

Effect of indoor environmental factors on development of atopic symptoms in children followed up to 4 years of age

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Summary

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The increased prevalence of atopic diseases reported in many Western countries is thought to be caused by changes in living conditions. For a long time attention was focused on indoor environmental factors and early feeding patterns, but during recent years other factors have received more attention. An unselected, Swedish, population-based cohort of 904 children were followed from the age of 3 months to 4 years. Questionnaires were sent to the mothers of the children when they were 3 months, 18 months and 4 years of age. A blood sample was taken from a subgroup of the children when they were 4 years old which was analysed for IgE specific antibodies to food and inhalant allergens. The prevalences of asthma, allergic eye-nose reactions, eczema, and food reactions at 4 years of age and a positive blood test were analysed as outcome factors.

Features of housing and early feeding patterns were found to have limited effect on the development of allergies in the children. Presence of older siblings resulted in a decreased tendency to produce IgE antibodies. Early exposure to furry animals seemed to prevent the development of asthma. Children who were frequently infected up to 18 months of age showed an increased prevalence of allergic symptoms at 4 years of age. Children of mothers with a higher prevalence of complaints about indoor factors, or who had increased general symptoms or skin or mucous membrane symptoms ran a greater risk of developing various allergic symptoms. However, these children did not have higher levels of IgE antibodies. The reported allergic symptoms in the children may be due to non-immunological reactions, although it is also possible that the mothers may have over-reported such symptoms.

Introduction

Several factors have been thought to contribute to the development of atopic manifestations in children. These include a family history of atopic disease,^{1,2} environmental tobacco smoke,^{3,4} increased indoor humidity,^{5,6} chemical emissions,⁷ exposure to furry animals,⁸⁻¹⁰ small number of siblings,^{11,12} short duration of breastfeeding¹³ and dietary factors.¹⁴ In 1996 our group carried out a follow-up study of children from birth to 18 months of age¹⁵ where we found no single risk factor associated with housing that was linked to an increased risk of developing allergy. However, other significant relationships were noted: (1) children attending day nurseries showed an

increased risk of developing recurrent colds and an increased use of antibiotics, (2) if the mother smoked, the child more often had protracted episodes of coughing, (3) children with siblings more commonly had obstructive airway symptoms, recurrent colds and a greater need for antibiotic treatment, and (4) mothers who frequently reported various symptoms or symptoms involving the mucous membranes or the skin more often had children with eczema, dry skin and food reactions.

The aim of the present study was to re-evaluate the children of the cohort when they were 4 years old to determine the effect of early exposure to indoor environmental factors and other factors of possible impor-

tance for the subsequent occurrence of atopic symptoms. Our hypothesis was that some indoor factors contribute to the development of allergic symptoms and sensitisation in children and to the complaints and symptoms (general symptoms or skin or mucous membrane symptoms) reported by the mothers.

Materials and methods

Population

All 904 children born between August 1991 and January 1992 and living in two municipalities (Örebro and Kumla) in the middle of Sweden were included. The mothers answered three questionnaires, the first when the children were 3 months old, the second at 18 months and the third at 4 years. The mothers were not aware of the specific aims of the study when responding to the questionnaires. Before mailing the second questionnaire, 87 children were excluded, 44 because of possible language problems, 41 because they had moved before 6 months of age, and two who had died. The first two questionnaires were answered by the parents of 638 of the remaining 817 children (response rate 78%). Children who had moved before 6 months of age did not differ from those who had not moved regarding a family history of atopic diseases or allergic symptoms.

The first questionnaire

This questionnaire was answered during the winter, when buildings were heated and the indoor environment is supposed to have the greatest effect on health. Information was obtained about the mother's perception of the indoor climate and symptoms presumed to be related to a poor indoor climate during a recall period of 3 months. Questions from the standardised MM-Questionnaire were used covering indoor climate complaints (draft, high-variable-low room temperature, stuffy bad air, unpleasant smell, static electricity, passive smoke, noise, dust and dirt) and symptoms (fatigue, heavy-headed, headache, nausea, concentration problems, eye irritation, hoarseness, cough, dry facial skin, scaly-itchy scalp/ears, dry itchy red hands).¹⁶ If the mother reported increased symptoms when in the dwelling, the symptoms were considered as housing-related. The validity of the questions in relation to professional

judgements and measurements and the reliability of specific questions had been tested and found to be acceptable.^{16,17}

For each symptom or feature of indoor climate perception, three answers could be given: 'yes, often' (every week), 'yes, sometimes' and 'no, never'. Information was also obtained concerning a parental history of allergy, characteristics of the dwelling (wall-to-wall carpet and condensation on the windows), presence of furry animals at home, maternal smoking pattern and presence of siblings.

The second questionnaire

At 18 months, data were collected about the time weaning took place, the time when cow's milk-based foods were introduced, and whether the child attended a day nursery. In addition, information was obtained about whether the child had had protracted coughing episodes, repeated colds or had been prescribed more than two courses of antibiotics during the preceding 12-month period.

The third questionnaire

This questionnaire was filled in by the parents of 613 (299 boys and 314 girls) of the 638 children whose mothers had answered the first two questionnaires (response rate 96.1%). The questions focused on asthma, allergic eye-nose problems, eczema and food reactions in the children that had occurred during the previous 12 months. Asthma was diagnosed if the child 'had had an asthmatic attack or used asthmatic drugs during the previous 12 months'. The child was considered to have atopic rhino-conjunctivitis if the parents reported that 'the child had had allergic eye or nose symptoms during the previous 12-month period when in contact with pollen or furry animals'. If the parents reported 'itching and eczematous skin', the child was diagnosed as having eczema. Food reactions included 'allergic reactions to any food during the last 12 months'. 'Any atopic manifestation' meant that any one of the symptoms mentioned had occurred.

Many children (59%) had lived in the same dwelling during the whole study period. More than 80% had lived in the same dwelling up to at least 2 years of age. Analyses of outcome factors were made for children who had lived in the same dwelling their whole life and for those who had moved.

Blood sampling

In two subgroups of children, selected based on the results of the third questionnaire, Pharmacia food mix (FX5) and Pharmacia Phadiatop blood tests were performed to detect specific IgE antibodies to food (milk, hen's eggs, fish, wheat, soybean or peanut) and common inhalant allergens. The selection was performed when 576 of the 613 questionnaires had been received. All children whose parents reported that their children had had an atopic reaction (to fish, egg or milk, or eye-nose allergic symptoms from pollen or furry animals, or reported wheezing) formed the first group ($n = 115$). The second group included all other children ($n = 461$). The 115 in the first group and 116 randomly selected children (25.2%) in the second group were asked to participate in the test, and 94 (81.7% of group 1) and 92 (79.3% of group 2) children accepted. One child was excluded because of an insufficient amount of blood for both tests. This child had a negative Phadiatop.

Sensitisation frequency

Weighting results from the defined groups from this cohort, the prevalence of positive blood tests in the general population of children at 4 years of age was estimated: 10.2% had a positive FX5, 13.2% a positive Phadiatop and 18.0% either.

Of 31 children who had at any time reacted to milk, fish or egg according to the third questionnaire, 35.5% had a positive FX5 test as compared with 12 (10.1%) positive tests in children with no such food reactions. Of children whose parents reported that their child had reacted with allergic eye or nose symptoms when in contact with pollen or furry pets ($n = 37$), 59.5% showed a positive Phadiatop as compared with 12.2% of children whose parents denied these symptoms.

Statistical analysis

The chi-square test was used to analyse the relationships between proportions. Analyses of the relationships between the allergic manifestations and exposure measures from the questionnaire were performed using multiple logistic regression methods, controlling for the complaint factor (described below). Odds ratios (OR) are presented with 95% confidence intervals [95% CI]. SPSS for Windows version 6.3.1 was used for all calculations.

Results

Explanatory factors

The prevalence of potential risk factors for the development of allergic symptoms in the children are listed

Table 1. Potential risk factors for development of allergies analysed according to type of building and family history of atopy (%)

	Total $n = 613$	No. families in house		Family history	
		Single $n = 381$	Multiple $n = 232$	Yes $n = 292$	No $n = 318$
Family history of atopy at 3 months	47.9	49.2	45.7	—	—
Wall-to-wall carpet at 3 months	12.7	15.4**	8.3	11.8	13.7
Condensation on windows at 3 months	19.2	22.1*	14.3	23.3*	15.6
Furry animals at 3 months	34.4	41.5***	22.8	27.7**	40.3
Mother's smoking at 3 months	15.1	12.4*	19.6	10.0***	19.6
Sibling <16 years at 3 months	59.1	70.4***	40.1	59.9	58.4
Breastfed <6 months	42.4	41.1	44.7	42.3	41.9
Breastfed <3 months	18.3	15.9	22.3	17.6	18.2
Cows' milk before 4 months	43.9	41.8	47.3	42.3	44.9
Attended day nursery before 18 months	26.0	25.9	26.3	27.9	24.2
Protracted coughing episodes before 18 months	18.8	17.0	21.7	22.4*	15.3
Repeated colds before 18 months	42.4	42.0	43.2	46.4*	38.3
Two or more courses of antibiotics before 18 months	38.6	39.5	37.2	42.6	34.8
Increased no. maternal complaints (at 3 months)	25.4	15.5***	41.8	26.0	24.5
Increased no. maternal symptoms (at 3 months)	34.4	30.7*	40.5	42.1***	27.0
Housing-related maternal symptoms	4.7	2.4***	8.6	6.8*	2.5

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Table 2. Prevalence of atopic symptoms at 4 years of age. Data presented according to type of housing, family history, and frequency of the mother's complaints about indoor factors when the child was 3 months old

Symptom	Total <i>n</i> = 613	No. families in house		Family history		Complaints	
		Single <i>n</i> = 381	Multiple <i>n</i> = 232	Yes <i>n</i> = 292	No <i>n</i> = 318	Yes <i>n</i> = 156	No <i>n</i> = 457
Asthma	6.2	5.8	6.9	9.2**	3.5	10.9**	4.6
Rhino-conjunctivitis	5.5	5.0	6.1	7.6*	3.5	6.5	5.1
Eczema	31.7	30.4	33.8	40.9***	23.2	41.6**	28.3
Food reactions	11.9	10.3	14.3	16.6***	7.6	19.4**	9.3
Any atopic manifestation	39.7	37.8	42.7	50.7***	29.6	51.3***	35.7

P* < 0.05, *P* < 0.01, ****P* < 0.001.

separately in Table 1 according to the type of housing they lived in and a family history of atopy.

Children in homes with just their own family (single-family home) had more wall-to-wall carpets, more condensation on windows, more furry pets, more siblings and fewer smoking mothers. Their mothers complained less often about the indoor climate and reported a lower frequency of symptoms, particularly building-related symptoms, than other mothers. When comparing the group of children who had changed dwellings with those who had not, no differences in the development of allergic symptoms were observed.

Children with a family history of atopy had fewer furry pets, less often had smoking mothers, more often had condensation on windows and more often had protracted coughing episodes and repeated colds before the age of 18 months, and their mothers more often reported weekly symptoms. However, no difference was seen in the complaint rate about the indoor climate (26.0% vs. 24.5%).

Mothers who often reported complaints related to the indoor climate when the child was 3 months of age more frequently lived in multi-family buildings (62.2%

vs. 29.5%, *P* < 0.001) and more often reported condensation on windows (29.7% vs. 15.7%, *P* < 0.001). In the second questionnaire they also reported that their children had more protracted coughing episodes before 18 months of age (26.5% vs. 16.2%, *P* < 0.01) and more repeated colds (49.4% vs. 40.1%, *P* < 0.05). Of these mothers, 14.1% also reported building-related symptoms as compared with 1.5% among those without complaints about the indoor climate.

Outcome measures

Prevalence figures for outcome measures are given in Table 2. A significantly higher prevalence was found for all outcome measures among children with a family history of atopy than among the other children. Similar findings were observed in children of mothers who complained about the indoor climate. Table 3 shows the results of blood tests in the same way. A significantly higher prevalence of positive blood tests was seen in children with a family history of atopy, but neither the type of building nor the mother's complaints correlated significantly with the results of the blood tests.

Table 3. Results of positive blood tests. Data presented according to family history, mother's complaints and type of housing

Test	Total <i>n</i> = 185	No. families in house		Family history		Complaints	
		Single <i>n</i> = 124	Multiple <i>n</i> = 61	Yes <i>n</i> = 107	No <i>n</i> = 76	Yes <i>n</i> = 48	No <i>n</i> = 137
Phadiatop positive	21.6	21.8	21.3	33.6***	5.3	16.7	23.4
FX5 positive	15.7	13.7	19.7	21.5*	7.9	16.7	15.3
Any blood test positive	27.0	26.6	27.9	40.2***	9.2	20.8	29.2

P* < 0.05, **P* < 0.001.

Table 4. Results of correlation between explanatory factors and outcome factors in a univariate analysis where significant results were found. Data are presented according to family history of atopy

Child outcome	Total OR [95% CI]	History positive OR [95% CI]	History negative OR [95% CI]
Asthma			
Furry pets	0.41 [0.18, 0.95]*	0.72 [0.28, 1.86]	0.14 [0.02, 1.12]
Mother's complaints	2.54 [1.30, 4.95]*	1.77 [0.77, 4.06]	5.82 [1.66, 20.44]*
Housing-related symptoms	4.50 [1.71, 11.83]*	3.79 [1.26, 11.40]*	4.29 [0.48, 38.21]
Repeated colds	2.08 [1.06, 4.10]*	1.97 [0.86, 4.49]	1.98 [0.59, 6.64]
Courses of antibiotics	1.95 [1.00, 3.80]*	1.39 [0.62, 3.11]	3.43 [0.98, 11.99]
Rhino-conjunctivitis			
Gender (girl)	0.39 [0.18, 0.84]*	0.28 [0.10, 0.78]*	0.71 [0.21, 2.38]
Protracted coughing episodes	2.40 [1.12, 5.14]*	2.12 [0.85, 5.31]	2.46 [0.61, 9.85]
Repeated colds	2.85 [1.36, 5.99]*	2.12 [0.86, 5.22]	4.51 [1.17, 17.34]*
Eczema			
Wall-to-wall carpet	0.83 [0.48, 1.42]	0.42 [0.18, 0.97]*	1.64 [0.80, 3.36]
Mother's smoking	0.54 [0.32, 0.93]*	1.30 [0.59, 2.84]	0.31 [0.13, 0.77]*
Gender (girl)	1.49 [1.05, 2.10]*	1.51 [0.94, 2.43]	1.60 [0.93, 2.74]
Mother's complaints	1.81 [1.23, 2.64]*	1.66 [0.98, 2.82]	2.14 [1.20, 3.79]*
Mother's symptoms	1.69 [1.19, 2.42]*	1.60 [0.99, 2.58]	1.49 [0.84, 2.64]
Repeated colds	1.54 [1.08, 2.18]*	1.17 [0.73, 1.89]	1.93 [1.13, 3.29]*
Food reaction			
Condensation on windows	1.87 [1.06, 3.30]*	1.44 [0.70, 2.94]	2.40 [0.94, 6.14]
Attends day-care centre	2.17 [1.30, 3.63]*	1.96 [1.02, 3.75]*	2.44 [1.03, 5.74]*
Mother's complaints	2.35 [1.41, 3.91]*	3.28 [1.72, 6.24]*	1.30 [0.52, 3.26]
Mother's symptoms	1.97 [1.20, 3.23]*	1.47 [0.79, 2.74]	2.48 [1.06, 5.78]*
Housing-related symptoms	3.69 [1.61, 8.44]*	3.83 [1.47, 9.97]*	1.76 [0.21, 14.96]
Protracted coughing episodes	2.57 [1.49, 4.42]*	2.28 [1.16, 4.47]*	2.65 [1.03, 6.83]*
Repeated colds	2.67 [1.60, 4.47]*	2.35 [1.23, 4.49]*	3.01 [1.27, 7.12]*
Positive blood test			
Siblings (yes)	0.56 [0.29, 1.08]	0.32 [0.14, 0.73]*	2.15 [0.39, 11.89]
Any atopic manifestation			
Wall-to-wall carpet	0.79 [0.48, 1.30]	0.42 [0.20, 0.89]*	1.47 [0.75, 2.89]*
Mother's complaints	1.90 [1.31, 2.74]*	1.71 [1.01, 2.92]*	2.32 [1.36, 3.96]*
Mother's symptoms	1.68 [1.20, 2.36]*	1.63 [1.02, 2.61]*	1.41 [0.83, 2.39]
Mother's housing-related symptoms	2.61 [1.21, 5.63]*	1.88 [0.73, 4.87]	4.14 [0.97, 17.68]
Protracted coughing episodes	2.21 [1.46, 3.33]*	2.27 [1.28, 4.05]*	1.92 [1.02, 3.63]*

*Significant findings.

Correlation analyses

All explanatory factors including a positive FX5 or Phadiatop test were correlated with the outcome factors, and the significant outcomes are presented as crude ORs with 95% CIs in Table 4 for both the total cohort of children and the groups defined according to a family history of atopy.

Housing factors

The effects of single characteristics of the dwelling on atopic manifestations at 4 years of age were low, and the ORs were often close to one. Condensation on win-

dows was positively correlated to food reactions. Wall-to-wall carpet had a protective effect on development of eczema, and this was significant for children with a family history of atopy. Multi-family buildings differ widely from single-family dwellings both regarding technical aspects and the degree of complaints and symptoms reported by the tenants. We therefore present the results according to this differentiation. No differences in the prevalence of symptoms according to type of home were observed among the children. The prevalence of allergic symptoms was similar in children who had lived their whole life in the same dwelling and those who had moved.

Smoking, day nursery, furry animals, siblings, gender and feeding pattern

Smoking habits of the mothers were related to a lower prevalence of eczema in the child. Attendance before 18 months of age at a day nursery was associated with an increased number of allergic food reactions. The presence of furry animals in the home at the age of 3 months resulted in a significantly reduced risk of developing asthma. Girls had a lower prevalence of eye–nose allergic symptoms than boys. On the other hand, girls more often had eczema. The effect of duration of breast feeding and cows' milk introduction on the development of allergic symptoms was analysed, but no relationships were observed.

Coughing, recurrent colds and use of antibiotics

Children who had suffered from protracted episodes of coughing before 18 months of age developed more eye–nose allergic reactions, had food reactions more often, and an increased prevalence of 'any atopic manifestation'. Recurrent infections in the upper airways before 18 months of age predicted an increased risk of asthma, eye–nose allergic symptoms, food reactions and 'any allergic manifestation' at 4 years of age. High antibiotic consumption before 18 months of age resulted in an increased risk of asthma.

Complaints and symptoms

Children of mothers who, when the child was 3 months of age, had often reported complaints about the indoor environment, ran an increased risk of developing asthma, eczema and food reactions. Similarly, children whose mothers had reported an increased frequency of symptoms more often had eczema, food reactions and 'any atopic manifestation'. Although few mothers had building-related symptoms (4.7%), a significant correlation was found between such symptoms and the development of asthma, food reactions and the occurrence of 'any atopic manifestation' among the children.

Multivariate analyses

In the logistic regression analyses, including gender of the child, the child's family history and the mother's complaints as covariates, we assessed the correlation

between all single factors in Table 1 and all outcome factors. However, the only significant findings were as follows:

- early day nursery and food reactions (OR = 2.21, 95% CI [1.30, 3.74]);
- protracted coughing episodes and food reactions (OR = 2.21, 95% CI [1.26, 3.89]);
- protracted coughing episodes and 'any allergic manifestation' (OR = 2.00, 95% CI [1.30, 3.09]);
- repeated colds and allergic rhino-conjunctivitis (OR = 2.78, 95% CI [1.30, 5.91]);
- repeated colds and food reactions (OR = 2.45, 95% CI [1.45, 4.14]);
- repeated colds and 'any allergic manifestation' (OR = 1.58, 95% CI [1.12, 2.23]).

Discussion

Atopic diseases can be difficult to diagnose early in life, because the clinical signs are often non-specific and the information has to be obtained by questions directed to the parents. Comparisons of questionnaire surveys will therefore depend on both the definitions of the outcome parameters and the way in which the questions are asked. Standardised procedures such as use of the ISAAC questions¹⁸ would have been preferable, but were not available when this study began. We therefore used the current 12-month prevalence of some atopic manifestations and a positive IgE blood test at 4 years of age as outcome parameters.

The prevalence of atopic manifestations varies with age, and few studies are available on children at the age of about 4 years. The prevalence of asthma in this study (6.3%) is in accord with that reported elsewhere,¹⁹ but the prevalence of rhino-conjunctivitis is fairly low (5.5%) compared with results of others²⁰ which are based on older populations. The prevalences of eczema (31.7%) and food reactions (11.9%) are similar to those reported in other studies.^{21,22} The indoor situations differ greatly between single- and multi-family dwellings (Table 1), and it is plausible that other conditions not studied here also differ. We have therefore analysed the results according to type of housing. In the children who developed allergic manifestations, the current indoor environment may have affected the severity of allergic symptoms. In this study we have focused on the effect of the environment in early life on the later development of atopic symptoms. However, we found no difference in the prevalence of allergic symptoms between the children who had moved

before 4 years of age and those who had not. If we had found such a difference, this might have been explained by factors in the environments occurring later in life.

A family history of atopy, which was the strongest explanatory factor for all outcome parameters in this study, has also been noted by others.^{1,2,23,24}

The effects of housing characteristics and indoor climate factors on health are contradictory. In this study most ORs in the univariable and multivariable analyses were close to one, with few exceptions, which indicates that no single factor of this kind seems to have any large effect on the development of allergic manifestations.

Early exposure to furry animals has been thought to be responsible for sensitisation to animals. This risk is supposedly greatest if the child is exposed very early in life, especially if there is a positive family history of atopy.^{10,25,26} In our study the ORs for the effect of early exposure to animals on later development of allergy indicated a protective effect. For asthma, this protective effect was significant in the univariable but not in the multivariable analysis. Some families may have removed the animal from the home because the child developed allergic symptoms during the first 3 months, which could have resulted in protective figures. The time-span however, is very short. Hypothetically, owning a pet is combined with lifestyle factors that were not evaluated in this study (i.e. factors that could be protective against allergy development). Possible examples of such confounding factors are more of an outdoor lifestyle, participation in more sports activities, and different food habits. In any case, the effect of exposure to animals seems to be limited to subsequent development of allergic symptoms.

Exposure to environmental tobacco smoke (ETS) during early life has been reported to be important regarding the child's sensitisation and regarding increased bronchial hyper-reactivity.^{4,27-29} We saw no clear-cut negative effect of ETS on the outcome parameters. On the contrary, we found a protective effect for development of eczema in the univariable but not in the multivariable analysis. It might have been difficult to obtain adequate information concerning tobacco smoking because of possible under-reporting, and only the mother's smoking habits were reported in this study.

We found no significant effect on the development of allergy from the time of weaning or the time of introduction of cows' milk-based formula. Most chil-

dren in this study were breast fed for a very long time compared with what is normal in other countries. However, we found no increased risk of allergic symptoms even in those breast fed for <3 months.

The presence of siblings has been reported to have a protective effect on the development of allergy.³⁰⁻³³ Whether this effect is the result of an increased number of infections spread by siblings, or to other causes, has been debated.^{30,34} The protective effect of the presence of siblings may be more pronounced in smaller dwellings, but could not be evaluated in this study because the population studied lived in large flats. In this study we found that the presence of siblings when the child was born resulted in a reduced tendency to form IgE antibodies. This tendency was marked in children with a family history of atopy. It may be that the mechanisms responsible for this finding could result in a lower prevalence of allergic symptoms later on.

In the present study we found a significant relationship between an increase in the number of early infections and subsequent development of asthma and allergic symptoms. This finding was also significant for food reactions, rhino-conjunctivitis, and 'any allergic reaction' in the multivariable analyses. A possible explanation may be confusion between the diagnosis of asthma and signs of infection early in life. However, this explanation does not apply to the other diagnoses. It can be argued that self-reported symptoms of infections may be influenced by an increased tendency by some parents to observe symptoms, and that this tendency may persist even when the child is older. The symptoms of allergy would therefore be over-reported. An objective way of diagnosing the children's allergic symptoms would be preferable.

Attendance at a day nursery is thought to result in an increased number of viral infections, which could affect the maturation of the immune system. In the multivariate analyses we found an increased prevalence of food reactions among those attending day nursery. Most of the children attending day nursery at 18 months of age are still there at 4 years of age, and one explanation may be that those children are observed more closely when they are eating and that the staff as compared with parents may have had a tendency to over-report reactions.

Maternal symptoms and complaints about the indoor climate are also important predictors for later development of allergic symptoms. The mothers in

this study complained about some factor related to the indoor climate to the same extent as was noted in the general Swedish population in the nationwide ELIB study, where 20% of the occupants of single-family houses and 40% of those living in multi-family buildings had such complaints.³⁵ Whether or not the residents lived in single- or multi-family buildings, those complaining about some factor in the indoor environment reported generally higher frequencies of both their own symptoms and those in their children. The latter were not supported by the results of the allergy tests. Therefore it is not possible to exclude over-reporting among those complaining about indoor air quality. However, other studies have shown an increased reactivity of the nasal mucous membranes to histamine in provocation tests among nonatopic persons who had been exposed to buildings with indoor climate problems, indicating a possible non-immunological reaction.^{36,37}

General conclusions

The aim of this study was to evaluate the impact of individual housing factors and indoor factors on the development of allergic manifestations and sensitisation in children. However, we found no particular factor to be a major cause of these outcomes. We also aimed to evaluate whether the mother's opinion about the indoor environment could be a predictor of the development of allergy in their children. A strong correlation was found between allergic manifestations in children and the mother's tendency to complain about the indoor climate. However, it is difficult to draw conclusions from this finding, as objective measures of allergy (IgE antibodies) were not increased among the children of these mothers.

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