

Factors related to allergic sensitization to aeroallergens in a cross-sectional study in adults: The Copenhagen Allergy Study

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Summary

Background The factors underlying recent increases in the prevalence of respiratory allergy are largely unknown.

Objective To assess the association between allergic sensitization and several lifestyle/environmental factors.

Methods A cross-sectional population-based study of 15–69-year-olds in Copenhagen was carried out in 1990. The participation rate was 77.5% (1112/1435). Different lifestyle/environmental factors (explanatory variables) were defined based on questionnaire data. Dependent (outcome) variables were skin prick test (SPT) positivity or specific IgE positivity to common aeroallergens. Explanatory variables associated with outcome in univariate analysis ($P < 0.25$) were selected for multivariate analysis. Subsequently, a final model for each dependent variable was obtained by stepwise regression analysis (cut-off for entry/removal of variables: $P < 0.1$).

Results Male sex, young age, low number of siblings, a positive family history of hay fever and never smoking, were independently associated with both SPT positivity and specific IgE positivity. Furthermore, SPT positivity was positively associated with alcohol consumption (dose–response relationship only), and negatively associated with previous keeping of a dog in the household. The association between alcohol consumption and SPT positivity was mainly due to the consumption of wine and remained after adjustment for educational level. Specific IgE positivity was furthermore associated with body mass index with no apparent dose–response relationship.

Conclusion Being male, young age, a positive family history of hayfever, low number of siblings and never smoking, were independently associated with allergic sensitization. In addition, the results indicated a possible relationship of alcohol consumption, body mass index and previous keeping of a dog in the household to allergic sensitization. There is a need for prospective studies of risk factors for respiratory allergy.

Keywords: adult, alcohol consumption, body mass index, respiratory hypersensitivity, risk factors, skin prick test, smoking, specific IgE.

Clinical and Experimental Allergy, Vol. 31, pp. 1409–1417. Submitted 13 October 2000; revised 26 February 2001; accepted 22 March 2001.

Introduction

The prevalence of respiratory allergy has increased in Denmark [1] and in many other countries [2–4] over recent

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decades. Diseases with substantial increases in prevalence over short periods of time are likely to be influenced by lifestyle or environmental factors. Furthermore, the prevalence of allergic sensitization seems to have been low in the former East Germany compared with the prevalence in the former West Germany, and subsequently increased dramatically after the unification of the two countries [5]. Thus, factors associated with westernized lifestyle or environment are probably responsible for the rising trends of respiratory allergy.

Subjects sensitized to aeroallergens by a specific IgE-mediated immune response are considered the group of individuals at risk of developing allergic airway disease such as allergic rhinitis and allergic asthma. Measurements of skin prick test (SPT) reactivity and specific IgE to allergens are generally accepted methods for the assessment of allergic sensitization. Although these two methods show good agreement, they may be considered complementary to one another in diagnosing allergic rhinitis [6]. In the present study, both methods were employed as outcome variables.

The aim of this study was to investigate the association between several lifestyle/environmental factors and allergic sensitization to common aeroallergens.

Methods

Study population

The study was conducted according to a two-stage protocol. In the first stage a screening questionnaire on respiratory symptoms was mailed in November 1989 to a sample of 15–69-years-olds ($n = 8000$), living in the western part of Copenhagen, the capital of Denmark. The sample was drawn randomly from the Civil Registration System. A total of 6998 or 87.5% responded to the screening questionnaire. In the second stage, a random group and a symptom group selected among the respondents were invited to a health examination. The symptom group comprised all respondents ($n = 788$) who had reported rhinitis symptoms (itchy or stuffy nose or sneezing) or shortness of breath on exposure to either pollen or furry animals in the screening questionnaire [7]. The random group comprised 647 subjects who were randomly selected from the remaining respondents. Subsequently, 635 (participation rate 80.6%) and 477 (participation rate 73.7%) subjects were examined in the symptom and the random group, respectively. Thus, a total of 1112 subjects (overall participation rate 77.5%) were examined. Examinations took place between February 1990 and January 1991. The invitational procedure and characteristics of both participants and non-participants have previously been described

[7]. The Ethical Committee of Copenhagen County approved the study.

Skin prick tests

Skin prick tests were performed with the Phazet[®] system (Pharmacia & Upjohn Diagnostics AB, Uppsala, Sweden) as previously described [7]. The Phazet lancets were coated with allergen solutions standardized as regards total allergenic activity (100 000 BU/mL), or with histamine dihydrochloride (10 mg/mL) (the positive control). The panel of allergens comprised birch, grass (timothy), mugwort, horse, cat, dog, two mites (*Dermatophagoides pteronyssinus* and *D. farinae*), and two moulds (*Cladosporium* and *Alternaria*). SPT reactivity was expressed as the allergen histamine weal ratio, i.e. the mean weal diameter at the allergen site divided by the mean weal diameter at the histamine site. A positive SPT was defined as an allergen histamine weal ratio of 0.5 or more, corresponding to grade 2 + as described by Aas & Belin [8]. The same technician performed all SPTs. The reproducibility of the SPT in the hands of the technician was established by performing two histamine SPTs on 20 volunteers. The coefficient of variation was 0.14.

Specific IgE measurements

Venous blood was taken on the day of examination and the blood samples were left to coagulate for 2 h. Then the serum was separated by centrifugation at 2000 *g* for 10 min, and frozen immediately thereafter. The serum samples were kept at -20°C without thawing until the analysis in 1999. We have previously reported that in these serum samples degradation of specific IgE antibodies during storage could not be detected [1]. Serum samples were available for analysis from 98.7% (1098/1112) of the subjects. The serum samples were analysed for specific IgE to birch, grass (timothy), mugwort, dog and cat dander, and house dust mite (*D. pteronyssinus*) using the ADVIA[®] Centaur; Specific IgE assay system (Bayer Corporation) [1,9]. The analysis for specific IgE was judged to be positive if the measurement was in excess of 0.35 kU/L.

Definition of variables

Information on health, lifestyle and socio-economic variables was obtained in a detailed questionnaire, which was completed at home. The questionnaire was collected and checked by one of the authors (NHN) on the day of the examination before SPTs were performed. Different variables on lifestyle and home environment were defined based on the questionnaire data (shown in Table 1). Alcohol consumption was defined as the number of drinks

Table 1. Distribution of explanatory variables among participants in the random and symptom group

	Prevalence in percentage	
	Random group <i>n</i> = 477	Symptom group <i>n</i> = 635
Educational level (years)		
7–9	31.9	28.8
10–11	29.6	33.2
12–13	20.3	16.7
> = 14	18.2	21.3
Body mass index (weight/(height) ⁽²⁾)		
< = 22.5	32.3	35.1
> 22.5 and < = 26.0	32.9	32.0
> 26.0	34.8	32.9
Day-care attendance		
Never	73.9	66.5
1–2 years before age 5	15.8	23.4
3–5 years before age 5	10.3	10.1
Number of siblings		
0	13.9	16.0
1	34.2	38.4
2	27.8	23.9
3	10.5	10.8
4 or more	13.5	10.9
Family history of asthma (Yes)	9.3	18.9
Family history of hayfever (Yes)	17.7	36.3
Alcohol consumption (drinks/week)		
0	12.8	15.4
1–2	17.0	21.6
3–4	19.7	20.6
5–10	26.3	23.6
> = 11	24.2	18.7
Weekly use of paracetamol or acetylsalicylic acid within last 12 months (Yes)	11.6	14.7
Smoking status		
Never smoker	26.8	37.8
Past smoker	21.8	18.4
Current smoker	51.4	43.8
Maternal smoking in childhood (Yes)	41.3	46.8
Physical exercise (> 1 h/week) (Yes)	50.2	54.3
Dog in household		
Never	32.7	34.0
Past	39.0	39.8
Current	28.3	26.1
Cat in household		
Never	59.7	58.0
Past	25.2	30.2
Current	15.1	11.8
Persons per room in residence		
< = 1	29.1	29.9
> 1 and < 2	39.6	38.3
> = 2	31.2	31.8

Table 1. *continued*

	Prevalence in percentage	
	Random group <i>n</i> = 477	Symptom group <i>n</i> = 635
Double-glazed windows (Yes)	80.0	79.6
Wall-to-wall carpets: living room (Yes)	75.5	71.8
Wall-to-wall carpets: bedroom (Yes)	63.6	63.3
Migration to Copenhagen (Yes)	58.8	55.8

per week (beer, wine and spirits) on average during the last 12 months ('0', '1–2', '3–4', '5–10', '> = 11', coded as 0, 1.5, 3.5, 7.5, 14.0 when used as trend variable). Migration to Copenhagen was defined as subjects who had not lived all their life in the area of Copenhagen ('no', 'yes'). A group variable defined whether subjects were in the random or the symptom group. Two dependent variables were defined: SPT positivity (a positive SPT to at least one of 10 allergens), and specific IgE positivity (specific IgE to at least one of six allergens).

Statistical analysis

The evaluation of potential determinants (explanatory variables) was done using multivariate logistic regression analysis with SPT positivity or specific IgE positivity as the dependent variable. Analyses were performed in two stages.

I. 'Univariate' analysis Each of the explanatory variables was included in a model together with sex, age group ('15–34 years', '35–49 years', '50–69 years') and the group variable. The explanatory variables that were associated with the dependent variable (overall *P*-value for the explanatory variable < 0.25) were selected for the second stage. Number of siblings, alcohol consumption and educational level were included as continuous categorical variables (trend variables).

II. Stepwise regression The explanatory variables selected in stage I were subsequently included in a logistic regression model selection of variables performed by stepwise regression. A *P*-value of 0.10 was considered the cutoff for entry or removal of variables. First order interactions between the different explanatory variables and the group variable were tested in the final models. In addition, a test for interaction of explanatory variables with sex or age was performed. Since familial predisposition to atopic disease could affect the individuals' habits as regards

smoking and keeping of pets, tests for interaction between family history of asthma (or hayfever) and smoking status or dog in household were also performed.

All data were analysed with the Statistical Products and Service Solutions package (SPSS) for Windows (Release 9.0); 95% confidence limits were used.

Results

The prevalence of SPT positivity was 17.4% (83/476) and 53.4% (338/633) in the random and the symptom group, respectively, while the prevalence of specific IgE positivity was 15.1% (71/470) and 52.0% (327/629) in the random and the symptom group, respectively. The distribution of explanatory variables among the participants is shown in Table 1.

The evaluation in 'univariate' analysis of each of the explanatory variables is presented in Table 2. It showed that number of siblings (included as trend variable), family history of hayfever, smoking status and physical exercise were significantly associated with both SPT positivity and specific IgE positivity. In addition, body mass index and use of paracetamol or acetylsalicylic acid was significantly associated with specific IgE positivity, whereas dog in household was significantly associated with SPT positivity.

The final models for both dependent variables obtained by stepwise regression analyses included sex, age group, group, number of siblings (included as trend variable), alcohol consumption (included as trend variable), family history of hayfever and smoking status. In addition, the final model with SPT positivity as the dependent variable included family history of asthma and dog in household, whereas the final model with specific IgE positivity as the dependent variable included body mass index. Essentially similar results were obtained when a positive SPT was defined as an allergen reaction of 3 mm or more. Moreover, the odds ratio estimates for the explanatory variables included in the final models changed little when educational level was added to the models. Table 3 shows the mutually adjusted odds ratio estimates for all variables selected in the final models.

In the final models, potential first order interactions between the group variable and each of the explanatory variables were investigated and none was found to be statistically significant. Thus, there was no evidence that the relationship between sensitization and the explanatory variables that remained in the final models were different between subjects who had been selected at random and subjects who had been selected on the basis of symptoms. Due to significant interaction between age group and smoking status, the association between smoking status and specific IgE positivity is reported separately for each age group (Table 4). It appears that the negative association of

current and past smoking with specific IgE positivity became stronger with increasing age group (Table 4). The association between smoking status and SPT positivity showed a similar age dependency (data not shown). Young age was also significantly associated with both dependent variables in the final models.

The association between alcohol consumption and SPT positivity was not significant in 'univariate' analysis, but became significant in multivariate analysis with SPT positivity as the dependent variable. This suggests confounding by other variables, and it was noted that when smoking was added to the univariate analysis, the association between alcohol consumption and SPT positivity became significant. Thus, smoking appeared to be a confounder for the association between SPT positivity and alcohol consumption. When analysing the consumption of wine, beer and spirits as separate variables it showed that the association between alcohol consumption and SPT positivity was mainly due to the consumption of wine. The association between wine consumption and allergic sensitization is shown in Table 5. It shows that also for wine consumption the dose-response relationship with sensitization was only significant for SPT positivity.

Discussion

We found that being male, young age, a positive family history of hayfever, low number of siblings and never smoking were independently associated with allergic sensitization as expressed by both SPT positivity and specific IgE positivity to common aeroallergens.

It is well established that an increasing number of siblings is inversely related to allergic sensitization, although the reasons for this are not fully understood [10,11]. Also sex, age and family history of atopic disease are well-known determinants of respiratory allergy [12].

Although smoking is a risk factor for asthma, its relation to the development of allergic sensitization is not clear. Several cross-sectional population-based studies have reported a negative association between smoking and allergic sensitization [13–16]. Jarvis *et al.* reported that smoking was positively associated with sensitization to house dust mite, and negatively associated with sensitization to grass and cat [17]. Gergen *et al.* found no association between smoking and sensitization, but details were not given [18]. From cross-sectional data it may, however, be difficult to determine whether smokers are less likely to develop sensitization or sensitized smokers tend to quit smoking or sensitized persons never start smoking. One prospective population-based study, reported by Barbee *et al.* [19], found that consistent smokers were less likely to develop sensitization during an 8-year period compared with consistent never smokers. In addition, this

Table 2. The evaluation of determinants in 'univariate' analysis with skin prick test positivity or specific IgE positivity as the dependent variable

Explanatory variable	Dependent variable Skin prick test positivity Odds ratio* (95% CI)	Specific IgE positivity Odds ratio* (95% CI)
Educational level (years)		
7–9	(reference) $P = 0.09^\dagger$	(reference) $P = 0.08^\dagger$
10–11	1.03 (0.71–1.49)	1.03 (0.70–1.50)
12–13	1.51 (1.00–2.29)	1.50 (0.98–2.30)
> = 14	1.25 (0.84–1.86)	1.28 (0.85–1.94)
Body mass index		
< = 22.5	(reference)	(reference)
> 22.5 and < = 26.0	1.41 (1.01–1.98)	1.99 (1.40–2.84)
> 26.0	1.09 (0.76–1.54)	1.24 (0.86–1.79)
Day care attendance		
Never	(reference)	(reference)
1–2 years before age 5	0.92 (0.66–1.29)	1.01 (0.71–1.43)
3–5 years before age 5	0.63 (0.40–1.01)	0.83 (0.52–1.32)
Number of siblings		
0	(reference) $P = 0.02^\dagger$	(reference) $P < 0.01^\dagger$
1	1.07 (0.71–1.61)	0.98 (0.64–1.48)
2	0.99 (0.64–1.52)	0.80 (0.51–1.25)
3	0.77 (0.45–1.32)	0.71 (0.41–1.23)
4 or more	0.56 (0.32–0.96)	0.47 (0.26–0.83)
Family history of asthma (Yes vs. No)	1.41 (0.98–2.04)	1.22 (0.83–1.78)
Family history of hayfever (Yes vs. No)	1.76 (1.31–2.37)	1.64 (1.20–2.22)
Alcohol consumption (drinks/week)		
0	(reference) $P = 0.16^\dagger$	(reference) $P = 0.29^\dagger$
1–2	0.89 (0.56–1.42)	1.07 (0.66–1.73)
3–4	0.98 (0.61–1.56)	1.21 (0.74–1.96)
5–10	1.11 (0.70–1.75)	1.10 (0.68–1.78)
> = 11	1.25 (0.76–2.05)	1.35 (0.81–2.26)
Alcohol consumption (trend variable)	1.02 (0.99–1.05)	1.02 (0.99–1.05)
Weekly use of paracetamol or acetylsalicylic acid (Yes vs. No)	0.68 (0.45–1.03)	0.63 (0.41–0.97)
Smoking status		
Never smoker	(reference)	(reference)
Past smoker	0.81 (0.55–1.19)	0.67 (0.45–1.00)
Current smoker	0.53 (0.39–0.71)	0.45 (0.33–0.62)
Maternal smoking in childhood (Yes vs. No)	0.84 (0.64–1.11)	0.78 (0.58–1.04)
Physical exercise (> 1 h/week) (Yes vs. No)	1.40 (1.07–1.84)	1.39 (1.05–1.85)
Dog in household		
Never	(reference)	(reference)
Past	0.60 (0.44–0.83)	0.81 (0.59–1.12)
Current	0.81 (0.58–1.14)	0.85 (0.60–1.22)
Cat in household		
Never	(reference)	(reference)
Past	0.84 (0.62–1.14)	0.78 (0.57–1.08)
Current	0.83 (0.55–1.25)	0.74 (0.48–1.14)
Persons per room in residence		
< = 1	(reference)	(reference)
> 1 and < 2	1.00 (0.72–1.39)	1.00 (0.71–1.40)
> = 2	1.33 (0.92–1.93)	1.15 (0.78–1.67)
Double-glazed windows (Yes vs. No)	0.88 (0.63–1.22)	0.83 (0.59–1.18)
Wall-to-wall carpets: living room (Yes vs. No)	0.97 (0.77–1.24)	1.03 (0.81–1.32)
Wall-to-wall carpets: bedroom (Yes vs. No)	0.77 (0.58–1.01)	0.77 (0.58–1.03)
Migration to Copenhagen (Yes vs. No)	0.98 (0.73–1.30)	1.06 (0.79–1.43)

*Odds ratio adjusted for group, sex and age group in a logistic regression model. † Test for trend.

Table 3. Logistic regression models with selected variables (see text) with skin prick test positivity or specific IgE positivity as the dependent variable

Explanatory variable	Dependent variable	
	Skin prick test positivity Odds ratio* (95% CI)	Specific IgE positivity Odds ratio* (95% CI)
Sex		
Male	1 (reference)	1 (reference)
Female	0.65 (0.47–0.89)	0.46 (0.33–0.65)
Family history of asthma (Yes vs. No)	1.37 (0.92–2.05)	1.20 (0.79–1.82)
Family history of hayfever (Yes vs. No)	1.59 (1.16–2.18)	1.53 (1.11–2.13)
Body mass index		
≤ 22.5	1 (reference)	1 (reference)
> 22.5 and ≤ 26.0	1.48 (1.04–2.10)	1.99 (1.37–2.89)
> 26.0	1.10 (0.76–1.60)	1.21 (0.82–1.79)
Number of siblings		
0	1 (reference) $P = 0.03^\dagger$	1 (reference) $P < 0.01^\dagger$
1	1.02 (0.67–1.55)	0.92 (0.59–1.42)
2	0.96 (0.61–1.51)	0.75 (0.47–1.20)
3	0.79 (0.45–1.40)	0.70 (0.39–1.25)
4 or more	0.54 (0.31–0.97)	0.45 (0.24–0.82)
Alcohol consumption (drinks/week)		
0	1 (reference) $P = 0.04^\dagger$	1 (reference) $P = 0.08^\dagger$
1–2	0.80 (0.49–1.31)	0.99 (0.59–1.66)
3–4	0.98 (0.60–1.60)	1.25 (0.75–2.10)
5–10	1.18 (0.73–1.92)	1.19 (0.71–1.98)
≥ 11	1.39 (0.82–2.35)	1.56 (0.90–2.72)
Dog in household		
Never	1 (reference)	1 (reference)
Past	0.63 (0.45–0.88)	0.85 (0.60–1.19)
Current	0.85 (0.59–1.21)	0.96 (0.66–1.40)

*Adjusted for other variables in the model including group, age group, smoking status and an interaction term between age group and smoking status. † Test for trend.

association was dependent on age, and was only significant in the two oldest age groups [19].

An age dependency of the effect of smoking was also apparent in the present study. Thus, the negative association

of current and past smoking with sensitization became stronger with increasing age group, and as for past smoking the association was not present at all in the youngest age group. One may speculate that this age dependency could

Table 4. The association between smoking and specific IgE positivity by age group

Smoking status	Specific IgE positivity (dependent variable)		
	Age 15–34 years Odds ratio* (95% CI)	Age 35–49 years Odds ratio* (95% CI)	Age 50–69 years Odds ratio* (95% CI)
Never smoker	1 (reference)	1 (reference)	1 (reference)
Past smoker	1.07 (0.53–2.16)	0.84 (0.41–1.71)	0.32 (0.14–0.74)
Current smoker	0.65 (0.40–1.07)	0.65 (0.37–1.15)	0.15 (0.07–0.34)

*Adjusted for sex, group, number of siblings, family history of hayfever and body mass index.

Table 5. The association between allergic sensitization and wine consumption

Wine consumption (glasses/week)	Dependent variable	
	Skin prick test positivity Odds ratio* (95% CI)	Specific IgE positivity Odds ratio* (95% CI)
0	1 (reference) $P < 0.01^\dagger$	1 (reference) $P = 0.15^\dagger$
1–2	0.87 (0.62–1.23)	0.84 (0.59–1.20)
3–4	1.25 (0.79–1.95)	1.03 (0.64–1.65)
5–10	1.39 (0.85–2.25)	1.18 (0.71–1.95)
> = 11	2.57 (1.19–5.56)	1.72 (0.77–3.86)

*Adjusted for sex, age group, group, number of siblings, family history of hayfever and asthma, educational level, dog in household, body mass index and an interaction term between smoking status and age group. † Test for trend.

reflect that the negative effect of smoking is dependent on the duration of time that subjects have been smoking, which was in fact the case in this population (data not shown). Alternatively, the age dependency could merely reflect the result of self-selective mechanisms, i.e. a healthy smoker effect, increases with time. In contrast to population-based studies, several occupational studies have reported that active smoking was associated with an increased risk of allergic sensitization to occupational allergens [20–22], although some have not [23,24]. In conclusion, the role of smoking in the development of allergic sensitization is not clear, and this issue will only be further elucidated when more data from prospective studies are available.

The observed relationship between alcohol consumption and allergic sensitization should be interpreted with caution, as to our knowledge there do not seem to be any previous reports addressing this relationship. Furthermore, it was only significant for SPT positivity, which may be less reproducible than specific IgE positivity. On the other hand, it has been reported that total IgE is increased in alcoholics admitted to hospital with abstinence syndrome independent of the severity of the underlying liver disease [25,26], and that this is accompanied by an increase of some type 2 cytokines [26]. Bjerke *et al.* found that alcohol consumption by mothers during pregnancy was positively associated with increased levels of total IgE in cord blood [27]. Furthermore, alcohol impairs the Th1-lymphocyte-regulated cell-mediated immune response in experimental animals (mice) favouring a Th2-lymphocyte deviation of the immune response [28]. The above evidence is, however, indirect, and it is not known whether alcohol-induced changes in the immune response increase the risk of the development of allergic sensitization, or alternatively only have an influence on SPT reactions. The finding that wine consumption was the main reason for the observed

association between alcohol consumption and SPT positivity could suggest that the association might be due to residual confounding by social status or diet. In fact, in this study population, the consumption of wine increased significantly with increasing educational level. However, adjustment for educational level did not change the estimates. Recent increases in weekly alcohol consumption and drunkenness among adolescents have been reported in many countries [29]. In Denmark, the frequency of weekly drinking among 15-year-olds has increased from 18% to 42% between 1985 and 1998 [30]. Considering this, the relationship of alcohol consumption to allergic sensitization deserves further investigation.

The interpretation of the observed association between specific IgE positivity and body mass index is not straightforward. Thus, a body mass index in the middle tertile, but not in the highest tertile, was significantly associated with a high prevalence of sensitization. This lack of any apparent dose–response relationship between body mass index and sensitization does not favour the interpretation that the relationship is one of causality. Moreover, performing analyses with body mass index in quintiles yielded essentially similar results. On the other hand, no significant association was seen when body mass index was categorized as underweight (< 20), normal weight (< 25) (used as reference), overweight (< 30) and obese (> 30) (data not shown). Few studies have addressed this issue. Huang *et al.* have reported a dose–response relationship of SPT positivity with increasing body mass index in teenage girls, but not in boys [31]. Xu *et al.* also found a significant positive association between body mass index and sensitization in 31-year-olds [32]. In addition, recent studies have proposed that fatness plays a role in asthma morbidity [33–36]. The underlying mechanisms for the possible relationship between body mass index and sensitization are speculative, but include hormonal and

dietary factors [32]. Since the prevalence of overweight people in Denmark has increased over recent decades as part of a world-wide epidemic of obesity in affluent countries [37], the role of body mass index in the development of allergic sensitization may be an interesting issue to address in prospective studies.

It has recently been questioned that previous exposure to pets should increase the risk of the development of allergic sensitization [38]. Results from the European Community Respiratory Health Survey showed in a large multicentre general population sample that the presence of a dog in the home in childhood was negatively associated with allergic sensitization in adulthood [39]. Our findings could confirm this negative association between previous keeping of a dog in the household and allergic sensitization as expressed by SPT positivity. In the present study, a total of 77 subjects reported that they had stopped having pets because of respiratory symptoms. Nevertheless, the estimates for dog in household were virtually unchanged when excluding these subjects from the analysis. However, we acknowledge that the assessment of early childhood exposures in adults may be unreliable. Assuming this association represents a causal relationship, what could be the possible mechanism? Exposure to livestock has been proposed as the factor responsible for the low prevalence of atopy among farmers and farmers' children [40]. The underlying mechanism might be that livestock increase the exposure to endotoxins in the environment [41], and that endotoxins induce a Th1-lymphocyte deviation of the immune system [42]. One may speculate that the same mechanism could represent the possible link between previous keeping of a dog in the household and sensitization.

In this cross-sectional study, variables relating to indoor environment, such as wall-to-wall carpets, were not associated with sensitization. The question is whether these variables reflect previous exposure levels to dust mite allergens or avoidance measures taken by persons at risk of developing allergy. Indeed a prospective design would be more appropriate for assessing the relationship between indoor environment and development of allergic sensitization.

In conclusion, being male, young age, a positive family history of hay fever, low number of siblings and never smoking were independently associated with allergic sensitization. The results also indicated a possible relationship of alcohol consumption, body mass index and previous keeping of a dog in the household with allergic sensitization. However, the limitations of cross-sectional studies are well known, and we cannot make inferences from these data about the causality of the observed associations. Moreover, several potential risk factors were evaluated, and therefore the likelihood of finding a statistically significant association solely due to the play of chance is increased.

However, this study has addressed some new potential risk factors for allergic sensitization that could be interesting to investigate in prospectively designed studies.

Acknowledgements

We thank the staff at the Centre for Preventive Medicine for their dedicated assistance and the Product Development staff at ALK-Abelló A/S Hørsholm (Denmark) for performing serologic analyses. The Copenhagen Allergy Study is supported by grants from the Danish Medical Research Council, the Danish Health Insurance Fund, the Danish Ministry of Health (the National Health Fund for Research and Development), the Danish Medical Research Council and the Danish Ministry of Health (Research Centre for Environmental Health: Environmental Health Research Programme 1997), and ALK-Abelló A/S, Denmark.

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