

Symptoms and Perceived Indoor Air Quality among Occupants of Houses and Apartments with Different Ventilation Systems

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Abstract

The purpose of the study was to evaluate the occurrence of symptoms and the perception of poor indoor air quality among the occupants of houses and apartments with different ventilation systems. The study population consisted of the 473 occupants of 242 dwellings in the Helsinki metropolitan area who responded to a self-administered questionnaire (response rate 93.1%) after a two-week period of indoor air quality measurements. The symptoms of interest were those often related to poor indoor air quality including dryness or itching of the skin; dryness, irritation or itching of the eyes; nasal congestion ("blocked nose"); nasal dryness; nasal discharge ("runny nose"); sneezing; cough; breathlessness; headache or migraine; and lethargy, weakness or nausea. Perception of coldness; warmth; draught; dryness; stuffiness; and sufficiency of air exchange was also requested. The age-standardized period prevalences of the symptoms and complaints were systematically more common among the occupants of the apartments than those of the houses. The occupants of the houses with natural ventilation

seemed to have more symptoms and complaints than those with balanced ventilation. However, in the apartments with balanced ventilation the occupants reported, in general, more symptoms and complaints than those with natural ventilation.

Introduction

Office workers have complained of a similar set of symptoms which has been called the "sick building syndrome" (Akimenko et al., 1986). There is not much information on how common these symptoms are among the occupants of dwellings and whether the occurrence of the symptoms is related to the home environment. Many physical, chemical and biological indoor air factors found in the indoor air of dwellings can cause mucosal irritation, allergic and asthmatic reactions and nonspecific central nervous symptoms such as lethargy or headache. The perception of poor indoor air quality is disturbing and can also indicate an unhealthful environment. Home dampness has been associated with respiratory symptoms and disease in both adults (Dales et al., 1991; Waegemaekers et al., 1989) and children (Strachan and Sanders, 1989). Nitrogen dioxide from heating and cooking (e.g. Melia et al., 1979) and passive smoking (e.g. Holt and Turner, 1984) are also recognized determinants of respiratory symptoms in children.

KEY WORDS:

Symptoms, Sick building syndrome, Perceived indoor air quality, Dwellings, Ventilation systems, Occupants.

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In the first phase of the Finnish Housing Epidemiology Study a descriptive study was carried out in order to define the focus of the problems. The objective of the study was to evaluate the differences in the occurrence of symptoms and the perception of poor indoor air quality among occupants in houses and apartments with different ventilation systems.

Methods

Study Population

A sample of 242 dwellings with 508 adult occupants (>15 years) in the metropolitan area of Helsinki was selected for the study from lists of service companies. The dwellings represent typical Finnish architecture and construction technology. The dwellings were in both detached or semi-detached houses and in blocks of flats. Three types of ventilation system were included in the sample: natural ventilation, mechanical exhaust and balanced ventilation (mechanical supply and exhaust).

Indoor air measurements were made between November 1988 and April 1989, over a two-week period in each dwelling. After the measurement period the occupants were

asked to fill in a questionnaire inquiring into symptoms and perceived indoor air quality and related individual, environmental and behavioural information.

The study population consisted of 473 adult occupants (>15 years), 224 males (47.4%) and 249 females (52.6%). The response rate was 93.1%. The dwellings were categorized into houses (detached and semi-detached) and apartments (in blocks of flats) and within each category, according to the ventilation system, into buildings with natural ventilation, mechanical exhaust and balanced ventilation.

The study population in the different categories of dwellings and ventilation systems is described in Table 1. The occupants of the houses and the apartments did not differ essentially in gender or smoking habits. 41% of the occupants in the apartments were young adults (25-34 years), but in the houses only 16% were young adults. However, the average age of the occupants did not differ essentially between the apartments (\bar{x} = 40.7 years, SD = 15.9 years) and the houses (\bar{x} = 40.2 years, SD = 13.5 years). In the houses with balanced ventilation a greater percentage of the occupants were middle-aged (35-44 years).

Table 1 Characteristics of the study population (n = 473).

	Houses								Apartments								Total	
	Nat. vent.		Mech. exh.		Bal. vent.		Total		Nat. vent.		Mech. exh.		Bal. vent.		Total		n	%
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%		
Gender																		
Male	61	49	56	46	48	51	165	49	10	36	36	48	13	43	59	44	224	47
Female	64	51	65	54	46	49	175	51	18	64	39	52	17	57	74	56	249	53
Age																		
15-24	20	16	23	19	18	19	61	18	2	7	10	13	1	3	13	10	74	16
25-34	19	15	25	21	11	12	55	16	9	32	34	45	11	37	54	41	109	23
35-44	35	28	33	27	44	47	112	33	3	11	15	20	11	37	29	22	141	30
45-54	26	21	26	21	14	15	66	19	1	4	7	9	1	3	9	7	75	16
55-	25	20	14	12	7	7	46	14	13	46	9	12	6	20	28	21	74	16
Smoking																		
No	97	78	93	77	78	83	268	79	24	86	53	73	18	60	95	73	363	77
< 15 cig/d	19	15	18	15	11	12	48	14	3	11	9	12	6	20	18	14	66	14
> 15 cig/d	9	7	10	8	5	5	24	7	1	4	11	15	6	20	18	14	42	9

There were more elderly occupants (> 55 years) in the apartments with natural ventilation than in the other type of dwellings.

Outcomes of Interest

A self-administered questionnaire inquiring into the symptoms and perceived air quality was distributed to each occupant immediately after the two-week indoor air measurement period. Subjects were asked about the occurrence of the symptoms during the previous 14 days. They were also asked whether the symptoms were experienced mostly at home, mostly at work or equally at home and at work. Also the time of the day with most symptoms was requested. The presence of the following symptoms was asked: dry-

ness or itching of the skin; dryness, irritation or itching of the eyes; nasal congestion ("blocked nose"); nasal dryness; nasal discharge ("runny nose"); sneezing; cough; breathlessness; headache or migraine; and lethargy, weakness or nausea. Another group of outcomes consisted of perceived indoor air quality in the bedroom including: warmth; coldness; draught; coldness of floors; dryness; stuffiness; and sufficiency of air exchange. The period prevalences were defined according to the presence of the symptoms and the perception of poor indoor air quality.

Statistical Methods

The period prevalences of the symptoms and the perception of poor indoor air quality

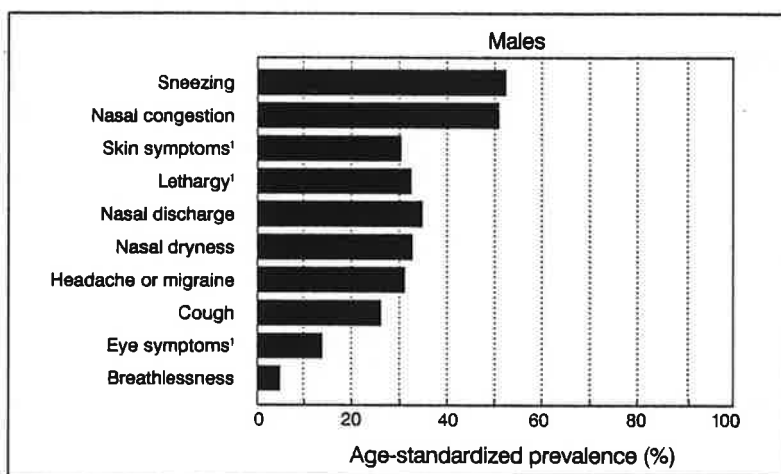


Fig. 1A The occurrence of symptoms among the occupants (males, $n = 224$); ¹see Methods.

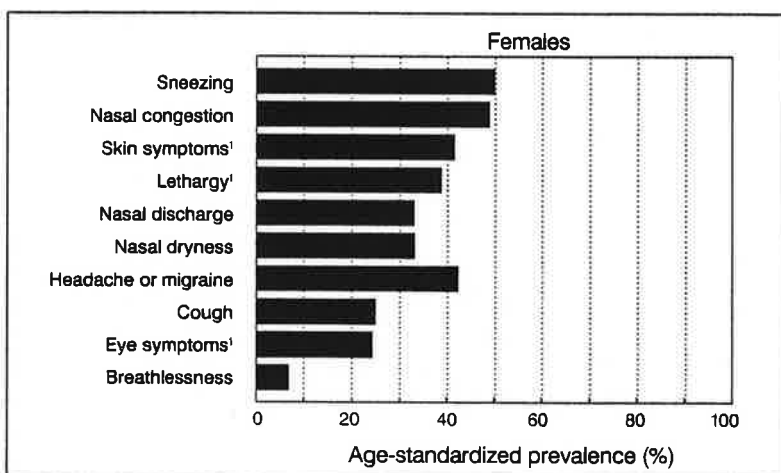


Fig. 1B The occurrence of symptoms among the occupants (females, $n = 249$); ¹see Methods.

were compared in the occupants of houses and apartments with different ventilation systems. The prevalences were age-standardized directly according to the Finnish age distribution in 1984. The standard errors of the prevalences and the statistical significance in the comparison of prevalences were calculated by using a binomial distribution assumption (Armitage, 1971). The males and females were first analysed separately. If the direction of the difference in the prevalence was the same in both males and females, the analysis was carried out on both genders combined.

Results

Symptoms

The presence of ten symptoms during the past two weeks was inquired of the occupants. Most commonly the occupants expressed nasal symptoms (Figures 1.a and 1.b). Half of the occupants reported that they had had sneezing (51%) and/or nasal congestion (50%) on at least one day during the past two weeks. One third of the occupants expressed nasal discharge (34%), nasal dryness (33%), dryness or itching of the skin (36%), headache or migraine (31%) and lethargy, weak-

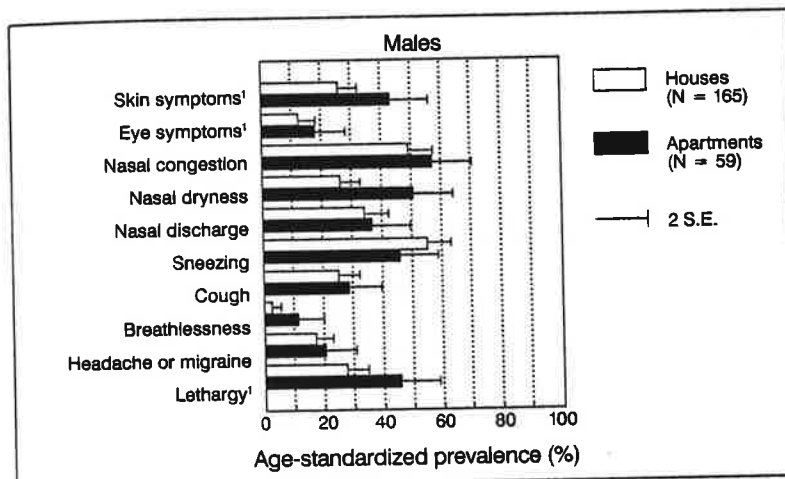


Figure 2A The occurrence of symptoms among the occupants of houses and apartments (males, $n = 224$); ¹see Methods.

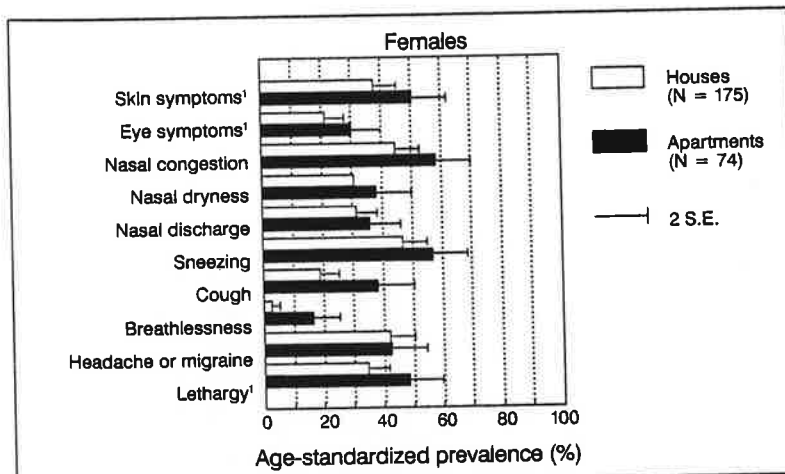


Figure 2B The occurrence of symptoms among the occupants of houses and apartments (females, $n = 249$); ¹see Methods.

ness or nausea (35%). 25% of the occupants reported that they had had cough and 19% dryness, irritation or itching of the eyes. 6% of the occupants expressed breathlessness on at least one day during the two weeks.

The occupants of the apartments, both males and females, reported systematically more symptoms during the past two weeks than the occupants of the houses (Figures 2.a and 2.b). The age-standardized period prevalences were statistically significantly greater in dryness or itching of the skin (males and females combined 46.8% vs. 31.9%, $p < 0.01$), nasal congestion (57.5% vs. 46.7%, $p < 0.05$),

nasal dryness (43.4% vs. 28.5%, $p < 0.01$), cough (33.8% vs. 21.9%, $p < 0.01$), breathlessness (13.9% vs. 2.6%, $p < 0.001$) and lethargy, weakness or nausea (46.8% vs. 31.1%, $p < 0.01$).

The occupants of the naturally ventilated houses reported eight out of ten symptoms more commonly than those in the houses with balanced ventilation (Figures 3.a and 3.b). The difference was statistically significant in lethargy, weakness or nausea (40.4% vs. 20.6%, $p < 0.01$).

In the apartments eight out of ten symptoms were more common in the occupants

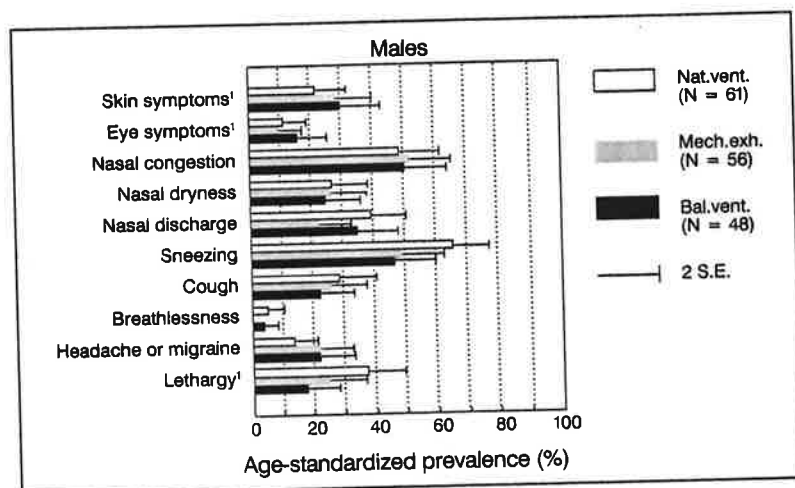


Figure 3A The occurrence of symptoms among the occupants of houses with different ventilation systems (males, $n = 165$); ¹see Methods.

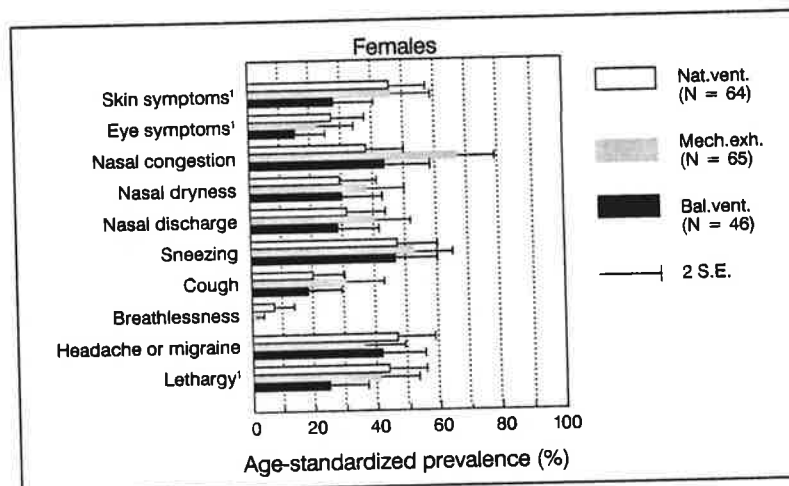


Figure 3B The occurrence of symptoms among the occupants of houses with different ventilation systems (females, $n = 175$); ¹see Methods.

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with balanced ventilation (Figures 4.a and 4.b). A statistically significant difference was in cough (60.9% vs. 7.5%, $p < 0.001$).

Perceived Indoor Air Quality

The experience of seven complaints of poor indoor air quality during the past two weeks was inquired of the occupants. The most common perception was stuffiness (Figures 5.a and 5.b). 46% of the occupants felt the bedroom air was sometimes or often stuffy in the mornings during the two weeks. 40% of the occupants felt the bedroom air was usually too dry in winter-time. Only one occupant

out of 473 felt the air was too humid. 39% of the occupants felt the bedroom air was at least sometimes too warm. 38% of the occupants felt the floors of the dwelling were too cold. According to 22% of the occupants the air exchange of the bedroom was often insufficient. 17% of the occupants felt the bedroom air was too cold and 12% experienced draught.

The occupants of the apartments reported significantly more often a sensation of dryness (males and females combined 51.1% vs. 35.7%, $p < 0.01$) and complaints of draught (21.1% vs. 8.3%, $p < 0.001$) and insufficient

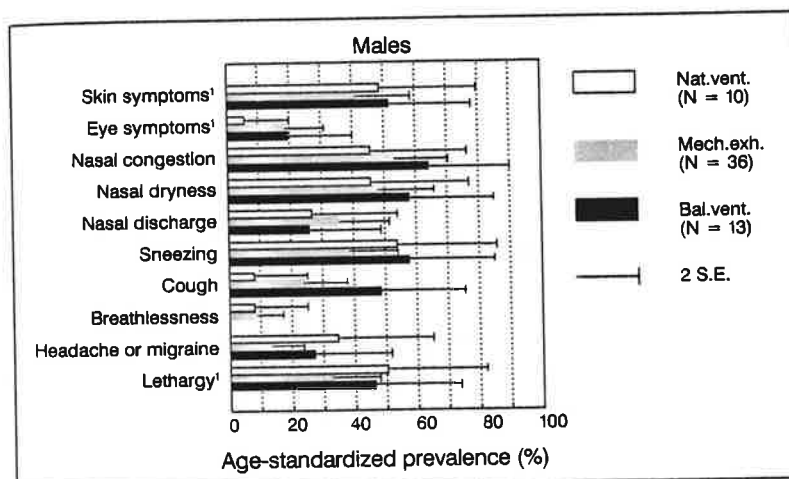


Figure 4A The occurrence of symptoms among the occupants of apartments with different ventilation systems (males, $n = 59$); ¹see Methods.

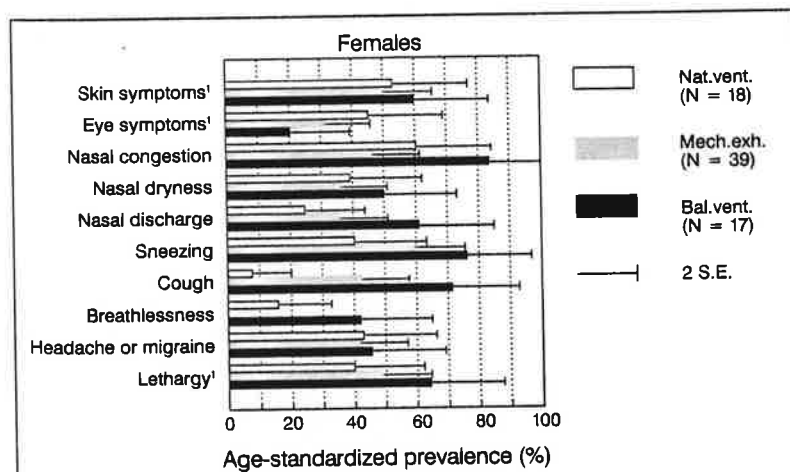


Figure 4B The occurrence of symptoms among the occupants of apartments with different ventilation systems (females, $n = 74$); ¹see Methods.

air exchange (31.4% vs. 18.0%, $p < 0.01$) than the occupants of the houses (Figures 6.a and 6.b).

In the naturally ventilated houses the occupants indicated significantly more often a sensation of dryness (40.3% vs. 21.1%, $p < 0.01$), warmth (42.2% vs. 23.8%, $p < 0.01$), stuffiness (53.9% vs. 32.9%, $p < 0.01$) and complaints of insufficient air exchange (23.8% vs. 5.9%, $p < 0.001$) than those in the houses with balanced ventilation (Figures 7.a and 7.b). In the apartments the occupants with balanced ventilation had more environmental complaints (six out of seven); in the

sensation of dryness the difference was statistically significant (74.4% vs 49.2%, $p < 0.05$) (Figures 8.a and 8.b).

Discussion

The occurrence of the symptoms and perceptions often related to poor indoor air quality was compared among the occupants of houses and apartments and among the occupants of houses and apartments fitted with different types of ventilation systems. The comparison was made in order to find the type of residences with the greatest prob-

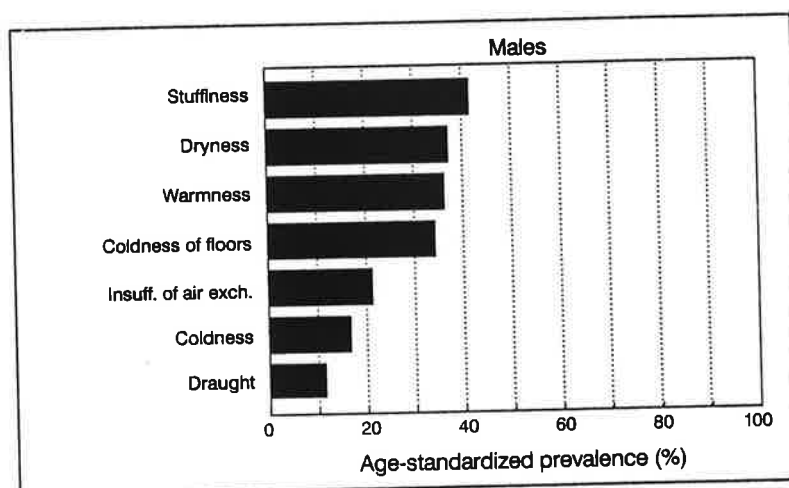


Figure 5A The occurrence of complaints of poor indoor air quality among the occupants (males, $n = 224$).

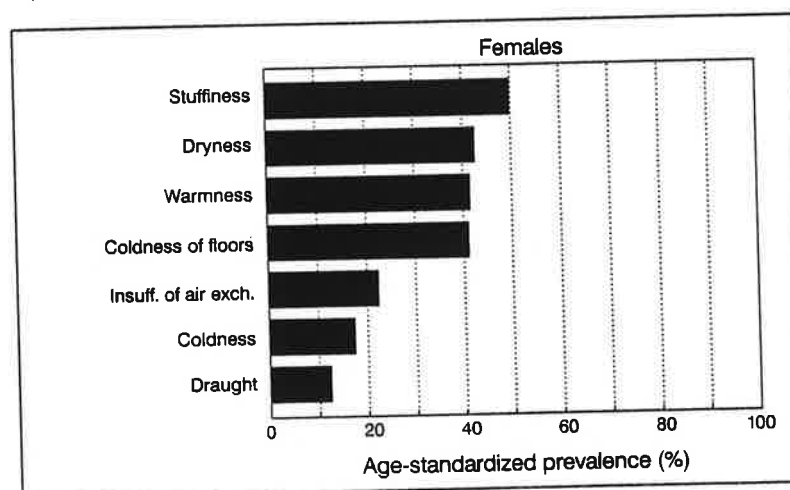


Figure 5B The occurrence of complaints of poor indoor air quality among the occupants (females, $n = 249$).

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lems. The period prevalences of the symptoms and complaints were age-standardized to eliminate the effect of different age distributions in the groups compared.

The symptoms and the perception of poor indoor air quality were systematically more common among the occupants of the apartments than those of the houses. The occupants of the houses with natural ventilation seemed to have more symptoms and complaints than those with balanced ventilation. However, in the apartments with balanced ventilation the occupants reported, in gen-

eral, more symptoms and complaints than those with natural ventilation.

The measurements of indoor air quality in the different types of dwelling did not provide a clear answer to the differences in the occurrence of symptoms and complaints (Rönnerberg et al., 1990). The measured air-exchange rates were on average higher in the apartments ($\bar{x} = 0.64$ ach, $SD = 0.30$ ach) than in the houses ($\bar{x} = 0.45$ ach, $SD = 0.22$ ach). The average temperatures of the bedroom air were slightly higher in the apartments ($\bar{x} = 22.2$ °C, $SD = 1.3$ °C) than in

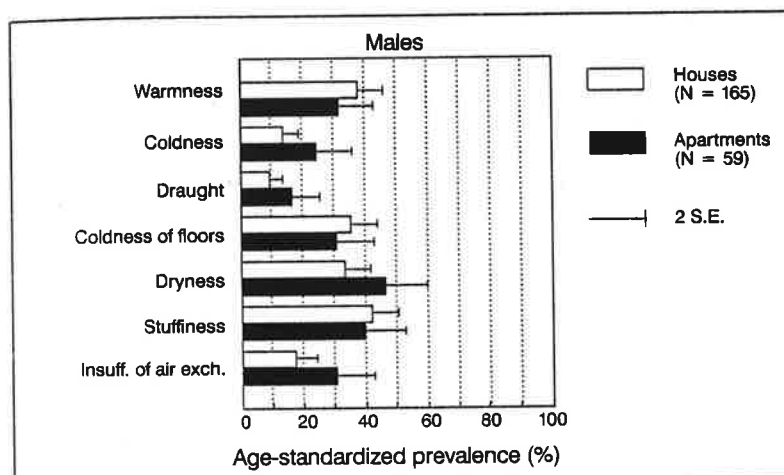


Figure 6A The occurrence of complaints of poor indoor air quality among the occupants of houses and apartments (males, $n = 224$).

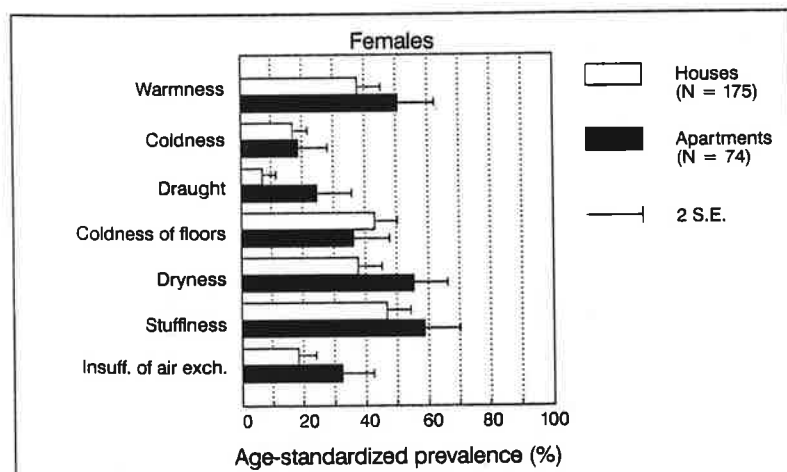


Figure 6B The occurrence of complaints of poor indoor air quality among the occupants of houses and apartments (females, $n = 229$).

the houses ($\bar{x} = 21.6^\circ\text{C}$, $\text{SD} = 1.4^\circ\text{C}$). Room temperature above 22°C has been associated with an excess of the symptoms of the sick building syndrome in a Finnish cross-sectional study of office workers (Jaakkola et al., 1989). The average relative humidities of the bedroom air were slightly lower in the apartments ($\bar{x} = 35.7\%$, $\text{SD} = 8.8\%$) than in the houses ($\bar{x} = 37.5\%$, $\text{SD} = 7.2\%$). Between the different types of ventilation system the differences in the measured parameters were smaller than between the different types of dwelling.

Our results suggest that there are more problems among the occupants of the apart-

ments than among the occupants of the houses. The association of the occurrence of symptoms and complaints with the type of ventilation system does not necessarily indicate that a certain type of ventilation system causes adverse effects, because the type of ventilation system is certainly associated with other potential environmental determinants in the home. However, in studying the determinants of reactions causing symptoms, the most efficient approach is to concentrate on the environment where the occupants have most problems.

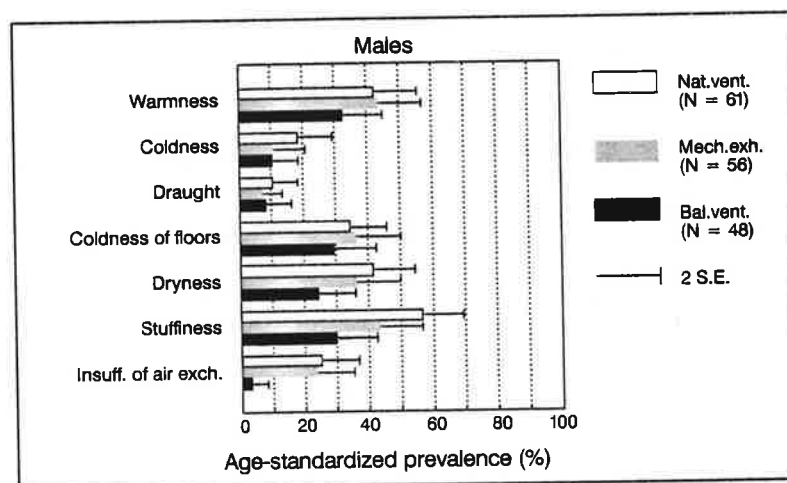


Figure 7A The occurrence of complaints of poor indoor air quality among the occupants of houses with different ventilation systems (males, $n = 165$).

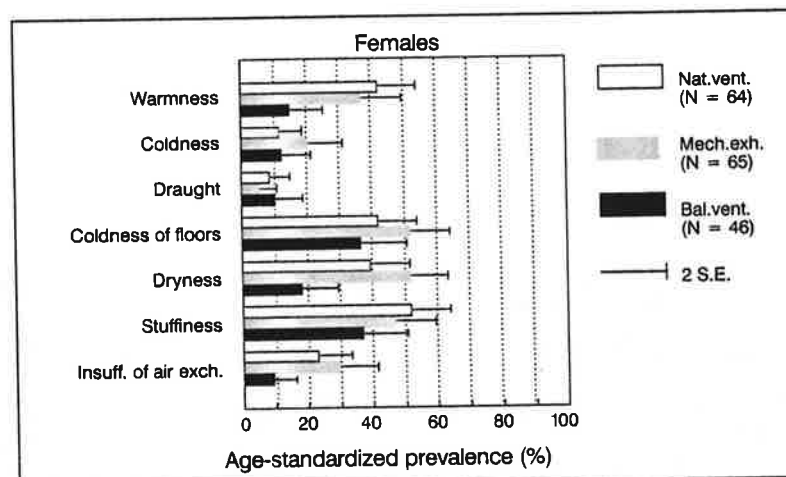


Figure 7B The occurrence of complaints of poor indoor air quality among the occupants of houses with different ventilation systems (females, $n = 175$).

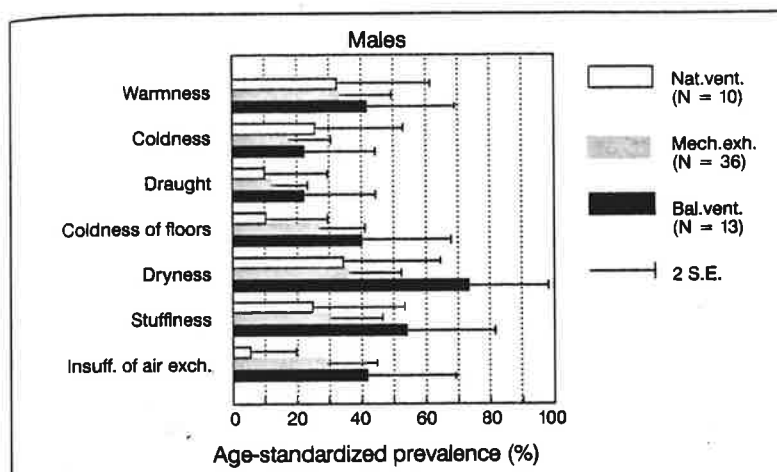


Figure 8A The occurrence of complaints of poor indoor air quality among the occupants of apartments with different ventilation systems (males, n = 59).

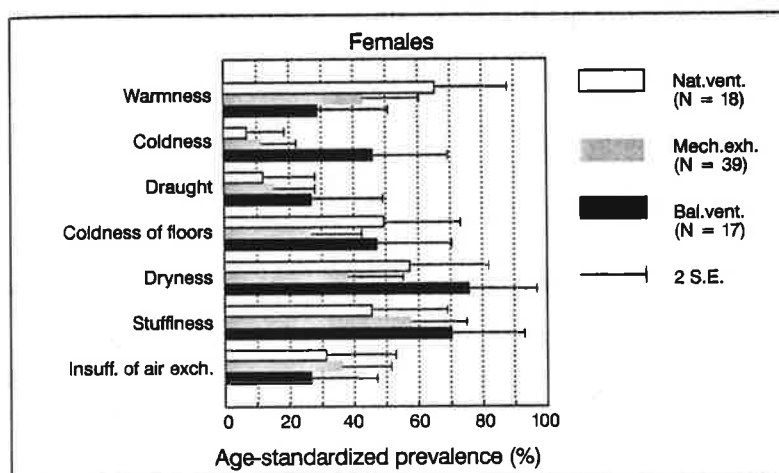


Figure 8B The occurrence of complaints of poor indoor air quality among the occupants of apartments with different ventilation systems (females, n = 74).

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