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Different pattern of risk factors for atopic and nonatopic asthma among children – report from the Obstructive Lung Disease in Northern Sweden Study

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Key words: asthma; children; epidemiology; risk factors; type-1 allergy.

Background: A cross-sectional study was performed among 7–8-year-old schoolchildren during the winter of 1996 in three municipalities in the most northern province of Sweden, Norrbotten. The study was the starting point of a longitudinal study of asthma, rhinitis, eczema, and type-1 allergy, and provided data on prevalence and risk factors for these conditions. The aim of the present study was to validate the classification of asthma based on a parental questionnaire, and to examine risk factors for atopic and nonatopic asthma.

Methods: The ISAAC questionnaire with additional questions was distributed by the schools to the parents. The response rate was 97%, and 3431 completed questionnaires were returned. The children in Kiruna and Luleå were also invited to be skin tested, and 2149 (88%) were tested with 10 common airborne allergens. A structured interview was administered by pediatricians in stratified samples of the children to test the validity of the diagnosis of asthma based on the questionnaire.

Results: After the validation study, the prevalence of "ever asthma" was estimated to be 8.0%. The specificity of the question, "Has your child been diagnosed as having asthma by a physician?", was high, >99%, while the sensitivity was around 70%. The strongest risk factor for "ever asthma" was a positive skin test (OR 3.9). Risk factors for asthma in the asthmatics who were not sensitized were family history of asthma, OR 3.6; breast-feeding less than 3 months, OR 1.8; past or present dampness at home, OR 1.8; smoking mother, OR 1.7; and male sex, OR 1.6. Among the sensitized asthmatics, only a family history of asthma was a significant risk factor (OR 3.0), while breast-feeding less than 3 months was not associated with an increased risk (OR 1.0). A synergistic effect between genetic and environmental factors was found especially in the nonatopic

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asthmatics; the children with a family history of asthma who had a smoking mother and past or present dampness at home had an OR for “ever asthma” of 13.

Conclusions: Different risk-factor patterns were found for asthma and type-1 allergy. In addition, the risk factors for atopic or allergic asthma diverged from those for nonatopic asthma.

In many countries, asthma and allergic diseases now comprise the largest group of diseases among children, teenagers, and young adults. An increasing prevalence of asthma and allergic diseases has been shown all over the world (1–3), but understanding of the cause of the increase is still limited. The high prevalence rates of asthma today are probably due partly to an increased diagnostic intensity and altered criteria for the disease. Postal questionnaires are commonly used in studies of asthma prevalence and in risk-factor analyses. For comparison with other studies, it is an advantage to use similar questionnaires (4); however, it is necessary to validate the questions used.

It is well known that a family history of asthma is a risk factor for the disease. This has been shown in cross-sectional studies in both adults (3) and children (5, 6), as well as in prospective longitudinal studies (3, 7). Family history is also a major risk factor for type-1 allergy (6, 8–10). The other major risk factor for asthma is allergic sensitization (11, 12). The relevant allergens vary, but they are predominantly indoor allergens (6, 12–16). In addition to genetic factors, studies have suggested that the environment (17–19) and lifestyle in industrialized countries (8, 20) are associated with an increased risk of asthma and allergic sensitization.

In northern Sweden, a longitudinal intervention study of allergic diseases in schoolchildren started in 1996. The design of this study makes it possible to measure the prevalence and the incidence of asthma as well as to identify risk factors for the condition (6). The aim of the present study was to examine risk factors for sensitized and nonsensitized asthma, and to validate the asthma classification derived from parental responses to a questionnaire.

Material and methods

As the first step in a longitudinal study of asthma, rhinitis, eczema, and type-1 allergy among 7–8-year-old schoolchildren, a cross-sectional study was performed during the

winter of 1996 in northern Sweden (6). All 3525 children enrolled in classes 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 and the University Hospital of Northern Sweden in Umeå.

Questionnaire

The ISAAC questionnaire (4), with additional questions (6) about symptoms, diagnosis of asthma, rhinitis, and eczema, use of medicines, family history of the diseases under study, past and present living conditions, indoor and outdoor environmental factors, smoking habits of the parents, and whether pets were kept at home, was distributed by the schools to the parents of the children. Completed answers were received from 3431 (97%) children. Asthma diagnosed by a physician, “physician-diagnosed asthma”, was reported by 5.7% of respondents, 7.1% had used asthma medicines during the last 12 months, and 12% reported wheezing during the last year (6).

Skin test

The 2454 children in Kiruna and Luleå were invited to be skin tested, and 2149 (88%) participated. The skin tests were carried out at the schools by two trained nurses. The tests were performed according to the standards developed by the European Academy of Allergology and Clinical Immunology (EAACI) (21); however, single tests on one arm were used. The allergen extracts used were Soluprick from ALK, Denmark, and included a Swedish standard panel: birch, timothy, mugwort, dog, cat, horse, two mites (*Dermatophagoides farinae* and *D. pteronyssinus*), and two molds (*Cladosporium* and *Alternaria*). Histamine 10 mg/ml and glycerol were used as positive and negative controls, respectively, and the potency of the extracts was 10 HEP, except for the two molds, which had a potency of 1:20 w/v. A positive reaction was recorded if the mean diameter of the wheal was ≥ 3 mm. The results showed that 21% had a positive test to at least one allergen. Of the children with physician-diagnosed asthma reported in the questionnaire, 49% had at least one positive skin test (6).

Validation study – “ever asthma”

The validation study took place during the winter of 1997. According to the answers from the questionnaire study, five stratified samples of symptomatic children were

invited to the validation study (Table 1). The five strata included 215 children, 117 (54%) boys and 98 (46%) girls, as follows:

- 1) *Physician-diagnosed asthma*: one-third of the 197 children who had been diagnosed as having asthma by a physician
- 2) *Users of asthma medicines*: all children who had used asthma medicines during the last 12 months, without having physician-diagnosed asthma
- 3) *Severe symptoms*: all children who during the last 12 months reported sleep disturbances one or more nights per week due to wheezing, or reported that wheezing had been severe enough to limit speech to only one or two words at a time between breaths, and who were not included in the samples above
- 4) *Wheeze >4 times*: all children who during the last 12 months reported wheeze at least four times, and who were not included in the samples above
- 5) *Wheezing apart from colds*: all children who during the last 12 months reported wheezing apart from colds, and who were not included in the samples above.

In addition, we invited a sixth control group comprising a random sample of 104 children without symptoms associated with asthma who also did not report either rhinitis or eczema.

The participation rate among the symptomatic groups was 88% in boys and 92% in girls; overall, 194 children participated. The participation rate within the different

samples was in the range 80–94%. Of the nonsymptomatic children, 64 (62%) participated.

The study consisted of a structured interview of the child and the parents, usually the mother, including questions about symptoms, year of onset, use of health care, and past and current medication. The interviews were administered by five pediatricians at the pediatric clinics in Kiruna, Luleå, and Piteå, respectively. The pediatricians did not know to which group each child had been assigned.

Diagnostic criteria

For the diagnosis of asthma in the validation study, the following criteria were used: wheezing *or* attacks of shortness of breath in combination with provoking factors such as allergens, irritants, cold air, physical exertion, or food; *or* wheezing *and* attacks of shortness of breath during colds, *and* at least two such periods over 12 months. Also classified as asthmatic were children not fulfilling either of these two criteria but who had asthma previously diagnosed by a physician, *and* used asthma medicines, *and* had a previous history of asthma.

In addition to these diagnostic criteria for asthma, the pediatricians made their own “overall assessment” based on their clinical examinations.

Definitions

If these criteria were present during the last 12 months, asthma was classified as “current”, and if asthma had been present previously, it was classified as “ex-asthma”. “Ever

Table 1. Results of validation study for five groups of symptomatic children identified from questionnaires

				Classification			
Sample	Invited <i>n</i>	Participated <i>n</i> (%)	Diagnostic instrument	Current asthma <i>n</i> (%)	Ex-asthma <i>n</i> (%)	Other diagnoses <i>n</i> (%)	Nonspecific respiratory symptoms <i>n</i> (%)
Physician-diagnosed asthma	65	60 (92)	Criteria	51 (85)	8 (13)	1 (2)	–
			Assessment	49 (82)	8 (13)	2 (3)	1 (2)
Medicine users	69	65 (94)	Criteria	38 (58)	9 (14)	11 (17)	7 (11)
			Assessment	32 (49)	10 (15)	12 (19)	11 (17)
Severe symptoms	22	19 (86)	Criteria	7 (37)	–	9 (47)	3 (16)
			Assessment	4 (21)	–	11 (58)	4 (21)
Wheeze > 4 times	15	12 (80)	Criteria	5 (42)	1 (8)	5 (42)	1 (8)
			Assessment	5 (42)	1 (8)	5 (42)	1 (8)
Wheezing apart from colds	44	38 (86)	Criteria	14 (37)	–	11 (29)	13 (34)
			Assessment	8 (21)	2 (5)	11 (29)	17 (45)
Children were classified according to defined asthma criteria (Criteria) or by pediatricians' overall assessment (Assessment). Samples are described in Material and methods.							

asthma" was defined as current asthma or ex-asthma. "Atopy" was defined as at least one positive skin test. The subjects with "ever asthma" and at least one positive skin test were classified as having atopic asthma, and those with "ever asthma" who did not have any positive skin test were classified as having nonatopic asthma.

Analyses

Statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS) at the National Institute for Working Life in Umeå (Sweden). When examining prevalence rates in relation to different determinants of asthma by bivariate models, Student's *t*-test, the chi-square test, and one-way analysis of variance (ANOVA) were used. Multiple regression analysis was performed when assessing the simultaneous influence of possible determinants of positive skin test, "ever asthma", atopic asthma, and nonatopic asthma, respectively. In calculating risks of "ever asthma", the whole study sample from Kiruna, Luleå, and Piteå was used in the analyses. In calculating risks of atopic and nonatopic asthma, the skin-

tested children from Kiruna and Luleå were included. The independent variables included family history of asthma, family history of allergic disease, sex, smoking mother, dampness at home, breast-feeding, and area of domicile (urban or rural, and which of the three municipalities).

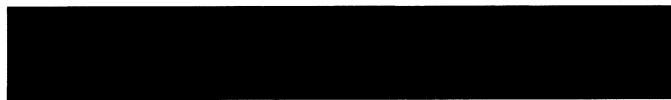
Results

The validation study

Among the children who had reported physician-diagnosed asthma, only one was classified as not having or not having had asthma. The diagnosis of this child was cystic fibrosis. Of the children who had used asthma medicines but who did not report that they had been diagnosed as having asthma, 72% were classified as "ever asthma" (Table 1). The most common diagnoses among the children who had used asthma medicines, but who were not classified as having asthma at the validation study, were pseudocroup and bronchitis. None of the children classified as asymptomatic

QUESTIONNAIRE STUDY

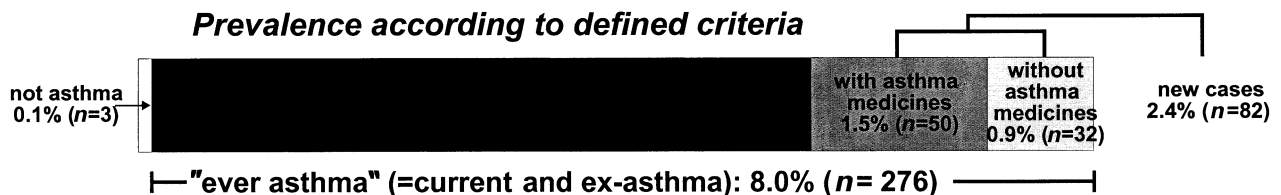
Prevalence



Physician-diagnosed asthma: 5.7% (*n* = 197)

VALIDATION STUDY

Prevalence according to defined criteria



Prevalence according to the pediatricians' "overall assessment"

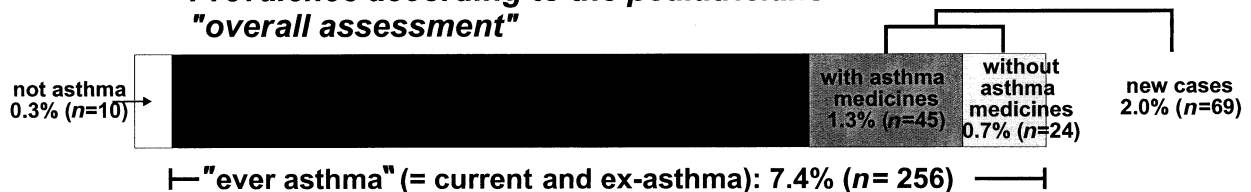


Figure 1. Prevalence of physician-diagnosed asthma according to postal questionnaire, and estimated prevalence of "ever asthma" according to validation study.

Table 2. Prevalence (%) of some potential risk factors by area and among children with (yes) and without (no) "ever asthma". Prevalence (%) of "ever asthma" among children who were exposed or not exposed to each potential risk factor

Risk factor	Prevalence of each risk factor				"Ever asthma"		Prevalence of "ever asthma"	
	Kiruna	Luleå	Piteå	All			Exposed	Unexposed
					Yes	No		
Family history of asthma	26.7	23.3	23.9	24.3	51.1***	22.0	17.0***	5.2
Family history of allergic disease	73.4	68.1	67.0	69.0	84.8***	67.6	9.9***	4.0
Mother smoker	36.1	29.0	32.6	31.5	38.6*	30.6	9.8*	7.1
Father smoker	22.7	21.8	23.4	22.4	22.3 NS	22.2	7.7 NS	7.8
Animals at home	73.2	68.2	76.4	71.6	63.5**	72.4	7.1**	10.3
Dampness at home	22.1	19.3	11.4	17.5	27.4***	16.7	12.4***	6.7
Breast-feeding <3 months	25.5	21.1	33.8	25.7	36.0***	24.8	11.2***	6.9
Positive skin test	20.9	20.5	–	20.6	46.6***	18.1	20.3***	6.1
Urban living	80.4	90.2	77.2	84.5	86.2 NS	84.4	8.0 NS	7.0
Living in apartment	28.2	26.9	9.1	21.9	27.1*	21.4	9.8*	7.3

***P value between groups is <0.001.
 **P value between groups is <0.01.
 *P value between groups is <0.05.
 NS: not significant.

on the basis of the questionnaire were judged to have asthma at the validation study.

After correction for the results from the validation study, the prevalence of "ever asthma" became 7.4% with the pediatricians' overall assessment, and 8.0% with the defined criteria as the validation instrument (Fig. 1). The specificity and the positive predictive value of the question, "Has your child been diagnosed as having asthma by a physician?", were somewhat greater with the asthma criteria as the validation instrument than with the pediatricians' "overall assessment"; 99.9% (specificity) and 98.5% (positive predicted value) vs 99.7% and 94.9%. In contrast, the sensitivity was somewhat lower, 70.3% vs 73.0%, with the asthma criteria.

Prevalence of potential risk factors

The pattern of some potential risk factors is given in Table 2. No big differences in the pattern were seen among the three areas except for housing; in Piteå, only 9% were living in an apartment, compared with 28% and 27% in Kiruna and Luleå, respectively. A history of asthma in the family was reported by 24%, and 69% reported a family history of allergic disease (asthma, rhinitis, or eczema). Smoking mothers were more prevalent than smoking fathers; 32% and 22%, respectively. A majority of the children, 72%, had or had had cat, dog, or other pets at home. Of the children, 26% had been breast-fed for less than 3

months. Past or present dampness at home was reported by 18%.

Prevalence rates of asthma in relation to various risk factors for asthma

The prevalence of "ever asthma" was strongly influenced by many of the risk factors. The prevalence of asthma was higher among the children exposed than in children not exposed to the studied determinants, except for having a smoking father and keeping animals at home. The prevalence of asthma was similar in children whose father smoked or did not, and the prevalence of asthma was lower among children who had or had had animals at home (Table 2). Furthermore, the prevalence of positive skin tests to cat or dog was higher in children who never had a cat or dog at home (16.4% and 9.6%, respectively) than in children who had or previously had a cat or dog at home (8.6% and 7.0%, respectively).

In children with the three risk factors family history of asthma, smoking mother, and past or present dampness at home, the prevalence of "ever asthma" was 22% (in Kiruna, 38%). If none of these three risk factors were present, the prevalence was 4% (in Kiruna, 2%). When both a smoking mother and past or present dampness at home were present, but not a family history of asthma, the prevalence was 10%. If the children had a family history of asthma, but not a

Table 3. Risk factors for atopic asthma, nonatopic asthma, and “ever asthma” by multiple regression analysis. Risks in odds ratios (OR)

Independent variables		Dependent variables		
Variables	Categories	Atopic asthma OR (95% CI)	Nonatopic asthma OR (95% CI)	“Ever asthma” OR (95% CI)
Sex	Girl	1	1	1
	Boy	1.26 (0.78–2.06)	1.62 (1.03–2.54)	1.51 (1.13–2.00)
Family history of asthma	No	1	1	1
	Yes	2.95 (1.81–4.81)	3.63 (2.33–5.66)	3.37 (2.54–4.46)
Dampness at home	No	1	1	1
	Yes	1.40 (0.81–2.42)	1.78 (1.10–2.89)	1.54 (1.10–2.14)
Mother smoker	No	1	1	1
	Yes	1.17 (0.68–2.01)	1.67 (1.04–2.68)	1.29 (0.95–1.74)
Pets at home	No	1	1	1
	Yes	0.60 (0.36–0.98)	0.75 (0.47–1.21)	0.68 (0.51–0.92)
Breast-feeding	>3 months	1	1	1
	<3 months	1.00 (0.55–1.82)	1.80 (1.11–2.92)	1.73 (1.28–2.35)
Area of domicile	Piteå*	–	–	1
	Luleå	1	1	1.09 (0.78–1.54)
	Kiruna	1.03 (0.60–1.76)	0.95 (0.59–1.54)	1.11 (0.74–1.67)

*Children in Piteå were not skin-tested.

smoking mother or past or present dampness at home, the prevalence of “ever asthma” was 13%.

Multivariate relationships

With multiple regression analysis, only a family history of allergic disease (OR 1.7) and urban living (OR 1.7) were significant risk factors for atopy. Mother’s smoking, dampness at home, length of breast-feeding, past or present pets at home, number of older siblings, sex, and geographic area did not significantly influence atopy.

Significant risk factors for “ever asthma” (Table 3) were family history of asthma (OR 3.4), breast-feeding less than months (OR 1.7), dampness at home (OR 1.5), and male sex (OR 1.5). Maternal smoking showed a strong trend (OR 1.3), and when breast-feeding less than 3 months was excluded from the model, this was a significant risk factor. When atopy was included in the model, the risk-factor pattern remained constant, but the variable atopy showed the highest risk (OR 3.9).

In children with a family history of asthma whose mother smoked, and who had been breast-fed less than 3 months, the risk (OR) for asthma was seven times greater than in children without these three risk factors (Table 4).

Risk-factor pattern for atopic and nonatopic asthma

When the asthmatics were separated into atopic and nonatopic asthma, the risks were generally higher in the nonatopic group (Table 3). Only a family history of asthma (OR 3.0) remained as a significant risk factor for atopic asthma, while past or present keeping cat or dog at home was associated with a significantly decreased risk. For nonatopic asthma, family history of asthma (OR 3.6), breast-feeding less than 3 months (OR 1.8), dampness at home (OR 1.8), mother’s smoking (OR 1.7), and male sex (OR 1.6) were each significant risk factors.

The combined risks were considerably higher for non-atopic asthma. The OR for nonatopic asthma was 13 among children with the three risk factors family history of asthma, smoking mother, and past or present dampness at home, while the corresponding figure for the atopic asthmatics was 4 (Fig. 2). When breast-feeding less than 3 months was used in the same logistic model instead of dampness at home, a similar risk factor pattern was seen (Table 4).

Moreover, the combination of risks for “ever asthma” of breast-feeding more or less than 3 months and the smoking habits of the mother (smokers vs nonsmokers) calculated by multiple logistic regression analysis showed that breast-feeding less than 3 months was a greater risk factor than mothers smoking; OR 2.1 vs 1.5. When the asthmatics were

Table 4. Risks of asthma in relation to family history of asthma (FH), breast-feeding (BF) more or less than 3 months, and maternal smoking (smoke)

Independent variables			Dependent variables		
Family history	Breast-feeding	Maternal smoking	Atopic asthma OR (95% CI)	Nonatopic asthma OR (95% CI)	"Ever asthma" OR (95% CI)
FH–	BF >3	smoke–	1	1	1
FH–	BF >3	smoke+	1.29 (0.59–2.86)	1.73 (0.83–3.58)	1.47 (0.91–2.37)
FH–	BF <3	smoke–	1.60 (0.64–4.02)	1.69 (0.67–4.27)	1.95 (1.18–3.24)
FH–	BF <3	smoke+	1.17 (0.39–3.46)	2.04 (0.85–4.95)	2.07 (1.22–3.51)
FH+	BF >3	smoke–	2.98 (1.59–5.59)	2.98 (1.57–5.67)	3.29 (2.22–4.89)
FH+	BF >3	smoke+	4.56 (2.07–10.04)	4.63 (2.09–10.26)	5.03 (3.06–8.25)
FH+	BF <3	smoke–	2.47 (0.71–8.61)	5.98 (2.39–14.98)	6.16 (3.45–10.99)
FH+	BF <3	smoke+	3.73 (1.35–10.32)	10.35 (4.92–21.77)	6.88 (4.03–11.75)

FH–: no family history of asthma.
 FH+: family history of asthma.
 BF >3: breast-feeding 3 months or more.
 BF <3: breast-feeding less than 3 months.
 smoke–: nonsmoking mother.
 smoke+: smoking mother.
 Dependent variables are atopic asthma, nonatopic asthma, and "ever asthma". Other independent variables used in model were sex, dampness at home, pets at home, and area. Odds ratios for these risk factors were similar to odds ratios given in Table 3.

separated into atopic and nonatopic, this was true only in the nonatopic asthmatics, and the combined risk yielded an OR of 2.9. Neither breast-feeding nor the combination of breast-feeding and the smoking habits of the mother appeared to have any significant influence on atopic asthma.

Discussion

Importance of validation of questionnaire-based diagnoses

Questionnaire-based results on prevalence are widely used in asthma epidemiology, and the rate of physician-diagnosed asthma is often used in prevalence studies. In risk-factor analysis, the classification of disease is particularly important (22, 23). Thus, it is important to validate the physician-diagnosed asthma reported by the parents.

The specificity of the question, "Has your child been diagnosed as having asthma by a physician?", was high. Among the children who participated in the validation study, only one child among the children whose parents had reported that they had asthma diagnosed by a physician was not classified as having asthma. The sensitivity, about 70%, has to be regarded as fair and was of the same degree of magnitude as has been shown in studies among adults in Europe (23, 24). This means that 3/10 children who were judged to have asthma had not been diagnosed as having asthma according to the parents' questionnaire responses. In reality, a smaller proportion than 3/10 had not been detected

as asthmatic by the health-care system, as the majority of these "undiagnosed" children had been prescribed asthma medicines. On the other hand, a few asthmatics could occur among the children with rhinitis and eczema not reporting respiratory symptoms. The high specificity of the term "physician-diagnosed asthma" will make this question useful as a dependent variable in future calculations of risk based on incident cases of asthma.

Based on the results of the validation study, the prevalence of "ever asthma" in the cohort was 7–8%. A high degree of agreement was found between the diagnosis of asthma based on the assigned criteria for asthma and the pediatricians' "over-all assessment".

Our intention was to investigate whether or not the children had or had had asthma. The choice of method is controversial; however, we decided to use a structured interview by pediatricians. The aim was to identify "ever asthma", an identification which would make it possible to measure incidence of asthma in the longitudinal study.

For this purpose, the use of physiologic tests would have been of limited interest. Bronchial challenge tests using histamine or methacholine as an objective test for asthma in epidemiologic studies have not shown a sufficiently close relationship between asthma and a positive test. Some subjects with asthma do not react to these tests (23, 25–27), whereas others without respiratory symptoms have a positive test (23, 27, 28). This view of challenge tests has been advocated by Swedish pediatricians and has support in the literature (25–28). Not even exercise testing has been

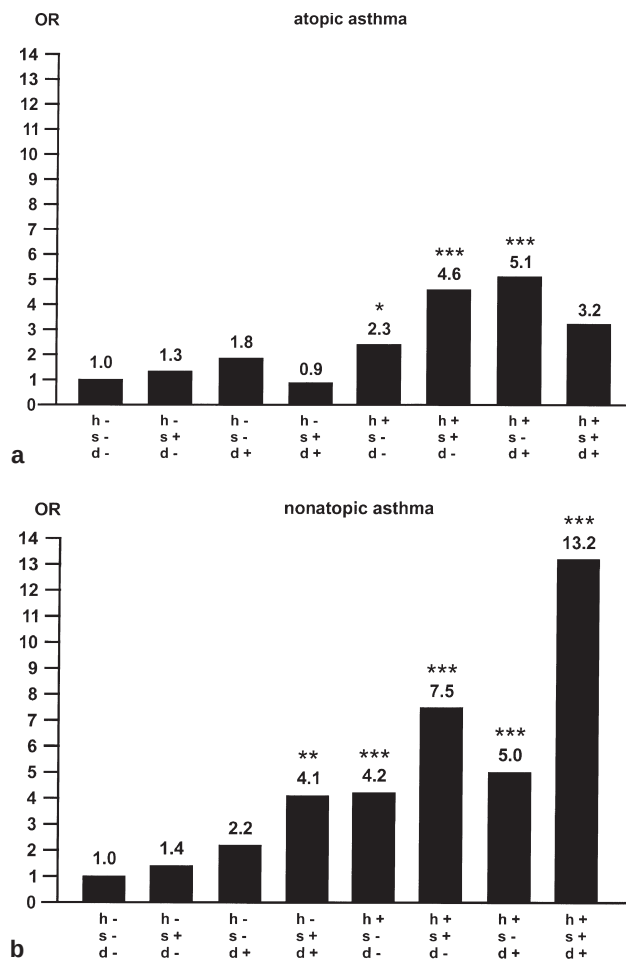


Figure 2. Risks for atopic (a), and nonatopic (b) asthma, respectively, in relation to family history of asthma (h), smoking mother (s), and dampness at home (d). Odds ratios (OR) calculated by multiple logistic regression analysis. (Other independent variables used in model were pets at home, sex, and area, and they were similar to results presented in Table 3.)

shown to be sufficiently reliable in diagnosing asthma in population studies (29, 30). Furthermore, there is a fairly uniform interpretation of the diagnosis of asthma in Sweden. The diagnosis is generally not based on single symptoms, and it is used less often for occasional wheezing or for other symptoms of children than in some other countries (6).

Risk-factor pattern

The present study clearly identified the two major risk factors for asthma. Atopy was the greatest risk factor (OR=3.9) followed by family history of asthma (OR=3.4). The multiple logistic model yielded consistent results, and the risk factors were of the same order of magnitude when both atopy and family history of asthma were

included in the same model, or if only one of them was included in the analyses. The risk factor family history of asthma may include both genetic and environmental components. The third risk factor was breast-feeding less than 3 months (OR 1.7). Other significant risk factors were dampness at home and male sex, while mother's smoking was a strong trend.

Mother's smoking became a significant risk factor when breast-feeding was excluded from the model. The risk-factor analyses showed that the risk of asthma when having a smoking mother was lower if the child had been breast-fed for more than 3 months. However, this effect could not be seen for atopic asthma. Breast-feeding has previously been reported to limit the effect of passive smoking on respiratory illness in small children (31). The fact that a smoking mother increases the risk of the child to develop asthma, while a smoking father does not, probably reflects the amount of exposure. In Sweden, children still spend more time with their mothers than with the fathers, and are likely to be exposed more heavily to passive smoke if the mother is the one who smokes in the family. The greater effect of maternal smoking than of others' smoking has been shown in several studies (6, 10, 31, 32).

The risk-factor analyses clearly showed that type-1 allergy and asthma have different risk-factor patterns. When the risk-factor analysis was performed separately in atopic and nonatopic asthmatics, family history of asthma appeared as the only significant risk factor for atopic asthma (OR=3.0), while the risk factors for nonatopic asthma were similar but greater. The fact that all environmental risk factors, such as dampness at home and mother's smoking, appear stronger in the nonatopic asthmatics than in the atopic may be due to the fact that atopy itself was the strongest risk factor for asthma. In particular, the combined risks were considerably greater for nonatopic asthma.

A protective effect of breast-feeding against asthma and allergic diseases has been discussed for many years, but there is still a lack of knowledge (33). Many studies have not shown any protective effect of breast-feeding (5, 33, 34), while some studies have shown a protective effect against asthma (35, 36), or have suggested a protective effect against allergy and atopic conditions (36, 37). In addition, an increase of allergic diseases as an effect of breast-feeding from a sensitized mother has also been suggested. In our study, we did not find any effect against type-1 allergy, but we did find an obvious protective effect against nonatopic asthma among children who had been breast-fed more than 3 months.

The higher risk of asthma in children who had been breast-fed less than 3 months may be an effect of more

frequent airway infections. Previous studies have shown that breast-feeding protects against airway infections, pneumonia, and wheezing, but only in early childhood (38). Two recent studies in small children have found recurrent wheeze to be significantly less common among nonatopic children who had been breast-fed (32, 39), results in accordance with ours.

The effect of having animals at home showed no increased risk of either asthma or type-1 allergy; instead, an opposite trend was found. This finding has to be examined in more detail, and we do not know whether or not these results are the effects of selection or avoidance of animals in atopic families. However, a protective effect cannot be excluded, as others have shown similar results (8).

The size of the present study, the high participation rate in both questionnaires and skin tests, and the evaluated diagnosis of asthma all support the validity of the results of the risk-factor analysis.

Conclusions

When parents reported that the child had asthma diagnosed by a physician, the diagnosis was correct. However, if only this question was used when screening for asthma, 3/10 children

with asthma would not have been identified. The main risk factors for asthma were type-1 allergy and family history of asthma, followed by breast-feeding less than 3 months and dampness at home. Type-1 allergy, atopic asthma, and nonatopic asthma each had a different risk-factor pattern. All risk factors, particularly the environmental, appeared stronger in the nonatopic asthmatics. Breast-feeding less than 3 months was a risk factor for nonatopic asthma, but had no influence on type-1 allergy or atopic asthma.

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