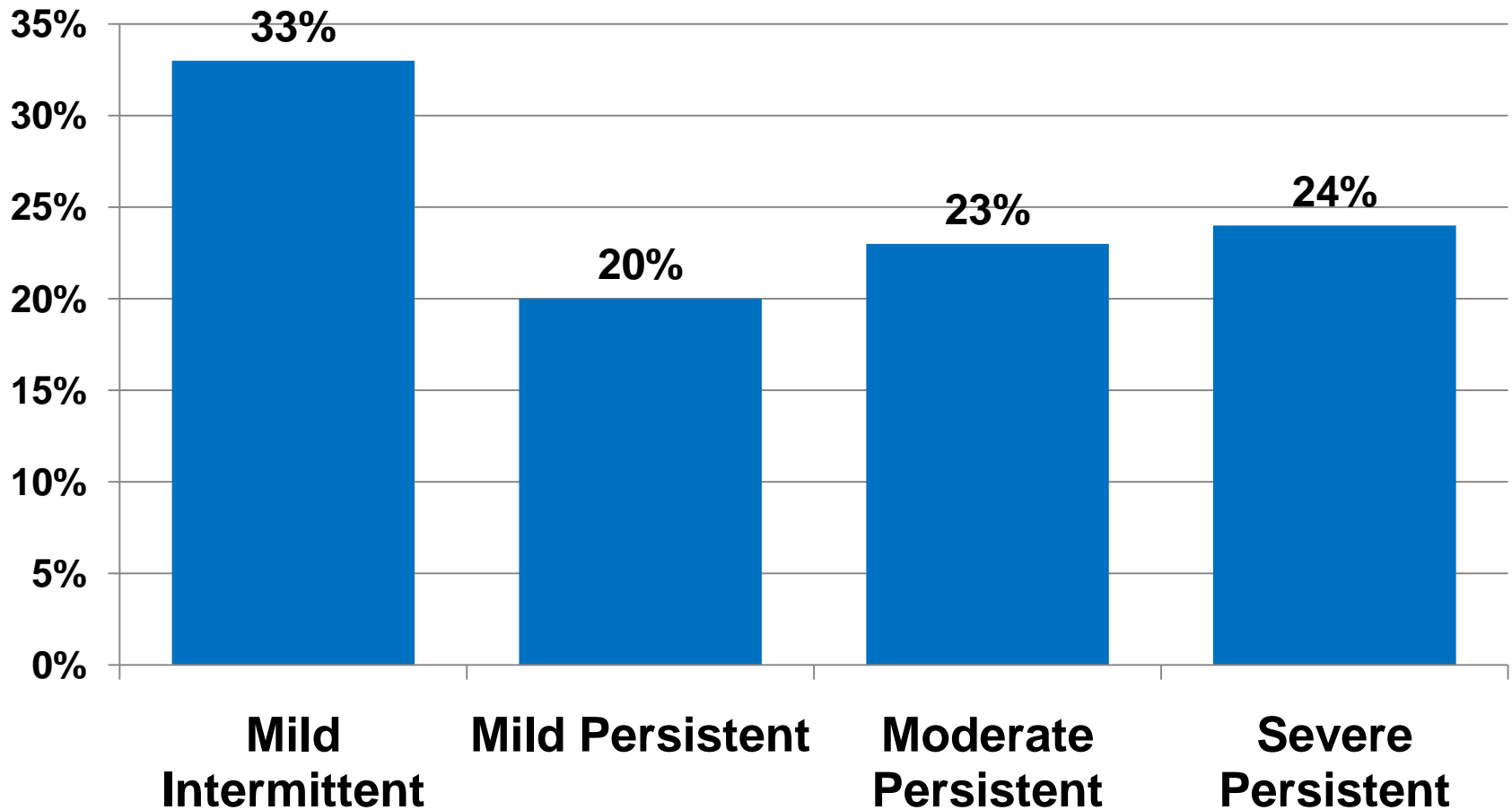
Pets



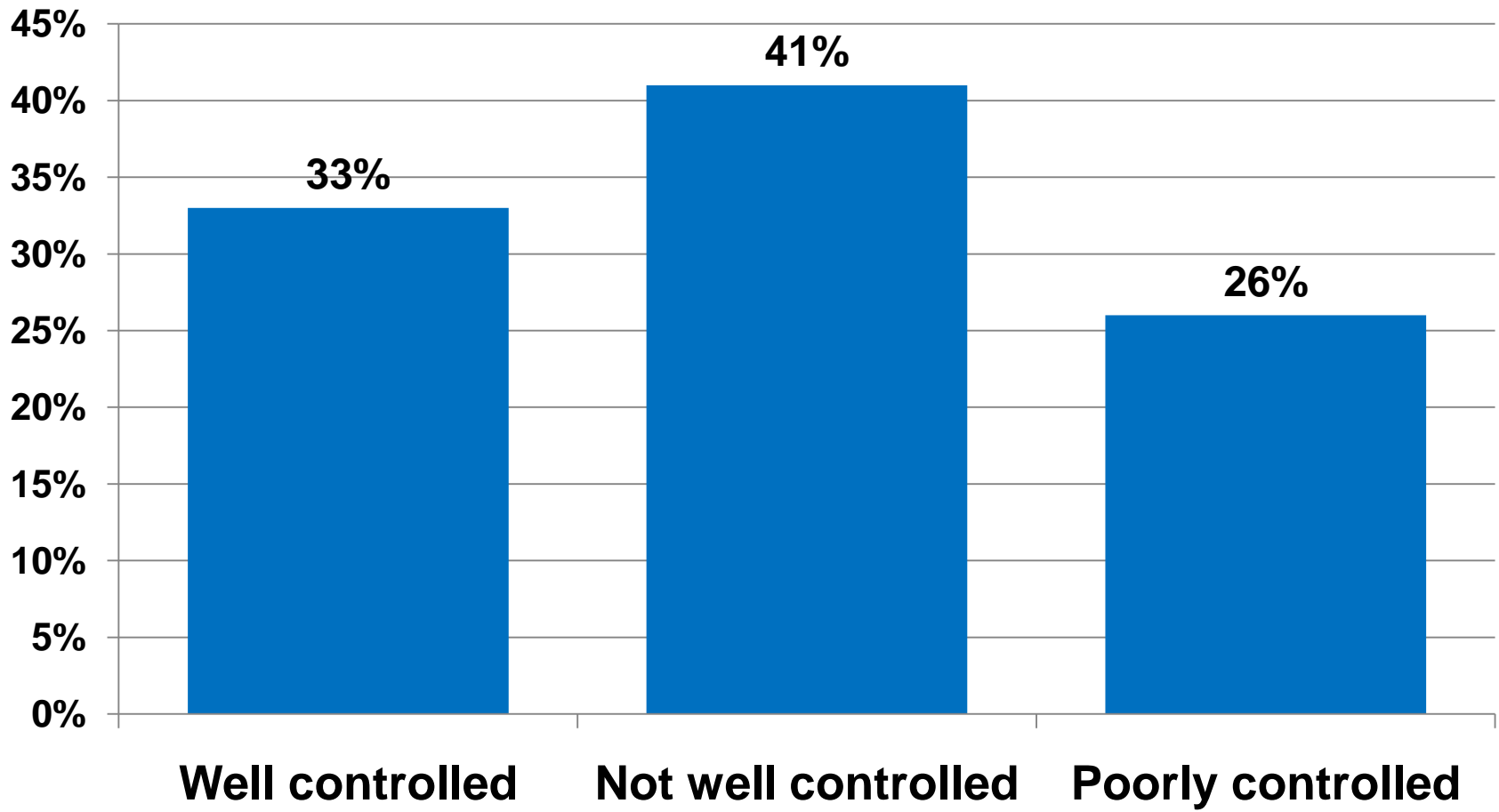
Asthma Results

- ACT score (5 best to 25 worst): median 17
- Number of symptom days: median once or twice a week
- Used rescue medication or nebulizer: median 2-3 times a week

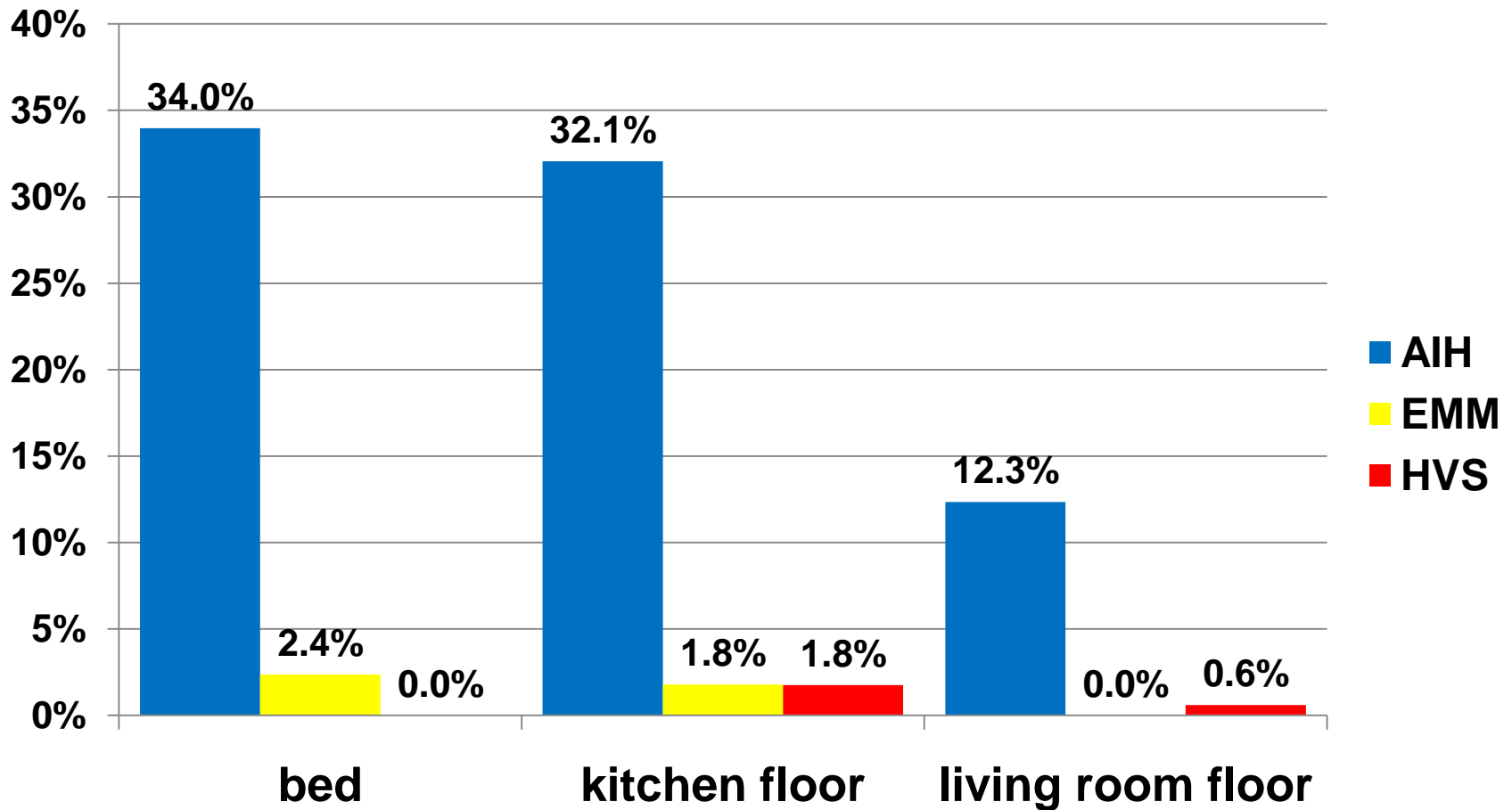
Asthma Severity



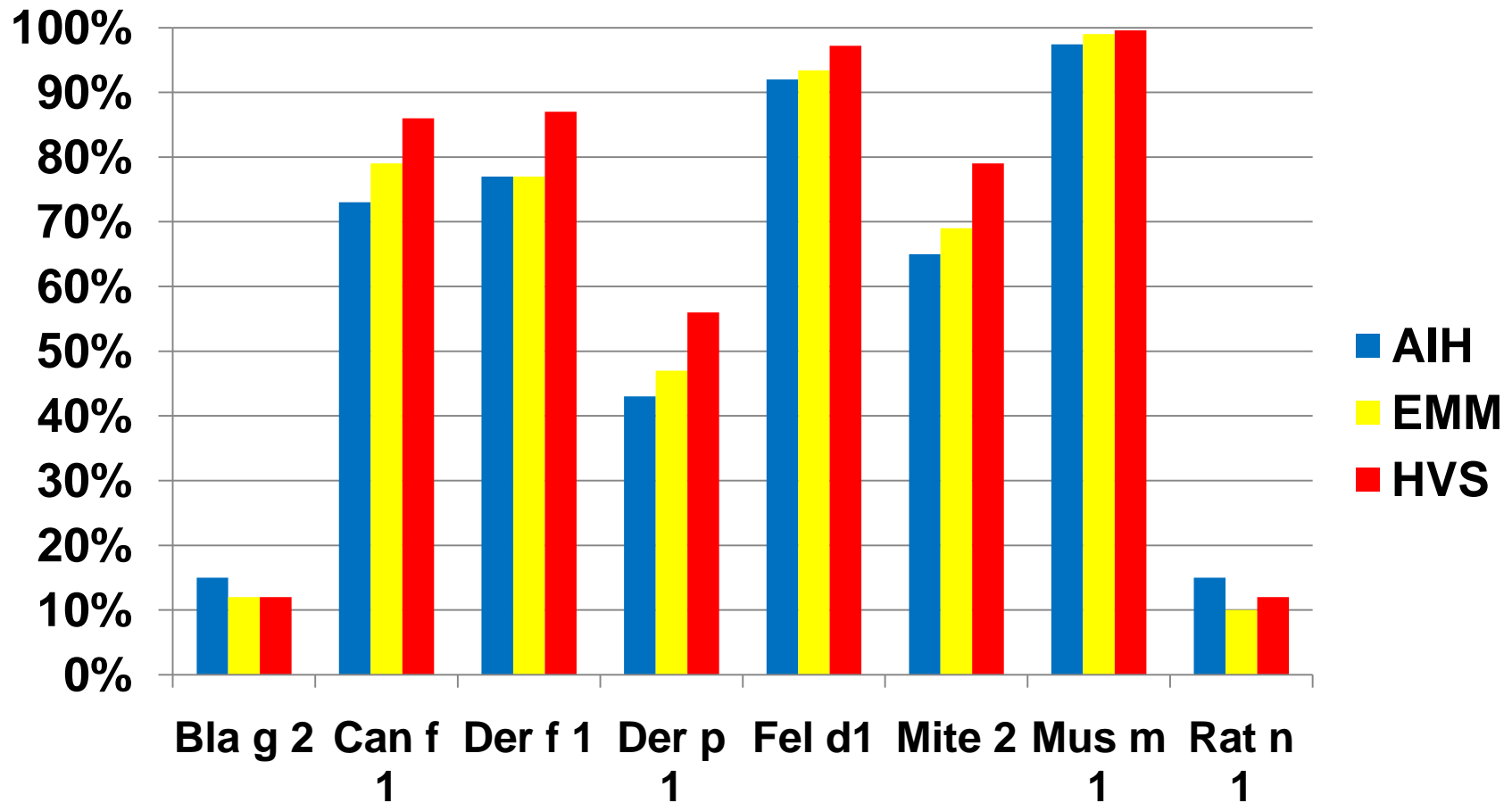
Asthma Control



Samples with an Insufficient Quantity of Dust to Analyze



Allergen Concentrations Above the Detection Limit

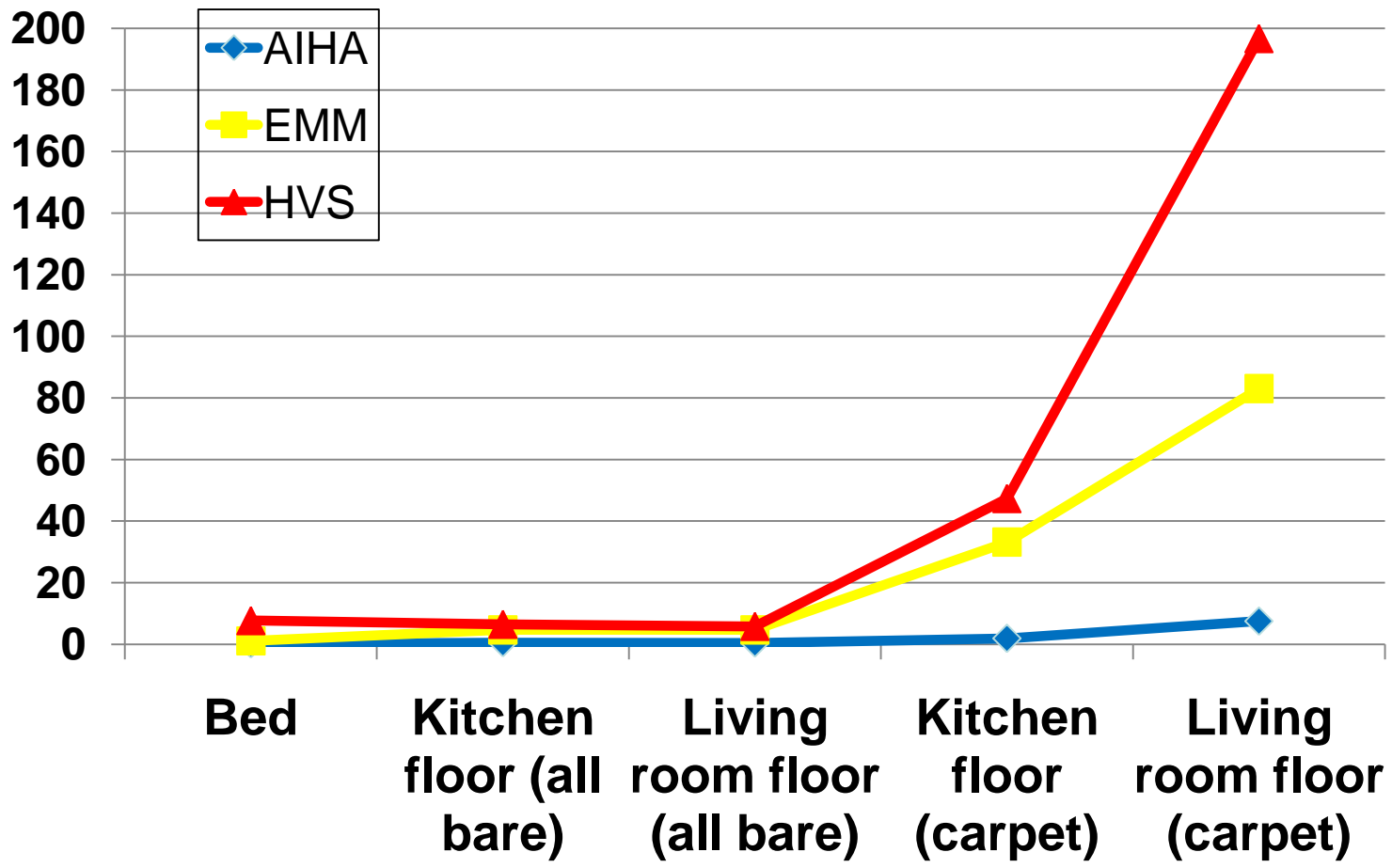


Rooms/Surface types

- Bed (162 samples)
- Living room
 - All bare: 50% (82 samples)
 - Carpet: 50% (82 samples)
- Kitchen
 - All bare: 84% (140 samples)
 - Carpet : 16% (26 samples)

“Carpet” includes wall-to-wall carpet or mix of bare and carpet

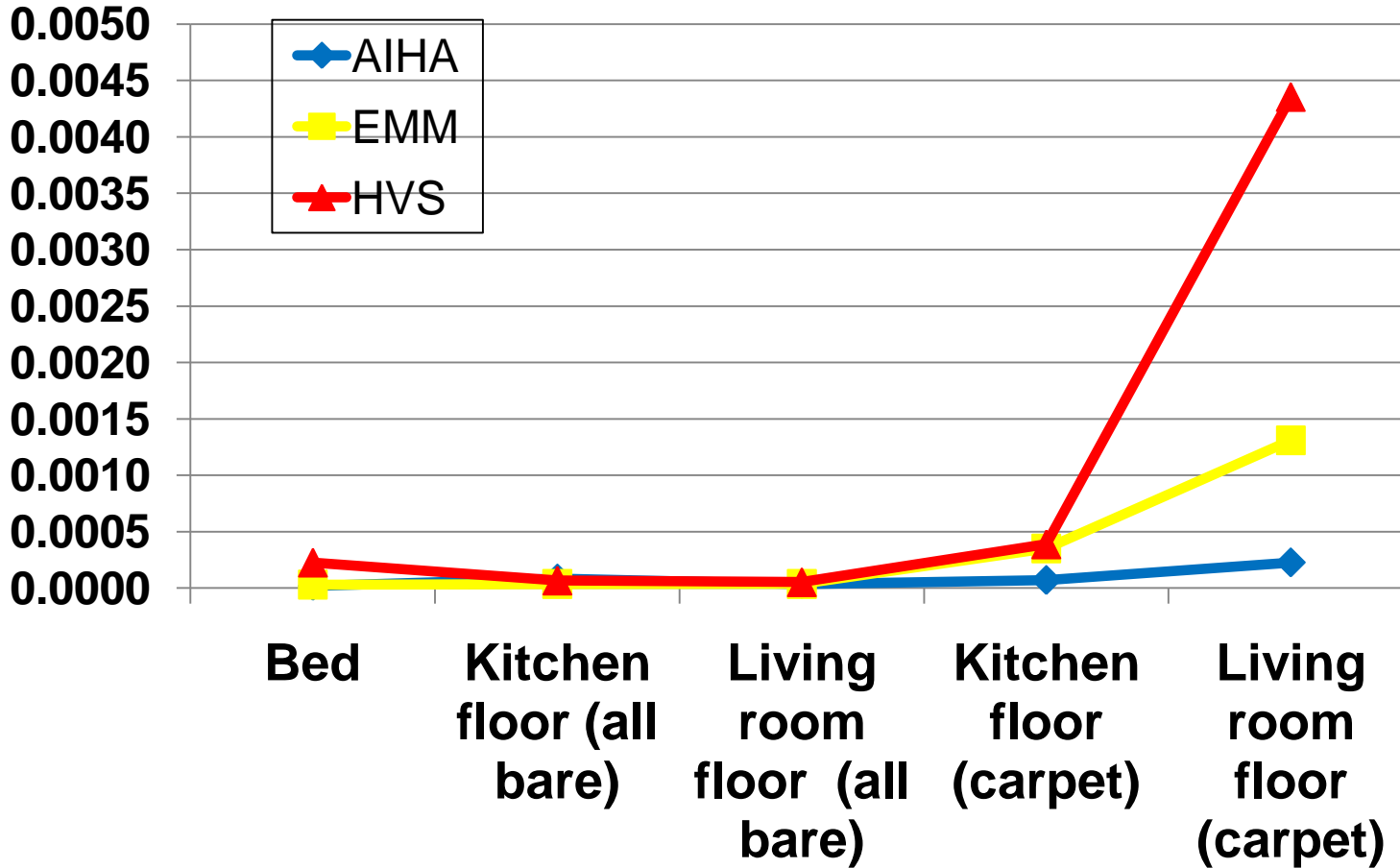
Median Total Sieved Dust Loading (mg/ft²) by Method and Room/Surface



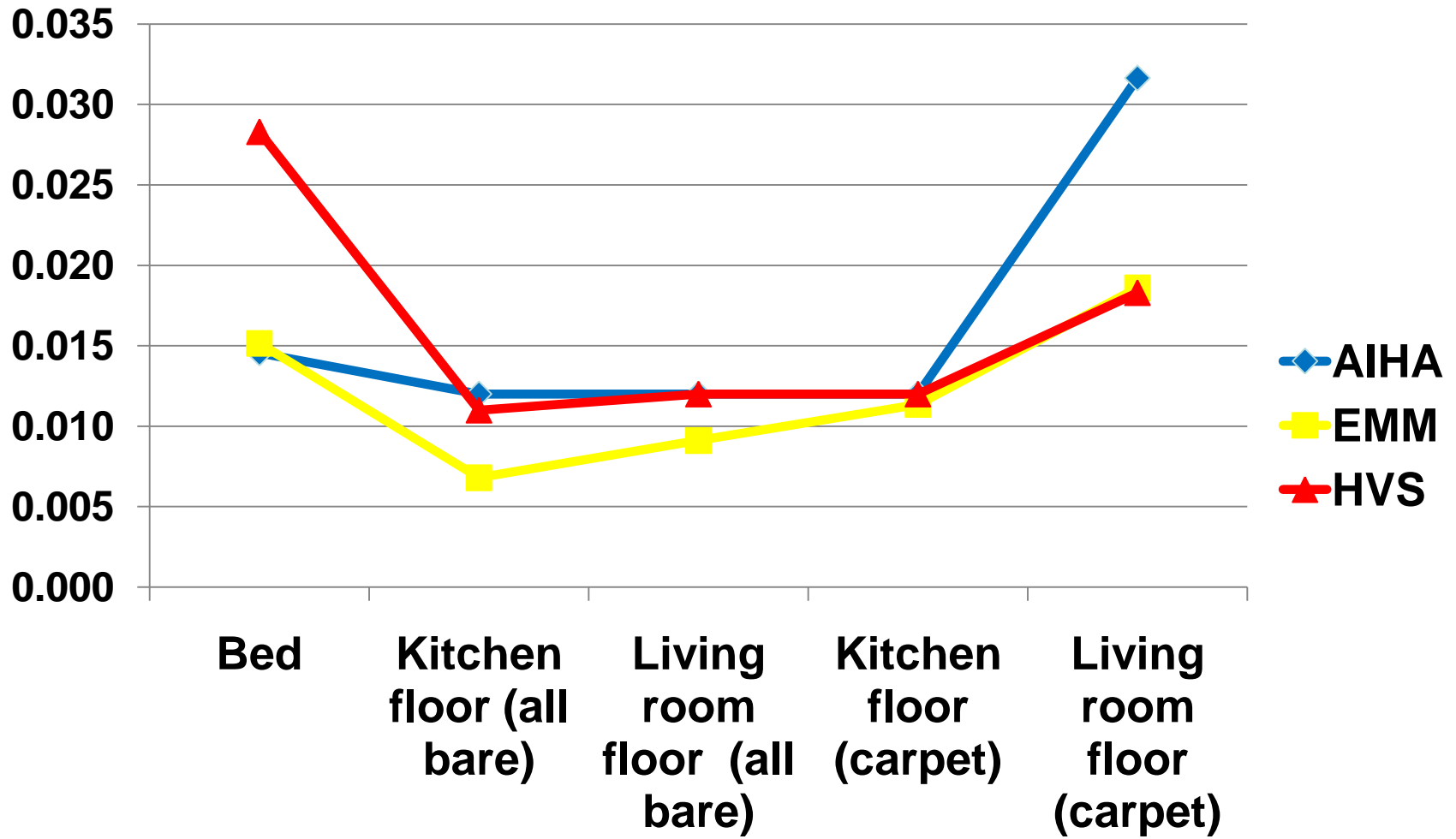
Select two allergens as examples

- Dog allergen (Can f 1)- found in larger particles (> 10 microns) and smaller particles (< 2.5 microns) that can remain airborne for a longer period of time.
- Dust mite allergen (Der f 1)- found in larger particles (10-40 microns) that settle out of the air rapidly.

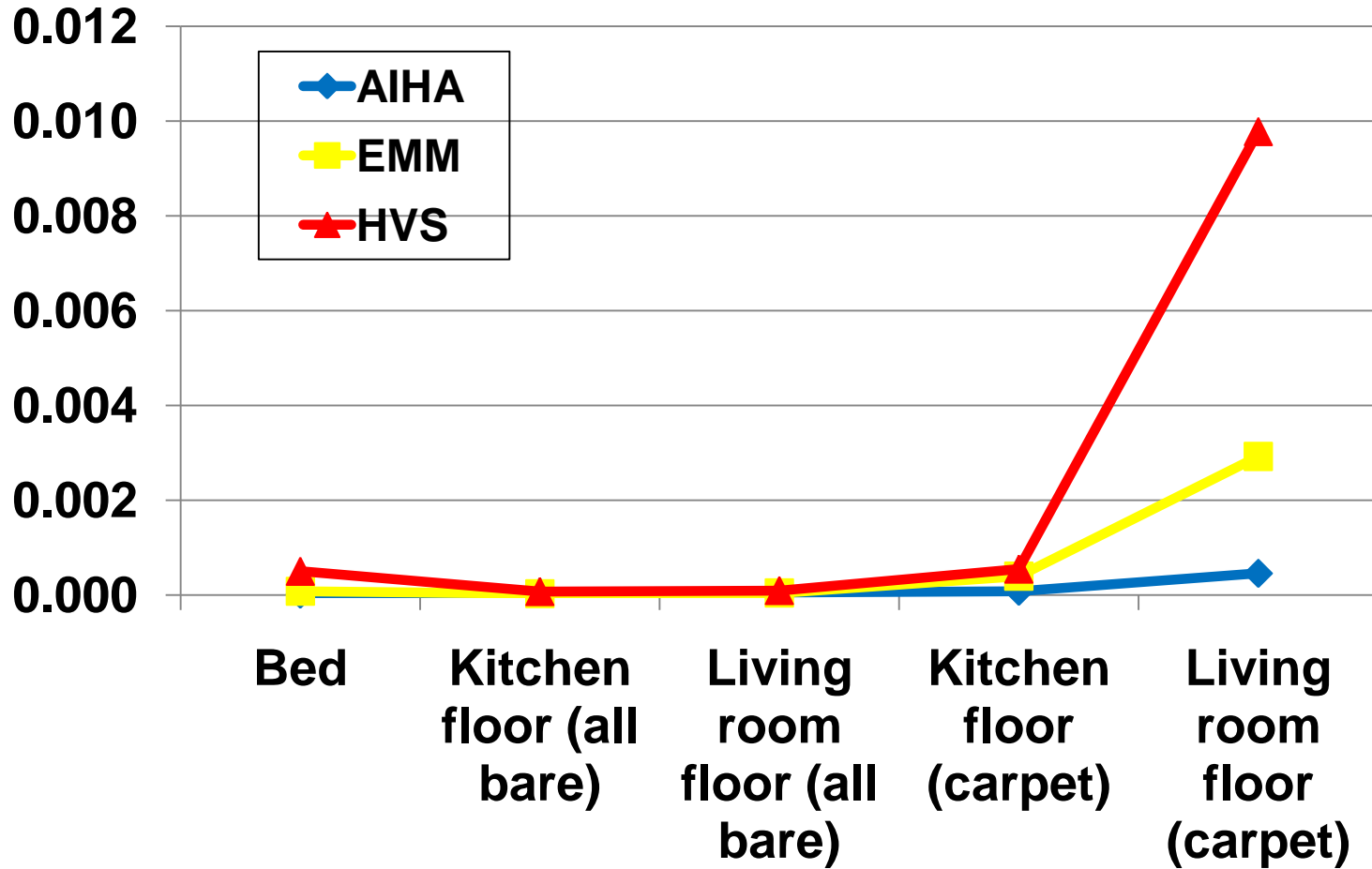
Median Can f 1 Allergen Loading ($\mu\text{g}/\text{ft}^2$) by Method and Room/Surface



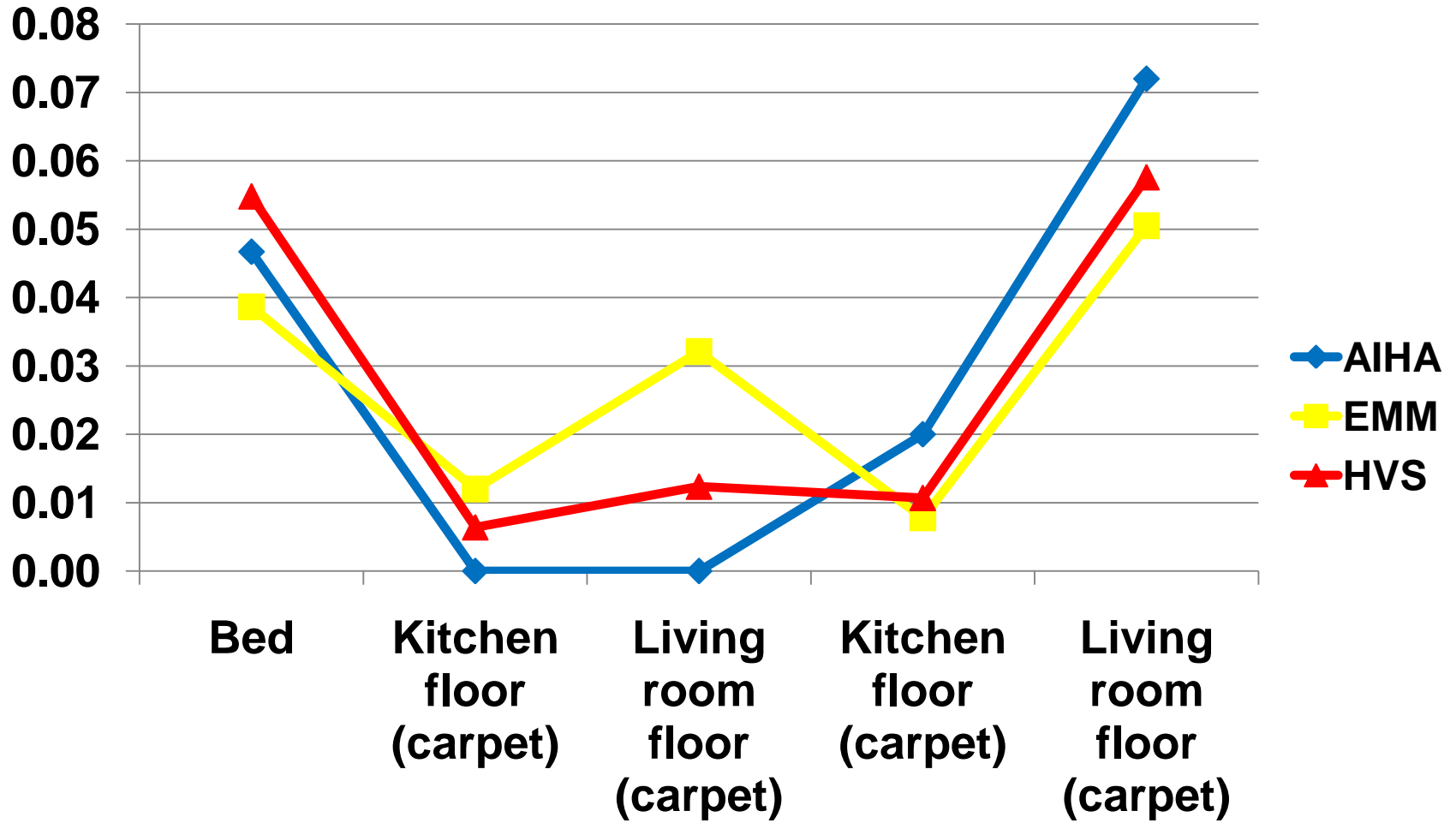
Median Can f 1 Allergen Concentration ($\mu\text{g/g}$) by Method and Room/Surface



Median Der f 1 Allergen Loading ($\mu\text{g}/\text{ft}^2$) by Method and Room/Surface



Median Der f 1 Allergen Concentration ($\mu\text{g/g}$) by Method and Room/Surface



Correlations

- Between methods on same room/surface type
- * Color coding: combine correlations for can f 1 and der f 1 loadings and concentrations
 - Green = Highest 1/3
 - Orange = Middle 1/3
 - Red = Lowest 1/3
- ** = Significant correlation at $p=0.05$.
- * = Significant correlation at $p=0.10$.

Dog (Can f 1) between method correlations

<i>room</i>	<i>Surface type</i>	<i>AIHA with EMM</i>	<i>AIHA with HVS</i>	<i>EMM with HVS</i>
CONCENTRATION				
Bedroom	Bed	0.93(n=70)**	0.92(n=75)**	0.89(n=140)**
Living room	Floor (Carpet)	0.95(n=73)**	0.88(n=69)**	0.92(n=72)**
Living room	Floor (All Bare)	0.86(n=32)**	0.82(n=36)**	0.83(n=54)**
Kitchen	Floor (Carpet)	0.96(n=13)**	0.97(n=15)**	0.94(n=17)**
Kitchen	Floor (All Bare)	0.73(n=41)**	0.61(n=47)**	0.82(n=84)**
LOADING				
Bedroom	Bed	0.79(n=113)**	0.70(n=119)**	0.83(n=140)**
Living room	Floor (Carpet)	0.86(n=74)**	0.80(n=70)**	0.90(n=72)**
Living room	Floor (All Bare)	0.77(n=40)**	0.72(n=48)**	0.84(n=54)**
Kitchen	Floor (Carpet)	0.88(n=14)**	0.74(n=18)**	0.95(n=17)**
Kitchen	Floor (All Bare)	0.50(n=62)**	0.41(n=78)**	0.77(n=86)**

Dust mite (Der f 1) between method correlations

<i>room</i>	<i>Surface type</i>	<i>AIHA with EMM</i>	<i>AIHA with HVS</i>	<i>EMM with HVS</i>
CONCENTRATION				
Bedroom	Bed	0.75(n=74)**	0.74(n=81)**	0.84(n=140)**
Living room	Floor (Carpet)	0.88(n=73)**	0.87(n=74)**	0.91(n=74)**
Living room	Floor (All Bare)	0.77(n=38)**	0.68(n=40)**	0.71(n=55)**
Kitchen	Floor (Carpet)	0.77(n=11)**	0.70(n=12)**	0.89(n=16)**
Kitchen	Floor (All Bare)	0.60(n=45)**	0.61(n=49)**	0.67(n=86)**
LOADING				
Bedroom	Bed	0.58(n=116)**	0.52(n=124)**	0.81(n=141)**
Living room	Floor (Carpet)	0.71(n=74)**	0.70(n=75)**	0.83(n=74)**
Living room	Floor (All Bare)	0.56(n=48)**	0.47(n=52)**	0.82(n=55)**
Kitchen	Floor (Carpet)	0.50(n=12)	0.33(n=15)	0.96(n=16)**
Kitchen	Floor (All Bare)	0.57(n=67)**	0.41(n=78)**	0.73(n=88)**

Correlations

- Between rooms/surface types with same method
- Color coding: combine correlations for can f 1 and der f 1 loadings and concentrations
 - Green = Highest 1/3
 - Orange = Middle 1/3
 - Red = Lowest 1/3

** = Significant correlation at $p=0.05$.

* = Significant correlation at $p=0.10$.

Dog (Can f 1) between room/surface correlations

<i>method</i>	<i>Bed with Kitchen Floor</i>	<i>Bed with Living room floor</i>	<i>Kitchen floor with Living room floor</i>	<i>Kitchen floor with living room floor(both carpet)</i>	<i>Kitchen floor with living room floor(both all bare)</i>
CONCENTRATION					
AIHA	0.78(n=51)**	0.66(n=39)**	0.82(n=53)**	0.99(n=8)**	0.80(n=26)**
EMM	0.77(n=120)**	0.76(n=99)**	0.81(n=101)**	0.84(n=13)**	0.89(n=46)**
HVS	0.80(n=130)**	0.78(n=131)**	0.79(n=126)**	0.96(n=15)**	0.83(n=57)**
LOADING					
AIHA	0.35(n=98)**	0.35(n=91)**	0.49(n=96)**	0.67(n=13)**	0.58(n=43)**
EMM	0.51(n=118)**	0.63(n=100)**	0.62(n=104)**	0.89(n=13)**	0.86(n=47)**
HVS	0.45(n=128)**	0.57(n=129)**	0.53(n=127)**	0.90(n=15)**	0.74(n=58)**

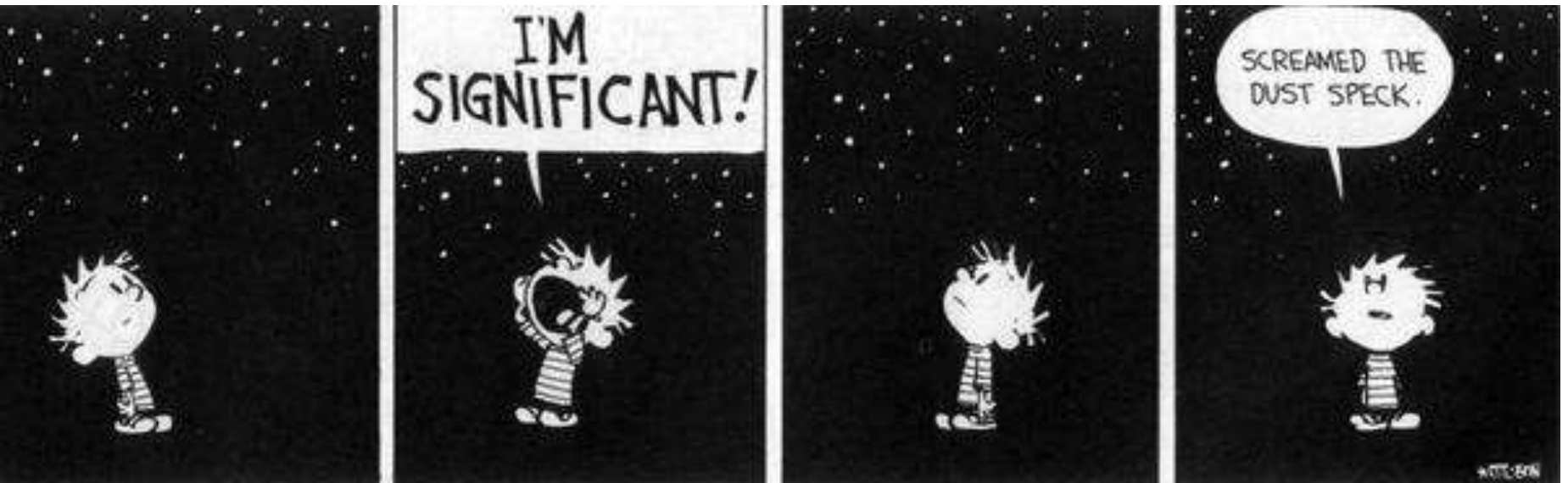
Dust Mite (Der f 1) between room/surface correlations

<i>method</i>	<i>Bed with Kitchen Floor</i>	<i>Bed with Living room floor</i>	<i>Kitchen floor with Living room floor</i>	<i>Kitchen floor with living room floor(both carpet)</i>	<i>Kitchen floor with living room floor(both all bare)</i>
CONCENTRATION					
AIHA	0.47(n=64)**	0.33(n=42)**	0.28(n=56)**	0.86(n=6)**	0.34(n=27)*
EMM	0.40(n=121)**	0.17(n=94)	0.22(n=98)**	0.71(n=13)**	0.36(n=43)**
HVS	0.41(n=143)**	0.13(n=125)	0.37(n=124)**	0.71(n=15)**	0.47(n=56)**
LOADING					
AIHA	0.11(n=107)	0.18(n=91)*	0.03(n=102)	0.34(n=11)	-0.03(n=43)
EMM	0.26(n=122)**	0.24(n=99)**	-0.02(n=101)	0.53(n=13)*	0.09(n=44)
HVS	0.21(n=140)**	0.09(n=122)	0.27(n=125)**	0.68(n=15)**	0.37(n=57)**

The Struggle to Standardize: Concluding Thoughts

Dave Jacobs, PhD, CIH

National Center for Healthy Housing



Tailored In-Home Multi-Factorial Asthma Interventions are Effective

TABLE 1 ● Summary of Intervention Findings

Panel	Sufficient Evidence for Implementation
Interior Biological Agents (Toxins)	<ol style="list-style-type: none"><li data-bbox="805 622 1792 929">1. Multifaceted, in-home, tailored interventions for asthma (reduce exposure to triggers, decrease symptoms and health care use, improve quality of life)<li data-bbox="805 958 1792 1100">2. Cockroach control through integrated pest management (reduce allergens)<li data-bbox="805 1129 1792 1266">3. Combined elimination of moisture intrusion and leaks and removal of moldy items

Variables at Work – Allergens Depressing or Challenging?

- Collection Efficiency
- Surface Type (carpet vs smooth)
- Room Type (Kitchen, Bedroom, Living Room)
- Bed vs Floor
- Spatial Variability
- Lab Analytical Procedures (drying, MARIA, stds, QA)
- Particle Size
- Settled Dust vs Airborne
- Ease of Use
- Reliability
- Asthma Severity Scales
- Loading vs Concentration
- Climate and Housing Type
- Allergen Type
- Biological Relevance
- More

Depressing or Challenging?

- Lead Dust Collection Variables Thought to be significant in early 1990s:
 - Vacuum vs wipe
 - Windows vs floors
 - Type of lead salt & bioavailability
 - Particle size
 - Surface condition
 - Entryway vs interior
 - Lab QA/QC
 - More

Conclusions on Allergen Collection Methods from Field Investigation

- For dog, 15 out of 30 correlations by method are high and significant and another 11 are middle
- For dust mite, 6 out of 30 correlations by method are high and significant and another 8 are middle
- Importance of lab and field based evaluation of methods – general agreement

Future Work

- Asthma as a complex constellation of symptoms
- Comparison of methods with various diagnostic criteria
- Elimination of variables that don't matter
- Sampling & analytical error quantification
- Selection of “best” method by:
 - Ability to predict asthma exacerbation
 - Most amenable to actual housing intervention
 - Ease and practicality of use
 - Reliability and amenable to QA/QC

Future Work - 2

- Development of Standards
- Letter from the EPA Children's Health Protection Advisory Committee (CHPAC) to EPA Administrator Jackson (April 2011):

CHPAC Letter - 1

Recommendations for Intra-agency Actions

- CHPAC recommends that EPA develop standardized housing and school inspection protocols that objectively measure asthma trigger exposures, using the most recent scientific data.
- CHPAC recommends that EPA establish indoor exposure limits for allergens and chemicals that cause or exacerbate asthma.

CHPAC - 2

- CHPAC recommends that EPA collaborate with other federal agencies and programs, such as the Department of Education (ED) and the Department of Health and Human Services (HHS) Office of Head Start (OHS), to develop national standards for healthier learning and living environments.

CHPAC recommends that EPA reach out and partner with the HHS Center for Medicare and Medicaid Services and others to provide asthma trigger reduction supplies and services for all eligible children with asthma.

Implications for Policy from this Research

- Asthma interventions focusing on the home environment can be better measured with standardized sampling methods
- Better focused interventions have large implications for cost
- Quantified standardized methods can be factored into health care cost containment

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- The views in this presentation are those of the authors, not the US Government