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Home dampness, moulds and their influence on respiratory infections and symptoms in adults in Finland

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Home dampness, moulds and their influence on respiratory infections and symptoms in adults in Finland. I. Pirhonen, A. Nevalainen, T. Husman, J. Pekkanen. ©ERS Journals Ltd 1996.

ABSTRACT: The aim of this study was to analyse the prevalence of mouldy homes and their association with respiratory symptoms and diseases in a subarctic climate.

A questionnaire was mailed to a random sample of 2,000 males and females, aged 25–64 yrs, living in the county of Kuopio, Finland. A total of 1,521 (76%) responded and 1,460 were selected for the final analysis.

The prevalence of homes with visible mould was 4%; with the odour of mould 5%; with damp spots, visible mould or the odour of mould 15%; and with moisture/water damage, damp spots, visible mould or the odour of mould 23%. The number of reports of bronchitis, common cold, atopy, allergic rhinitis, rhinitis, fever and chills, hoarseness, fatigue, difficulties in concentration, lumbar backache and stomach ache were strongly associated with living in a damp home. Bronchitis, hoarseness and difficulties in concentration had the strongest associations, with adjusted odds ratios (95% confidence limits) of: 2.04 (1.49–2.78), 2.23 (1.37–3.63) and 2.17 (1.35–3.50), respectively. After controlling for a possible reporting bias by excluding those subjects reporting lumbar bachache and recurrent stomach pain, eye irritation and tiredness remained significant.

In conclusion, living in a home with mould problems may increase the risk of respiratory infections and symptoms in adults.

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The quality of indoor air in homes may be influenced by many biological, chemical and physical agents, *e.g.* viruses, bacteria, mites, actinomycetes, fungal spores, arthropod fragments and droppings, animal and human dander, tobacco smoke, chemicals [1–3], temperature, humidity and poor ventilation [4, 5]. There may also be as yet unknown interactions between indoor air pollutants.

During recent years, the health risks due to dampness and mould problems in homes have received considerable attention. Mould problems occur if there is excess dampness or moisture in a building. Fungi may grow on practically any building material, provided that there is sufficient moisture or condensation [6].

The concept of dampness of a building is to some extent associated with climatic factors. In the subarctic climate, building structures should be dry since the heating season is long, buildings are well-insulated, and during the cold period (three quarters of the year) the relative humidity of indoor air is low. However, moisture problems occur even in these conditions [7].

Emissions from mould growth in homes are a potential risk factor for respiratory infections and symptoms. Adverse health effects have been reported among children and adults due to dampness and moulds in buildings in Britain [8–14], The Netherlands [15, 16], USA [17, 18], Canada [18, 19] and Scandinavia [20, 21]. A summary of some of these studies is presented in table 1. Most studies indicate that living in a damp or mouldy home is associated with respiratory infections and various other symptoms, both among children and adults. MARTIN *et al.* [10] found such an association in children, but not in adults.

The association between home dampness and symptoms may be caused by a reporting bias, *i.e.* people who are aware of the problems in the house are more likely to report the occurrence of symptoms [11]. Reporting of mould seems to be more likely in those families with an asthmatic child [14], where a child is atopic, the parents are well-educated and when they have asthma or chronic obstructive pulmonary disease (COPD) [18]. SPENGLER *et al.* [18], after controlling for atopy, gender, parental COPD, parental asthma and parental education, reported that there was a significant association between home dampness and respiratory symptoms among children. DALES *et al.* [19] indicated that atopy did not significantly influence the association in adults.

PLATT *et al.* [12] and DALES *et al.* [19] controlled for possible overreporting by including a "general complainer" variable. However, this did not affect the association between the symptoms and living in damp and mouldy dwellings.

Table 1. – Studies on home dampness, mould and their influence on respiratory diseases and other symptoms in adults

First author [Ref] Year Location	Subjects n, age and methods	Definition of home dampness and mold	Damp and mouldy home - prevalence %	Statistical significance between symptoms and living in damp and mouldy homes
BURR [9] 1981 South Wales	469, 20–44 yrs, cross-sectional questionnaire	Asked whether bedrooms were damp	19	Wheezing with breathlessness, p<0.025
MARTIN [10] 1987 Edinburgh	294, 19–91 yrs, cross-sectional questionnaire and independent observation	Independent visible mould and dampness assessments	Damp 24 Mould 17	Significant differences among children, but not among adults (non-respiratory symptoms: aches and pains, diarrhoea, "nerves", headache)
PLATT [12] 1989 Glasgow, Edinburgh and London	597 households, cross-sectional questionnaire and independent observation	Surveyors assessment of dampness and mould	Damp 23 Visible mould 46	Bad nerves, aching joints, nausea-vomiting, backache, blocked nose, fainting spells, constipation and breathlessness, p<0.05
WAEGEMAEKERS [15] 1989 Katwijk, The Netherlands	328 adults, cross-sectional questionnaire	1. A home was damp if two or more were reported positive: a) visible moulds b) damp spots c) silverfish or sow-bugs (woodlice) d) a stale odour e) wet crawl space 2. Responders own perception of their home (dry or damp)	Definition 1. 42 Definition 2. 25	Phlegm, wheeze, asthma (among females) and allergy, p<0.05
DALES [19] 1991 Canada (six regions)	14,799, >20 yrs, cross-sectional questionnaire	Four definitions by reporting: 1. Moisture (wet or damp spots) 2. Mould (mould or mildew growing) 3. Flooding (leak, flooding or water damage) 4. Dampness and mould (presence of 1, 2 or 3)	Definition 1. 14 Definition 2. 27 Definition 3. 19 Definition 4. 38	Upper respiratory symptoms, lower respiratory symptoms, chronic respiratory disease, asthma, eye irritation and other symptoms, p<0.01
BRUNEKREEF [16] 1992 Helmond, The Netherlands	3,344 adults, cross-sectional questionnaire	Three definitions by reporting: 1. Damp stains 2. Visible mould growth 3. Home dampness (1 and/or 2)	Definition 1. 24 Definition 2. 15 Definition 3. 25	Cough, phlegm, wheeze and lower respiratory symptoms, p<0.01 (asthma was near the level of significance)

Damp and mouldy homes occur even in Scandinavia, although the buildings are well-insulated, the heating season is long (up to 8 months), and the indoor air is relatively dry for most of the year [21]. However, in subarctic regions, mould problems may have their own special features, due to the airtightness of the houses and the long hours spent indoors during the cold weather.

The aim of this study was to determine the prevalence of mould problem homes and their possible association with respiratory diseases and symptoms among a randomly selected adult population living in the subarctic climate of Eastern Finland.

Subjects and methods

The study material was collected as a part of the Finrisk-study, which was carried out in the spring of 1992 by the National Public Health Institute. The Finrisk-study is a survey of risk factors of cardiovascular diseases and nutrition in adults living in Eastern and South-western Finland, and in the area of the capital city [22]. Cross-sectional random sampling was drawn from the national population register.

A questionnaire on the condition of the home and respiratory diseases and symptoms was sent by mail to 2,000 males and females aged 24–65 yrs living in Eastern Finland. The respondent rate was 76% (n=1,521). In the analyses, the 1,460 individuals who had responded to all the questions on dampness and mould were included.

The definition of a home with damp and mould problems was based on four questions: 1) have you previously had or are you at present able to see visible mould growth on the walls or the structure of your home? 2) have you previously or are you currently aware of an odour of mould or cellar-like fusty air in your home? 3) have you previously, or do you currently notice moisture stains in the structures of your home? and 4) have you previously or are you currently suffering from water/moisture damage in your home?

Based on the answers to these questions, the following definitions of a home with damp or mould problems were formed: Definition 1) the answer "yes" to Question 1; Definition 2) the answer "yes" to Question 2; Definition 3) the answer "yes" to any of Questions 1, 2 or 3; and Definition 4: the answer "yes" to any of Questions 1, 2, 3 or 4.

A person was defined as being atopic if he/she had answered "yes" to at least one of the following questions: 1) Have you ever had asthma diagnosed by a physician? 2) Have you ever had hay fever or other allergic rhinitis? 3) Have you had infantile eczema or atopic eczema in the hollows of elbows or knees?

We tried to control for any possible reporting bias by means of control questions on lumbar backache and recurrent stomach ache. Positive answers to either of these questions were used to build a "complainer" variable. For the same purpose, we also used questions on stress and depression. The "stress and depression" variable was compiled by combining one question and three statements of mental health. Firstly, "Have you been stressed in the last month?"; secondly, "It seems to me impossible to achieve the goals in life which I would like to reach for"; thirdly, "The future seems to me hopeless and I cannot believe that things are going to become any better"; and finally, "I feel that I don't have any proper friends".

The prevalence of reported infections and symptoms was analysed with logistic regression models [23]. Odds ratios were adjusted for age, sex, smoking, education and type of dwelling.

Results

The prevalences of damp and mould problem homes varied according to the definition used. The prevalences were: Definition 1) visible mould 3.7%; Definition 2) odour of mould 5.5%; Definition 3) moisture stains or visible mould or odour of mould 14.7%; and Definition 4) water/moisture damage or moisture stains or visible mould or odour of mould 23.9%.

Subjects living in homes with damp or mould problems (Definition 4) were slightly older, were better educated and more often lived in a single-family dwelling (table 2). Other differences were minor.

One possible confounder, chronic illness diagnosed by physician, was also analysed with Definition 4. Chronic illnesses included: hypertension, heart failure, angina pectoris, cancer, bronchial asthma, emphysema, chronic bronchitis, gall stones, cholecystitis, rheumatoid arthritis, other articular disease, chronic back pain, chronic urinary tract infection and chronic pyelonephritis. No differences were found between the tenants of "mould problem" or "healthy" homes.

Bronchitis, atopy and allergic rhinitis were significantly more prevalent in inhabitants of damp or mouldy homes ($p<0.001$) when Definition 4 was used and age, sex, tobacco smoking, education years and dwelling type were adjusted for with a logistic regression model. Symptoms such as phlegm ($p<0.05$), rhinitis ($p<0.001$), eye irritation ($p<0.01$), fever and chills ($p<0.01$), impaired sense of smell ($p<0.05$) and hoarseness ($p<0.01$) were also more prevalent among subjects reporting home dampness or moulds (table 3). Fatigue/tiredness ($p<0.001$), difficulties in concentration ($p<0.01$) and "control" variables, lumbar backache ($p<0.01$) and recurrect stomach ache ($p<0.001$) were also more prevalent (table 3).

Table 2. – Background variables

	Living in a home with damp or mould problem Definition 4, see text)		
	No %	Yes %	p-value
Female gender	(n=1,126)	(n=334)	
	53	55	0.51
Age group	(n=1,126)	(n=334)	
25–34 yrs	25	23	
35–44 yrs	24	29	0.30
45–54 yrs	25	27	
55–64 yrs	26	22	
Marital status	(n=1,010)	(n=310)	
Married or common-law married	77	81	
Unmarried	12	8	0.08
Legally separated or divorced	8	8	
Widow or widower	4	2	
Education	(n=1,010)	(n=310)	
<8 yrs	16	12	
8–9 yrs	29	26	0.76
10–12 yrs	27	31	
>12 yrs	28	31	
Occupation	(n=1,010)	(n=310)	
Agriculture or forestry	9	11	
Industry or construction work	17	11	
Service sector, housewife, student, pensioner or unemployed	74	79	0.44
Dwelling place	(n=1,011)	(n=310)	
Central part of the town	13	13	
Housing estate in the town	38	36	0.99
Population centre in the country	24	24	
Scattered settlement in the country	26	28	
Type of dwelling	(n=1,117)	(n=334)	
Detached house	54	63	
Terraced house	16	15	0.38
Block of flat	30	22	
Ownership of the dwelling	(n=1,011)	(n=310)	
Owner-occupied flat or house	79	79	1.00
Rented flat	21	21	
Smoking	(n=1,126)	(n=334)	
Never smoked	41	42	
Last more than half year ago	21	23	0.89
Last less than half year ago	38	35	

After adjusting for atopy, the following associations remained significant: bronchitis ($p<0.001$); rhinitis ($p<0.05$); fever and chills ($p<0.05$); hoarseness ($p<0.05$); fatigue/tiredness ($p<0.001$); difficulties in concentration ($p<0.05$); lumbar backache ($p<0.05$); and recurrent stomach ache ($p<0.01$).

There were no differences in the prevalence of "wheezing" and "difficulty in breathing" between dwellers in homes with or without mould. When Definition 2, "odour of mould", was used (data not shown), the results differed in the risk of tonsillitis, asthma, atopic eczema, chronic bronchitis and allergic eczema. According to Definition 2, other new associations were observed for common cold and cough. The number of subjects exposed to damp or mould by applying Definition 2 was fairly small (n = 80). After excluding the "complainers", only eye irritation and fatigue remained significant, while after excluding the "stressed and depressive, the main findings were unchanged (table 4).

Table 3. – Respiratory infections and symptoms and living in a home with damp or mould problem

Disease or symptom	Living in a home with damp or mould problem (Definition 4, see text)			
	No (n=1,126)	Yes (n=334)	AOR	95% CL
Common cold times·yr^{-1}	1.26	1.39	1.68	0.96–1.21
Tonsillitis times·yr^{-1}	0.07	0.05	0.68	0.38–1.21
Otitis media times·yr^{-1}	0.06	0.07	1.12	0.66–1.89
Sinusitis times·yr^{-1}	0.20	0.27	1.24	0.95–1.62
Bronchitis times·yr^{-1}	0.11	0.23	2.04***	1.49–2.78
Pneumonia times·yr^{-1}	0.01	0.01	2.30	0.66–8.03
Asthma %	5.9	6.1	1.02	0.60–1.72
Atopy %	35.0	47.0	1.63***	1.26–2.10
Allergic rhinitis %	21.6	31.9	1.66***	1.25–2.19
Atopic eczema %	19.2	24.2	1.31	0.97–1.76
Chronic bronchitis %	8.7	12.0	1.51	0.96–2.35
Cough %	16.2	20.1	1.37	0.99–1.88
Phlegm %	18.8	23.6	1.36*	1.01–1.85
Rhinitis %	42.8	56.1	1.69***	1.31–2.18
Eye irritation %	34.1	44.8	1.52**	1.18–1.96
Allergic eczema %	13.6	16.5	1.21	0.86–1.71
Fever and chills %	15.0	21.6	1.61**	1.17–2.22
Impaired sense of smell %	6.0	9.4	1.71*	1.05–2.78
Nosebleed %	1.0	1.7	2.06	0.68–6.22
Dry or sore throat %	4.5	6.9	1.68	0.97–2.89
Hoarseness %	4.7	10.0	2.23**	1.37–3.63
Fatigue, tiredness %	22.6	34.5	1.81***	1.37–2.39
Headache %	11.0	13.2	1.20	0.81–1.77
Nausea %	2.4	4.1	1.80	0.87–3.71
Difficulties in concentration %	5.2	10.0	2.17**	1.35–3.50
Other symptoms %	5.9	6.8	1.03	0.58–2.04
Lumbar backache %	56.1	66.1	1.49**	1.15–1.93
Recurrent stomachache %	19.8	28.7	1.65***	1.24–2.20

AOR: odds ratios adjusted for age, sex, smoking, education and type of dwelling; 95% CL: 95% confidence limits. *, **, ***: p<0.05, p<0.01, p<0.001 comparing positive and negative responses.

Table 4. – "Noncomplainers" and "no stress and depression" and the association between respiratory infections and symptoms and living in a home with damp or mould problem

Disease or symptom	Damp or mould problem home (Definition 2, see text)			"Noncomplainers"# Damp or mould problem home (Definition 4, see text)			"No stress and depression"# Damp or mould problem home (Definition 4, see text)		
	No (n=1,380)	Yes (n=80)	AOR	No (n=390)	Yes (n=92)	AOR	No (n=799)	Yes (n=213)	AOR
Common cold times·yr^{-1}	1.26	1.65	1.25*	1.05	0.99	0.94	1.26	1.43	1.11
Bronchitis times·yr^{-1}	0.13	0.23	1.83*	0.08	0.14	1.57	0.10	0.23	2.17***
Atopy %	37	46	1.36	29	36	1.34	34	48	1.78***
Allergic rhinitis %	23	34	1.56	17	21	1.37	21	30	1.63**
Cough %	16	24	1.73*	11	13	1.48	14	20	1.59*
Phlegm %	20	29	1.70*	13	13	0.94	18	25	1.64**
Rhinitis %	44	65	2.34***	32	36	1.21	40	54	1.79***
Eye irritation %	36	48	1.58	21	31	1.69*	31	44	1.74***
Fever and chills %	16	24	1.75*	9	10	1.19	12	18	1.55*
Impaired sense of smell %	6	11	1.83	4	3	0.61	4	9	2.37**
Hoarseness %	6	12	2.18*	3	1	0.93	3	8	3.10**
Fatigue, tiredness %	24	38	1.82*	12	20	2.06*	19	23	1.24
Poor concentration %	6	9	1.72	3	1	0.39	4	4	1.13
Lumbar backache %	57	72	1.90*				53	65	1.66**
Recurrent stomachache %	21	35	2.13**				18	23	1.43

#: see Subjects and Methods. AOR: odds ratio adjusted for age, sex, smoking, education and dwelling type. *: p<0.05; **: p<0.01; ***: p<0.001 comparing positive and negative responses.

Discussion

The prevalence of mouldy homes depended on the definition used. An objective measurement or definition of home dampness and mould problem is important for the definition of exposure in future research. According to preliminary findings, mould problems are more commonly detected by an expert's walk-through examination rather than being reported by the residents of the homes themselves [7].

In the present study, self-reported home dampness or mould problems were associated with an increased

prevalence of reported respiratory infections and respiratory symptoms. However, using different definitions did not essentially cause any change in the pattern of symptoms or respiratory diseases associated with exposure to damp or mould problem houses. In the present study, no objective measures of mould problems or respiratory infections or diseases were made. The main findings remained after adjusting for confounding factors and possible reporting bias. A similar association has also been reported in several other studies (table 1). The only report where this association was not verified for adults, though it was present in children, was that of MARTIN *et al.* [10]. In their study, the socioeconomic structure of the study population was not equivalent to the average of the country; unemployment was high and a third of all households were receiving supplementary benefit.

Reporting bias has been investigated in studies by PLATT *et al.* [12] and DALES *et al.* [19]. They inquired about other symptoms and diseases as control variables. In both studies, the main results were unchanged after adjusting for this bias in the analysis. It may also be necessary to discuss possible underreporting of moulds, which could be caused by feeling of shame of the mould problem in the house. For example, the odour of mould may be underreported for this reason.

In conclusion, the results of our study indicate that there is an association between increased risk of respiratory symptoms and infections and living in a home with damp or mould problems. Further research is needed to study the aetiology and causes of the symptoms and infections, as well as possible interactions between moulds and other indoor air pollutants, *e.g.* viruses, bacteria, mites, animal dander and volatile organic compounds.

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