

REGULAR ARTICLE

High prevalence of allergic diseases and sensitization in a low allergen country

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Abstract

Background: The prevalence of adult atopic diseases in Iceland is lower than in other West European countries, despite an affluent lifestyle, but limited data are available on children. The main aim of this study was to investigate the prevalence of atopic diseases and sensitivity to common allergens in 10- to 11-year-old Icelandic schoolchildren as part of phase II of the International Study of Asthma and Allergies in Children (ISAAC).

Methods: Nine hundred and forty-six children and their parents answered a questionnaire about atopic diseases. Skin prick tests with six allergens were performed on 773 children and they were examined for signs of atopic dermatitis (AD).

Results: The 12-month prevalence of allergic rhinoconjunctivitis and asthma was 11.5% and 8.9% respectively. The reported prevalence of AD was 27%, but only 9.2% had signs when inspected. A positive skin prick test (SPT) was found in 24.4% of the children, that is 18.8% to grass, 12.9% to cat, 3.6% to trees, 3.0% to *Dermatophagoides pteronyssinus*, 1.4% to *D. farinae* and 0.5% to *Alternaria*.

Conclusion: The high prevalence of atopic diseases in children at 10–11 years is surprising, as the prevalence in adults is low in Iceland. The findings resemble those in developing countries. Iceland has had an affluent lifestyle for a considerable time, but the absence of dust mites, low pet ownership and relatively low pollen counts in the country raise doubts about the role of exposure levels in the development of sensitization and atopic diseases.

There is worldwide concern about the increasing prevalence of asthma, allergic rhinitis and atopic dermatitis (AD) in childhood. This increase is particularly obvious in affluent countries (1,2), while the prevalence is still low in developing countries (3). Recent studies have indicated that, at least in some countries, the increase in the prevalence of atopic diseases has reached a plateau (4). The causes of this increase in atopic diseases remain unknown, although many recent publications have reported an association between atopic diseases and 'western lifestyle' (5).

The prevalence of asthma and allergic rhinitis in adults, as well as sensitization to common allergens, is lower in Iceland than in most other European countries, despite an affluent lifestyle (6–8). Pet ownership in Iceland is one of the lowest in Europe and the cat allergen level is lower in Iceland than in most European countries (6,9–11), while house dust mite allergens are almost nonexistent (12), grass pollen levels are low and tree pollen levels are extremely low (13,14). Furthermore, air pollution, measured as particulate matter <2.5 µm in diameter (PM_{2.5}), is very low in Iceland (15). All these factors could possibly influence the prevalence of atopic diseases in Iceland.

The International Study of Asthma and Allergies in Childhood (ISAAC) has established standardized methods for measuring the prevalence rate and severity of allergic conditions in children all over the world and for exploring the possible causes of and risk factors for these conditions (16).

As one of 35 global participants in ISAAC phase II, we conducted a study to provide data on the prevalence of allergic diseases in Icelandic schoolchildren. We hypothesized that the prevalence would be low compared with that in other West European countries.

The aim of this study was to provide a detailed analysis of the prevalence and severity of self-reported symptoms and diagnoses of asthma, allergic rhinitis and AD in 10- to 11-year-old schoolchildren in Iceland. Detailed information was obtained about several possible risk factors, including genetic factors and environmental factors. Furthermore, the prevalence of sensitization to common allergens was studied by means of skin prick tests (SPTs).

MATERIALS AND METHODS

Subjects

The study was conducted during May 2000 to May 2001 in Reykjavík (latitude 64°) and two neighbouring towns, Kópavogur and Garðabær, with a total population of slightly more than 142 000 inhabitants and comprising about 45% of the entire population of the country. This is the most heavily populated area in Iceland. The annual mean temperature is 4.5°C and the annual precipitation is 800 mm. All 2018 10- to 11-year-old schoolchildren in the 5th grade in these three cities were invited to participate in this study. We used the ISAAC core questions on symptoms of asthma, asthma

treatment, allergic rhinitis, AD, home environment, atopic heredity and possible risk factors as defined by the ISAAC committee. The parents were asked to complete the questionnaire at home with their children.

Skin prick tests

A nurse trained according to the standards of ISAAC performed SPT on the volar aspect of the left forearm (16). Standardized extracts, the ALK Soluprick® (ALK laboratories, Hørsholm, Denmark) and ALK lancets were used. A mean weal diameter of at least 3 mm after 15 min was regarded as a positive test. The allergens that were used were alternaria, cat, grass mix, tree mix and *Dermatophagoides pteronyssinus* and *D. farinae*. The children were inspected according to ISAAC protocols for atopic dermatitis (16).

Statistical analysis

All the statistical calculations were performed using the SPSS package (standard version, release 11.0.1). Chi-square tests were used to compare rates between groups. Calculations of odds ratio estimates were made using the Mantel-Haentzel statistics. A p-value of <0.05 was regarded as statistically significant.

Ethics

The Icelandic National Bioethics Committee and Data Protection Authority approved the study. All the parents of the participating children gave their written consent after receiving written information.

RESULTS

The questionnaire was completed by a total of 946 children (46.8% response rate). There were 510 (53.9%) girls and 436 (49.9%) boys, giving a female-to-male ratio of 1.2:1. Of these 946 children, 773 agreed to participate in SPT and examination for AD. The response rate differed substantially between schools. As the response rate could raise concerns about the introduction of selection bias and restrictions to generalisability, we divided the schools into high responders ($\geq 70\%$ response rate) and low responders ($\leq 30\%$ response rate). We found no significant difference between the respective groups when it came to those who had ever had asthma or in mothers having asthma, as 92% of the questionnaires were answered by the child and the mother.

Asthma and wheezing

Exercise-induced asthma in the preceding 12 months was reported by 67 (7.1%) children and 15 (1.5%) had current symptoms of both wheezing and rhinoconjunctivitis, as well as eczema (Fig. 1).

Asthma ever was reported by 208/946 (22.0%) (Table 1). Eighty-four children (8.9%) reported current wheezing. Most of them had had three or fewer attacks during the past 12 months, while 30 (36%) had had four or more attacks of wheezing. Of the 84 children reporting wheezing in the past 12 months, 60 (71%) had taken asthma medication during that period. Disturbed sleep because of wheezing was re-

ported by 33 children (39.2%). The female-to-male ratio of wheezing was 1:1.2. Rhinoconjunctivitis was reported by 32 (38%) of the children with current wheeze, 25 (30%) had eczema and 32.8% had a positive SPT (Table 2).

Rhinoconjunctivitis

Symptoms of rhinoconjunctivitis were reported by 161 (17%), of whom 109 (11.5%) reported ever having hay fever (Table 1). Of the 109 children who reported ever having hay fever, 73 children (67.0%) had at least one positive SPT (Table 2). Symptoms of rhinoconjunctivitis resulted in little or no interference with daily activities in most of the children. Moderate or severe interference with daily activities was reported in 31 of the 109 children (28.4%).

Atopic dermatitis

Atopic dermatitis at some time was reported by 330 (34.9%) of the children and it was reported in 204 girls (62%), with a female-to-male ratio of 1.7:1. Recurrent itchy rash during the preceding 12 months was reported by 255 children (27%). Of these, 204 children (80.3%) had had an itchy rash on typical areas for AD, such as the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck or eyes. Six (2.5%) had severe symptoms, which kept them awake at least one night a week. Of the 255 children who reported current AD, 25.3% had at least one positive SPT (Table 2).

When 773 of the 946 children were inspected by the trained nurse, 71 (9.2%) had signs of AD. The most common signs of AD were found in front of the elbows (6%) and this was related to having at least one positive SPT (OR 3.4 [1.86–6.21], $p < 0.001$). The SPT was positive in 26 (37.5%) of the 71 inspected children with AD.

Skin prick test

A positive SPT to at least one allergen was found in 188 (24.3%) of the children. Current wheeze, rhinoconjunctivitis and/or eczema were reported by 57% of those who had at least one positive SPT. A positive SPT to grass was most common (18.8%), followed by cat (12.9%), trees (3.6%), *D. pteronyssinus* (3.0%), *D. farinae* (1.4%) and alternaria (0.5%) (Table 3).

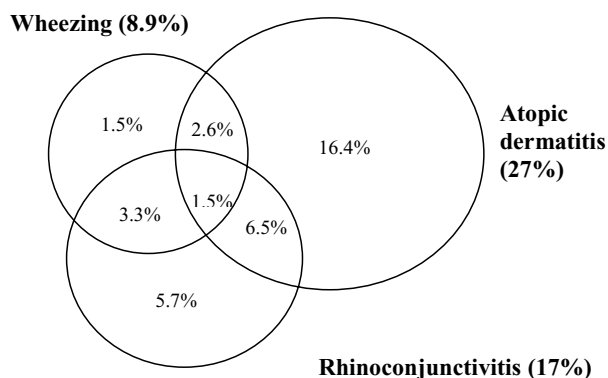


Figure 1 Prevalence of reported symptoms of wheezing, rhinoconjunctivitis and AD in 10- to 11-year-old Icelandic schoolchildren.

Table 1 Parentally reported prevalence of wheezing, allergic rhinoconjunctivitis and AD among schoolchildren in Europe

	Iceland, n = 946 %	Sweden (10), Östersund, n = 1197 %	Sweden (17), Linköping, n = 911 %	Germany (18), n = 772 %	Estonia (17), n = 979 %	UK (19), n = 1 000 %
Wheezing						
Lifetime prevalence	25.6	22.5	23.7	31.1	20.4	
12-month prevalence	8.9	10.2	7.9	10.5	8.4	16.1
Asthma						
Lifetime prevalence	22	10.9	9.6		2.5	20.2
Allergic rhinoconjunctivitis						
12-month prevalence	17	12.3	14.1		6.2	
Hay fever						
Lifetime prevalence	11.5	13.9	22.6		21.6	19.5
Atopic dermatitis						
12-month prevalence	27	26.6	24.6		20.4	14.5
Positive SPT						
Any allergen	24.3	26.8	20.1		14.8	15.0

Table 2 Wheezing, rhinoconjunctivitis and AD and the percentage with atopy in a cohort of Icelandic schoolchildren

Questionnaire-reported symptoms	Positive SPT, n = 773 %	Odds ratio (95% confidence interval)
Current wheezing	32.8	1.66 (0.93–2.98)
Lifetime asthma	28.7	1.42 (0.95–2.17)
Current rhinoconjunctivitis	50	4.76 (3.03–8.33)
Lifetime hay fever	67.0	9.09 (5.26–16.6)
Current AD	25.3	1.14 (0.76–1.72)
Lifetime AD	28.9	1.58 (0.58–1.31)
No current wheezing or rhinoconjunctivitis or AD	10.1	0.47 (0.32–0.68)

Table 3 Prevalence of positive SPT among schoolchildren in Iceland, Sweden and the UK performed using the standardized ISAAC II method

	Iceland, n = 773 %	Sweden (10), n = 1197 %	UK (19), n = 841 %
Grass	18.8	14.5	10.7
Cat	12.9	16.1	4.2
Tree	3.6	10.6	2.9
<i>D. pteronyssinus</i>	3.0	1.0	7.7
<i>D. farinae</i>	1.4	0.6	5.1
Alternaria	0.5	0.1	0.1
Any allergen	24.3	26.8	17.8

Relationship to environmental factors and furry pets

Current cat ownership was reported by 13% of the families and 7.8% had a dog. The ownership of other furry pets was reported by 14.2% of the families. Cat ownership during the first year of life was reported by 11.6%. Those who had a cat during the first year of life were less likely to be sensitized to cats at the age of 10–11 years (OR 0.27 [0.08–0.88], $p = 0.021$). Dog ownership, both current or during the first year of life, had no relationship with sensitization, but dog exposure during the first year of life was associated with wheezing

during the last 12 months (OR 2.3 [1.02–5.26], $p = 0.038$). Current cat or dog ownership or having a cat or a dog during the first year of life had no relationship with reported symptoms of allergic rhinoconjunctivitis or ever having hay fever, or signs of AD on inspection at the age of 10–11 years.

Ninety-five percent of the children had attended kindergarten. There was no relationship with current wheezing, asthma ever, hay fever, AD at inspection or sensitization.

Smoking during pregnancy was reported by 19.8% of the mothers; 25.7% smoked during the child's first year of life and 23% reported current smoking. Maternal smoking during pregnancy was related to AD at 10–11 years (OR 2.0 [1.1–3.8], $p = 0.018$), as was maternal smoking during the child's first year of life (OR 2.0 [1.1–3.6], $p = 0.013$). Ninety-five percent of the children were breastfed and 66% were breastfed for longer than 6 months. Exclusive breast-feeding for up to 4 months was reported for 38.7% of the children, while 7.1% had been exclusively breastfed for longer than 6 months. Breastfeeding (exclusive or partial) for less than 6 months was related to AD on inspection at 10–11 years (OR 1.7 [1.0–3.0] $p = 0.04$). Exclusive breastfeeding for at least 4 months was associated with a positive SPT at the age of 10–11 years (OR 1.6 [1.1–2.3], $p = 0.01$). This relationship was only observed in children with a parent who had asthma, AD or allergic rhinoconjunctivitis.

Fish was eaten once or twice a week by 87% of the children. There was no relationship between fish consumption and current wheezing, asthma, hay fever, signs of AD or sensitization.

DISCUSSION

This cross-sectional survey describes the prevalence of atopic diseases in Icelandic schoolchildren and was part of the ISAAC multi-centre study (20). We found that the prevalence of atopic diseases and wheezing in Icelandic children was high and comparable to that in other countries in Europe (Table 1). These findings are of interest, because the allergen load in Iceland is very low. The pollen count is very

low compared with other European countries, pet ownership is low and house dust mites are absent.

Grass pollen is the major airborne allergen in Iceland and it is also the most common cause of allergic rhinoconjunctivitis in our study, where 18.8% of the children were sensitized. The average seasonal pollen index in Reykjavik is low, 1600 grains/m³, compared with 12 404 grains/m³ in Münster, Germany and 5079 grains/m³ in Wales, United Kingdom (13,14). Tree pollens are extremely low as few trees grow in Iceland. In a multi-centre study in 11 countries, the authors found a weak yet consistent tendency for the prevalence of allergic symptoms to be inversely associated with pollen exposure (13). Our finding of a high prevalence of atopic diseases and low allergen load is in accordance with the findings of others, who have found that IgE sensitization and asthma prevalence rise at very low levels of allergen exposure and attenuate thereafter (21). Other investigators have reported that high-dose exposure to cat allergens has been associated with clinical tolerance (22).

Several studies have indicated that there is a relationship between house dust mites and the occurrence of asthma (23). Analyses of dust samples from Icelandic homes were not able to reveal the existence of dust mites at all (12). In the European Community Respiratory Health Study (ECRHS), Icelandic adults had one of the lowest prevalences of asthma, allergic rhinitis and atopy measured as total IgE in Europe (7,8,24). Furthermore, air pollution measured as PM_{2.5} is lowest in Iceland among 21 European countries (15). It is therefore surprising to find the high prevalence of atopic diseases in Icelandic schoolchildren. Our findings indicate that the factors other than allergens play an important role in the development of atopic diseases. One of these factors may be lifestyle changes and urbanization, as seen in Iceland, as well as other West European countries, in recent decades. Perinatal mortality in Iceland decreased from 24/1000 births total in the early 1960s to 5.3/1000 births total in 2000 (25). Body mass index in 9-year-old children has increased during the last few decades, with 3.4% of boys and 6% of girls being overweight in 1958 and 17.9% and 19.7% in 1998, respectively (26). The gross domestic product per capita in Iceland has increased almost fourfold (3.57) since 1960 (27). Dietary changes have also been remarkable and, in the last few decades, there has been a substantial reduction in fish consumption in Iceland, with a decline of as much as 30% in the 1990s (28). The majority of the children in the study ate fish less than three times a week. Regular fish consumption has been linked to a reduced risk of having asthma and allergic disease, as fatty acid from fish may interfere with the regulation of the immune system (29,30). Cod liver oil was given to all schoolchildren in Iceland until the early 1960s. A recent survey showed that only 18% of 9-year-old children and 3% of 15-year-old children in Iceland take cod liver oil on a daily basis.

The poor response rate in some schools is a weakness of our study. However, the findings were similar in schools meeting the response rate required in ISAAC (70%) and schools with low response rates. Another potential weakness is the lack of lung function tests. The ISAAC question-

naires have been thoroughly validated in many countries, and we therefore regard the conclusions of our study as reasonable.

We would like to speculate that this change to an affluent lifestyle has contributed to the high prevalence of atopic diseases in Icelandic schoolchildren. These changes in affluence were most dramatic during the last decades of the twentieth century. The difference in living conditions, with a loss of some protective factors when our study group of children was raised compared with adults in the ECHRS study group, might explain the higher prevalence of atopic diseases in our group of children, as the majority of atopic diseases start in childhood. A recent study found four times higher risk of atopy in children in Finland compared with children in Russia from areas geographically adjacent but differing fundamentally in terms of living conditions, with a more affluent lifestyle in Finland (31). von Mutius et al. found a similar effect in Germany and even found an increase in atopy in the former East Germany, which experienced rapid westernization after the reunification (32). Our results therefore strongly support the multifactorial pathogenesis and epidemiology of atopic diseases.

To summarize, the prevalence of atopy and atopic diseases is high in Icelandic schoolchildren and is on a par with that in other European countries. The absence of dust mites, low pet ownership and relatively low pollen count do not appear to have a protective effect on atopy and atopic diseases.

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