Risk factors for respiratory symptoms and atopic sensitisation in the Baltic area

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Abstract

Recent studies have indicated that atopic sensitisation is uncommon while respiratory symptoms are common among schoolchildren in Eastern Europe. Risk factors for respiratory symptoms and atopic sensitisation were evaluated in a cross sectional study involving 2594 schoolchildren (10–12 years) from Sweden (n=665), Poland (n=410), and Estonia (n=1519). The measurements included parental questionnaires and skin prick tests with eight standardised allergens. Multiple logistic analyses demonstrated that atopic heredity was a significant independent risk factor for respiratory symptoms and atopic sensitisation in all the countries. Current dampness and maternal smoking were related to respiratory symptoms whereas domestic crowding, male gender, and passive smoking during infancy were related to atopic sensitisation. Current maternal smoking had a strong dose response association with current coughing attacks (nocturnal cough >4 weeks or exercise induced coughing attacks) but only in Eastern Europe. A strong inverse relationship was recorded between domestic crowding and sensitisation as the risk for sensitisation increased with decreasing number of persons per room in the household (odds ratio (OR) 0·58, 95% confidence interval (CI) 0·43 to 0·77). Exposure to tobacco smoke at home during infancy was a risk factor for atopic sensitisation but only to animal dander and only in Eastern Europe (OR 1·41, 95% CI 1·03 to 1·93). In conclusion, there were small differences in the pattern of risk factors between Eastern and Western Europe. The only exception was environmental tobacco smoke being a risk factor only in Eastern Europe. The study also suggests that factors related to domestic crowding protect against atopic sensitisation in Estonia and Poland. A higher standard of living with less crowding may give rise to an increasing prevalence of atopic sensitisation also in Eastern Europe.

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Atopic symptoms are common public health problems among schoolchildren in industrialised countries. Several studies indicate an increasing prevalence of allergies and asthma in Western countries over the last few decades.[1–3] Despite exposure to high levels of outdoor air pollutants, allergies seem to be uncommon in Eastern Europe.[4] Recurrent bronchitis was common but atopic symptoms uncommon among schoolchildren in Leipzig as compared with Munich.[5] A similar pattern was found in a study comparing Swedish and Polish schoolchildren, in which urban schoolchildren in Sweden had a high prevalence of atopic sensitisation, while non-atopic respiratory symptoms were more common in Poland.[6] It has been suggested that the increase of allergies in Western countries is related to changes in lifestyle and standard of living over the last 30 or 40 years.[6 7] The aim of the present study was to assess the importance of risk factors for respiratory symptoms and atopic sensitisation among 10–12 year old Swedish, Polish, and Estonian schoolchildren. In particular the possibilities were studied that the pattern of risk factors between Eastern and Western Europe were different and that factors related to a low socioeconomic level may protect against atopic sensitisation.

Subjects and methods

STUDY POPULATIONS

All pupils who were enrolled in grade 4, 5, and 6 (10–12 years) from three areas were studied. (1) All schools in central Sundsvall in Northern Sweden and all schools in surrounding rural areas 20–70 km from the town centre (688 children). (2) One school in the centre of Konin in central Poland (425 children). This school was chosen because it was judged to be representative for the central parts of Konin. (3) Eleven Estonian schools in Tallinn (806 children) and four schools in Tartu (774 children) in Estonia. Selected schools were judged to be representative for the different types of residential areas in Tallinn and Tartu. An explanatory letter was distributed by a teacher or a school nurse to the parents of all children in the selected classes. Written consent was obtained from all parents before measurements were taken.

Sundsvall is an administrative and industrial centre with 94 000 inhabitants (1992). The total emission of sulphur dioxide from the local factories was 515 tons in 1992 and the half annual mean sulphur dioxide was 3 $\mu g/m^3$ in 1991/1992. The centre of Sundsvall is situated in a valley with mountains to the north and south and a bay of the Baltic Sea in the east. In the centre of Sundsvall outdoor levels of

nitrogen dioxide are sometimes high by Swedish standards as a result of inversion, in conjunction with dense motorised traffic. One hour mean nitrogen dioxide levels were 39 $\mu g/m^3$ in 1986/7, 36 $\mu g/m^3$ in 1989/90, and 32 $\mu g/m^3$ in 1992/3. Corresponding 98 centile levels were 90 $\mu g/m^3$, 84 $\mu g/m^3$, and 88 $\mu g/m^3$ respectively. The levels of air pollutants in surrounding rural areas were low.[6]

Konin is an industrial town with 85 000 inhabitants. The town has an aluminium plant and three brown coal power stations (supplying 10% of the total electricity production in Poland). The power stations emit about 120 000 tons of sulphur dioxide per year. The town centre is situated on a low hill with windy and open surroundings. Levels of air pollutants are high compared with Sundsvall but generally well below the upper levels as defined by the World Health Organisation.[6] Daily mean sulphur dioxide levels during the heating season were 31·4 $\mu g/m^3$ (maximum level 108 $\mu g/m^3$) in 1992 and 46·3 $\mu g/m^3$ (maximum level 225 $\mu g/m^3$) in 1993. Daily mean nitrogen dioxide levels were 29·7 $\mu g/m^3$ (maximum level 108 $\mu g/m^3$) in 1992 and 24·7 $\mu g/m^3$ (maximum level 65 $\mu g/m^3$) in 1993. The selected school was situated in the town centre. Most of the population in Konin live in blocks of flats with 5–12 flats and housing is not yet segregated by socioeconomic conditions.

Tallinn is situated on the Baltic coast. The town is heavily industrialised and has 452 000 inhabitants (1993). The power station in Tallinn emits about 20 000 tons of sulphur dioxide annually. Tartu is a university town with 109 000 inhabitants (1993) in central Estonia with little industry. Both towns have different types of residential areas including modern blocks of flats, small bungalows, and old wooden buildings. Reliable data on the levels of ambient air pollutants are not available.

PROCEDURE

The study was carried out between September 1991 and February 1992 in Sweden and Poland and between September 1992 and March 1993 in Estonia.

(1) Questionnaire to parents

The questionnaire was a revised and extended version of a questionnaire used in a previous study.[8] The Swedish questionnaire was translated into English, Estonian, and Polish. The translations were checked by back translation into Swedish by independent persons. The questionnaires were distributed to the parents by the school nurse or a teacher. The questionnaire included 60 questions concerning each parent's occupation, housing conditions, household pets, atopic heredity, and atopic symptoms in the study child. The current smoking habits of each family member were defined (0, 1–9, 10–20, >20 cigarettes/day). The questionnaire also asked whether the study child was exposed to tobacco smoke at home during infancy. Information was sought on past or present dampness at home: 'Any signs of damp or mould damage?'

Atopic heredity was defined as presence of self reported atopic disease (that is, bronchial asthma, hay fever, or eczema) in other members of the immediate family (that is, parents, brothers, and sisters). A positive response to the question 'wheezing in the chest during, for example, a cold, physical exertion or in contact with animals?' was classified as 'wheezing'. A positive response to 'nocturnal cough for a period longer than 4 weeks (with no signs of cold or whooping cough)' and/or 'exercise-induced coughing attacks without concomitant cold' was classified as 'coughing attacks'. A positive response to 'runny or blocked up nose, itchiness around the nose and persistent sneezing, together with red, itching eyes' was classified as 'nasal and/or ocular symptoms'.

Data were collected in autumn 1991 in Sundsvall and Konin and in autumn 1992 in Tallinn and Tartu. Replies to the questionnaire were received from 665 (96·7%) children in Sundsvall, 410 (96·5%) in Konin, 753 (93·4%) in Tallinn, and 766 (99·0%) in Tartu.

(2) Skin prick test

Skin prick tests were performed on the volar aspects of the forearms with eight standardised allergen extracts (Solu-Prick SQ, ALK, Hørsholm, Denmark). The allergens were labelled in histamine equivalent prick units (HEP) or weight/volume (w/v): birch (10 HEP), timothy (10 HEP), and mugwort pollen (10 HEP), *Dermatophagoides pteronyssinus* (10 HEP), cladosporium (1:20 w/v), and horse (10 HEP), cat (10 HEP), and dog dander (10 HEP). Only the largest wheal was registered if the test was performed in duplicate (single tests only in Sweden and Poland). The skin prick tests were performed in January and February 1992, by one nurse in Sweden and one doctor in Poland. The tests in Estonia were performed in duplicate by two doctors in Tallinn and two doctors in Tartu. The skin prick tests were carried out on 640 (93·0%) children in Sundsvall, 358 (84·2%) in Konin, 597 (74·1%) in Tallinn, and 637 (82·3%) in Tartu. The results were compared with the concentrations of specific serum IgE antibodies to birch and timothy grass pollen, dog and cat dander and *D pteronyssinus* (Magic Lite/ALK) in 145 children in Sundsvall, 49 children in Konin, and 156 in Estonia. The sensitivity of the skin prick test in relation to specific serum IgE was 91·3%, 76·2%, and 46·5% in Sweden, Poland, and Estonia respectively. Corresponding figures for the specificity were 81·6%, 96·4%, and 97·4%.

(3) Statistics

The statistical calculations were done with SPSS-PC. Comparisons were made using Student's t test for continuous variables, and the χ^2 test for proportions. All the tests were two tailed. Test for trends were done using the Mantel-Haenszel test statistic.[9]

Table 1 Prevalence rates (in %) of respiratory symptoms in relation to hereditary and environmental factors among 2594 schoolchildren in Sweden, Poland, and Estonia

	Sweden (n=665)	*Poland (n=410)*	*Estonia (n=1519)*
Wheezing	10·6	10·6	7·6
Atopic heredity (yes/no)	14·9/4·0***	13·3/9·5	11·8/4·7***
Maternal smoking			
No smoking	11·9	9·4	7·1†
1–9 cigarettes/day	7·1	8·9	8·5
>9 cigarettes/day	8·7	13·9	17·0
Current dampness at home (yes/no)	18·2/9·4*	23·3/9·8*	8·9/7·3
Cat at home (past or present) (yes/no)	7·7/14·9**	2·9/11·9*	7·8/7·3
Gender (male/female)	13·4/8·2*	11·5/9·7	8·3/7·0
Coughing attacks	8·6	9·9	9·1
Atopic heredity (yes/no)	10·7/5·0*	24·2/4·9***	11·1/8·0
Maternal smoking			
No smoking	8·4	6·7	7·4‡
1–9 cigarettes/day	5·9	12·2	12·8
>9 cigarettes/day	10·2	14·7	27·7
Cat at home (yes/no)	6·0/12·3••	4·4/11·8	9·5/8·8
Nasal and/or ocular symptoms	17·9	15·9	15·3
Atopic heredity (yes/no)	23·3/9·2***	30·6/11·4***	22·6/10·7***
Current dampness at home (yes/no)	22·0/17·4	26·7/15·0	21·0/13·8**
Cat at home (past or present) (yes/no)	14·4/23·1**	17·9/14·7	13·8/16·4

*p<0·05, **p<0·01, ***p<0·001 (χ^2 test).
†p<0·05, ‡p<0·001 (Mantel-Haenszel test for linear association).

Logistic regression was used to obtain estimates of odds ratios (OR) for respiratory symptoms and atopic sensitisation adjusting for significant covariables. Breathing problems, coughing attacks, nasal and/or ocular symptoms, and skin prick test results were defined as dependent variables. Independent variables were: atopic heredity, gender, passive smoking at home during infancy, current maternal smoking, current paternal smoking, signs of dampness at home (past or present), number of siblings, number of persons per room in the household, past or present cat at home, and study site (study area was included in all regression models). Maternal and paternal smoking were used as indicator variables with three levels: no smoking (reference group), 1–9 cigarettes/day and more than 9 cigarettes/day.

A backward reduction modelling strategy was employed. First non-significant interaction terms were removed. Afterward, non-significant variables were dropped if their removal did not result in a change of more than 10% of any other variables. Wald's statistic has been used to exclude variables from the models and only significant variables have been included in the final models. Ninety five per cent confidence intervals (CIs) for the parameter estimates were calculated in the usual manner (B±1·96×SE(B)).

Table 2 Prevalences (in %) of atopic sensitisation (at least one positive skin prick test) in relation to hereditary and environmental factors among 2232 schoolchildren in Sweden, Poland, and Estonia

	Sweden (n=640)	*Poland (n=358)*	*Estonia (n=1234)*
Sensitisation to any allergen	30·3	13·6	10·9
Atopic heredity (yes/no)	34·2/23·5**	20·5/11·8*	11·9/10·4
Gender (male/female)	33·3/27·4	15·5/11·4	14·0/8·6**
Passive smoking at home during infancy (yes/no)	32·7/27·7	11·8/17·7	11·9/9·9
Sensitisation to pollen	23·3	10·0	6·1
Atopic heredity (yes/no)	26·8/17·7**	14·8/9·1	6·8/5·9
Gender (male/female)	24·9/21·9	11·3/8·4	7·6/4·8*
Passive smoking at home during infancy (yes/no)	24·2/22·2	7·6/15·9*	7·6/4·8*
Sensitisation to animal dander	21·4	3·9	5·4
Atopic heredity (yes/no)	24·6/16·1*	9·1/2·8*	7·0/3·9*
Gender (male/female)	24·6/18·4	4·2/4·2	6·0/5·0
Passive smoking at home during infancy (yes/no)	22·6/19·8	5·1/2·7	6·1/4·3
Cat at home (past or present) (yes/no)	16·4/28·2***	4·9/4·4	3·9/6·2

*p<0·05, **p<0·01, ***p<0·001 (χ^2 test).

(4) Ethical considerations

The study was approved by the ethics committee of Umeå University in Sweden, Poznan University School of Medical Sciences in Poland, and Tartu University in Estonia.

Results

Sociodemographic characteristics of the children in Sweden and Poland are presented in detail elsewhere.[6] Briefly, most families in Poland and Estonia lived in apartments as compared with 36·3% in urban Sundsvall and 7% in rural Sundsvall. The average number of persons per room in the household was 0·9 in Sundsvall, 1·7 in Poland, and 1·5 in Estonia. Approximately half the children in all countries were exposed to tobacco smoke at home during infancy. Current smoking habits differed between the countries: 19·6% of the fathers and 37·0% of the mothers were current smokers in Sweden as compared with 59·1% *v* 51·1% in Poland and 46·2% *v* 23·7% in Estonia. Cats and dogs were common as pets, with only small differences between the countries.

(1) UNIVARIATE ANALYSES

Respiratory symptoms

The prevalence of symptoms from the airways in relation to hereditary and environmental variables are shown in table 1. Atopic heredity was associated with airway related symptoms in all the countries. The only exception was that no significant association was seen between atopic heredity and coughing attacks in Estonia. Having or having had a cat at home was uncommon among Swedish children with airway related symptoms. Wheezing symptoms were more common among boys in Sweden. Dampness at home was related to symptoms from both the upper and lower airways.

A dose-response relationship was found between current maternal smoking habits and respiratory symptoms among schoolchildren in Estonia. The linear association between maternal smoking and coughing attacks was highly significant. The association between paternal smoking and respiratory symptoms was not statistically significant.

Atopic sensitisation

As shown in table 2, atopic heredity was associated with an increased prevalence of sensitisation at all study sites. In Estonia, however, this was true only for sensitisation to animal dander. Sensitisation was slightly more common among boys at all study sites but the difference was significantly only in Estonia. No clear association was seen between early exposure to tobacco smoke and sensitisation. Having or having had a cat at home was uncommon among Swedish children with sensitisation to animal dander.

Table 3 Risk factors for respiratory symptoms among 2594 schoolchildren in Sweden, Poland, and Estonia. Adjusted ORs with 95% CI obtained from multiple logistic regression analysis controlling for significant variables (including study site)

	All areas (n=2594)	*Sweden (n=665)*	*Poland (n=410)*	*Estonia (n=1519)*
Wheezing				
Atopic heredity	2·67 (1·93 to 3·67)***	3·94 (1·88 to 8·27)***	1·41 (0·65 to 3·08)	2·81 (1·82 to 4·32)***
Gender (male *v* female)	1·40 (1·04 to 1·89)*	1·93 (1·10 to 3·38)*	1·16 (9·56 to 2·41)	1·30 (0·86 to 1·96)
Maternal smoking				
1–9 cigarettes/day	0·92 (0·62 to 1·38)	0·58 (0·23 to 1·43)	0·79 (0·27 to 2·30)	1·23 (0·74 to 2·03)
>9 cigarettes/day	1·52 (0·97 to 2·38)	0·85 (0·41 to 1·77)	2·32 (1·03 to 3·41)*	2·32 (0·98 to 5·52)
Current dampness at home	1·47 (1·01 to 2·12)*	2·20 (1·11 to 4·36)*	3·11 (1·04 to 5·16)*	1·11 (0·69 to 1·79)
Cat at home (past or present)	0·74 (0·53 to 1·02)	0·58 (0·32 to 1·04)	0·21 (0·05 to 0·94)*	1·00 (0·66 to 1·52)
Coughing attacks				
Atopic heredity	2·13 (1·57 to 2·88)***	2·57 (1·27 to 5·20)**	6·92 (3·25 to 14·76)***	1·54 (1·03 to 2·50)*
Maternal smoking				
1–9 cigarettes/day	1·55 (1·07 to 2·24)*	0·67 (0·25 to 1·78)	1·38 (0·52 to 3·70)	1·80 (1·15 to 2·80)**
>9 cigarettes/day	2·60 (1·69 to 4·01)***	1·40 (0·70 to 2·80)	2·88 (1·23 to 6·74)**	4·27 (2·04 to 8·91)***
Current dampness at home	1·41 (0·97 to 2·03)	1·05 (0·44 to 2·46)	1·85 (0·54 to 6·34)	1·60 (1·03 to 2·50)*
Overcrowding (No of persons/room)	1·09 (0·84 to 1·42)	1·10 (0·48 to 2·51)	1·99 (1·04 to 3·78)*	0·83 (0·58 to 1·17)
Nasal and/or ocular symptoms				
Atopic heredity	2·63 (2·07 to 3·34)***	2·70 (1·65 to 4·40)***	3·75 (2·01 to 7·01)***	2·44 (1·79 to 3·31)***
Current dampness at home	1·59 (1·20 to 2·11)**	1·22 (0·68 to 2·18)	2·43 (0·92 to 6·40)	1·67 (1·19 to 2·35)**
Cat at home (past or present)	0·76 (0·59 to 0·97)*	0·60 (0·39 to 0·94)*	1·57 (0·74 to 3·56)	0·80 (0·59 to 1·09)

*p<0·05, **p<0·01, ***p<0·001 (χ^2 test).

Crowding was inversely related to atopic sensitisation both in Poland and Estonia. The mean differences in number of persons per room in the household between children with and without atopic sensitisation in Poland and Estonia were 0·199 (95% CI 0·027 to 0·371) and 0·140 (95% CI 0·031 to 0·223) respectively.

(2) MULTIPLE LOGISTIC REGRESSION ANALYSES

Respiratory symptoms

The results of the logistic regression analyses are presented in table 3. Atopic heredity and current dampness at home were independent risk factors for all types of symptoms in the whole group after adjusting for study site and other significant characteristics. Maternal (but not paternal) smoking was a risk factor for coughing attacks. Thus, a highly significant dose-response relationship was seen between maternal smoking and coughing attacks (both in the whole study group as well as in Poland and Estonia). No such association between maternal smoking habits and respiratory symptoms was recorded among the Swedish schoolchildren.

Atopic sensitisation

As shown in table 4, and looking upon the whole group, atopic heredity and male gender were important risk factors for atopic sensitisation to at least one allergen. Domestic crowding (number of persons per room) and family size (number of children in the family) were inversely related to atopic sensitisation. The inclusion of the variable 'domestic crowding' in the logistic model, however, resulted in a bigger change in the log likelihood (difference 58·09) than the inclusion of the variable 'family size' (difference 37·34). The variable domestic crowding was skewed and therefore we tested a logistic regression model with ln (domestic crowding). The outcome with and without log transformation was similar.

The risk of atopic sensitisation decreased at all study sites with increasing number of persons per room in the household, although not significantly so in Sweden. Current parental smoking was not related to atopic sensitisation whereas exposure to tobacco smoke at home during infancy was associated with an increased risk for atopic sensitisation to animal dander. Among Swedish children, however, no association at all was seen between passive smoking and atopic sensitisation. Cat ownership was inversely related to atopic sensitisation to animal dander in all the countries.

Table 5 demonstrates the differences in odds ratios for atopic sensitisation between Sweden and the study sites in Poland and Estonia. The differences were diminished

Table 4 Risk factors for atopic sensitisation (at least one positive skin prick test) among 2232 schoolchildren in Sweden, Poland, and Estonia. Adjusted ORs with 95% CI obtained from multiple logistic regression analyses controlling for significant variables (including study site)

	All areas (n=2232)	*Sweden (n=640)*	*Poland (n=358)*	*Estonia (n=1234)*
Sensitisation to any allergen				
Atopic heredity	1·56 (1·22 to 1·99)***	1·75 (1·20 to 2·56)**	2·21 (1·14 to 4·30)*	1·19 (0·80 to 1·76)
Gender (male *v* female)	1·51 (1·19 to 1·92)***	1·23 (0·86 to 1·76)	1·74 (0·89 to 3·35)	1·78 (1·20 to 2·65)**
Crowding (No of persons/room)	0·58 (0·43 to 0·77)***	0·63 (0·35 to 1·15)	0·47 (0·24 to 0·90)*	0·55 (0·36 to 0·84)**
Sensitisation to pollen				
Atopic heredity	1·56 (1·16 to 2·09)**	1·63 (1·08 to 2·46)*	2·25 (1·03 to 4·90)*	1·23 (0·75 to 2·02)
Passive smoking at home during infancy	1·21 (0·91 to 1·61)	1·16 (0·79 to 1·71)	0·46 (0·21 to 0·97)*	1·94 (1·15 to 3·28)*
Cat at home (past or present)	0·71 (0·52 to 0·96)*	0·62 (0·41 to 0·92)*	1·17 (0·54 to 2·54)	0·80 (0·49 to 1·33)
Crowding (No of persons/room)	0·58 (0·40 to 0·83)**	0·78 (0·43 to 1·43)	0·44 (0·20 to 0·97)*	0·53 (0·31 to 0·92)*
Sensitisation to animal dander				
Atopic heredity	1·92 (1·39 to 2·67)***	1·73 (1·13 to 2·67)*	3·63 (1·25 to 10·48)*	1·86 (1·06 to 3·27)*
Passive smoking at home during infancy	1·41 (1·03 to 1·93)*	1·18 (0·79 to 1·76)	2·21 (0·60 to 8·13)	1·83 (1·03 to 3·26)*
Cat at home (past or present)	0·63 (0·45 to 0·88)**	0·58 (0·38 to 0·89)*	0·72 (0·19 to 2·74)	0·65 (0·36 to 1·14)
Crowding (No of persons/room)	0·51 (0·33 to 0·78)**	0·62 (0·32 to 1·22)	0·45 (0·15 to 1·36)	0·43 (0·22 to 0·84)*

*p<0·05, **p<0·01, ***p<0·001 (χ^2 test).

Table 5 Adjusted ORs (95% CI) for atopic sensitisation (at least one positive skin prick test) at the different study sites (rural Sundsvall reference group). Comparison between two logistic models, one including and the other not including domestic crowding

	Not adjusting for domestic crowding	*Adjusting for domestic crowding*
Urban Sundsvall, Sweden	1·67 (1·17 to 2·38)	1·71 (1·19 to 2·45)
Konin, Poland	0·56 (0·37 to 0·85)	0·84 (0·52 to 1·36)
Tallinn, Estonia	0·54 (0·38 to 0·78)	0·72 (0·48 to 1·08)
Tartu, Estonia	0·29 (0·19 to 0·43)	0·38 (0·25 to 0·59)

when the variable domestic crowding was included in the logistic model.

Discussion

This cross sectional study demonstrated many similarities in the pattern of risk factors for respiratory symptoms and atopic sensitisation in Eastern and Western Europe despite large differences in the prevalence of symptoms and signs of respiratory disease and atopy. A major finding was that domestic crowding was inversely related to atopic sensitisation at all study sites, though statistically significant so only in Estonia and in Poland. This could explain some of the differences in atopic sensitisation between Sweden on one hand and Poland and Estonia on the other hand.

The high rate of participation in all the three countries was probably due to a considerable local interest in the study and an efficient health care system in the schools. The selection of schools was not randomised and this could possibly have influenced our results. There was, however, no strong evidence for a selection bias. The study area in urban Sundsvall included a mixture of one family houses and blocks of flats. Most of the population in Konin live in small apartments in blocks of flats and housing is not yet segregated by socioeconomic conditions. The selected schools in Estonia were uniformly distributed from different residential areas in Tallinn and Tartu.

The use of questionnaires in international studies is problematic as the responses to them may be influenced by differences in translation and interpretation of questions. To reduce the risk of language differences the questionnaires were back translated into Swedish. The awareness of asthma and allergic diseases is probably lower in Estonia and Poland than in Sweden. We therefore based our analyses on parent reported symptoms, rather than on a particular disease diagnosis.

The validation of the skin prick test technique showed between site discrepancies indicating some overestimation of the differences in atopic sensitisation between the countries. In addition, the lower sensitivity of the skin prick tests in Poland and Estonia could possibly have weakened the associations between exposure variables and sensitisation in Eastern Europe.

The results are based on cross sectional data. Thus, it is difficult to conclude whether the exposure to a risk factor preceded the symptoms or not. A negative association between a putative risk factor and a symptom could for example also be explained by preventive measures taken by affected individuals. This could explain why current or previous ownership of cats at home was negatively associated with respiratory symptoms and atopic sensitisation despite the fact that cat allergen is a common cause of atopic sensitisation among schoolchildren in Sweden.[8]

Atopic heredity was an important risk factor in all countries for most of the study parameters, including respiratory symptoms. This was true despite the big differences in living conditions and the much lower prevalence of sensitisation in the two formerly socialist countries. Recall bias could, however, have influenced our results. It is quite likely that a family history of allergy is more promptly recalled in a child with symptoms. The weak association between heredity and sensitisation in Estonia is possibly explained by the low prevalence of positive skin prick tests in the children and by possible underdiagnosis among the adults due to a previous lack of diagnostic tests. Male gender was a risk factor for atopic sensitisation as well as respiratory symptoms. This is consistent with other similar studies on schoolchildren.[10–12]

There was a close dose-response association between current maternal smoking and both nocturnal cough and exercise induced coughing attacks. Several studies show that parental smoking is a major risk factor for respiratory symptoms among schoolchildren.[13 14] In our study paternal smoking was not associated with airway complaints, however. This is consistent with other reports showing a greater effect of maternal than of paternal smoking on salivary cotinine concentrations[15] and respiratory conditions, even in schoolchildren.[16]

The prevalence of maternal smoking in Sweden was similar as in Poland and much higher than in Estonia. There was, however, no association between atopic sensitisation nor respiratory symptoms and passive smoking among the Swedish children. This difference between Eastern Europe on one hand and Sweden on the other may be related to differences in standards of living. In a study from the UK salivary cotinine concentrations in schoolchildren were strongly related to low socioeconomic status, even after adjustment for maternal cigarette intake.[15] Children in small apartments are more exposed to environmental tobacco smoke. Furthermore, many Swedish parents are probably aware of the dangers of smoking as a result of public health work and antismoking propaganda and therefore usually try to restrict their smoking to outdoor areas.

Environmental tobacco smoke at home during infancy was a risk factor for sensitisation to animal dander. In contrast, current maternal smoking was unrelated to sensitisation. There is evidence from several studies that exposure to allergen and adjuvants in early life increases the risk of sensitisation in individuals with a propensity to atopy.[17] Animal studies show that exposure to environmental

tobacco smoke at the time of initial exposure to allergens may interfere with the normal tolerance indication process and exaggerate the risk for sensitisation.[18] It is also interesting to note that exposure to environmental tobacco smoke was related to sensitisation to indoor allergens, that is, pets, in this and two recent Swedish studies,[14 19] whereas exposure to outdoor air pollutants was related to outdoor allergens, that is, pollen.[14]

Dampness at home has often been associated with respiratory symptoms.[14 20–22] In this study, however, the strength of this association differed considerably, not only between study sites but also between symptoms. It would be reasonable to believe that the interpretation and meaning of the term 'dampness at home' varies between and also within populations. Damp housing has become an increasing problem in Sweden during the last 20 years, usually as a result of energy saving measures including insulation and reduced ventilation. In Estonia, however, dampness probably reflects poor housing conditions and a low standard of living. The parental attitude to report dampness could also be a confounding factor, as parents of children with wheezing may be more prone to report signs of dampness at home.[23]

A new finding in our study was the highly significant inverse relationship between domestic crowding and atopic sensitisation. Factors related to domestic crowding could explain some of the differences in sensitisation between Eastern and Western Europe. This finding supports the assumption that the increasing prevalence of allergies in Westernised countries is related to an improved standard of living. Other studies have demonstrated a higher prevalence of atopic sensitisation and eczema in the higher socioeconomic classes.[24 25] Our results are also consistent with two recent reports showing a strong inverse relationship between the number of siblings and either hay fever[26] or positive skin prick tests.[27]

In a previous report on a subset of the data used in this study we concluded that there was no relation between allergy and the size of the family.[6] In the present study we have explored the full data set, comparing two different variables: crowding (number of persons per room) and family size (number of siblings). Both variables were significant predictors of atopic sensitisation. However, crowding improved the logistic model more than family size. Domestic crowding is usually related to low socioeconomic conditions and would be expected to be associated with an increased exposure to infections.

Experimental as well as epidemiological studies indicate that air pollutants may act as adjuvants and increase the risk for sensitisation,[28 29] especially among children with an atopic propensity.[14] Paradoxically, recent studies demonstrate a low prevalence of allergies in Eastern Europe despite exposure to higher levels of air pollutants.[5–7] A low standard of living with domestic crowding and frequent viral respiratory infections during early infancy could possibly induce a T cell immune response expressing the TH_1 phenotype and protecting against atopic sensitisation. On the other hand, a high standard of living without crowding and less infections during the first months could exaggerate an immune response of the TH_2 type in children with an atopic propensity, making them more vulnerable to adjuvants, that is, pollutants.[30] This would also explain the high prevalence of atopic sensitisation in urban areas of Sweden.[8]

In conclusion, this study demonstrated domestic crowding as a highly significant negative risk factor for atopic sensitisation. Our findings are consistent with the hypothesis that frequent infections during infancy could protect against the development of allergy. A higher standard of living with less crowding may give rise to an increasing prevalence of atopic sensitisation also in Eastern Europe. Finally, health authorities need to pay attention to the problem of passive smoking in Poland and Estonia.

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