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Different sensitization profile for asthma, rhinitis, and eczema among 7–8-year-old children: Report from the Obstructive Lung Disease in Northern Sweden studies

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Sensitization to different airborne allergens in relation to asthma, rhinitis, and eczema has been studied. A cross-sectional study was performed among 7–8-year-old children living in northern Sweden. The ISAAC-questionnaire with additional questions were sent to the parents, and 3431 (97%) participated. Two-thirds of the children were invited to undergo a skin test with 10 common airborne allergens, and 2148 (88%) participated. The prevalence rates of all three diseases were significantly higher among the children who were sensitized to any of the tested allergens. Among asthmatics, 40% were sensitized to cat, 34% to dog, 28% to horse, 23% to birch and 16% to timothy. The corresponding figures for rhinitis were: cat 49%, dog 33%, horse 37%, birch 46%, timothy 32%; and for eczema: cat 29%, dog 21%, horse 15%, birch 20%, and timothy 11%. Only a few children were sensitized to mites or moulds. The main risk factors for all three diseases were type-1 allergy and a family history of the disease. Independently from other risk factors, sensitization to dog (OR 2.4) and horse (OR 2.2) were significant risk factors for asthma. Sensitization to birch (OR 6.0), horse (OR 4.1), and timothy (OR 2.8) were significant risk factors for rhinitis, while birch (OR 2.4), dog (OR 2.0) and cat (OR 1.6) were significant risk factors for eczema. Despite a large over-lapping of the diseases the pattern of sensitization was different for asthma, rhinitis and eczema. Sensitization to cat was most common among all children, but sensitization to dog and horse was associated with the highest risk for asthma, and sensitization to birch showed the highest risk for rhinitis and eczema. The different risk factor pattern for the often coexisting diseases; asthma, rhinitis, and eczema, may indicate differences in the etiology.

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Allergic diseases, such as asthma, rhinitis, and eczema, are common among children and young adults, and the occurrence of these diseases has increased in most parts of the world (1–3). Asthma (2, 4, 5), rhinitis (2, 4, 6, 7), and eczema (4, 8) are closely related to allergy, confirmed by increased levels of total IgE, specific IgE to common allergens, or a positive skin test. Further, the diseases are closely related to each other. Both rhinitis and eczema are known risk factors for asthma (9), and eczema is identified as a predictor of rhinitis (7).

A family history of asthma and allergic sensitization are the most important risk factors for asthma in children and young adults (2, 4, 9), as well as for rhinitis (6, 7). Among a number of potential risk factors, urban living (4, 10, 11) and having few number of siblings have been

identified as risk factors for allergic sensitization (12), asthma (13), and rhinitis (13). The indoor exposure to environmental tobacco smoke and dampness at home are associated with an increased risk for asthma among children (4).

The sensitization profile is different in different parts of the world. In many parts, sensitization to house dust mite is a major risk factor for asthma (5). However, asthma and rhinitis are common and have also increased in areas where dust mites do not exist or only exist to a limited degree (2, 4, 14). In Sweden, sensitization to pets, in particular cats, is most common, followed by sensitization to pollen (4, 10, 14). The relationship between allergen exposure, sensitization, asthma, and other allergic diseases is not fully understood. Recent studies have even suggested that high exposure from the cat at home may prevent sensitization and asthma (15–17).

Within the Obstructive Lung Disease in Northern Sweden studies (OLIN), a study of asthma, rhinitis, eczema, and allergy among school children is in progress. The study concluded that in this cold and dry area in the northernmost part of Sweden, the prevalence of asthma among 7–8-year-old children was 7–8%, and 21% were sensitized to at least one out of 10 tested allergens (4).

The aim of this study was to examine the sensitization profile among 7–8-year-old children with asthma, rhinitis and eczema, to illustrate the relationship between the diseases, and to examine allergic sensitization as determinant for the diseases, taking into account the influence of other possible risk factors. The large sample size also allows a comparison between the results of the skin tests and specific IgE.

Materials and methods

The present study is based on a cross-sectional questionnaire survey performed in 1996 in 7 and 8-year-old children in the northernmost province of Sweden, Norrbotten. The survey is described in detail (4, 15), and was a starting point for longitudinal studies. All 3525 children enrolled in class one and two in three municipalities, Kiruna, Luleå and Piteå were invited to participate. The study was approved by the Ethical Committee at the University of Umeå and the University Hospital of Northern Sweden in Umeå.

Questionnaire

An expanded ISAAC questionnaire (18) was used. Questions for screening of risk factors for asthma, rhinitis, and eczema were also included. The questionnaire was distributed by the schools to the childrens' parents, and answers were received for 3431 (97%) children. Asthma diagnosed by a physician was reported by 5.7%, while 12% reported wheezing during the last 12 months. Allergic rhinitis or hay fever diagnosed by a physician was reported by 6.5%, and physician-diagnosed eczema by 13.4% (4). The diagnosis of asthma has been validated (15).

Skin test

The children in Kiruna and Luleå were invited to receive a skin test, and 2149 (88%) were tested. The tests were performed on the volar aspects of one forearm, as single tests, with allergen in 50% glycerol and by using a lancet with a tip of 1 mm. The allergens used were birch, timothy, mugwort, dog, cat, horse, *Dermatophagoides farinae*, *D. pteronyssinus*, Cladosporium and Alternaria (Soluprick; ALK, Hørsholm, Denmark). The potency of the extracts was 10 HEP, except for the two moulds, which had a potency of 1 : 20 w/v. Histamine 10 mg/ml and glycerol were used as positive and negative controls, respectively. The tests were performed as recommended by the European Academy of Allergology and Clinical Immunology. A positive reaction was recorded if the diameter of the wheal was 3 mm or more. Twenty-one percent of the children had a positive test to at least one allergen (4).

Serum collection

As a part of a validation study of the questionnaire (15), serum was collected from stratified samples of the children. In total, 236 serum samples were collected from symptomatic and asymptomatic children, and of these 185 had been skin tested. Specific IgE antibodies to cat, dog, birch, alternaria, and *D. pteronyssinus* were measured by the Immuno CAP system (Pharmacia Upjohn, Uppsala, Sweden) at the University of Virginia, Charlottesville, USA.

Definitions

The definitions used in the analyses were based on an affirmative answer to the following questions:

- Physician-diagnosed asthma: 'Has the child been diagnosed by a physician as having asthma?
- Physician-diagnosed rhinitis: 'Has the child been diagnosed by a physician as having hayfever or allergic rhinitis/conjunctivitis?

- Physician-diagnosed eczema: 'Has the child been diagnosed by a physician as having eczema?
- Wheezing: 'Has your child had wheezing or whistling in the chest in the last 12 months?
- Symptoms of rhinitis: 'In the past 12 months, has your child had a problem with sneezing or runny or blocked nose when he/she did not have a cold or the flu?
- Symptoms of eczema: 'Has your child had itchy rash at any time in the last 12 months?
- Positive skin test: A mean diameter of at least 3 mm was considered positive.
- Positive serum IgE: Two cut off levels were used to define positive serum IgE, ≥0.35 IU/ml (CAP class 1+) and ≥0.7 IU/ml (CAP class 2+).
- Currently owned cat (dog): Cat (dog) in the home in 1996.
- Previously owned cat (dog): Cat (dog) in the home at any time before 1996.

Analyses

Risk ratio (RR) and 95% confidence intervals (CI) were calculated in uni- and bi-variate analysis between sensitization to different allergens and asthma, rhinitis, eczema, current wheeze, current symptoms of rhinitis, and current symptoms of eczema, respectively. Odds ratios (OR) for various independent variables were analyzed by multiple logistic regression analysis; confidence intervals of 95% were used. In addition to allergic sensitization; gender, family history of asthma or allergic disease, breast feeding ≤3 months, smoking habits of the mother, past or present dampness at home, birth order, urban living, and cat and dog ownership were used as independent variables. The effect of allergic sensitization was assessed step by step. In the first analysis the independent variable 'any positive skin test' was used. Secondly, the variable was divided into four variables: 'any animal', 'any pollen', 'any mite', and 'any mould'. Thirdly, the individual allergens of pollen and animals were included. The dependent variables were: physician-diagnosed asthma, physician-diagnosed rhinitis and physician-diagnosed eczema.

Results

Validation of the skin tests

The correlation between the results from the skin tests and the sera tests was high. The assays showed that all children with a positive skin test, with a wheal of at least 7.5 mm or more, had specific IgE of at least CAP class 2 +. A small proportion of the children with a negative skin test had measurable specific IgE. The results were similar if CAP class 1 + was used as a definition of positive serum IgE (Table 1).

Asthma, rhinitis, and eczema in relation to skin test results

The prevalence rates of asthma, rhinitis and eczema were generally higher among the children who had a positive skin test to each of the tested allergens. A positive skin test to any of the tested allergens showed the highest risk for physician-diagnosed rhinitis, RR 11.19 (7.94–15.76). The corresponding figure for physician-diagnosed asthma was 3.72 (2.71–5.11), and for eczema 2.34 (1.92–2.86). Of the single allergens, 'any

Table 1. Correlation between the results of the skin tests and serum IgE test by CAP class. Percentage and number of positive serum IgE by number of children with different size of the wheal of the skin prick test

		Size of the weal at the skin prick test			
Allergen	CAP class*	<3 mm	3 ≤ 5 mm	5 mm ≤ 7.5 mm	>7.5 mm
Cat	CAP class 1 +	3.9% (6/153)	70% (7/10)	67% (8/12)	100% (10/10)
	CAP class 2 +	2.6% (4/153)	70% (7/10)	67% (8/12)	100% (10/10)
Dog	CAP class 1 +	3.2% (5/158)	80% (12/15)	63% (5/8)	100% (10/10)
	CAP class 2 +	2.5% (4/158)	68% (10/15)	38% (3/8)	100% (4/4)
D. pteronyssinus	CAP class 1 +	2.2% (4/183)	100% (2/2)	– (0/0)	– (0/0)
	CAP class 2 +	1.1% (2/183)	100% (2/2)	– (0/0)	– (0/0)
Alternaria	CAP class 1 +	3.8% (7/183)	50% (1/2)	– (0/0)	– (0/0)
	CAP class 2 +	3.3% (6/183)	50% (1/2)	– (0/0)	– (0/0)
Birch	CAP class 1 +	3.6% (6/166)	100% (5/5)	100% (12/12)	100% (2/2)
	CAP class 2 +	2.4% (4/166)	100% (5/5)	100% (12/12)	100% (2/2)

*Positive serum IgE by CAP (Pharmacia), class 1 +, ≥ 0.35 I.U/ml; class 2 +, ≥ 0.7 I.U/ml. *D. pteronyssinus, Dermatophagoides pteronyssinus.*

Table 2. Prevalence (%) of positive skin test in the population, and prevalence (%) of physician-diagnosed asthma, physician-diagnosed rhinitis and physician-diagnosed eczema among the children with positive and negative skin test, respectively

	Physician-diagnosed asthma		Physician-diagnosed rhinitis		Physician-diagnosed eczema	
Allergen	%	RR (95% CI)	%	RR (95% CI)	%	RR (95% CI)
Cat (13.4%)						
Negative	4.6		4.4		12.6	
Positive	19.2	4.23 (3.08– 5.81)	27.0	6.17 (4.61–8.25)	32.6	2.59 (2.10–3.19)
Dog (8.7%)						
Negative	4.8		5.4		13.3	
Positive	25.1	5.26 (3. 82–7.25)	28.5	5.26 (3.90–7.09)	36.5	2.75 (2.20–3.44)
Horse (6.1%)						
Negative	5.1		4.9		13.7	
Positive	29.7	5.87 (4.23–8.16)	44.4	9.04 (6.85–11.92)	37.8	2.75 (2.14–3.53)
Birch (7.9%)						
Negative	5.5		4.4		13.3	
Positive	18.7	3.39 (2.35–4.89)	42.5	9.59 (7.30–12.61)	38.6	2.91 (2.30–3.64)
Timothy (6.7%)						
Negative	5.9		5.4		14.5	
Positive	15.9	2.72 (1.79–4.16)	36.0	6.72 (5.02–9.01)	25.4	1.75 (1.29–2.38)
Mugwort (0.9%)						
Negative	6.3		7.0		15.0	
Positive	21.1	3.37 (1.39–8.17)	30.0	4.27 (2.14–8.49)	25.0	1.66 (0.77–3.57)
'Any mite' (0.9%)						
Negative	6.3		6.8		14.9	
Positive	15.8	2.50 (0.87–7.16)	45.0	6.62 (3.97–11.03),	47.4	3.19 (1.96–5.17)
'Any mould' (1.4%)						
Negative	6.0		6.7		14.6	
Positive	39.3	6.55 (4.01–10.71)	46.4	6.96 (4.53–10.69)	48.3	3.30 (2.23–4.87)
'Any allergen' (20.6%)						
Negative	4.2		2.4		12.0	
Positive	15.7	3.72 (2.71–5.11)	27.3	11.19 (7.94–15.76)	28.1	2.34 (1.92–2.86)

RR, risk ratio.

mould' showed the highest risk for both 'physician-diagnosed asthma' and eczema, while sensitization to birch showed the highest risk for physician-diagnosed rhinitis (Table 2).

As expected, the patterns of risk ratios were similar but lower for current wheeze, current symptoms of rhinitis and eczema, as for a diagnosis of the diseases related to the symptoms due to a lower specificity. A positive skin test to any of the tested allergens was associated with an increased risk for symptoms of rhinitis, RR 3.44 (2.86–4.14), wheezing, 2.59 (2.08–3.21), and for symptoms of eczema 1.41 (1.24–1.62). Of the children with physician diagnosed rhinitis, 75% had a positive skin test, 86% reported nasal symptoms during the last 12 months, and 100% had experienced symptoms of rhinitis. Among children with physician-diagnosed eczema, 84% reported symptoms during the last 12 months, and 98% had experienced symptoms of eczema.

Of the tested allergens, a positive skin test to cat was the most common allergic sensitization among all children, as well as among the children with asthma, rhinitis and eczema. The children with rhinitis had the highest prevalence of positive skin test to any of the allergens (Fig. 1).

Of the children with both a positive skin test to any allergen and 'physician-diagnosed asthma', 91% had a positive skin test to 'any animal' (80% to cat, 66% to dog, and 55% to horse) and 58% to 'any pollen'. Of the children with both a positive skin test to any allergen and physician-diagnosed rhinitis, 80% had a positive skin test to 'any animal' and 81% to 'any pollen', while of the allergic children with eczema, 92% had a positive skin test to 'any animal', and 65% to 'any pollen'.

The overlapping between the three conditions were greatest among the allergic children. Of the children with a positive skin test to any of the tested allergens, 7.5% had both asthma and allergic rhinitis diagnosed by a physician, while 4.5% had all three diagnoses: asthma, rhinitis and eczema. Of all children, with or without a

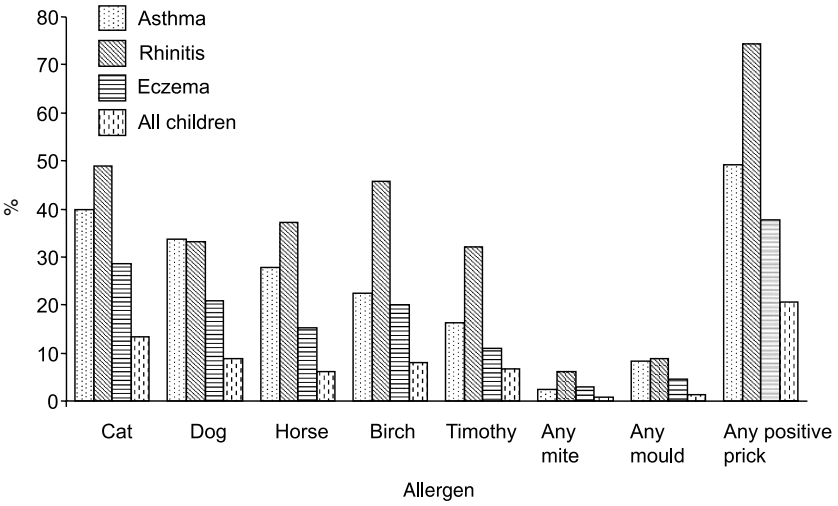


Fig. 1. Prevalence (%) of positive skin test to different allergens among children with physician-diagnosed asthma, rhinitis, ezcema, and among all children, respectively.

positive skin test, 1.1% had all three diagnoses (Fig. 2). The overlapping was similar if symptoms of the diseases were used instead of a diagnoses from a physician, while the prevalence of wheeze, symptoms of rhinitis, and symptoms of eczema were around twice as high: wheeze 11.7%, symptoms of rhinitis 14.0%, and symptoms of eczema 27.2%.

Multivariate relationships

A positive skin test against at least one allergen (any positive skin test) was the strongest risk factor for the three diseases independently from other risk factors used in the analyses: family history, gender, breast feeding ≤3 months, smoking habits of the mother, dampness at home, birth order, and urban living. The risk was highest for rhinitis, OR 13.86 (9.18–20.93), with a corresponding risk for asthma of 3.88 (2.61–5.76), and for eczema of 2.77 (2.10–3.66).

In the next step, the same independent variables were used, but the variable 'any positive skin test' was divided into four groups: 'any animal', 'any pollen', 'any mite' and 'any mould'. 'Any animal' was a significant risk factor for asthma, OR 3.52 (2.11–5.86). Significant risk factors for rhinitis were: 'any pollen', OR 7.38 (4.50–12.11); and 'any animal', OR 3.23 (1.97–5.32), while significant risk factor for eczema was 'any animal', OR 2.75 (1.92–3.94) (Table 3).

In the following analyses, the individual allergens; cat, dog, horse, birch, and timothy were included instead of 'any animal' and 'any pollen'. Significant risk factors for asthma were positive skin test to dog, OR 2.37 (1.17–4.80), and horse, OR 2.17 (1.03–4.57). Significant risk factors for rhinitis were a positive skin test to birch OR 6.00 (3.59–10.06), horse, OR 4.07 (2.40–9.20), and timothy, OR 2.78 (1.58–4.89), and significant risk factors for eczema were a positive test skin to birch, OR 2.38 (1.52–3.73), dog, OR 1.96 (0.17–3.29), and cat, OR 1.57 (1.02–2.41) (Table 4).

When the analyses were performed in the same way as above, but included only one animal allergen in each analysis (instead of all three), the ORs increased, and a positive skin test to any of the animals tested appeared as significant risk factors for asthma. The odds ratio was highest for horse, OR 4.77 (2.55–8.92), while the odds ratio for dog was 4.50 (2.60–7.63), and for cat 3.07 (1.87–5.06).

Other significant risk factors for asthma were family history of asthma, OR 3.31 (2.21–4.95), dampness at home, OR 1.88 (1.23–2.89), a smoking mother, OR 1.54 (1.01–2.35), and male sex, OR 1.48 (1.00–2.22), while breast feeding less than 3 months was a strong trend, OR 1.56 (0.96–2.43). A significant risk factor for rhinitis was a family history of rhinitis, OR 1.64 (1.07–2.51), and significant risk factors for eczema were family history of eczema, OR 2.00 (1.53–2.62), and dampness at home, OR 1.49 (1.11–2.01) (Table 3). The risk of these independent variables used in the models remained stable on the same level when including the different combinations of the individual allergens in the analyses.

Effect of cat and dog ownership

The effects of cat and dog ownership were examined by using multiple regression analysis (Table 5). Current cat ownership significantly decreased the risk for physician diagnosed asthma, OR 0.34 (0.12–0.95). A similar trend was found for current dog ownership, however it was less strong. In addition, current dog ownership

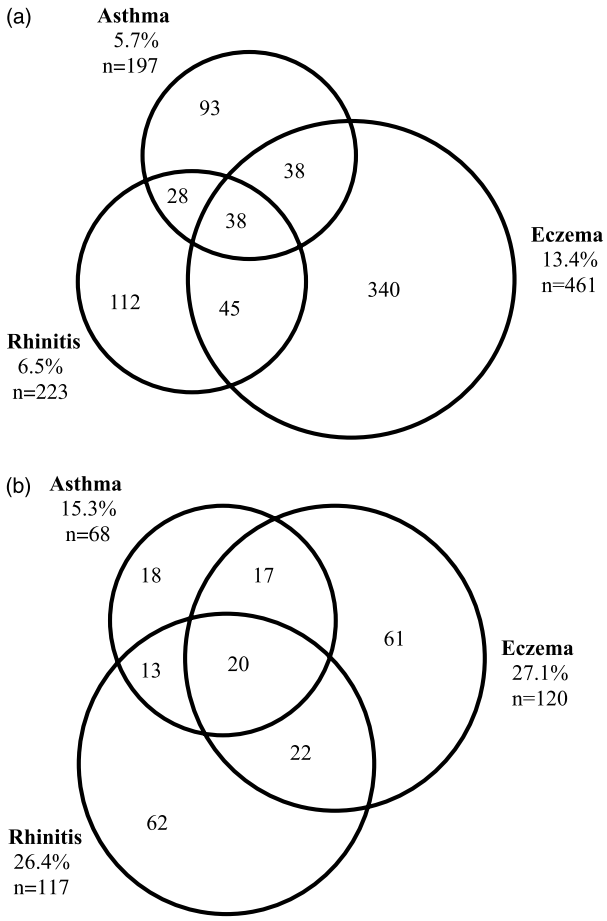


Fig. 2. (a) Prevalence (%), and number of children with physician-diagnosed asthma, eczema, and rhinitis in the population (N = 3431). The circles in this figure are drawn to scale relative to each other, but overlapping areas are estimated based on the following prevalences: 1.9% asthma and rhinitis, 2.2% asthma and eczema, 2.4% rhinitis and eczema, and 1.1% asthma, rhinitis and eczema. (b) Prevalence (%), and number of children with physician-diagnosed asthma, eczema, and rhinitis among the atopic children, defined as a positive skin test (≥3 mm) to at least one allergen (n = 443). The circles in this figure are drawn to scale relative to each other, but the overlapping areas are estimated based on the following prevalences: 7.4% asthma and rhinitis, 8.3% asthma and eczema, 9.4% rhinitis and eczema, and 4.5% asthma, rhinitis and eczema.

was significantly associated with a decreased risk of physician-diagnosed eczema, OR 0.58 (0.38–0.87). Further, current cat significantly decreased the risk of having a positive skin test, OR 0.45 (0.28–0.72), while the corresponding OR for dog was 0.56 (0.40–0.82). Having previously owned a cat or dog did not affect the risk of positive skin test, asthma, rhinitis, or eczema.

Discussion

The study confirmed a strong correlation between type-1 allergy and asthma, rhinitis and eczema, respectively. Further, a large overlapping of these conditions was confirmed. Several studies have indicated eczema to be a predictor for asthma (9) and rhinitis (7, 9), and rhinitis as a predictor for asthma (9). Despite the strong connection, the diseases showed large differences of their risk factor patterns at age 7–8 years.

Before correcting for influences of other factors, including other allergens, all individual allergens were significantly associated with rhinitis. Further, all allergens, except mite, were significantly associated with asthma, and all, except mugwort, were significantly associated with eczema.

Increased exposure to mites has been discussed as a cause of the increasing prevalence of asthma and allergic diseases world-wide (5, 19). In addition, in the southern and the middle parts of Sweden, mites have been identified as common in homes (20). In our cold and dry study area less than 1% of the children had a positive skin test to mites. Despite lack of mites, the prevalence of both asthma and rhinitis has increased (2, 3).

For all three diseases, allergic sensitization was the strongest risk factor for each disease followed by a family history of the disease. These two risk factors were related to each disease independently of each other according to multivariate analyses. Allergic sensitization showed the strongest relation to rhinitis, OR 13.86. The effect of having a family history of the disease was most pronounced for asthma. Asthma and eczema were significantly related to environmental factors, such as dampness at home and environmental tobacco smoke. Neither urban living nor birth order had a significant influence on the studied diseases. Other studies have found a higher prevalence of rhinitis in rural areas (12, 21) and in more polluted areas (21, 22). Being the first born has been associated with an increased risk for allergic diseases, mainly allergic sensitization and rhinitis (12, 13).

After the division of allergic sensitization into four groups – allergy against at least one animal, one pollen, one mite, and at least one of the two moulds – and still including correction for other factors – environmental and demographic – asthma was significantly associated only with sensitization to 'any animal'. Rhinitis and eczema were significantly associated to both 'any animal' and 'any pollen'.

Asthma is generally mainly correlated to indoor allergens (5). However, an Australian study concluded a higher prevalence of asthma to be among children living inland. These children had predominantly allergy to grass compared to children living at the coast, who predominantly

Table 3. Risk factors for physician-diagnosed asthma, physician-diagnosed rhinitis, and physician-diagnosed eczema by multiple logistic regression analysis

	Dependent variables		
Independent variables	Physician-diagnosed asthma OR (95% CI)	Physician-diagnosed. rhinitis OR (95% CI)	Physician-diagnosed eczema OR (95% CI)
Gender: boy	1.48 (1.00–2,22)	1.47 (0.97–2.24)	0.98 (0.76–1.28)
Family history of condition	3.31 (2.21–4.95)	1.64 (1.07–2.51)	2.00 (1.53–2.62)
Dampness at home	1.88 (1.23–2.89)	1.37 (0.85–2.20)	1.49 (1.11–2.01)
Mother smoker	1.54 (1.10–2.35)	0.89 (0.55–1.42)	0.96 (0.72–1.29)
Breast feeding < 3 months	1.56 (0.96–2.43)	0.86 (0.50–1.47)	0.96 (0.69–1.33)
Urban living	0.99 (0.52–1.88)	1.13 (0.57–1.31)	0.99 (0.66–1.48)
Birth order:			
number 2	0.89 (0.55–1.45)	0.80 (0.49–1.29)	1.04 (0.77–1.41)
number 3 or more	1.22 (0.75–1.99)	0.76 (0.45–1.31)	0.95 (0.68–1.33)
Positive skin prick test to:			
'any animal'	3.52 (2.11–5.86)	3.23 (1.97–5.32)	2.75 (1.92–3.94)
'any pollen'	1.40 (0.79–2.48)	7.37 (4.50–12.11)	1.39 (0.93–2.09)
'any mites'	0.58 (0.10–3.48)	1.14 (0.33–3.92)	2.19 (0.69–6.94)
'any mould'	2.25 (0.78–7.05)	2.00 (0.74–5.39)	1.53 (0.59–3.97)

OR, risks in odds ratios; 95% CI, 95% confidence intervals.

Table 4. Different allergens as risk factors for asthma, rhinitis, and, eczema calculated by multiple logistic regression analysis

	Dependent variables		
Independent variables	Physician-diagnosed asthma OR (95% CI)	Physician-diagnosed rhinitis OR (95% CI)	Physician-diagnosed eczema OR (95% CI)
Positive skin prick test to:			
cat	1.65 (0.88–3.07)	1.42 (0.79–2.54)	1.57 (1.02–2.41)
dog	2.37 (1.17–4.80)	0.91 (0.46–1.80)	1.96 (1.17–3.29)
horse	2.17 (1.03–4.57)	4.07 (2.40–9.20)	1.40 (0.77–2.49)
birch	1.31 (0.71–2.30)	6.00 (3.59–10.06)	2.38 (1.52–3.73)
timothy	1.30 (0.68–2.51)	2.78 (1.58–4.89)	0.76 (0.45–1.28)

OR, risks in odds ratios; 95% CI, 95% confidence intervals.
Other independent variables used in the model were: sex, family history of asthma, rhinitis, and eczema, respectively, dampness at home, a smoking mother, breast feeding <3 months, urban living, and birth order.

Table 5. Risk factors (adjusted odds ratios, OR, with 95% confidence intervals) calculated by multiple logistic regression analysis for physician-diagnosed asthma, physician-diagnosed rhinitis, and physician-diagnosed eczema, respectively

	Dependent variable		
Independent variables	Physician-diagnosed asthma* OR (95% CI)	Physician-diagnosed rhinitis† OR (95% CI)	Physician-diagnosed eczema‡ OR (95% CI)
Never owned cat	1	1	1
Previously owned cat	0.86 (0.49–1.50)	1.08 (0.63–1.87)	0.91 (0.63–1.33)
Currently owned cat	0.34 (0.12–0.95)	0.53 (0.20–1.37)	0.73 (0.46–1.18)
Never owned dog	1	1	1
Previously owned dog	1.19 (0.73–1.94)	0.78 (0.45–1.34)	0.80 (0.56–1.15)
Currently owned dog	0.60 (0.32–1.15)	0.55 (0.28–1.09)	0.58 (0.38–0.87)

*Adjusted for a positive skin test, family history of asthma, sex, dampness at home, breast feeding <3 months, smoking mother, urban living, birth order.
†Adjusted for a positive skin test, family history of rhinitis, sex, dampness at home, breast feeding <3 months, smoking mother, urban living, birth order.
‡Adjusted for a positive skin test, family history of eczema, sex, dampness at home, breast feeding <3 months, smoking mother, urban living, birth order.

had allergy to dust mites (23). Pollen allergy was significantly associated to asthma in a German study (24), while alternaria was the major allergen related to asthma in Tucson (25). In our study, sensitization to pollen was not a significant risk factor for asthma, a result in accordance

with others (26). Our data support the suggestion that various allergens have different effects on the development of different allergic conditions.

The pattern of sensitization reflects the exposure in the population. Having pets at home is common, and has been for a long time in this area. In addition, moderate levels of allergen from cat and dog were found in schools (14). It is not likely that the levels of indoor allergens have increased, explaining the reported increasing prevalence of allergic disease in this area (3). In a study from the UK asthma was only significantly related to mite allergy, rhinitis to grass pollen, and eczema both to mites, grass pollen and cat (27).

Studies from Scandinavia have shown sensitization to cat to be the most important risk factor for asthma (10). Regarding this question, there are two different findings. First, sensitization to cat was most common among the children, including the children with asthma. However, this does not mean that sensitization to cat was the highest risk factor for asthma, as a large number of children were sensitized against cat but had no symptoms. Only sensitization to dog and horse were significant risk factors for asthma. A similar result was found in a recent study of rhinitis, in which sensitization to dog was significantly associated with an increased risk for development of rhinitis, while sensitization to cat was not (7). Even if sensitization to cat was not the highest risk factor for asthma, allergy to cat is central. Of the asthmatic children with allergic asthma, 80% were sensitized to cat, while 66% were sensitized to dog, and 55% to horse. The longitudinal study in progress will point out the pattern of sensitization associated with the highest risk for incident cases of asthma, rhinitis and eczema.

Also in this study, keeping cats at home was not found to be a risk factor either for asthma or for allergic sensitization, but the inverse was true. Keeping dogs resulted in a similar negative association, however, less pronounced. The extended multivariate model confirms previously shown data (15), and the results conform to findings from other recently published studies (15–17) but are in conflict with others (28). The diverging results may at least in part be explained by differences in the selection of samples. Further, selection bias may occur. The mechanisms of this 'protecting effect' are under discussion (16, 29) and no general agreement exists.

The results from our study showed the importance of the methods when assessing the influence of sensitization to different allergens. The levels of the odds ratios are highly dependent of which allergens have been included in the model. The odds ratios will increase with decreasing number of allergens included in the analyses, presumed that the allergens excluded from the model covariate with those in the model, and further, are of importance for the disease under study. In another study the risk for asthma in relation to sensitization to house dust mite increased from OR 4.8 to OR 6.6 when fewer allergen variables were included in the model (30). Further, the risk ratios increase with increasing specificity of the dependent variable, i.e. wheeze vs. 'physician-diagnosed asthma'.

When performing risk factor analyses, it is of great importance that the variable expressing the studied condition has a high specificity. Regarding the asthma variable 'physician-diagnosed asthma', the specificity was high (15). In another study of adults, the agreement between self-reported rhinitis and the clinical picture of rhinitis collected by interview was high (6). In that study the level of positive skin test was similar to our 75%. The condition of eczema may be connected with some uncertainty when collecting data by questionnaire. Of the children, 35% reported having experienced eczema, 20% were using medicines to treat eczema, and 13% reported a diagnosis of eczema by a physician (4). The high participation rate at the questionnaire survey and the skin testing, and the high correlation between the skin test results and the results of specific IgE from sera, support the validity of the results.

Conclusion

In this population-based study of 7–8-year-old children, we found different patterns of sensitization for asthma, rhinitis and eczema despite a large over-lapping of the diseases. Allergy was the greatest risk factor for each disease. Sensitization to cat was most common among all children, as well as among the children with asthma, rhinitis and eczema, respectively. However, sensitization against horse and dog yielded the highest risks for asthma, while sensitization to birch was the highest risk factor for both rhinitis and eczema. The results indicate differences in the etiology of the often coexisting diseases asthma, rhinitis, and eczema.

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