

ORIGINAL ARTICLE

AIRWAY DISEASES

The link between parental allergy and offspring allergic and nonallergic rhinitis

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Keywords

BAMSE; children; heredity; parental allergy; rhinitis.

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Abstract

Background: Parental allergy-related disease increases the risk for rhinitis, but it remains unknown how different phenotypes of parental allergy affect this risk. The aim of this study was to investigate how parental hay fever, asthma, and eczema affect the risk of allergic rhinitis (AR) and nonallergic rhinitis (NAR) at 8 years of age.

Methods: Information on 2413 children from a population-based birth cohort was used combining questionnaire data and IgE to inhalant allergens. Logistic regression was used to estimate the association between parental allergy-related disease and AR and NAR. In addition, cluster analysis was used to search for latent phenotypes of heredity likely to be associated with AR and NAR.

Results: At age 8 years, 13.8% of the children had AR, while 6.4% had NAR. Parental isolated hay fever increased the odds of AR (OR 2.2, 95% CI 1.6–3.2), whereas isolated asthma or eczema did not. The odds of NAR increased when one parent had two or more allergy-related diseases. In the cluster analysis, the highest proportion of AR, 37.5%, was seen in a cluster where both parents had hay fever and pollen allergy and that of NAR, 11.0%, in a cluster where one parent had hay fever, pollen allergy, and eczema.

Conclusions: Parental allergy-related disease may be an important risk factor for NAR as well as AR, and the risk is comparable for maternal and paternal allergy. Parental hay fever seems to be the dominating hereditary risk factor for AR.

It is known that parental allergy increases the risk of allergic rhinitis in the offspring (1, 2), but less known how different aspects of parental allergy affect that risk. Results indicate that parental allergic rhinitis may be more important than parental asthma or eczema for the children to develop allergic rhinitis (3–5). Moreover, the importance of maternal versus paternal rhinitis has been compared, but the results are conflicting (6, 7).

Abbreviations

AR, allergic rhinitis; BAMSE, Barn/Children, Allergy/Asthma, Milieu, Stockholm, Epidemiology; IgE, immunoglobulin E; ISAAC, International Study of Asthma and Allergy in Childhood; NAR, nonallergic rhinitis.

Symptoms of noninfectious rhinitis without sensitization is a well-known phenomenon among adults and has been described also among children (7–10). Previous studies in children have shown that not only allergic, but also nonallergic rhinitis is associated with asthma, eczema, and food hypersensitivity (8–10). However, little is known about risk factors for nonallergic rhinitis in children. In a report from a British birth cohort where 815 children were followed for 5 years, parental allergic disease was associated with increased odds of current rhinoconjunctivitis (7). When rhinoconjunctivitis was divided into atopic and nonatopic, comparable prevalences of maternal and paternal allergic disease were observed in the two groups, but the odds of allergic and nonallergic rhinitis were not examined.

In clinical practice, it would be of use to be able to predict allergic disease in the children.

Therefor, we examined how maternal and paternal hay fever, asthma, and eczema affect the risk of allergic rhinitis (AR) and nonallergic rhinitis (NAR) at 8 years of age in an unselected, population-based, birth cohort. In addition to logistic regression analyses, unsupervised methods (cluster analysis) were performed to search for latent phenotypes of heredity likely to be associated with AR and NAR.

Method

Study design

We analyzed data from the population-based birth cohort BAMSE (Barn/Children, Allergy/Asthma, Milieu, Stockholm, Epidemiology) of 4089 children born from 1994 to 1996 in Stockholm, Sweden. The study has been described in detail previously (11). In brief, baseline data such as background exposures and parental allergy were obtained shortly after birth. The children were followed up at 1, 2, 4, and 8 years of age using questionnaires asking about symptoms of allergy-related disorders. The response rate at the 8-year follow-up was 84% from baseline. Families that completed the questionnaire were invited for the clinical follow-up including blood sampling ($n = 2480$). Sera were analyzed using the Phadiatop® IgE test for allergic sensitization to pollen of birch, timothy, and mugwort, cat, dog, horse, *Cladosporium herbarum*, and *Dermatophagoides pteronyssinus* with ImmunoCAP System (Phadia AB; Uppsala, Sweden). A level of ≥ 0.35 kU/l was considered as positive. Included in our analyses were children with information on parental allergic diseases from the baseline questionnaire as well as rhinitis symptoms and results from the Phadiatop test at 8 years ($n = 2413$).

Permission for the study was obtained from the Ethics Committee of Karolinska Institutet, Stockholm, Sweden. The parents of all participating children gave informed consent.

Exposures

Information on maternal and paternal hay fever, asthma, eczema, pollen, and pet allergy was collected at baseline (Table S1). As the definition of parental allergic rhinitis was self-reported and not based on sensitization, we chose to label it as 'hay fever'.

Classification of outcomes

Allergic rhinitis (AR)

Reported symptoms of rhinitis (sneezing, runny or blocked nose in the absence of cold or flu within the last 12 months (12), or after exposure to pollen or furred animals), in combination with sensitization to the inhalant allergens tested (Phadiatop ≥ 0.35 kU/l) (10).

Nonallergic rhinitis (NAR)

Reported symptoms as above with no sensitization to any of the inhalant allergens tested (Phadiatop < 0.35 kU/l) (10).

Asthma

At least 4 episodes of wheezing or at least 1 episode of wheezing among patients that had received a prescription for inhaled steroids, in the last 12 months (13).

Eczema

Dry skin in combination with itchy rash for 2 or more weeks, at typical localizations, within the last 12 months and/or doctor's diagnosis of this disorder (13).

Statistical analyses

The odds ratios (ORs) and 95% confidence intervals (CIs) for AR and NAR were estimated using logistic regression models.

Firstly, we explored differences between maternal and paternal heredity in relation to AR and NAR (results presented in Table 1). We used categorical variables, where 'reported hay fever' was stratified into 'mothers', 'fathers', or 'both' and analyzed with 'no heredity' as reference category. To not reduce the number in the analysis, the other two diseases, asthma and eczema, were allowed. The same principle was used for asthma and eczema.

Secondly, we compared the associations between parental hay fever, asthma, and eczema, and AR and NAR in the offspring (results presented in Table 2). One combined variable was used and analyzed with 'no heredity' as reference category. Hay fever only consisted of mothers, fathers, or both reporting only hay fever. The other diseases were excluded. The same yields for asthma only and eczema only.

To be included in the reference category, 'no heredity', both mothers and fathers had to have answered 'no' to the questions of hay fever, asthma, and eczema.

We tested for potential confounding by environmental and lifestyle factors (sex, socioeconomic status, maternal smoking, furred animals in the home, older siblings, early fish intake, birth month, mothers age, breastfeeding, home dampness). All these had little effect on the observed odds ratio (less than 2%), which is why we kept the final analyses unadjusted.

As co-occurrence between allergy-related diseases is common (1, 10) and may exist in one or both parents, there are many possible patterns of parental allergic disease. Thus, as a complement to the logistic regression analysis, we also performed a cluster analysis to search for latent phenotypes of heredity that are likely to be associated with AR and NAR. In a cluster analysis, it is not decided beforehand how to group the variables. Instead the data itself form the groups (clusters). For the cluster analysis, we used the k-means method, which is a frequently used method for clustering of large data sets (14–16). We tested 3-, 4-, 5-, and 6-cluster models. The 10 variables clustered were reported hay fever, reported asthma, reported eczema, reported pollen allergy, and reported allergy to furred animals in mothers and in fathers, respectively. When a cluster model was found, proportions of the outcome variables AR and NAR were calculated for the different clusters. After repeated trials, we chose the cluster solution with the most commonly appearing clusters.

Table 1 Maternal versus paternal allergic disease, and the risk of allergic and nonallergic rhinitis at 8 years of age, with the different diseases analyzed as separate categorical variables stratified into mother, father, or both, among 2413 children, in the BAMSE birth cohort

N = 2413	N	Allergic rhinitis N = 333 (13.8%)				Nonallergic rhinitis N = 155 (6.4%)			
		n	%	OR	95% CI	n	%	OR	95% CI
No heredity	898	78	8.7	ref	ref	39	4.3	ref	ref
Any heredity*	1515	255	16.8	2.4	1.8–3.1	116	7.7	2.2	1.5–3.2
Any heredity†									
Mother	578	76	13.2	1.8	1.3–2.5	47	8.1	2.2	1.4–3.4
Father	506	71	14.0	1.9	1.3–2.6	39	7.7	2.0	1.3–3.2
Both	431	108	25.1	4.3	3.1–5.9	30	7.0	2.4	1.4–3.9
Reported hay fever									
Mother‡	450	69	15.3	2.2	1.5–3.1	42	9.3	2.7	1.7–4.2
Father§	469	73	15.6	2.2	1.5–3.1	37	7.9	2.2	1.4–3.5
Both	198	72	36.4	8.2	5.5–12.1	12	6.1	2.7	1.4–5.4
Reported asthma									
Mother‡	250	53	21.2	3.3	2.2–4.9	26	10.4	3.3	1.9–5.5
Father§	211	42	19.9	3.4	2.2–5.2	27	12.8	4.4	2.6–7.5
Both	28	10	35.7	8.8	3.6–21.9	2	7.1	3.5	0.7–16.7
Reported eczema									
Mother‡	463	82	17.7	2.7	1.9–3.8	38	8.2	2.5	1.6–4.0
Father§	301	48	16.0	2.2	1.5–3.2	25	8.3	2.3	1.3–3.8
Both	105	19	18.1	2.6	1.5–4.6	10	9.5	2.8	1.3–5.8

No heredity: Reference category. Neither mother nor father reported hay fever, asthma, or eczema.

*Mother and/or father reported hay fever, asthma, and/or eczema.

†Hay fever and/or asthma and/or eczema in mothers only, fathers only, or both.

‡In mothers but not fathers. The other two diseases were not excluded in the analysis.

§In fathers but not mothers. The other two diseases were not excluded in the analysis.

Table 2 Patterns of parental allergic diseases, isolated or in combinations, and the odds for allergic and nonallergic rhinitis at 8 years of age, among 2413 children in the BAMSE birth cohort

N = 2413	Parental allergic disease	N	Allergic rhinitis N = 333 (13.8%)				Nonallergic rhinitis N = 155 (6.4%)			
			n	%	OR	95% CI	n	%	OR	95% CI
	No heredity*	898	78	8.7	ref	ref	39	4.3	ref	ref
	Hay fever only†	404	67	16.6	2.2	1.6–3.2	20	5.0	1.3	0.8–2.3
	Asthma only†	70	7	10.0	1.2	0.5–2.8	3	4.3	1.0	0.3–3.5
	Eczema only†	283	26	9.2	1.1	0.7–1.7	15	5.3	1.2	0.7–2.3
	Hay fever† and asthma†	172	32	18.6	3.0	1.9–4.8	20	11.6	3.8	2.1–6.7
	Hay fever† and eczema†	339	57	16.8	2.5	1.7–3.7	26	7.7	2.3	1.4–3.9
	Asthma† and eczema†	45	8	17.8	2.9	1.3–6.8	7	15.6	5.2	2.1–12.7
	Hay fever†, asthma† and eczema†	202	58	28.7	5.6	3.8–8.4	25	12.4	4.9	2.8–8.4

Note: The diseases not given were excluded from the analysis.

*Neither mother nor father had hay fever, asthma, or eczema.

†In mother and/or father.

All analyses were conducted using STATA statistical software version 11 (College Station, Texas, USA).

Results

Main analyses

Characteristics such as sex, parental history of allergic disease, and socioeconomic status were comparable between the 2413 children included in the study and the original

BAMSE birth cohort (Table S2). Compared with the 41% of the cohort not included in this study, the study population had somewhat higher prevalence of heredity for allergic disease (31.9% vs 26.5%, $P < 0.001$), high socioeconomic status (39.2% vs 35.2%, $P = 0.009$), and mothers breastfeeding exclusively more than 4 months (81.5% vs 76.4% $P < 0.001$), but lower prevalence of mothers smoking (12.2% vs 16.1%, $P < 0.001$). The majority (87.8%, $n = 2118$) of the baseline questionnaires were filled out by both parents.

A total of 41.8% of the mothers and 38.8% of the fathers had at least one allergy-related disease, and consequently, 62.8% of the children had at least one parent with at least one allergy-related disease. Overlap between the different allergy-related diseases was common both among mothers and fathers (Figure S1).

At age 8 years, 13.8% of the children had AR, while 6.4% had NAR. The prevalence was higher among children with parental allergy-related disease, compared with children with no parental allergy-related disease (Table 1). Both maternal and paternal heredity increased the odds ratio for AR (OR 1.8, 95% CI 1.3–2.5 for maternal heredity and OR 1.9, 95% CI 1.3–2.6 for paternal heredity) and NAR (OR 2.2, 95% CI 1.4–3.4 for maternal heredity and OR 2.0, 95% CI 1.3–3.2 for paternal heredity). When both mother and father had hay fever or asthma, the odds of AR, but not of NAR, increased even further (Table 1).

Hay fever of the parents was the only disease which when isolated, without comorbid asthma or eczema, increased the odds of AR (OR 2.2, 95% CI 1.6–3.2) (Table 2). Isolated parental asthma or eczema did not increase the odds of AR. For NAR, there was no parental allergy-related disease which when isolated increased the odds of AR, but two or more parental allergy-related diseases were needed (Table 2). In addition, we analyzed the children with sensitization but without rhinitis symptoms and found an association with any parental allergy-related disease (OR 1.6, 95% CI 1.3–2.1) as well as 'hay fever only' (OR 1.4, 95% CI 1.0–2.1).

In the cluster analysis, we did not find a stable model. There were, however, clusters that reappeared several times in different models. The model that best explained these typical, often re-occurring clusters was a 6-cluster model (Table 3).

Cluster 1

Both parents reported hay fever and pollen allergy.

Cluster 2

The mother had hay fever and pollen allergy.

Cluster 3

The father had hay fever and pollen allergy.

Cluster 4

The father had hay fever, pollen allergy, and eczema.

Cluster 5

Low proportions of allergy-related diseases among both parents except for eczema among fathers.

Cluster 6

Low proportions of allergy-related diseases among both parents.

The prevalence of AR and NAR among the children in the different clusters are shown in Fig. 1. The highest prevalence of AR among 8-year-olds, 37.5% (95% CI 30.0–45.3), was seen in Cluster 1. The highest prevalence of NAR, 11.0% (95% CI 5.7–16.4), was seen in Cluster 4. Similar prevalence of AR (8.0%, 95% CI 3.8–12.3%) and NAR (6.8%, 95% CI 2.9–10.7%) was seen in Cluster 5.

Secondary analyses

Comorbidity was common among the children with AR, and at age 8 years, 24.5% had comorbid asthma and 33.0% had comorbid eczema. In contrast to children with AR without asthma, the odds of AR with asthma were increased by isolated parental asthma (OR 4.5, 95% CI 1.4–14.5) (Table S3). Also among children with NAR, comorbid asthma (11.7%) or eczema (26.9%) was more common than among children without rhinitis. Due to small numbers, we were not able to stratify the analyses on parental allergic disease and risk of NAR by comorbidity.

When the logistic regression analyses on parental allergic disease and AR and NAR in the offspring were restricted to parents reporting doctor's diagnoses of hay fever, asthma, and eczema, the observed odds ratios remained unchanged (Tables S4, S5). Neither did the results change when the

Table 3 From the cluster analysis of the 2413 children from the BAMSE birth cohort, the proportions of the clustered variables in each cluster, (C), are presented as percent (%)

	C 1*	C 2*	C 3*	C 4*	C 5*	C 6*
	<i>n</i> = 152	<i>n</i> = 443	<i>n</i> = 322	<i>n</i> = 136	<i>n</i> = 162	<i>n</i> = 1198
<i>N</i> = 2413	6.3%	18.4%	13.3%	5.6%	6.7%	49.7%
Mother						
Hay fever	96.2	95.3	6.8	5.5	6.0	3.2
Asthma	31.5	34.4	4.0	4.1	4.9	3.7
Eczema	39.1	46.3	19.3	20.3	25.4	14.3
Pollen allergy	88.1	80.7	1.2	2.8	2.5	2.1
Pet allergy	63.8	60.6	5.2	6.0	7.4	4.9
Father						
Hay fever	97.4	5.0	95.2	94.9	7.1	3.3
Asthma	27.7	2.6	23.7	39.2	6.4	3.3
Eczema	31.1	12.9	0	100	100	0
Pollen allergy	87.7	1.4	90.1	91.2	3.2	2.4
Pet allergy	55.3	5.8	56.3	68.2	7.8	4.2

*C1: Cluster 1, C2: Cluster 2, etc.

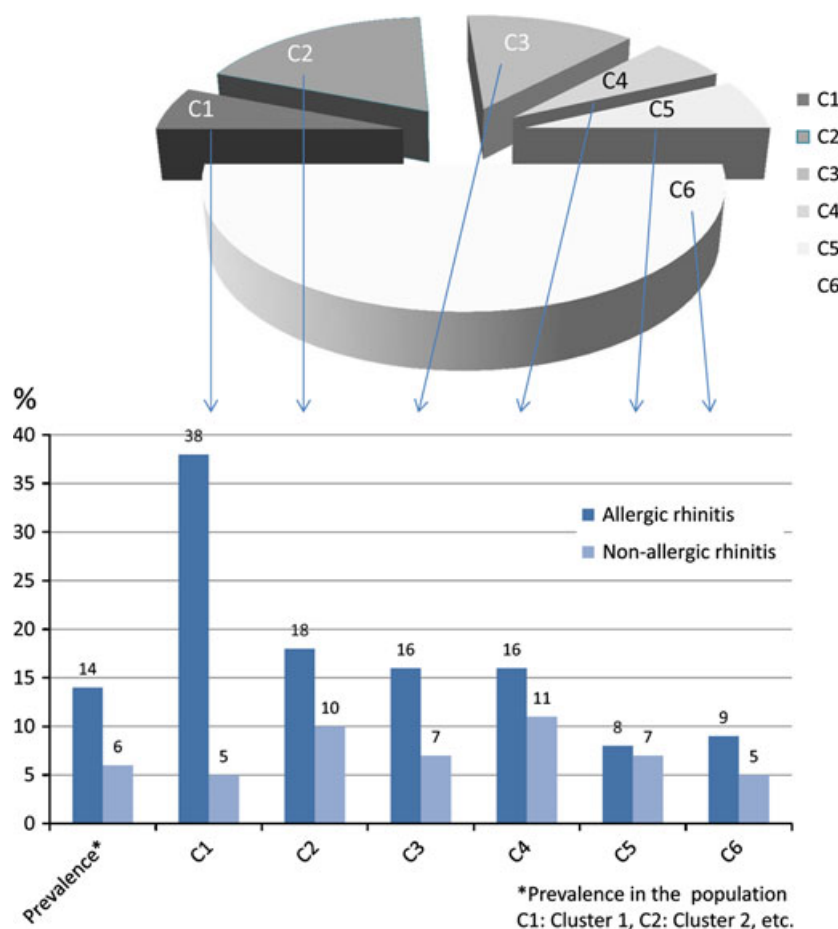


Figure 1 From the cluster analysis of the 2413 children from the BAMSE birth cohort, proportions of the children's allergic and

nonallergic rhinitis, for each of the 6 clusters (C1-C6), are presented as percentages (%).

analysis was restricted to the children where both parents had filled out the questionnaire ($n = 2118$, data not shown).

observed in the cluster where one of the parents had hay fever and pollen allergy in combination with eczema.

Discussion

Principal findings

In this prospective study of 2413 children, we investigated patterns of parental allergy-related diseases and the odds of AR and NAR in 8-year-olds. Parental allergy was associated with increased odds of AR, but notably also of NAR. Maternal and paternal allergy increased the odds of AR, as well as NAR, similarly, and when both parents had hay fever or asthma, the odds of AR increased even further. Interestingly, isolated parental hay fever, but not isolated asthma or eczema, increased the odds of AR. In contrast, the odds of NAR increased only if one parent had two or more allergy-related diseases. These findings were supported when we conducted a cluster analysis of 10 characteristics of parental allergy-related disease. The highest proportion of AR was observed in the cluster where both parents had hay fever and pollen allergy, while the highest proportion of NAR was

Strengths and limitations

The strengths of this study are the population-based, prospective design and the large sample size. We had information on sensitization to inhalant allergens from all children in our study, which allowed us to distinguish between AR and NAR.

Our study has some potential limitations. Only children who participated in the clinical follow-up at 8 years of age could be included in the present analyses (corresponding to 59% of the original cohort). However, the prevalence of parental history of allergic disease was comparable between the study population and the original cohort. Thus, the observed associations between heredity and rhinitis are not likely to be influenced by the selection of study population.

Parental allergic diseases were based on questionnaires. The questions used have been used by others (6). Validation studies on questions for parental allergy are scarce, but reported asthma and reported hay fever may be more specific

than reported eczema (17, 18). We compared the results between self-reported allergy and self-reported doctor's diagnosis of allergy, and a similar pattern was observed. Eighty-eight percentage of the questionnaires were filled out by both parents. Restricting the analyses to these children had no major influence on the observed odds ratios. Moreover, information on exposure was collected before the children had developed rhinitis; accordingly, any misclassification of exposure is likely to be nondifferential and thus rather lead to an underestimation of the true association.

Another potential limitation of our study, as well as others with similar design, is that parents with rhinitis might identify symptoms of their children more frequently than parents without rhinitis leading to an overestimation of the association. However, the different patterns of parental allergy-related disease observed for AR and NAR argue against this being the only explanation for the observed results. In addition, parental hay fever was also associated with increased odds of sensitization to inhalant allergens without symptoms of rhinitis. Thus, it is likely that the association is not only a result from parental over-reporting.

Cluster analysis has previously been used by others in the area of allergy research (15, 19, 20). The advantage of this method is that it is not decided prior to analysis how to group the variables. In the ideal situation, the variables group (cluster) in a stable model that does not differ wherever you start in the data set. We did not find a stable model. This could be due to either a difficulty in finding good starting points or that the latent clusters are overlapping. However, the clusters described tended to reappear when trying different models.

Classification of AR and NAR among the children was based on parental reports of rhinitis symptoms in combination with presence or absence of sensitization to inhalant allergens. Sensitization was measured by Phadiatop, which includes the 8 most common inhalant allergens in our region. The Phadiatop test has been shown to correlate well with both skin prick test and specific IgE, measured by CAP-RAST (21). Thus, it is likely that we have been able to distinguish children with AR from children with NAR.

Meaning of the study

As expected, we found that any parental allergy-related disease increased the odds of AR in the offspring. The results did not seem to differ when comparing maternal and paternal allergy-related disease, neither in the logistic regression analysis, nor in the cluster analysis. This is consistent with the findings from a British birth cohort, although the authors did not present odds ratios for atopic and nonatopic rhinitis separately (7). Other studies show conflicting results. Stronger association for maternal atopy was seen in an Australian cohort followed from 7 to 44 years of age (22), while stronger association for paternal rhinitis was observed in a British cohort followed from birth until 18 years of age (6). The conflicting results may be explained by the different definitions of outcome used in these studies or by true differences in the patterns of allergic disease in the study populations.

Hay fever was the only parental allergy-related disease that independently increased the odds of AR. This result is supported by other studies (3–5). In addition, there are prospective studies which have shown that parental asthma seems to be more important for the children to develop asthma, than parental rhinitis or eczema (23, 24). When stratifying AR for comorbid asthma, parental asthma increased the odds of AR with asthma, but not for AR without asthma. This supports the theory that specific allergy-related diseases among parents might be more important for the children's risk to develop a certain allergic disease than just 'any family history of allergic disease'.

In our study, parental allergy-related disease also increased the odds of NAR. Although previous studies on this relation are scarce, one study supports an association also with NAR (7). It is possible that NAR could develop into AR over time, but previous results from our cohort indicate that sensitization may proceed nasal symptoms (10). However, other studies have shown conflicting results regarding the timing between sensitization and nasal symptoms (25, 26). Moreover, children classified as having NAR may have local allergic rhinitis (27). This could not be evaluated in our study as we had no possibilities to perform nasal challenges. However, the different patterns of parental allergic disease observed for NAR and AR support the idea that although they share the common vulnerability of being affected by parental allergy, NAR and AR may be two different conditions.

Genetic studies on asthma, eczema, and rhinitis have indicated both shared and unique pathways for the development of these diseases (28–30). Because of the comorbidity between allergy-related diseases, few studies have been able to address the genetic contribution in individuals with isolated disease. We were in our study able to show that isolated parental hay fever, but not asthma or eczema, was associated with AR at 8 years of age, which indicates that genes specific for rhinitis may be of importance in this context. On the other hand, presence of comorbidity between asthma, eczema, and hay fever in the parents was associated with an even higher risk of AR, suggesting that shared genetic factors are also likely to influence disease development. From a genetic point of view, the role of shared and unique pathways for respective allergy-related disease needs further exploration.

In summary, the results from our prospective birth cohort suggest that parental allergy-related disease may be an important risk factor for NAR as well as AR and that the risk is comparable for maternal and paternal allergy. Parental hay fever (with pollen allergy) seems to be the dominating hereditary risk factor for AR.

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Author contributions

Wickman initiated the BAMSE birth cohort. Kull supervised the data collection. Wickman, Kull, Bergström, and Westman designed the current study. Westman and Lind performed the

data analysis. Westman, Bergström, and Wickman drafted the manuscript. All authors participated in interpretation of data, critical revision, and final approval of the manuscript.

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Conflict of interest

All authors have completed the ICMJE form and claim no conflict of interest.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Prevalence of self-reported allergic disease among mothers and fathers of 2413 children in the BAMSE birth cohort at baseline.

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ONLINE SUPPLEMENT

Table E1: Definitions of parental allergic disease in the BAMSE birth cohort, Stockholm, Sweden.

Parental allergic disease	Question addressed to the parents in the baseline questionnaire [*]
Hay fever	“Do you have or have you previously had allergic rhinitis (hay fever)?”
Asthma	“Do you have or have you previously had asthma?”
Eczema	“Do you have, or have you previously had eczema?”
Pollen allergy	“Are you allergic to pollen?”
Pet allergy	“Are you allergic to furred animals?”

^{*} Mean age of the child: 2 months.

Table E2: Background characteristics of participants in the BAMSE birth cohort, Stockholm, Sweden

	Study population N=2413			BAMSE cohort N=4089		
	n	%	CI	n	%	CI
Sex						
Male	1242	51.5	49.5-53.5	2065	50.5	49.0-52.0
Birth month						
Dec-feb	424	17.6	16.1-19.1	722	17.7	16.5-18.8
Mar-May	715	29.6	27.8-31.5	1201	29.4	28.0-30.8
June-Aug	694	28.8	27.0-30.6	1190	29.1	27.7-30.5
Sep-Nov	580	24.0	22.3-25.7	976	23.9	22.6-25.2
Mothers age						
<26 yrs	172	7.1	6.1-8.2	319	7.8	7.0-8.6
Parent born outside Scandinavia						
Yes	508	21.1	19.5-22.7	707	20.8	19.4-22.2
Older siblings						
Yes	1147	47.5	45.5-49.5	1980	48.4	46.9-50.0
Heredity for allergic disease						
Yes	769	31.9	30.0-33.7	1200	29.7	28.3-31.1
Socioeconomic status						
Blue collar worker	363	15.1	13.7-16.5	695	17.1	15.9-18.2
Lower white collar worker	1072	44.5	42.5-46.5	1784	43.8	42.3-45.3
Higher white collar worker	946	39.3	37.3-41.3	1539	37.8	36.3-39.3
Other	26	1.1	0.7-1.5	54	1.3	1.0-1.7
Breast feeding exclusively ≥ 4 m						
Yes	1925	81.5	80.0-83.1	3116	79.5	78.2-80.8
Furred animals at home						
Yes	349	14.5	13.1-15.9	629	15.4	14.3-16.5
Mother smoking						
Yes	294	12.2	10.9-13.5	563	13.8	12.7-14.8
Smell of mildew in the home						
Yes	177	7.3	6.3-8.4	324	7.9	7.1-8.8
Moisture damage in the home						
Yes	473	19.6	18.0-21.2	812	19.9	18.6-21.1
AOM < 1 y						
Yes	545	23.1	21.4-24.8	942	24.0	22.7-25.3

RSV < 1 y						
Yes	98	4.2	3.3-5.0	165	4.2	3.6-4.8
Antibiotics < 1 y						
Yes	1005	42.5	40.5-44.5	1710	43.6	42.0-45.1
Daycare attendance at 2 y						
Yes	1732	73.2	71.4-75.0	2773	72.2	70.8-73.6
Fish intake < 1y						
>twice/month	1892	80.0	78.4-81.6	3143	80.1	78.8-81.3

Table E3: Patterns of parental allergic diseases, isolated or in combinations, and the odds for allergic rhinitis at 8 years of age, stratified for asthma, among 2406 children in the BAMSE birth cohort.

N=2406		Allergic rhinitis N=327							
		AR without asthma N=247 (75.5 %)				AR with asthma N=80 (24.5 %)			
Parental allergic disease	N	n	%	OR	95 % CI	n	%	OR	95 % CI
No heredity*	894	63	7.1	ref	ref	12	1.3	ref	ref
Hay fever only [†]	404	53	13.1	2.2	1.5-3.2	14	3.5	3.0	1.4-6.6
Asthma only [†]	70	3	4.3	0.6	0.2-2.1	4	5.7	4.5	1.4-14.5
Eczema only [†]	282	22	7.8	1.1	0.7-1.9	3	1.1	0.8	0.2-2.9
Hay fever [†] and asthma [†]	172	22	12.8	2.6	1.5-4.4	10	5.8	6.1	2.6-14.5
Hay fever [†] and eczema [†]	338	44	13.0	2.4	1.6-3.7	12	3.6	3.5	1.5-7.8
Asthma [†] and eczema [†]	45	4	8.9	1.8	0.6-5.4	4	8.9	9.6	2.9-31.9
Hay fever [†] , asthma [†] and eczema [†]	201	36	17.9	4.3	2.7-6.9	21	10.5	13.3	6.3-27.9

* Neither mother nor father reported hay fever, asthma or eczema.

[†] In mother and/or father.

Note: The disease(s) not given were excluded from the analysis.

Table E4: Maternal vs. paternal allergic disease, restricted to parents reporting doctor's diagnosis of asthma, hay fever or eczema, and the risk of allergic and non-allergic rhinitis at eight years of age, with the different diseases analyzed as separate categorical variables stratified into mother, father or both, among 2413 children, in the BAMSE birth cohort.

	N	Allergic rhinitis N=333 (13.8 %)				Non-allergic rhinitis N=155 (6.4 %)			
		n	%	OR	95 % CI	n	%	OR	95 % CI
No heredity	898	78	8.7	ref	ref	39	4.3	ref	ref
Any heredity *	1194	209	17.5	2.6	1.9-3.4	93	7.8	2.3	1.5-3.4
Any heredity[†]	N=1944								
Mother	438	58	13.2	1.8	1.3-2.6	36	8.2	2.3	1.4-3.6
Father	361	49	13.6	1.9	1.3-2.7	30	8.3	2.3	1.4-3.7
Both	247	66	26.7	4.7	3.2-6.9	18	7.3	2.6	1.4-4.6
Reported hay fever N=1610									
Mother [‡]	303	51	16.8	2.5	1.7-3.7	29	9.6	2.9	1.7-4.8
Father [§]	313	52	16.6	2.4	1.6-3.5	26	8.3	2.4	1.4-4.0
Both	96	35	36.5	8.4	5.0-14.0	6	6.3	2.9	1.1-7.2
Reported asthma N=1328									
Mother [‡]	224	44	19.6	3.0	2.0-4.5	24	10.7	3.3	1.9-5.6
Father [§]	188	37	19.7	3.4	2.2-5.3	24	12.8	4.4	2.5-7.6
Both	18	9	50.0	13.3	4.6-38.3	0	0.0	-	-
Reported eczema N=1506									
Mother [‡]	334	61	18.3	2.9	2.0-4.1	31	9.3	2.9	1.8-4.8
Father [§]	217	35	16.1	2.2	1.4-3.4	18	8.3	2.3	1.3-4.1
Both	57	14	24.6	4.3	2.2-8.4	7	12.3	4.3	1.8-10.4

No heredity: Reference category. Neither mother nor father reported hay fever, asthma or eczema.

* Mother and/or father reported hay fever and/or asthma and/or eczema.

† Hay fever and/or asthma and/or eczema in mothers only, fathers only or both.

‡ In mothers but not fathers. The other two diseases were not excluded in the analysis.

§ In fathers but not mothers. The other two diseases were not excluded in the analysis.

Table E5: Patterns of parental allergic diseases, isolated or in combinations, and the odds for allergic and non-allergic rhinitis at 8 years of age, restricted to parents reporting doctor's diagnosis of hay fever, asthma or eczema, among 2413 children in the BAMSE birth cohort.

N=1882		Allergic rhinitis N=333 (13.8%)				Non-allergic rhinitis N=155 (6.4 %)			
Parental allergic disease	N	n	%	OR	95 % CI	n	%	OR	95 % CI
No heredity*	898	78	8.7	ref	ref	39	4.3	ref	ref
Hay fever only [†]	247	44	17.8	2.5	1.6-3.7	8	3.2	0.9	0.4-2.0
Asthma only [†]	65	6	9.2	1.1	0.5-2.7	3	4.6	1.1	0.3-3.8
Eczema only [†]	183	13	7.1	0.8	0.4-1.5	11	6.0	1.4	0.7-2.8
Hay fever [†] and asthma [†]	137	28	20.4	3.5	2.1-5.7	17	12.4	4.2	2.3-7.9
Hay fever [†] and eczema [†]	179	34	19.0	2.9	1.9-4.6	10	5.6	1.7	0.8-3.5
Asthma [†] and eczema [†]	31	5	16.1	2.8	1.0-7.8	6	19.4	6.6	2.5-17.9
Hay fever [†] , asthma [†] and eczema [†]	142	44	31.0	6.1	3.9-9.5	20	14.1	5.5	3.0-10.0

* Neither mother nor father reported hay fever, asthma or eczema.

[†] In mother and/or father.

Note: The disease(s) not given were excluded from the analysis.

Figure E1: Prevalence of self-reported allergic disease among mothers and fathers of 2413 children in the BAMSE birth cohort at baseline.

