

Growing disparities in atopy between the Finns and the Russians: A comparison of 2 generations

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Background and objective: Western lifestyle has consistently been associated with the current asthma and atopy epidemics. We examined the occurrence and risk factors of atopy among schoolchildren and their mothers in 2 geographically adjacent areas with fundamental differences in living conditions and lifestyles.

Methods: A population-based study of 2 generations was carried out in eastern Finland and in western Russia. Randomly selected schoolchildren aged 7 to 16 years (367 in Finland and 446 in Russia) and their mothers (365 and 437, respectively) were enrolled. Data were obtained by using a modified International Study of Asthma and Allergies in Childhood questionnaire and by performing skin prick tests against 14 common airborne and food allergens.

Results: In children a 4-fold higher risk for atopy (≥ 1 positive prick test result) was found in Finland compared with Russia. Sensitization rates in Finland were generally higher among children compared with those of their mothers, whereas in Russia the opposite trends emerged. Parental farming in early life (<1 year) in Finland (odds ratio [OR], 0.53; 95% CI, 0.28-0.99) and in Russia (OR, 0.47; 95% CI, 0.22-1.03) and currently in Finland (OR, 0.45; 95% CI, 0.22-0.91) conferred protection against atopy. Having pets, dogs in Finland (OR, 0.57; 95% CI, 0.35-0.95) and cats in Russia (OR, 0.43; 95% CI, 0.24-0.80), in early life was also inversely associated with atopy. **Conclusion:** Atopy was several-fold more common in Finland compared with in Russia, and disparities in sensitization rates between the countries have further increased during these generations. The similarity of explanatory variables of atopy in both countries suggests that determinants of atopy are shared, at least in similar geoclimatic conditions. (*J Allergy Clin Immunol* 2006;117:151-7.)

Key words: Allergy, asthma, atopy, Finland, Russia

Although a number of recent reports have consistently shown an association between atopic disease and western lifestyle and urbanization,^{1,2} the ultimate causes of the asthma and allergy epidemics are not known. Data are accumulating that saprophytic bacteria in the gut and environment^{3,4} might play a crucial role in immunomodulation in early life. Not only viable microbes but also nonviable microbial components, such as LPS, peptidoglycan, and bacterial DNA, are recognized by the innate immune system, leading to immune responses that might have immunomodulatory potential.⁴⁻⁶ Saprophytic mycobacteria, lactobacilli, and certain intestinal parasites have been shown to have such immunomodulatory capacity⁷⁻¹¹ and have been proposed to be recognized by the innate immune system as nonenemies that do not elicit intense inflammatory responses to eliminate the microbe but might have an ability to trigger rapid T regulatory cell responses.¹² In affluent western societies characterized by living in apartment houses in environments heavily covered with asphalt, exposure to such microorganisms has dramatically been reduced. Low occurrence of atopy and atopic disease has consistently been found in children living in nonaffluent societies with traditional lifestyles¹³⁻¹⁵ and in children living or having lived on a farm.¹⁶ One common denominator for living in both environments is the heavy exposure to soil microorganisms.

In 1998, we carried out a study among adults in the province of North Karelia, Finland, and in Pitkäranta district, the Republic of Karelia, Russia, to examine the occurrence of atopy and atopic disease.¹⁷ These areas are geographically adjacent but differ fundamentally in living conditions. We found significant differences between the Finns and the Russians aged 25 to 65 years in the occurrence of asthma, hay fever, and atopic eczema, as well as in the occurrence of atopy, as determined by using skin prick tests (SPTs) to 12 common aeroallergens.¹⁷ The aim of this further study was to examine the occurrence of atopy and atopic disease among schoolchildren and their mothers in the same areas by using the same methods. We also wanted to clarify whether any signs of increasing prevalence of atopy, a proxy for westernization,

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Abbreviations used

HEP: Histamine equivalent prick
ISAAC: International Study of Asthma and Allergies
in Childhood
OR: Odds ratio
SPT: Skin prick test

are discernible in the Republic of Karelia, Russia, by assessing generational differences in atopy prevalence.

METHODS

Study areas and subjects

This study was carried out in 2003 in Finland and Russia. The study areas have been described in detail previously.¹⁷ Briefly, the Finnish study area, North Karelia, is the most eastern province of Finland, and on the other side of the border is Pitkäranta district, the Republic of Karelia in Russia, which was part of the Soviet Union until the collapse of the country in 1991. Even today the cultural, political, and socioeconomic differences between the areas are fundamental. For example, the average life expectancy among men in Russian Karelia in 2002 was only 55.9 years compared with 74.0 years among men in Finland, and for women, the average life expectancy was 69.7 and 81.1 years, respectively.¹⁸ The gross domestic product per capita in Russia was only 24% of that in Finland in 1996, and the economic gap is likely to have widened even further.¹⁹ Nonetheless, because the areas are located close to each other, the geoclimatic conditions are similar. Both populations are racially white.

A random sample of schoolchildren aged 7 to 16 years and their mothers were recruited for this study from 24 schools in Finland and 11 schools in Russia. Five hundred forty-six child-mother pairs from Finland and 550 from Russia were enrolled in the study. Data obtained by using a questionnaire were available from 413 (75.6%) children and from 409 (74.9%) mothers in Finland and from 448 (81.5%) children and 439 (79.8%) mothers in Russia. We report here the data from 367 children who participated in SPTs and their 365 mothers in Finland and from the respective 446 children and their 437 mothers in Russia.

The study protocol was approved by the Ethics Committee of the Helsinki University Central Hospital, and written informed consent was obtained from all participants. Subject and living characteristics among the Finns and the Russians are presented in Table I.

Questionnaire

The questionnaire used in this study was an extended modification of the Phase I International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire,²⁰ including items on demographic factors and home-living characteristics (number of siblings, acute infection in the past 12 months, day-care attendance, immunizations, indoor pets, indoor smoking, parental farming, and contacts with farm animals in the past 12 months), as well as occurrence of atopic disease in the child and the parents. The questionnaire was completed by the mother before the study visit.

SPTs

During the study visit, clinical examination and SPTs were performed. A standard set of 9 airborne and food allergens, birch (10 histamine equivalent prick [HEP]), timothy grass (10 HEP), mugwort (10 HEP), cat (10 HEP), dog (10 HEP), horse (10 HEP),

cow (1:100), *Dermatophagoides pteronyssinus* (10 HEP), and fish (10 HEP; Solu-Prick SQ ALK A/S, Copenhagen, Denmark), was used. The following 5 food allergens were tested as raw material by using the prick-prick method: hen's egg, wheat, cow's milk, peanut, and hazelnut. A positive (histamine dihydrochloride, 10 mg/mL) and negative (solvent) control were used throughout the study. A wheal diameter of 3 mm or larger was defined to indicate a positive test result,²¹ and the subject was considered atopic if he or she had at least one positive prick test result.

Statistical analysis

Continuous variables were presented as means (SD) or medians (range). Categorical data were compared with the χ^2 test, and continuous data were compared with the *t* test. When age adjustment was performed (Table II and Table E1 in the Online Repository of this article at www.jacionline.org), the likelihood ratio test was used. Logistic regression analysis adjusted for age, sex, and country was used to identify risk factors for atopy. A 2-tailed *P* value of less than .05 was considered significant. All analyses were carried out with the SAS program, version 6.12 (SAS Institute Inc, Cary, NC).

RESULTS

Occurrence of atopic disease among both children and mothers differed significantly between the countries. Physician-diagnosed asthma occurred 5.5-fold more frequently among children in Finland than among those in Russia (8.8% vs 1.6%, *P* = .000); for mothers, the difference was 7-fold (11.3% vs 1.6%, *P* = .000). Prevalences of physician-diagnosed and self-reported asthma ever were similar.

For prevalence of hay fever ever, the disparities between the countries were even larger: a 14-fold difference between children in Finland and those in Russia was observed (15.6% vs 1.1%, *P* = .000). Among mothers, the respective difference was 8.5-fold (19.7% vs 2.3%, *P* = .000).

Furthermore, with the occurrence of atopic eczema ever, the difference in children was 5-fold (38.4% vs 7.7%, *P* = .000) between the countries, and in mothers, it was 3.8-fold (23.8% vs 6.2%, *P* = .000). The only condition that showed no difference between the countries was wheezing in children during the last 12 months (see this article's Table E1 in the Online Repository at www.jacionline.org). This wheezing was associated with atopy in Finland (*P* = .035) but not in Russia (*P* = .216).

Similar to atopic diseases, the occurrence of atopy, determined by means of SPT, differed substantially both among children and mothers between the countries. The most common allergens causing sensitization in Finland were birch and timothy grass in children (26.6% and 28.2%, respectively) and mothers (14.0% and 11.5%, respectively). In Russia only house dust mite in children (9.1%) and mugwort in mothers (9.0%) caused notable sensitization (Table II).

The disparities between the countries in atopy prevalence were larger among the children than among the mothers. For birch, the difference among children was 13.5-fold (26.6% vs 2.0%, *P* = .000), and among mothers,

TABLE I. Subject and living characteristics in Finnish and Russian children

Variable	Finland	Russia	P value
N	367	446	
Mean age, y (SD)	10.9 (2.5)	11.3 (2.5)	.033
Sex ratio (F/M)	186/181	226/219	.976
Mean no. of older siblings (SD)	1.13 (1.3)	1.02 (0.9)	.211
Mean no. of younger siblings (SD)	0.88 (1.0)	0.75 (0.7)	.052
Parental history of atopic disease*	200/367 (54.5)	49/446 (11.0)	<.0001
Smoking†			
Occasional	10/122 (8.2)	10/182 (5.5)	
Current regular	13/122 (10.7)	25/182 (13.7)	.505
Indoor exposure to tobacco smoke	8/213 (3.8)	165/423 (39.0)	<.0001
Parental farming, <1 y	53/367 (14.4)	88/444 (19.8)	.044
Parental farming, current	45/366 (12.3)	74/443 (16.7)	.078
Indoor pets, <1 y			
Cats	66/367 (18.0)	158/446 (35.4)	<.0001
Dogs	89/367 (24.3)	100/446 (22.4)	.539
Indoor pets, 1-9 y			
Cats	132/367 (36.0)	324/446 (72.6)	<.0001
Dogs	160/367 (43.6)	190/446 (42.6)	.775
Indoor pets, 10-16 y			
Cats	70/367 (19.1)	221/446 (49.6)	<.0001
Dogs	104/367 (28.3)	140/446 (31.4)	.345
Contacts with farm animals (12 mo)			
Never	198/367 (54.0)	322/432 (74.5)	
Rarely (weekly or less)	157/367 (42.8)	88/432 (20.4)	
Daily	12/367 (3.3)	22/432 (5.1)	<.0001
Visits to stable (12 mo)			
Never	206/367 (56.1)	314/443 (70.9)	
Rarely (weekly or less)	147/367 (40.1)	98/443 (22.1)	
Daily	14/367 (3.8)	31/443 (7.0)	<.0001
Day-care attendance			
<1 y	29/361 (8.0)	8/439 (1.8)	<.0001
1-3 y	195/366 (53.3)	283/439 (64.5)	.0013
Contracted infections (12 mo)			
0-4	9/367 (2.5)	31/443 (7.0)	
5-6	227/367 (61.9)	266/443 (60.1)	
≥7	131/367 (35.7)	146/443 (33.0)	.011
Use of antibiotics (12 mo)	160/365 (43.8)	191/435 (43.9)	.984
Parasitic infections, 0-16 y			
<i>Enterobius vermicularis</i>	41/366 (11.2)	196/418 (46.9)	<.0001
<i>Ascaris</i> species	1/367 (0.27)	34/439 (7.7)	<.0001
<i>Giardia</i> species	0/367 (0.00)	9/439 (2.1)	.055
Immunization			
BCG	365/366 (99.7)	439/440 (99.7)	.896
PDT	364/365 (99.7)	442/443 (99.8)	.891
MPR	363/366 (99.2)	442/443 (99.8)	.231
Polio	366/366 (100.0)	443/443 (100.0)	

Values are presented as n/N (%) unless otherwise specified.

PDT, Pertussis/diphtheria/tetanus; MPR, measles/mumps/rubella.

*Parental-reported asthma, hay fever, or atopic eczema ever.

†Smoking was asked about in a questionnaire given to schoolchildren aged 13 years or older: current regular smoking, daily or weekly; occasional smoking, less than weekly.

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it was only 2.3-fold (14.0% vs 6.2%, $P = .002$). For other allergens tested, the difference between the countries ranged from 3-fold (cow) to 31.5-fold (horse) among children and from 1.6-fold (mite) to 8.6-fold (mugwort) among mothers. Overall, 42.8% of the children in Finland and 15.7% of those in Russia had positive responses to one or more allergens (Table II).

Analysis of generational differences revealed that sensitization rates among children in Finland were 40% to 145% higher compared with those of their mothers for most aeroallergens tested (birch, timothy, cat, dog, and horse), whereas in Russia children generally showed considerably lower sensitization rates compared with those of their mothers (Table II).

TABLE II. Occurrence of positive SPT results in Finnish and Russian children and their mothers adjusted for age and generational differences (child vs mother)

Allergen	Children			Mothers			Generational difference (%)	
	Finland	Russia	P value	Finland	Russia	P value	Finland	Russia
N	365*	442*		357	324			
Birch	97 (26.6)	9 (2.0)	<.0001	50 (14.0)	20 (6.2)	.002	90.0	-67.7
Timothy grass	103 (28.2)	21 (4.8)	<.0001	41 (11.5)	13 (4.0)	.000	145.2	20.0
Mugwort	29 (8.0)	22 (5.0)	.077	32 (9.0)	29 (9.0)	.996	-11.1	-44.4
Cat	74 (20.3)	16 (3.6)	<.0001	37 (10.4)	13 (4.0)	.001	95.5	-10.0
Dog	79 (21.6)	11 (2.5)	<.0001	50 (14.0)	16 (4.9)	<.0001	54.3	-49.0
Horse	23 (6.3)	1 (0.2)	<.0001	16 (4.5)	3 (0.9)	.003	40.0	-77.8
Cow	11 (3.0)	5 (1.1)	.055	28 (7.8)	11 (3.4)	.012	-61.5	-67.6
<i>Dermatophagoides pteronyssinus</i>	34 (9.3)	40 (9.1)	.857	41 (11.5)	23 (7.1)	.053	-19.1	28.2
Fish	1 (0.3)	1 (0.2)	.828	10 (2.8)	6 (1.9)	.425	-89.3	-89.5
Egg	7 (1.9)	4 (0.9)	.201	11 (3.1)	6 (1.9)	.313	-38.7	-52.6
Wheat	43 (11.8)	5 (1.1)	<.0001	31 (8.7)	5 (1.5)	<.0001	35.6	-26.7
Cow's milk	1 (0.3)	1 (0.2)	.872	10 (2.8)	6 (1.9)	.420	-89.3	-89.5
Peanut	30 (8.2)	2 (0.5)	<.0001	36 (10.1)	8 (2.5)	<.0001	-18.8	-80.0
Hazelnut†	17 (6.3)	3 (0.8)	<.0001	31 (11.3)	7 (2.7)	<.0001	-44.2	-70.4
Any allergen	157 (42.8)	70 (15.7)	<.0001	132 (36.1)	60 (18.3)	<.0001	18.6	-14.2
Any aeroallergen	156 (42.5)	70 (15.7)	<.0001	118 (32.2)	57 (17.4)	<.0001	32.0	-9.8
Any pollen	132 (36.0)	36 (8.1)	<.0001	75 (20.5)	40 (12.2)	.003	75.6	-33.6

Values are presented as n (%) unless otherwise specified.

*Two SPT results among children in Finland and 4 results among children in Russia were excluded from the analysis because of unclear positive control or noncompliance during the test procedure.

†Tested in 271 Finnish and 356 Russian children and in 275 Finnish and 260 Russian mothers.

Regression analysis to identify risk factors for atopy showed that the overall risk for atopy among children was 4-fold in Finland compared with that in Russia, whereas among mothers, the risk in Finland was 2.4-fold (odds ratio [OR], 2.38; 95% CI, 1.61-3.52). Parental history of atopic disease was significantly associated with increased risk of atopy in Finland (OR, 1.60; 95% CI, 1.04-2.45) and showed a borderline significance in Russia (OR, 1.96; 95% CI, 0.96-4.03; Table III). Pets conferred protection in both countries. In Finland having dogs in early life (<1 year) was found to be inversely associated with the subsequent development of atopy (OR, 0.57; 95% CI, 0.35-0.95), and a borderline significance was achieved for having dogs at the age of 1 to 9 years (OR, 0.69; 95% CI, 0.45-1.05). In Russia cats, but not dogs, were found to be highly protective against atopy in early life only (OR, 0.43; 95% CI, 0.24-0.80).

Parental farming, both in early life (OR, 0.53; 95% CI, 0.28-0.99) and currently (OR, 0.45; 95% CI, 0.22-0.91), was shown to be highly protective against atopy in Finland. This inverse association was also found in Russia, although it was of borderline significance (OR, 0.47; 95% CI, 0.22-1.03). Daily contacts with farm animals were inversely associated with atopy only in Finland (OR, 0.28; 95% CI, 0.08-0.99; Table III).

No association between atopy and the number of older-younger siblings, routine vaccinations, day-care attendance, recent acute infections, parasitic infections ever, and exposure to indoor smoking was found in this study.

DISCUSSION

Substantial disparities in the prevalence of atopy and atopic disease were found between the study areas, and the disparities in atopy among children seem to have even increased. Analysis of generational differences revealed that in Finland the sensitization rates for most aeroallergens tested were remarkably higher among children compared with among their mothers, whereas the opposite (ie, lower sensitization rates among children than among mothers) was found in Russia. To clarify the effect of environment *per se* on these generational differences, an analysis among individuals (mothers and children) without genetic predisposition was performed. The differences were similar (Finland) or even larger (Russia) compared with the whole population (see this article's Table E2 in the Online Repository at www.jacionline.org). Disparities in the occurrence of atopy thus appear to have increased, rather than decreased, between North Karelia, Finland, and Pitkäranta district, Russia, between these generations and in the 14 years since the collapse of the Soviet Union. Two previous studies have examined atopy trends after major governmental changes. Data from the former East Germany showed an increase in atopy prevalence among schoolchildren after the reunification of the country (1991-1996),²² suggesting rapid westernization of eastern Germany, whereas among Estonian schoolchildren, no such an increase in atopy prevalence 6 years after independence was seen.²³

TABLE III. Determinants of atopy (at least one positive SPT result) in Finnish and Russian children derived from logistic regression analysis adjusted for age and sex and, in the analysis of "All," country

Variables	Finland		Russia		All	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Parental history of atopy	1.60 (1.04-2.45)	.031	1.96 (0.96-4.03)	.066	1.68 (1.16-2.43)	.006
Indoor pets, <1 y						
Cats	0.68 (0.39-1.19)	.176	0.43 (0.24-0.80)	.007	0.55 (0.36-0.83)	.004
Dogs	0.57 (0.35-0.95)	.031	0.65 (0.33-1.28)	.215	0.60 (0.40-0.91)	.015
Indoor pets, 1-9 y						
Cats	1.06 (0.69-1.64)	.799	1.39 (0.75-2.58)	.298	1.16 (0.82-1.65)	.411
Dogs	0.69 (0.45-1.05)	.081	1.18 (0.70-1.98)	.536	0.85 (0.62-1.19)	.344
Parental farming						
<1 y	0.53 (0.28-0.99)	.047	0.47 (0.22-1.03)	.059	0.50 (0.31-0.81)	.005
Currently	0.45 (0.22-0.91)	.026	0.64 (0.29-1.42)	.271	0.52 (0.31-0.88)	.015
Contacts with farm animals						
Never	Reference = 1		Reference = 1		Reference = 1	
Rarely*	0.46 (0.13-1.60)	.661	0.90 (0.26-3.06)	.933	0.71 (0.32-1.58)	.969
Daily	0.28 (0.08-0.99)	.014	0.76 (0.24-2.34)	.516	0.49 (0.23-1.07)	.019
Day-care attendance						
<1 y	0.87 (0.40-1.89)	.721	—	.983	0.76 (0.36-1.59)	.465
1-3 y	1.09 (0.72-1.66)	.689	0.96 (0.56-1.66)	.895	1.04 (0.75-1.45)	.823
Acute infections (12 mo)						
≤4	Reference = 1		Reference = 1		Reference = 1	
5-6	1.86 (0.81-4.26)	.297	1.58 (0.56-4.46)	.356	1.74 (0.92-3.30)	.133
≥7	0.74 (0.07-8.44)	.626	0.77 (0.17-3.47)	.537	0.78 (0.22-2.80)	.429
Parasitic infections						
<i>Enterobius vermicularis</i>	0.99 (0.51-1.92)	.973	0.94 (0.56-1.60)	.829	0.96 (0.63-1.45)	.829
<i>Ascaris lumbricoides</i>	—		0.87 (0.32-2.34)	.782	0.81 (0.30-2.17)	.676
<i>Giardia lamblia</i>	—		3.47 (0.80-15.04)	.097	3.44 (0.79-14.90)	.099
Any	1.07 (0.55-2.05)	.850	0.96 (0.57-1.60)	.866	0.99 (0.66-1.49)	.976
Exposure to indoor smoking	0.75 (0.17-3.25)	.695	0.93 (0.54-1.60)	.790	0.91 (0.54-1.51)	.700

—, Too few cases for analysis.

*Weekly or less.

An analysis of the European Community Respiratory Health Survey results showed that the increase between generations in atopy and allergic rhinitis could not be observed in subjects who had grown up on a farm in childhood.²⁴ However, it is likely that other factors associated with traditional lifestyle (eg, frequent contacts with soil, compost, and fire wood) are involved in Russia in addition to farming.

The prevalence of asthma, self-reported or physician diagnosed, as well as sensitization rates among school-children in Finland, are comparable with those reported from Europe, where peak prevalence values have in many countries already been reached.²⁵⁻²⁷

Contrary to many earlier studies,² no sibling effect could be found in this study, which we consider to be an issue of power. Most families here were small, and no major differences in this respect could be seen between the countries.

Current wheezing in children was the only disorder that appeared to occur at similar rates both among the Finns and the Russians, a finding similar to that reported from a Swedish-Estonian study.²⁸ It is evident that much of the wheezing in Russia, as in Estonia,²⁸ is not associated with atopy, which is also indicated by the several-fold

higher occurrence of wheezing ever compared with the occurrence of atopy or asthma ever among Russian mothers.

Logistic regression analysis identified parental farming to confer protection against atopy. Similar findings have been reported in numerous previous studies mostly obtained from affluent western societies.^{2,16,29} The effect of current parental farming was even stronger than that in early life, which is in line with findings reported earlier in Finland.²⁹ The role of saprophytic mycobacteria,¹² *Streptomyces* species, and other gram-positive bacteria abundant in soil and vegetation in conferring protection against atopy clearly deserves further investigation.

Interestingly, the inverse association between farming and atopy appears not to be restricted to affluent western countries because this association emerged also from the Russian data, although of much lower magnitude, given that atopy is uncommon on the Russian side. Daily contacts with farm animals were also inversely associated with atopy in Finland, but because this is closely associated with farming, it most probably represents only a proxy for farming. Pets, dogs in Finland and cats in Russia, were shown to confer protection against atopy, particularly when they were kept in early life, which

is in line with a number of previous reports.^{2,30-32} In genetically predisposed children the effect of having pets on atopy was virtually similar to that in the whole population (data not shown). Besides differences in the magnitude of exposure,³² cultural differences in keeping pets (outdoor-indoor pets) between Finland and Russia might affect their ability to provide protection. Use of a multivariate model did not change the interpretation of the results (see this article's Table E3 in the Online Repository at www.jacionline.org).

Nearly half of the Russian mothers reported that their child had infections caused by intestinal parasites, mainly *Enterobius vermicularis*, significantly more frequently than their Finnish peers. However, neither *E. vermicularis* nor *Ascaris lumbricoides* were associated, inversely or positively, with atopy here. Because these data were based on questionnaires only, the results must be interpreted with caution.

Some other limitations of this study should be acknowledged. Cultural and linguistic differences in perceiving and reporting symptoms and disease might cause a bias. However, we used the core questions of the standardized ISAAC questionnaire, translated into local languages, to assess the occurrence of atopic disease, which renders the results comparable with other ISAAC studies. The dependence of prevalences on the recall in general might include a source of bias, particularly when early events and exposure that are not directly related to emotional experiences are considered,³³ but this is less likely to affect the interpretation of the results in comparative studies such as this.

The strengths of this study include the unique study areas that allowed comparisons of asthma and atopy prevalences across an east-west gradient that is currently considered among the largest in the world and allowed analyses of the effect of 2 fundamentally different living conditions on asthma and atopy prevalences. In addition, we performed objective measurements of atopy (ie, SPTs) on all participants without seasonal effects on the results because testing was performed during a 4-month period, 1 week in turn on both sides of the border. Moreover, inclusion of both children and their mothers allowed the assessment of generational differences in both countries, which gives clues about atopy trends in these areas. In Russia several indicators have shown that the socioeconomic environment in the 1990s has not improved but rather has changed for the worse.^{34,35} Nor could we find any signs of westernization in Russian Karelia by using atopy prevalence as a proxy.

In conclusion, on the basis of comparisons of children with their mothers, the disparities in the occurrence of atopy between the countries appear to have further increased during these generations. Parental farming and having pets in early life were inversely associated with atopy; however, both farming and pets might be surrogate markers for exposure to microorganisms in soil and vegetation. Their role as immunomodulators needs to be clarified.

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