Good Homes Alliance:
Good Health through Good Homes
07th July 2009

Energy Efficiency, Health and Housing

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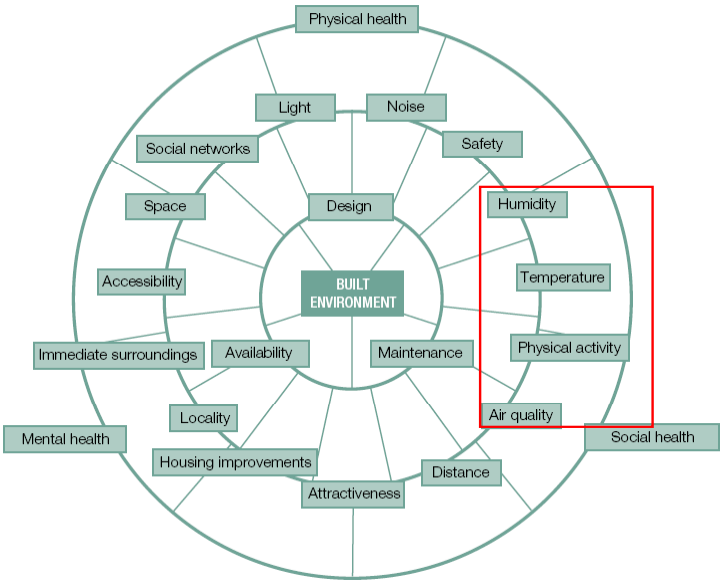
Contents of Presentation

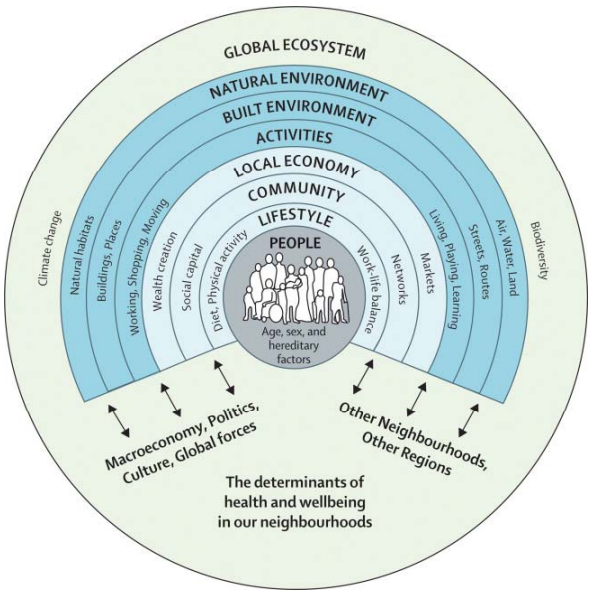
- Background: built environment, housing and health;
- Role of house dust mites and mould;
- Impact of ventilation and heating;
- Conclusions.

Built Environment and Health



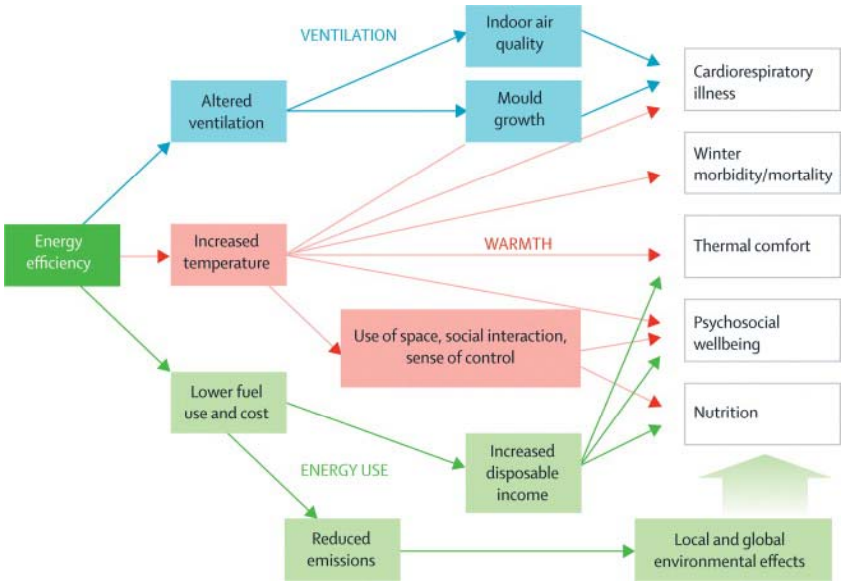
Lavin et al., (2006), *Health Impacts of the Built Environment: a Review,* The Institute of Public Health in Ireland.

Determinants of Health and Wellbeing



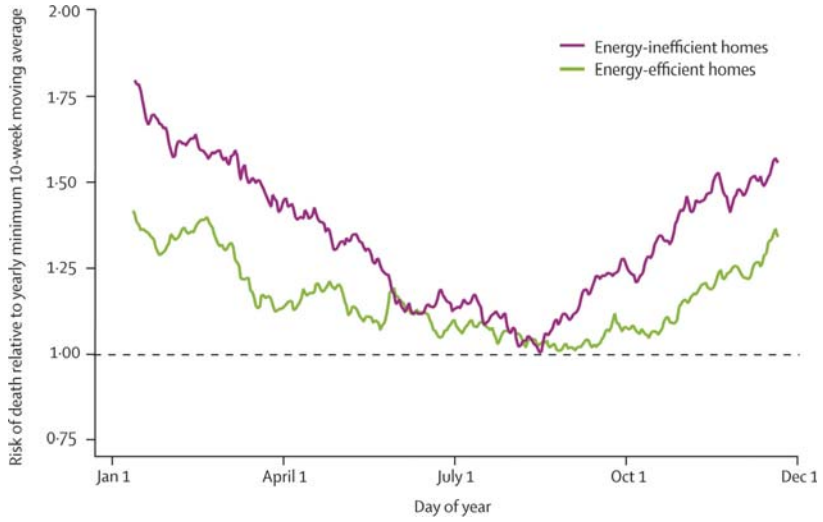
Rao et al., (2007), *The Built Environment and Health*, The Lancet, 370 (9593).

Energy Efficiency, Health and Housing

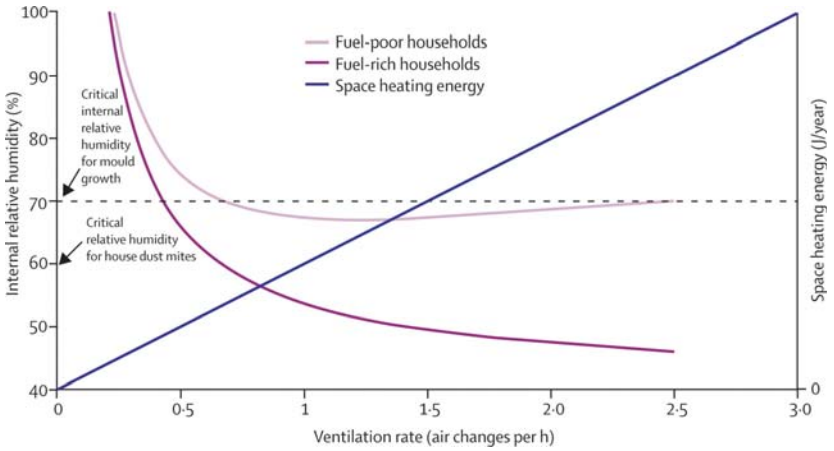


Wilkinson et al., (2007), *Energy, energy efficiency and the built environment*, The Lancet, 370 (9593):1175-1187

Excess Winter Deaths and Energy Efficient Homes



Wilkinson et al., (2007), *Energy, energy efficiency and the built environment*, The Lancet, 370 (9593):1175-1187



Wilkinson et al., (2007), *Energy, energy efficiency and the built environment*, The Lancet, 370 (9593):1175-1187

Risk Index, Domestic Health and Safety Hazard

Domestic Health and Safety Hazard	Category	Risk Index
Hygrothermal conditions	A	83
Slips, trips and falls on the level		78
Particles and fibres		78
Radon		78
Environmental tobacco smoke		72
Slips, trips and falls on stairs, ramps and escalators		71
Security and the effects of crime	B	70
Noise		70
House dust mites		69
Burns and scalds		68
Fires in buildings		67
Carbon monoxide		66
Fungal growth		62
Lighting		62
Space and crowding		62
Lead		61
Slips, trips and falls from windows, balconies and roofs	C	60
Oxides of nitrogen		60
Toilet facilities		60
Volatile organic compounds		59
Collision/entrapment involving doors		59
Sources of infection other than toilets		58
Electrical hazards		56
Drowning		56
Collision/entrapment involving windows	D	50
Sulphur dioxide		50
Cockroaches		48
Structural collapse and falling objects		48
Explosions in buildings		48
Land contamination including landfill gas		41
Biocides		26
Collision/entrapment involving lifts and escalators		14
Electromagnetic fields	NBRA	

CLG, (2008), *BD 2518 Review of Health and Safety Risk Drivers*, Communities and Local Government, www.communities.gov.uk

EU Project on IAQ and Health: EnVIE

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Contribution of non-ideal IAQ to symptom and disease burden

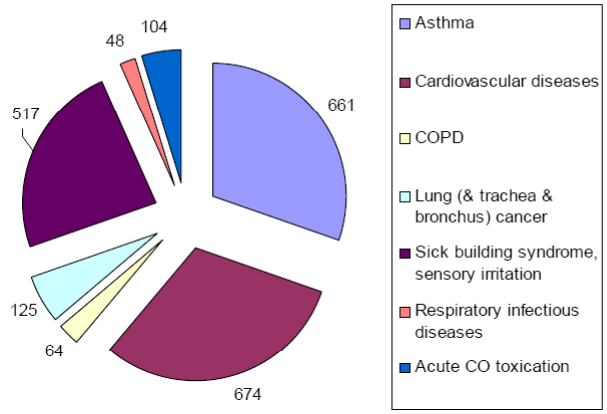

Figure 4. Contribution of non-ideal IAQ to symptom and disease burden in Europe, DALYs per year (thousands). ETS is not included.

EnVIE, (2009), *Final Project Report*, www.envie-iaq.eu.

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Asthma: Facts and Figures

- Up to 300 million people estimated as asthma sufferers worldwide (Masoli et al., 2004);
- Estimated asthma accounts for 1 in 250 deaths worldwide (Masoli et al., 2004);
- 5.2 million asthmatics living in the UK (Asthma UK, 2004);
- Asthma accounts for 12.7 million work-days lost each year in the UK (Asthma UK, 2004);
- Asthma has been reported as costing the UK £2 billion a year (Chaytor, 2004).

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Asthma Triggers

Some people know that certain things (or 'triggers') will make their asthma worse. Every person has his or her own triggers. Some examples are: colds and viral infections, house-dust mites, tobacco smoke, pollen, or exercise. When you get asthma symptoms, changes happen in the airway that make it difficult to breathe.

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House Dust Mites and Asthma Severity, Adults Worldwide

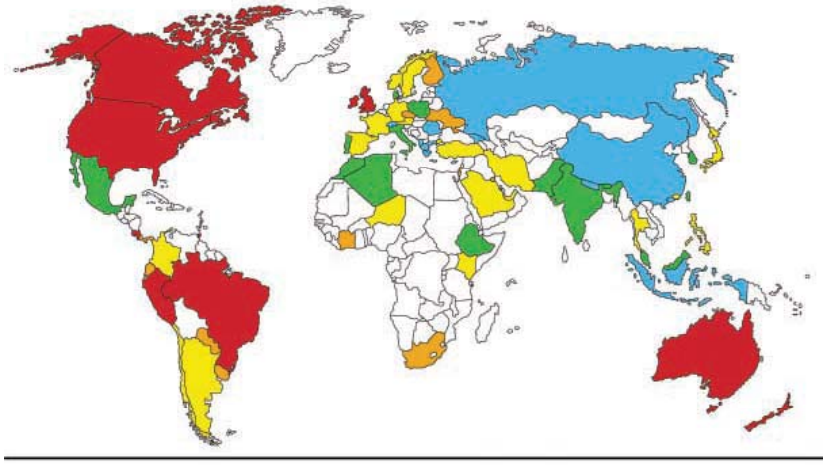
TABLE III. AF* (95% CI) of asthma caused by atopy† by using different definitions of asthma in the 36 centers

Response variable	%	House dust mite	Cat	Timothy grass	Atopy†
Symptoms of asthma‡	8.7	18.2 (13.7-22.4), $P < .001$§	14.1 (11.8-16.3), $P = .296$	17.1 (14.0-20.1), $P = .911$	30.4 (24.9-35.5), $P = .012$
Wheezing apart from cold and breathlessness	8.0	19.8 (14.5-24.8), $P < .001$	15.7 (12.3-18.9), $P = .008$	15.5 (12.3-18.6), $P = .178$	29.9 (25.2-34.2), $P = .22$
Wheezing and bronchial responsiveness	5.4	31.5 (25.8-36.8), $P = .009$	21.2 (17.0-25.1), $P = .003$	24.0 (19.9-27.9), $P = .845$	42.6 (35.0-49.3), $P = .007$
Physician diagnosis of asthma	7.7	28.7 (23.7-33.5), $P = .003$	18.4 (16.1-21.6), $P = .304$	22.9 (19.4-26.2), $P = .376$	45.3 (40.8-49.5), $P = .38$
No. of attacks of asthma in past year>12	0.5	47.8 (24.1-64.1), $P = .989$	28.0 (11.3-41.5), $P = .965$	29.4 (8.3-45.6), $P = .971$	47.6 (7.4-70.4), $P = .879$

*Adjusted for age, sex, and smoking, with data obtained by using meta-analysis.
†To any of the following allergens: house dust mite, ¦at, timothy grass, *C herbarum*, and birch, *P judaica*, or ragweed.
‡Nocturnal attack of shortness of breath, asthma attacks, or asthma medication.
§*P* value for test of heterogeneity.

Sunyer et al., (2004), *Geographic variations in the effect of atopy on asthma in the European Community Respiratory Health Study*, Journal Allergy Clinical Immunology, 114 (5).

Asthma Prevalence Worldwide



>10.2
7.6-10.00
5.1-7.5
2.5-5
0-2.5
Not available

Source: Masoli et al., 2004

The Allergy and Asthma "Epidemic": Why?

Several theories, for example:

- Changes in diet
- Changes in hygiene standards
- Increased allergen exposure, due to:
  - Carpet use
  - More time spent indoor
  - Lower ventilation rates for energy efficiency.

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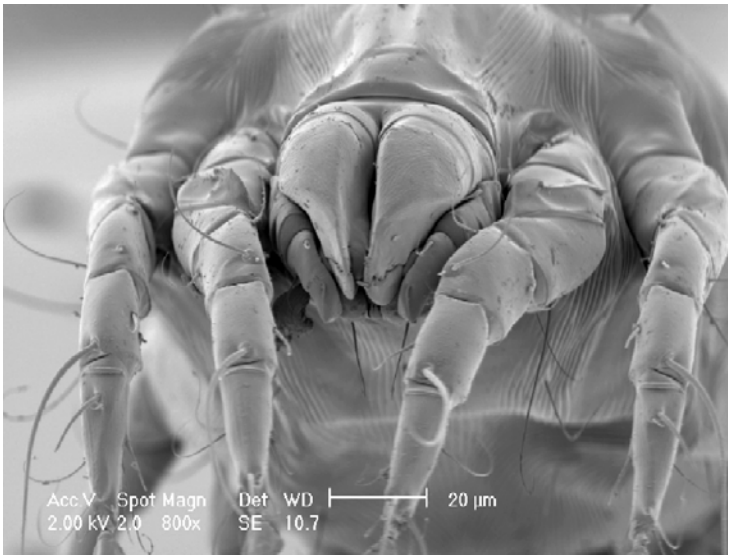
House Dust Mites



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HDM: Where They Live

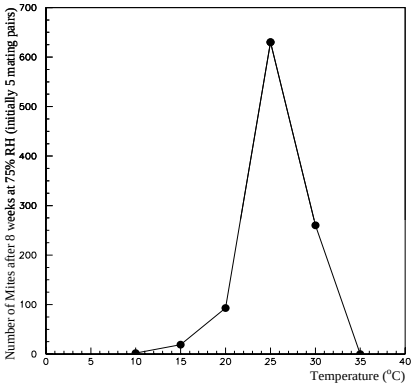
A person typically produces 0.5-1g of dead skin per day whilst several thousand mites are able to survive for months on just 0.25g of food (Korsgaard 1998)

Hart and Whitehead (1990) found a 6 month old mattress supported a population of 318 mites per 0.1g of dust

Beds are a crucial source of HDM allergens (e.g. high concentrations)

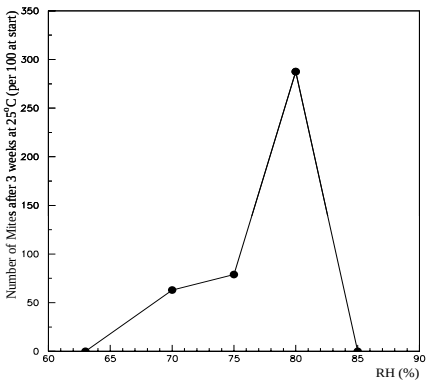
Dependency of house dust mites on hygrothermal conditions

Number of mites after 8 weeks at 75% RH



Temperature (º C)

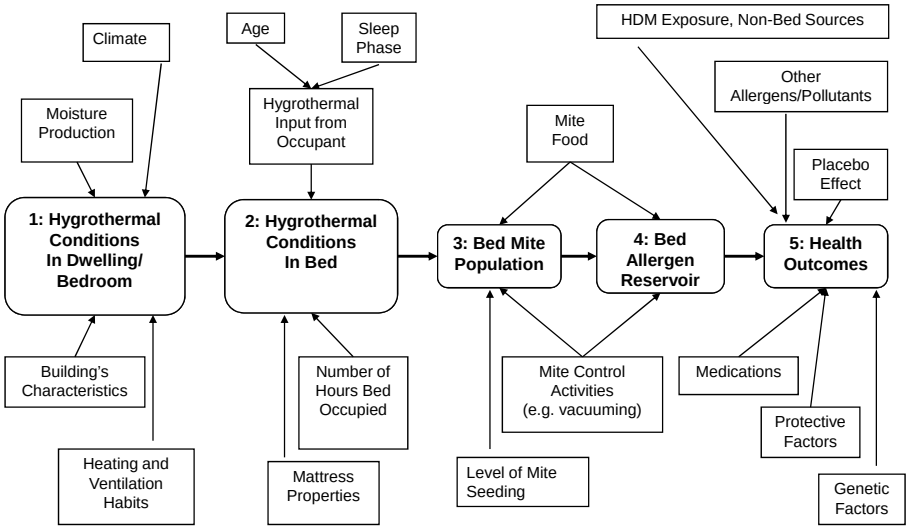
Number of mites after 3 weeks at 25 º C



RH (%)

Ref: *van Bronswijk* 1981

Dust Mites, Buildings and Health: Complexity



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Research Team

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Industrial Partners

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Mr Ian Burgess (Insect Research and Development)

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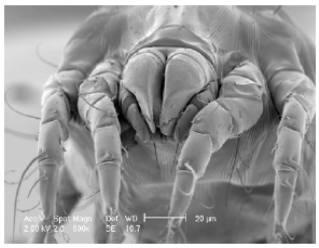

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Bartlett Graduate Studies, University College London

Insect Research and Development Ltd.

Acaris Healthcare Solutions

NES National Energy Services Ltd.

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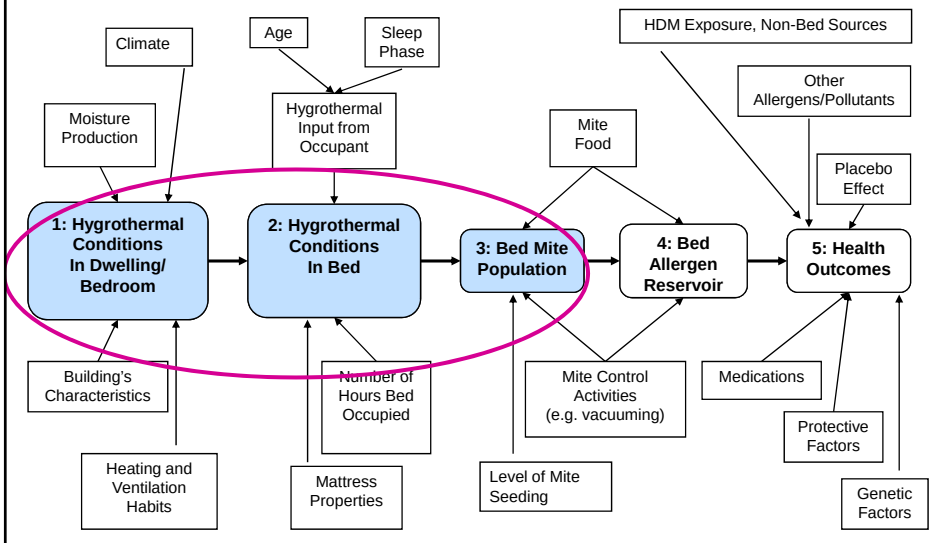

Models Validation: Methodology

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1. Labwork:

- Measuring the reproduction, development and survival rates of wild DP mites under different steady-state hygrothermal conditions;
- Measuring survival rates of wild DP mites kept under unfavourable RH with brief spells of favourable RH.

2. Fieldwork:

- Encapsulated live wild DP mites in real occupied beds for 6 weeks ("mite cages");
- Monitoring hygrothermal conditions of real beds (and of associated bedrooms), over 6 weeks.

3. Further Model Development

Validation Fieldwork

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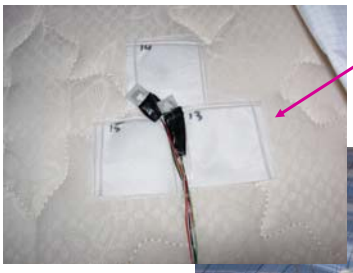
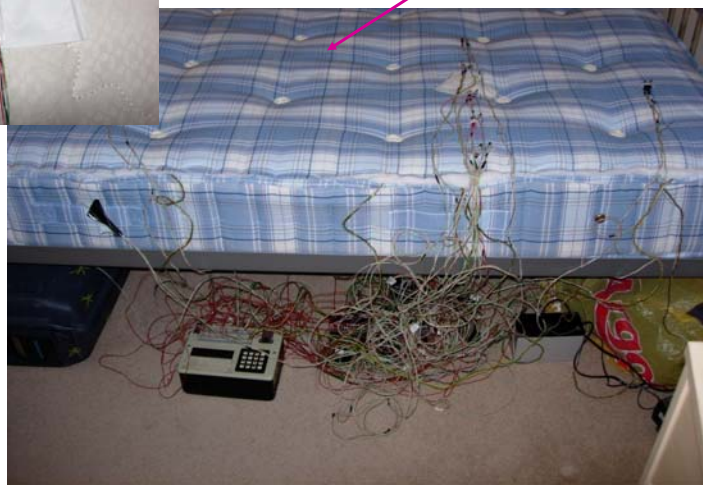


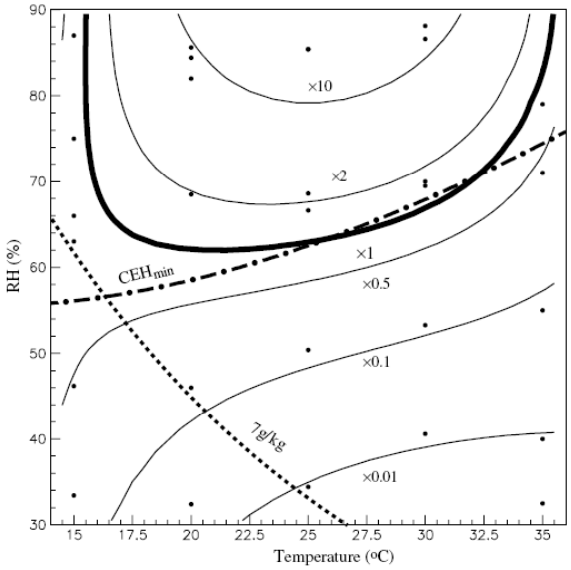
"Mite Cages"

Series 2 Bed



TinyTag

MPI Model: Steady State Conditions



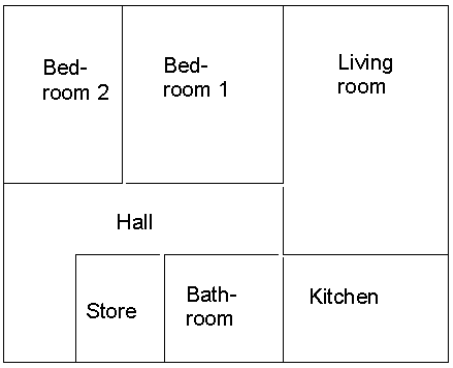
Crowther et al., (2006), A simple model for predicting the effect of hygrothermal conditions on populations of house dust mite Dermatophagoides pteronyssinus (Acari: Pyroglyphidae), *Experimental and Applied Acarology*, Vol 39.

Scenarios

Modelling

(Transient Conditions)

Scenarios Modelling: Base-Case



2 bedrooms mid-floor flat, London area, 4 occupants (2 adults, 2 children)

Floor Area: 45 m^2; Volume: 108 m^3

Foam Mattress in Bedroom 2 Examined: 15 cm thick, divided into 4 layers (thickness: 2.5, 2.5, 5 and 5 cm)

Scenarios Modelling: Base-Case

Building model details

Envelope leakage (permeability)	10 m^3 h^{-1} m^{-2} at 50 Pa
Envelope insulation (U-value)	**Walls**: 0.35 W m^{-2} K^{-1} **Windows**: 2.2 W m^{-2} K^{-1}
Trickle vents (equivalent areas)	**Bedroom 1**: 10000 m^2 **Living Room & Kitchen**: 12500 m^2 in each room **Bedroom 2 & Bathroom**: 7500 m^2 in each room **Total**: 50000 m^2
Extract fan	**Kitchen**: 60 l/s (intermittent use) **Bathroom**: 15 l/s (intermittent use)
Heating system	**Thermostat set point** (living room): 20 °C **Heating season**: 1st October to 31st of May **Size of electric heaters**: 2 kW in each room **Hours heating per day**: 10 hours at weekdays, 17 hours at weekends.
Window opening	10% open (intermittent use)
Moisture input	Equivalent to 6 kg/day (moist occupancy*) *BSI, 2002
Outdoor climate	London (EnergyPlus weather file: Present-kew.epw)

Mattress Details

Density	36 Kg/m^3
Thermal Conductivity	0.06 W/mK
Heat Capacity	850 J/kgK
Vapour Permeability	2.33E-12 kg/msPa
Moisture Capacity	2.00E-05 kg/kgPa
Thickness	0.15 m
Time in Bed	8 hours

Scenarios: Results

Scenarios	Mite Predictions*			Energy Cons.*
	Cell A *Base-Case: Max*	Cell B *Base Case: Min (≠ 0)*	Cell C *Base Case: Same as Room*	
1) U-value: 1.6 W/m²K	0.65	8.77	0.62	1.27
2) U-value: 0.25 W/m²K	1.10	1.03	1.10	0.97
3) Permeability: 20 m³/m²h	0.08	0.38	0.20	1.58
4) Permeability: 3 m³/m²h	269.05	2538.55	31.73	0.55
5) Windows open all night	0.75	0.91	0.75	1.02
6) Windows closed	1.03	1.16	0.99	1.00
7) Extract fan, longer use	0.45	0.35	0.58	1.07
8) No extract fan	5.49	54.37	2.43	0.89
9) Thermostat: 22 °C	0.03	0.00	0.88	1.20
10) Thermostat: 18 °C	5.41	15.50	0.41	0.80
11) Heating period: plus 2 hours	0.94	0.08	1.05	1.05
12) Heating period: minus 2 hours	5.59	54.24	0.82	0.94
13) Moisture: 14 kg/day	7.08	55.61	1.83	1.00
14) Moisture: 5 kg/day	0.02	0.00	0.03	1.00
15) MVHR, option 1	159.67	369.69	25.37	0.31
16) MVHR, option 2	20.43	0.00	0.07	0.33
17) MVHR, option 3	7.32	42.60	1.32	0.51
18) U-value 0.25 W/m²K and permeability 3 m³/m²h	312.63	3032.87	38.78	0.52
19) Boundary conditions: best case	0.10	0.73	(1.0)#	(1.0)#
20) Boundary conditions: worst case	10.11	45.91	(1.0)#	(1.0)#

* Ratio with Base-Case; #No changes expected

HDM Scenarios Modelling: Conclusions

- Options reducing mite numbers:
  - Greater ventilation (e.g. extract fans, greater fabric permeability);
  - Greater thermostat setting (depending on thresholds);
  - Reduced moisture production rates.
- Strong threshold effects
- But further research is needed on the overall mite carrying capacity of a mattress, particularly for:
  - Effect of mite movement;
  - Food and space availability.
- Allergen Model

Important Issue to Be Resolved….

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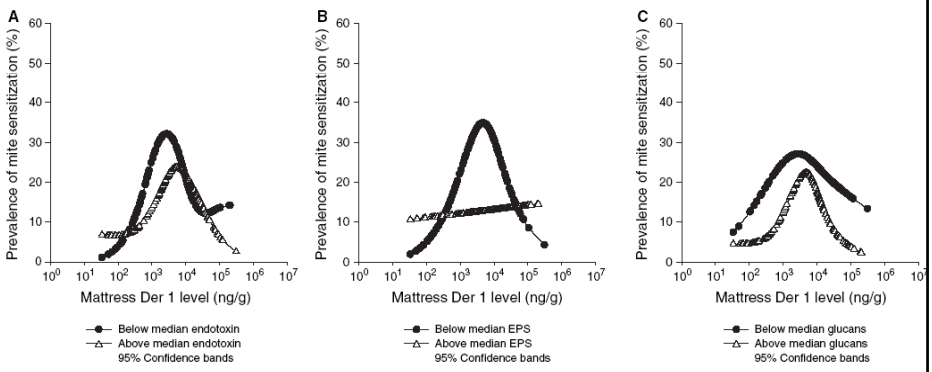
Exposure and Sensitisation



Source: Schram-Bijkerk *et al.*, 2006

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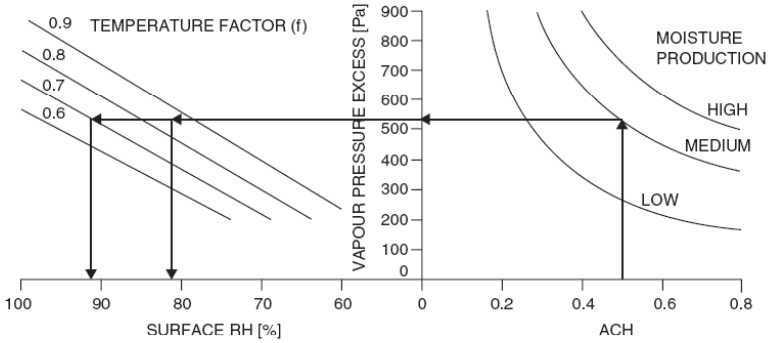
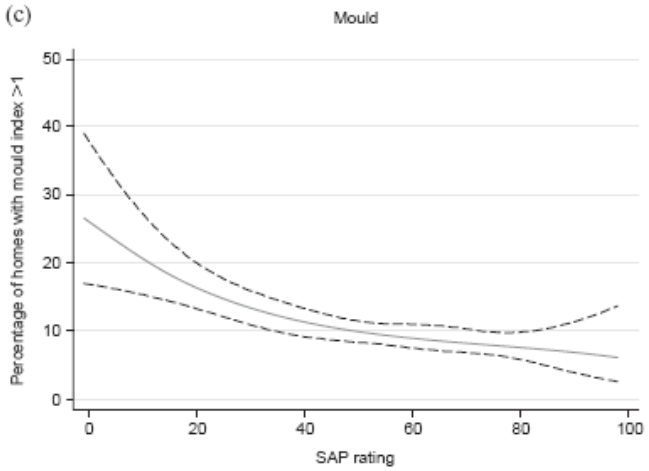
Ventilation, Moisture and Temperature



Fitted curves from 54 simulations, with mean January temperature for London (3.7 degr C).

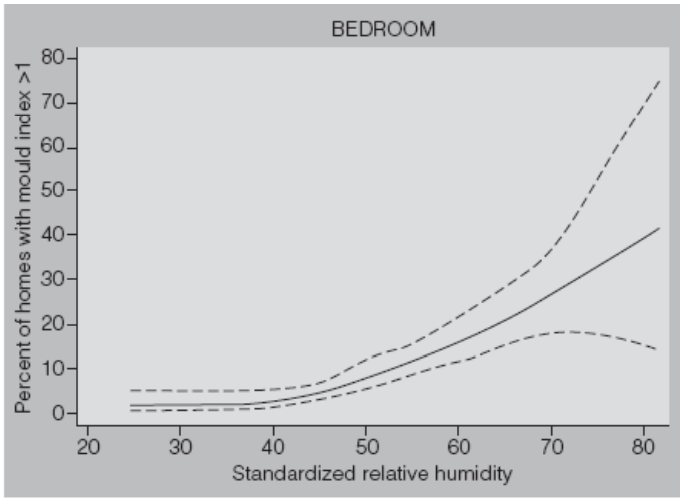
Altamirano-Medina H et al., (2009), *Guidelines to avoid mould growth in buildings*, Advances in building energy research, 3.

Mould Growth and SAP Rating



Oreszczyn et al., (2006), Mould and winter indoor relative humidity in low income households in England, Indoor and Built Environment, 15(2): 125-135.

Mould Occurrence and Relative Humidity



Oreszczyn et al., (2006), Mould and winter indoor relative humidity in low income households in England, Indoor and Built Environment, 15(2): 125-135.

Conclusions

- Indoor conditions in housing can have an impact on occupants health;
- Several interrelated variables affect the links between health and housing design;
- An adequate balance of ventilation, moisture production and heating can avoid the risk of moisture-related allergens.
- The impact of measures on health is difficult to quantify against the energy penalties.

Thank You

Any Questions?

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