

Allergic sensitization among adults in Tallinn, Estonia

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Summary

Background The prevalence of allergic sensitization has increased worldwide during recent years.

Objective The aim of the study was to estimate the prevalence of allergic sensitization and to evaluate the influence of age, gender, number of siblings, pet keeping in childhood, and residential area before the age of five on allergic sensitization among adolescents and adults aged 17–66 years in the capital of Estonia, Tallinn. A cross-sectional study was carried out between March 1997 and December 1998.

Methods The sensitization to 15 inhalant allergens was assessed. The associations between sensitization based on skin prick tests (SPTs), symptoms based on a structured interview, and possible risk factors were estimated. A random sample of 516 subjects was included in the study analysis.

Results The prevalence of allergic sensitization was 34.5%, while it was 39.3% in subjects aged 20–44 years. The most prevalent sensitization was against the German cockroach, 15.5%, and it was particularly high among adolescents. It was followed by mugwort, dog, two storage mites species, and cat dander. Subjects with wheezing during the last 12 months, attacks of shortness of breath, wheezing due to furred animals, and allergic rhinitis or conjunctivitis had a significantly higher prevalence of positive SPT.

Conclusion We found a surprisingly high prevalence of allergic sensitization among adults in Tallinn. Our results suggest that the cockroach allergen should be included in the investigation panel in order to reach a true prevalence of allergic sensitization in Estonia. Further, the pattern of allergic sensitization in Estonia appears to be different from published data about allergic sensitization in Scandinavia.

Keywords allergic sensitization, asthma, prevalence, respiratory symptoms, skin prick tests

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Introduction

The prevalence of diseases related to allergic sensitization has increased in western European countries during recent decades [1–4]. A lower prevalence of allergic rhinitis and allergic sensitization in adults was found in eastern Germany compared with those living in western Germany [5, 6]. Atopy data in the general population in the former Soviet Union are sparse. Studies have generally been conducted on patients with a variety of diagnoses or exposures. However, reports have been published in the past few decades showing a low prevalence of allergic diseases [7–10]. In 1980, asthma was diagnosed in 0.9% of the students in Tallinn, Estonia [11]. According to the Estonian Bureau of Medical Statistics, the prevalence of asthma diagnosed by physicians in 1990 was 0.5%, 0.9%, and 0.2% in Tallinn, Tartu, and Narva, respectively [12]. The presented data so far suggest a low

prevalence of allergic sensitization in the former Soviet Union.

The only Estonian study of allergic sensitization in a general population sample of adults has been performed in the city of Tartu in subjects aged 20–44 years. The prevalence of at least one positive skin prick test (SPT) was 32% [13]. Investigations carried out among Estonian schoolchildren found a relatively high prevalence of bronchial hyper-responsiveness activity, but a low prevalence of allergic sensitization [14–16].

To estimate the prevalence of respiratory symptoms, asthma, chronic bronchitis, chronic obstructive pulmonary disease, and type-1 allergy among Estonian adults, a large epidemiological study is in progress. Parallel studies in Finland and Sweden, the FinEsS studies, enable us to compare the prevalence and characteristics of the above-mentioned conditions between several areas in Finland, Estonia, and Sweden [17–21].

The aim of the present study was to assess the prevalence of allergic sensitization, to analyse the relationship between allergic sensitization and respiratory symptoms, asthma, and

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allergic rhinitis or conjunctivitis, and to estimate the effects of age, gender, number of siblings, pet keeping in childhood, and residential area during the first 5 years of life on allergic sensitization in adults and adolescents in a general population sample in Tallinn, the capital of Estonia.

Material and methods

Study area

Estonia is the northernmost of the three Baltic countries. Tallinn is situated on the east coast of the Baltic Sea and had 460 000 inhabitants in 1996. The major ethnic group is Estonian (49%); other ethnic groups include mainly Russian-speaking persons (41%). Tallinn is heavily industrialized and has different types of residential areas, including suburbs with modern private houses, old wooden buildings, and medieval stone houses in the centre. Still, the majority of the inhabitants live in blocks of apartment houses with 5–14 floors.

Study design and population

The study was carried out between March 1997 and December 1998, and 1332 subjects, stratified by age and gender, were randomly selected from the 8392 responders to a postal questionnaire in a previous study of the general population [21]. Eighty-six subjects could not participate in the study: eight persons were deceased, one was imprisoned, 62 had unknown location, and 15 had severe health reasons. The sample thus consisted of 1246 persons who received an invitation to an examination at the Department of Pulmonology of the Institute of Experimental and Clinical Medicine (IECM) in Tallinn. After two reminders, 579 persons aged 17–66 years, or 46.5% of the study sample, participated. They were investigated by means of a structured interview, a physical examination, spirometry, bronchodilation test or a metacholine challenge test, and an SPT. Sixty-two subjects were excluded from the skin prick testing due to acute asthma, upper or lower airways infection, unstable heart failure, pregnancy, breastfeeding, or cancer. Thus, skin prick testing was undertaken in 517 persons. The interview included questions regarding respiratory symptoms and diseases, whether diagnoses were established by a physician, use of medicines, symptoms at various exposures, characteristics of childhood and profession, smoking habits, and food consumption. Estonian and Russian versions of the interview questionnaire were employed by Estonian- and Russian-speaking persons, respectively.

The study sample included 233 (45.1%) men and 283 (54.9%) women. The age distribution is shown in Table 1. Current smokers were 196 (38.0%), ex-smokers 65 (12.6%), and non-smokers 255 (49.4%). Residential areas during the first 5 years of life were 184 (35.7%) rural, 100 (19.3%) suburban, and 232 (45.0%) urban, respectively, and 249 (48.3%) persons had had a pet at home during the first 5 years of life. Compared with the postal questionnaire study, the prevalence of respiratory symptoms reported by these 517 subjects was similar; the prevalence of recurrent wheeze was 12.2% vs. 11.4%, wheezing with shortness of breath 7.2% vs.

7.2%, wheezing with shortness of breath apart from colds 4.2% vs. 4.3%, and physician-diagnosed asthma 2.3% vs. 2.9%. Similar proportions, 11%, had reported a family history of asthma. The study was approved by the Ethics Committee of Tallinn.

SPTs

SPTs were performed in duplicate on the volar aspects of the forearms with 15 allergen extracts that were labelled in histamine equivalent prick units (HEP), weight/volume (w/v), or biologic units (BU). Unless otherwise stated, the allergens were provided by ALK, Hørsholm, Denmark. The following allergen extracts were used: two house dust mites (*Dermatophagoides pteronyssinus* (10 HEP) and *Dermatophagoides farinae* (10 HEP)), two storage mites (*Lepidoglyphus destructor* (10 000 BU/mL) and *Acarus siro* (10 000 BU/mL, Laboratorium Diephuis, the Netherlands)), four furred animals (cat (10 HEP), dog (10 HEP), cow (1:100 w/v), and horse (10 HEP)), pollen from birch (10 HEP), timothy (10 HEP), and mugwort (10 HEP), two moulds (*Alternaria alternata* (1:20 w/v) and *Cladosporium herbarum* (1:20 w/v)), latex (100 IR/mL, Alyostal ST-IR, Stallergenes SA, France), and the German cockroach (1:10 w/v, Bayer, Elkhart, IN, USA). Lancets from ALK were used. Histamine dihydrochloride (10 mg/mL) was used as a positive control and 50% glycerol was used as a negative control. The prick tests were performed according to the position paper 'Allergen standardisation and skin tests by EAACI Subcommittee on Allergen Standardisation and Skin Tests' [22] and carried out by two trained physicians (A. R.-K. and E. R.).

An SPT was regarded as positive if the weal was = 3 mm, calculated as the sum of the longest and the mid-point orthogonal diameters divided by two. The size of both duplicated weals was registered, whereas only the size of the larger weal was used in the analyses of the results.

Definitions

Allergic sensitization: A person was classified as sensitized if at least one positive SPT was registered.

Adolescents: Refer to the age group 17–24 years of age.

Domestic location: The question 'Where did you live mostly during the first 5 years of your life' divided the subjects into urban, rural, and suburban groups.

The following conditions were considered as existing based on an answer 'yes' to the following questions from the interview questionnaire:

Wheezing in the last 12 months: 'Have you had wheezing or whistling in your chest at any time in the last 12 months?'

Attacks of shortness of breath with wheezing: 'Have you had any attacks of breathlessness or attacks of shortness of breath with wheezing in the last 12 months?'

Wheezing with shortness of breath apart from colds: 'Have you had wheezing or whistling in your chest at any time in the last 12 months?', 'Have you been at all breathless when the wheezing noise was present?', and 'Have you had this wheezing or whistling when you did not have a cold?'

Wheezing due to furred animals: 'Does exposure to furred animals provoke wheezing or whistling, or attacks of shortness of breath, with or without cough?'

Physician-diagnosed asthma: 'Have you been diagnosed as having asthma by a doctor?'

Allergic rhinitis or conjunctivitis: 'Do you have or have you had hay fever or allergic rhinitis or conjunctivitis?'

Analyses

One person out of 517 investigated subjects presented a positive reaction to the negative control and was excluded from the study analysis. Thus, the analyses were based on the 516 persons who participated in the interview and the skin prick testing, and had a negative reaction to the negative control. Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS 10.0, Chicago, IL, USA). The χ^2 test and one-way analysis of variance (ANOVA) were used for bivariate calculations and test for trend. Odds ratios (ORs) for various independent variables as risk factors for allergic sensitization were calculated using multiple logistic regression analysis.

Results

Allergic sensitization

Of 516 analysed subjects, 178 (34.5%) had at least one positive SPT, and the prevalence decreased with increasing age. The prevalence was 37.9% in subjects aged 25–44 years, while it was 45.8% in those aged 17–24 years (Table 1). When estimated at ages 20–44 years, the prevalence was 39.3%.

Men were significantly more sensitized to the storage mites *Acarus siro*, 10.3%, and *Lepidoglyphus destructor*, 10.3%, compared with women, 5.0% ($P = 0.036$) and 5.3% ($P = 0.049$), respectively. No other gender differences were found. Sensitization to the German cockroach was found to be the most prevalent in all age groups, 28.8% among subjects aged 17–24 years, 15.7% among those aged 25–44 years, and 12.4% among those aged 45–66 years, and on

average 15.5%. Overall, mugwort was the second most prevalent allergen causing a positive SPT, 9.7%, and the prevalence in the age group 25–44 years was 15.2%. In the age group of 17–24 years, birch pollen yielded the second highest prevalence, 17.0%.

Domestic location before the age of 5 years

The sensitization to at least one of the 15 allergens was 39.2% in the urban group, 36.0% in the suburban group, and 28.3% in the rural group (test for trend: $P = 0.02$). Furthermore, the sensitization to pollen was 19.4% in the urban group, 17.0% in the suburban group, and 8.7% in the rural group ($P = 0.003$). Similarly, significant trends were found for sensitization to cat (urban 9.9%, suburban 9.0%, and rural 3.3%, $P = 0.01$) and to dog (urban 12.1%, suburban 9.0%, and rural 4.9%, $P = 0.01$). Also, mite and cockroach sensitization was lowest in the rural group (both 13.0%) but highest in the suburban groups (mites 23.0%; cockroach 19.0%, although not significantly higher for cockroach).

Allergic sensitization related to symptoms and diseases

The proportions of persons with allergic rhinitis or conjunctivitis, physician-diagnosed asthma, attacks of shortness of breath with wheezing, wheezing in the last 12 months, wheezing with shortness of breath apart from colds, and wheezing when exposed to furred animals who were SPT positive are shown in Table 2. The presence of the defined respiratory symptoms, physician-diagnosed asthma, and allergic rhinitis or conjunctivitis was found to be significantly associated with positive SPT. Of the persons having wheezing or shortness of breath when exposed to furred animals, 68.8% had at least one positive SPT, and allergic sensitization to furred animals was significantly more prevalent among subjects with almost any of the symptoms and diseases. At the same time, allergic sensitization to pollen was significantly

Table 1. Prevalence (%) of positive skin prick tests to various allergens by age and gender

Allergen	17–24 years (n = 59)			25–44 years (n = 198)			45–66 years (n = 259)			Total	
	Male	Female	All	Male	Female	All	Male	Female	All	Abs.	%
<i>Dermatophagoides pteronyssinus</i>	4.2	5.7	5.1	10.3	8.9	9.6	6.3	3.4	4.6	34	6.6
<i>Dermatophagoides farinae</i>	4.2	2.9	3.4	8.3	6.9	7.6	8.9	2.7	5.4	31	6.0
Cat	12.5	17.1	15.3	9.3	8.9	9.1	1.8	6.1	4.3	38	7.4
Dog	8.3	14.3	11.9	9.3	7.9	8.6	5.4	10.9	8.5	46	8.9
Cow	—	—	—	2.1	1.0	1.5	0.9	2.0	1.5	7	1.4
Horse	—	—	—	2.1	1.0	1.5	1.8	0.7	1.2	6	1.2
Birch	20.8	14.3	17.0	7.2	8.9	8.1	0.9	4.8	3.1	34	6.6
Timothy	20.8	2.9	10.2	8.3	10.9	9.6	0.9	2.7	1.9	30	5.8
Mugwort	16.7	2.9	8.5	17.5	12.9	15.2	3.6	7.5	5.8	50	9.7
<i>Alternaria alternata</i>	4.2	2.9	3.4	3.1	—	1.5	—	2.7	1.5	9	1.7
<i>Cladosporium herbarum</i>	—	—	—	4.1	—	2.0	0.9	3.4	2.3	10	1.9
<i>Acarus siro</i>	12.5	—	5.1	12.4	5.0	8.6	8.0	6.1	7.0	38	7.4
<i>Lepidoglyphus destructor</i>	16.7	5.7	10.2	12.4	3.0	7.6	7.1	6.8	7.0	39	7.6
Cockroach	41.7	20.0	28.8	19.6	11.9	15.7	13.4	11.6	12.4	80	15.5
Latex	—	—	—	2.1	—	1.0	0.9	2.0	1.5	6	1.2
Total	50.0	42.9	45.8	41.2	34.7	37.9	27.7	30.6	29.3	178	34.5

Table 2. Prevalence of positive SPTs to various allergens among the subjects who responded to have vs. not to have the symptoms and diseases

Symptom or condition		% of positive SPT									
		At least one positive SPT	<i>P</i> -value	Pollen	<i>P</i> -value	Animal dander	<i>P</i> -value	Mould	<i>P</i> -value	Cockroach	<i>P</i> -value
Wheezing in the last 12 months	Yes	44.1	<i>P</i> = 0.018	19.5	NS	21.2	<i>P</i> = 0.004	1.7	NS	20.3	NS
	No	31.8		13.8		10.5		3.5		14.3	
Attacks of SOB with wheezing	Yes	55.6	<i>P</i> = 0.032	3.7	NS	37.0	<i>P</i> < 0.001	3.7	NS	25.9	NS
	No	33.5		15.7		11.6		3.1		15.1	
Wheezing with SOB apart from colds	Yes	41.2	NS	14.7	NS	23.5	NS	2.9	NS	29.4	<i>P</i> = 0.042
	No	51.9		15.1		12.2		3.1		14.7	
Wheezing when exposed to furred animals	Yes	68.8	<i>P</i> = 0.008	25.0	NS	62.5	<i>P</i> < 0.001	25.0	<i>P</i> < 0.001	37.5	<i>P</i> = 0.037
	No	33.5		14.8		11.4		2.3		15.0	
Physician-diagnosed asthma	Yes	55.6	NS	11.1	NS	38.9	<i>P</i> = 0.003	5.6	NS	22.2	NS
	No	33.9		15.2		12.0		3.0		15.4	
Allergic rhinitis or conjunctivitis	Yes	42.6	<i>P</i> < 0.001	20.0	<i>P</i> = 0.002	18.9	<i>P</i> < 0.001	3.4	NS	19.6	<i>P</i> = 0.016
	No	26.2		9.9		6.8		2.8		11.5	

The *P*-values are calculated between symptomatic vs. non-symptomatic subjects and the subjects with asthma or allergic diseases vs. subjects without asthma or allergic diseases. SPT: skin prick test; SOB: shortness of breath; NS: not significant.

Table 3. Effects of independent variables on positive skin prick tests, odds ratios, and 95% confidence interval (95% CI) were calculated by multiple logistic regression analysis

Independent variables		Dependent variables							
Variable	Category	Any*	Pollen	Animal dander	Mite	Cat	Dog	Cockroach	
Age (years)	45–66	1	1	1	1	1	1	1	
	25–44	1.4 (0.88–2.12)	2.5 (1.41–4.59)	0.8 (0.42–1.46)	1.1 (0.63–1.91)	2.0 (0.88–4.71)	0.8 (0.38–1.59)	1.2 (0.67–2.14)	
	17–24	1.6 (0.83–2.95)	1.9 (0.84–4.43)	1.4 (0.63–3.07)	0.9 (0.37–2.06)	3.0 (1.05–8.31)	0.9 (0.34–2.34)	2.6 (1.23–5.61)	
Gender	M	1	1	1	1	1	1	1	
	F	0.9 (0.61–1.34)	1.0 (0.61–1.70)	1.6 (0.90–2.79)	0.5 (0.31–0.87)	1.2 (0.60–2.55)	1.3 (0.68–2.51)	0.6 (0.38–1.05)	
No. of siblings	>2	1	1	1	1	1	1	1	
	0–1	1.4 (0.90–2.13)	1.4 (0.83–2.38)	1.7 (0.88–3.19)	1.2 (0.67–2.04)	2.5 (0.94–6.37)	1.9 (0.89–4.23)	1.3 (0.73–2.32)	
Animals at home < 5 years	No	1	1	1	1	1	1	1	
	Yes	1.2 (0.80–1.81)	1.4 (0.83–2.38)	1.2 (0.70–2.12)	1.5 (0.92–2.60)	2.4 (1.15–4.80)	1.1 (0.56–2.06)	1.1 (0.64–1.83)	
Domestic area < 5 years	Rural	1	1	1	1	1	1	1	
	Suburban+urban	1.3 (0.80–2.05)	1.8 (0.93–2.38)	2.1 (1.02–4.21)	1.7 (0.90–3.09)	2.4 (0.86–6.46)	2.3 (0.96–5.25)	1.0 (0.53–1.85)	

*At least one positive skin prick test.

associated only with allergic rhinitis or conjunctivitis, but not with lower respiratory symptoms or asthma (Table 2).

The sensitization to cockroach was associated with an increase in symptoms and diseases. Positive SPT to cockroach was found in 29.4% of the subjects who had wheezing with shortness of breath apart from colds vs. 14.7% among those without this symptom (*P* = 0.042). The corresponding percentages of rhinitis or conjunctivitis were 19.6% vs. 11.5% (*P* = 0.016), and for asthma 22.2% vs. 15.4% (not significant) (Table 2). In comparison, of all persons having at least one positive SPT, 5.6% had been diagnosed as having asthma, while the corresponding figure was 2.4% among those not having positive SPT. Monoallergy to cockroach occurred in 3.0%, while sensitization to at least one more allergen added

to cockroach was registered on 12.5%, among them 3.9% with cockroach–mite (*D. pteronyssinus*, *D. farinae*) combined allergy.

Multivariate relationships

ORs for different independent variables, which might have an influence on allergic sensitization, were calculated using multiple logistic regression analysis (Table 3). Being 17–24 years yielded an OR of 1.6 for having at least one positive skin test compared with the oldest age group of 45–66 years. The age group of 25–44 years was significantly associated with a positive SPT to pollen, OR 2.5, compared with the oldest age group.

An urban or suburban environment in early childhood revealed an increased risk for sensitization to cat and dog, OR 2.4 and 2.3, respectively, although not significantly so in the multivariate model, and a significantly increased risk for sensitization to at least one of the animal dander antigens, OR 2.1. The age group of 17–24 years yielded a significantly increased risk for sensitization to cockroach compared with that of 45–66 years (OR 2.6).

The OR of having a positive SPT against cat dander among subjects with animals at home before the age of five yielded an OR of 2.4 compared with subjects without this risk factor. An interesting finding was that the sensitization to animal dander in general, and to dog dander in particular, was not dependent on whether the subject had had a furred animal at home before the age of five or not. This was the case for sensitization to all allergens, except cat allergens (Table 3).

Discussion

The present study is a complex audit of the overall prevalence of allergic sensitization, the distribution of sensitization to different allergens relevant in Tallinn, and the relation between allergic sensitization and respiratory symptoms and allergic diseases presumably influenced by atopic status. The prevalence of SPT reactivity to common airborne allergens among the adult and adolescent general population of Tallinn, Estonia, was 34.5%. In the ages of 20–44 years, the prevalence was 39.3%.

In comparison with skin test reactivity in other studies of the general population, our results reach prevalence rates similar to the findings in western European countries ranging from 21% to 46% [23–30]. On comparing with the ECRHS results covering the ages of 20–44 years, the prevalence in three Swedish centres was 35–37% [30], and in Tartu, Estonia, it was 32% [13]. Our data yielded a surprisingly high prevalence of allergic sensitization in this age group, and suggest that previous results had underestimated the prevalence of allergy in Estonia.

An important factor that may influence the study outcome is the higher number of allergen extracts used in the current study compared with previous studies of allergic sensitization in Estonia. The high prevalence of positive SPT is partly due to the inclusion of cockroach in our test panel. However, the total prevalence of allergic sensitization stays at 31% after omitting the cockroach SPT results. The low level of cockroach monoallergy, 3.0%, indicates the probability that the registered cockroach prevalence rate is true and not depending on other factors, such as errors in SPT procedures or the choice of the current cockroach antigen extract. At the same time, there are publications about a positive covariation between cockroach and *Anisakis simplex* as well as *D. pteronyssinus* [31, 32].

A. simplex, a parasite of salt ocean water fish, has also been found in herring and other Baltic Sea fish common in the Estonian diet, and has not been investigated yet by allergologic means in any of the Estonian studies. Investigations in Spain strongly suggest that sensitization to *A. simplex* is caused only by living larvae and not by allergens contained in fish tissue [33]. Regarding cross-reactivity with mite

allergen, we estimated cockroach and house dust mite polyallergy, and the corresponding polyallergies of cockroach and *A. siro* and *L. destructor*, and they stayed at 3.9%, 5.6%, and 5.4%, respectively. The prevalence of symptoms among those sensitized to cockroach remained similar after the exclusion of subjects also sensitized to mites and to cat. For instance, after the exclusion of subjects sensitized to cat, the prevalence of wheezing in the last 12 months remained at 23–24%.

An important source of variability among different epidemiological studies is the use of different allergens and the significance of the allergens on sensitization and disease in defined areas. A major finding of our study was that the distribution of allergens causing allergic sensitization was more or less incomparable to those from studies previously conducted in Estonia and in countries geographically close to Estonia, as these did not include allergen from cockroach [13, 15, 30, 34–37]. However, in some areas, cockroach allergen does not exist [29], according to analyses of dust and sera from northern Sweden [38]. In contrast, allergy to cockroach is significant in Norway [39]; further, sensitization to cockroach is common in the former Soviet Union areas, particularly in St Petersburg located at the Baltic Sea [40].

The prevalence of allergic sensitization to German cockroach exceeded the prevalence of sensitization to any other allergen nearly twice, followed by sensitization to mugwort, dog dander, and two storage mite species. Unfortunately, at least three recent studies did not include cockroach allergen in their SPT investigation among Estonian infants and schoolchildren [15, 36, 37]. Our data suggest that allergic sensitization against cockroach should be examined in order to reveal the true prevalence of allergic sensitization in Estonia and probably adjacent geographic locations.

Furthermore, other allergens such as cow dander, storage mites, and latex were included in our panel. Sensitization to these allergens has previously not been studied in Estonia. However, omitting these allergens from the analyses did not significantly influence the total prevalence of allergic sensitization, implicating that a larger allergen panel *per se* does not have a major influence on the prevalence of positive SPT in a general population sample. The awareness of allergy and its symptoms may still be lower in Estonia than in western European countries [34]. However, the rapid assimilation of daily life in many aspects is easily detectable and the large number of positive SPT may be an indication of lifestyle changes in Estonia.

Our study may have been influenced by the low participation rate. In order to correct for the possible bias caused by non-participants, we analysed the representativity of the participating persons by comparing the prevalence of rhinitis, physician-diagnosed asthma, respiratory symptoms common in asthma, and smoking habits with the prevalence rates of all responders to the postal questionnaire. We did not observe any significant differences in these aspects.

In Scandinavian studies of the general population, common allergens have been birch and timothy pollen as well as cat and dog dander [29, 30, 35]. Although the pattern of allergens used in the test panels has not been identical, the proportion of sensitized subjects with asthma and rhinitis or conjunctivitis in previous studies was similar to the results in the present study [29, 30, 35]. In contrast to Swedish studies,

having animals at home in childhood was found to be a risk factor for sensitization to cat [29, 30].

Italian students living in an urban area were more frequently sensitized to pets, while students living in a rural area were more often sensitized to pollen [41]. In our investigation, living in urban and suburban areas up to the age of five was a strong risk factor for allergic sensitization, particularly against animal dander but also to pollen and to allergic sensitization in general. This finding is in concordance with results from several recent studies [29, 42–44]. Explanations may include environmental exposure to immune modulating agents in rural locations during childhood. Such exposure may trigger immune tolerance and diminish the probability of atopy [44]. Another explanation may be the production of IgG related to high allergen exposure instead of development of allergy [45].

In conclusion, our study showed that 46% of persons aged 17–24 years and more than one-third of the general adult and adolescent population of Tallinn, Estonia, had positive SPT. Subjects with asthma, symptoms associated with asthma, and rhinitis or conjunctivitis were found to have a significantly higher prevalence of allergic sensitization. Cockroach allergy dominated in the general population in all age groups, and was related to wheezing symptoms and rhinitis.

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References

- Upton MN, McKonnackie A, McSharry C et al. Intergenerational 20 year trends in the prevalence of asthma and hay fever in adults: the Midspan family study surveys of parents and offspring. *BMJ* 2000; 321:88–92.
- Kronqvist M, Johansson E, Pershagen G et al. Increasing prevalence of asthma over 12 years among dairy farmers on Gotland, Sweden: storage mites remain dominant allergens. *Clin Exp Allergy* 1999; 29:35–41.
- Nicolai T, Bellach B, Mutius EV et al. Increased prevalence of sensitisation against aeroallergens in adults in West compared with East Germany. *Clin Exp Allergy* 1997; 27:886–92.
- Lundbäck B. Epidemiology of rhinitis and asthma. *Clin Exp Allergy* 1998; 28:3–10.
- Trepka MJ, Heinrich J, Wichmann HE. The epidemiology of atopic diseases in Germany: an east–west comparison. *Rev Environ Health* 1996; 11:119–31.
- Nowak D, Heinrich J, Jorres R. Prevalence of respiratory symptoms, bronchial hyperresponsiveness and atopy among adults: west and east Germany. *Eur Respir J* 1996; 9:2541–52.
- Vershigora AE, Sidorenko EN. Sensitization to microbial and exogenous allergens in patients with bronchial asthma. *Vrach Delo* 1965; 10:94–8, (in Russian).
- Jannus L, Karusoo J, Raukas E et al. Chronic non-specific pathology of the lungs among the population of the Estonian SSR. *Ter Arkh* 1972; 12:80–83, (in Russian).
- Tesalova OT. Incidence of allergic dermatoses among the rural population of the Lithuanian SSR. *Vestnik Dermatol Venerol* 1975; 7:44–8, (in Russian).
- Moshkevich VS. Epidemiology of allergic diseases of the respiratory passages in the Kazakh SSR. *J Hyg Epidemiol Microbiol Immunol* 1985; 29:47–58, (in Russian).
- Jannus L, Sauemägi L, Tamm S. Prebronchitis and chronic bronchitis in adolescents. Abstracts of 18. USSR Therapeutic Conference, Moscow 1981; 2:183–5, (in Russian).
- Jannus-Pruljan L, Loit HM. Bronchial asthma in Estonia. *Tuber Lung Dis* 1994; 1 (Suppl.):117s.
- Jogi R, Janson C, Björkstén B. Prevalence of atopy in an Estonian adult population. *Eur Respir J* 1995; 19 (Suppl.):107.
- Vasar M, Brabäck L, Julge K et al. Prevalence of bronchial hyperreactivity as determined by several methods among Estonian schoolchildren. *Pediatr Allergy Immunol* 1996; 7:141–6.
- Riikjäär MA, Annus T, Brabäck L, Rahu K, Björkstén B. Similar prevalence of respiratory symptoms and atopy in Estonian schoolchildren with changing lifestyle over 4 yrs. *Eur Respir J* 2000; 16:86–90.
- Julge K, Vasar M, Björkstén B. Development of allergy and IgE antibodies during the first five years of life in Estonian children. *Clin Exp Allergy* 2001; 32:1854–61.
- Pallasaho P, Lundback B, Laspa SL et al. Increasing prevalence of asthma but not of chronic bronchitis in Finland? Report from the FinEsS-Helsinki Study. *Respir Med* 1999; 93:798–809.
- Kotaniemi JT, Lundback B, Nieminen MM, Sovijärvi AR, Laitinen LA. Increase of asthma in adults in northern Finland? – a report from the FinEsS study. *Allergy* 2001; 56:169–74.
- Lindström M, Kotaniemi J, Jonsson E, Lundback B. Smoking, respiratory symptoms, and diseases: report from the FinEsS study. *Chest* 2001; 119:852–61.
- Larsson M, Frisk M, Hallström J, Kiviloog J, Lundback B. Environmental tobacco smoke exposure during childhood is associated with increased prevalence of asthma among adults. *Chest* 2001; 120:711–7.
- Meren M, Jannus-Pruljan L, Loit HM et al. Asthma, chronic bronchitis and respiratory symptoms among adults in Estonia according to a postal questionnaire. *Respir Med* 2001; 95: 954–64.
- The European Academy of Allergology and Clinical Immunology Position paper: allergen standardisation and skin tests. *Allergy* 1993; 48:48–82.
- D'Souza W, Lewis S, Cheng S et al. The prevalence of asthma symptoms, bronchial hyperresponsiveness and atopy in New Zealand adults. *N Z Med J* 1999; 112:198–202.
- Baldacci S, Modena P, Carrozzi L et al. Skin prick test reactivity to common aeroallergens in relation to total IgE, respiratory symptoms, and smoking in a general population sample of northern Italy. *Allergy* 1996; 51:149–56.
- Wuthrich B, Schindler C, Leuenberger P, Ackermann-Liebrich U. Prevalence of atopy and pollinosis in the adult population of Switzerland (SAPALDIA study). Swiss Study on Air Pollution and Lung Diseases in Adults. *Int Arch Allergy Immunol* 1995; 106:149–56.
- Garcia-Gonzalez JJ, Vega-Chicote JM, Rico P et al. Prevalence of atopy in students from Malaga, Spain. *Ann Allergy Asthma Immunol* 1998; 80:237–44.
- Linneberg A, Jorgensen T, Nielsen NH, Madsen F, Frolund L, Dirksen A. The prevalence of skin-test-positive allergic rhinitis in Danish adults: two cross-sectional surveys 8 years apart. The Copenhagen Allergy Study. *Allergy* 2000; 55:767–72.
- Kranke B, John SM, Schwanitz HJ. Increase of allergy in East Germany. *Lancet* 1998; 351:1813–4.

- 29 Rönmark E, Lundbäck B, Jönsson E, Platts-Mills T. Asthma, type-1 allergy and related conditions in 7- and 8-year-old children in Northern Sweden: prevalence rates and risk factor pattern. *Respir Med* 1998; 92:316–24.
- 30 Plaschke P, Janson C, Norrman E et al. Skin prick tests and specific IgE in adults from three different areas of Sweden. *Allergy* 1996; 51:461–72.
- 31 Pascual CY, Crespo JF, San Martin S et al. Cross-reactivity between IgE-binding proteins from *Anisakis*, German cockroach, and chironomids. *Allergy* 1997; 52:514–20.
- 32 Sidenius KE, Hallas TE, Poulsen LK, Mosbech H. Allergen cross-reactivity between house-dust mites and other invertebrates. *Allergy* 2001; 56:723–33.
- 33 Valinas B, Lorenzo S, Eiras A, Figueiras A, Sanmartin ML, Ubeira FM. Prevalence of and risk factors for IgE sensitisation to *Anisakis simplex* in a Spanish population. *Allergy* 2001; 56:667.
- 34 Jogi R, Janson C, Björnsson E, Roman G, Björkstén B. The prevalence of asthmatic respiratory symptoms among adults in Estonian and Swedish university cities. *Allergy* 1996; 51:331–6.
- 35 Norrman E, Rosenhall L, Nyström L, Jonsson E, Stjernberg N. Prevalence of positive skin prick tests, allergic asthma, and rhinoconjunctivitis in teenagers in northern Sweden. *Allergy* 1994; 49:808–15.
- 36 Braback L, Breborowicz A, Julge K et al. Risk factors for respiratory symptoms and atopic sensitisation in the Baltic area. *Arch Dis Child* 1995; 72:487–93.
- 37 Vasar M, Julge K, Björkstén B. Development of atopic sensitisation and allergic diseases in early childhood. *Acta Paediatr* 2000; 89:523–7.
- 38 Perzanowski M, Ronmark E, Nold B, Lundback B, Platts-Mills TAE. Relevance of allergens from cats and dogs to asthma in the northernmost province of Sweden: schools as a major site of exposure. *J Allergy Clin Immunol* 1999; 103: 1018–24.
- 39 Lodrup Carlsen KC, Carlsen KH, Buchmann MS, Wikström J, Mehl R. Cockroach sensitivity in Norway: a previously unidentified problem? *Allergy* 2002; 57:529–33.
- 40 Eriksson NE, Holmen A, Moller C, Wihl JA. Sensitization according to skin prick testing in atopic patients with asthma or rhinitis at 24 allergy clinics in Northern Europe and Asia. *Allergol Int* 1998; 47:187–96.
- 41 Crimi P, Boidi M, Minale P, Tazzer C, Zanrdi S, Ciprandi G. Differences in prevalence of allergic sensitisation in urban and rural school children. *Ann Allergy Asthma Immunol* 1999; 83: 252–6.
- 42 Ernst P, Cormier Y. Relative scarcity of asthma and atopy among rural adolescents raised on a farm. *Am J Respir Crit Care Med* 2000; 161:1563–6.
- 43 Kilpelainen M, Terho EO, Helenius H, Koskenvuo M. Farm environment in childhood prevents the development of allergies. *Clin Exp Allergy* 2000; 30:201–8.
- 44 Riedler J, Eder W, Oberfeld G, Schreuer M. Austrian children living on a farm have less hay fever, asthma and allergic sensitisation. *Clin Exp Allergy* 2000; 30:194–200.
- 45 Platts-Mills T, Vaughan J, Squillace S, Woodfolk J, Sporik R. Sensitisation, asthma, and a modified Th2 response in children exposed to cat allergen: a population-based cross-sectional study. *Lancet* 2001; 357:752–6.