

Allergen sensitization and allergen exposure in Greenland Inuit residing in Denmark and Greenland

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Abstract The aim of this study was to estimate the prevalence of allergic sensitization and possible risk factors in a genetically homogenous Inuit population living under widely differing climatic and cultural conditions. A written questionnaire and skin prick test for 10 aeroallergens were obtained from 1119 adult Greenlanders residing in Denmark, Nuuk (main city in Southern Greenland) and Uummannaq (rural settlement in Northern Greenland). Allergen exposure was assessed by pollen counts, questions on pet keeping and counts of house dust mites in dust samples. The overall prevalence of at least one positive skin prick test was 22.8% in Denmark, 10.6% in Nuuk, and 6.4% in Uummannaq. In Denmark, the total birch pollen counts were 40–1000 times higher compared to Nuuk, whereas the grass pollen count was 13–30 times higher in Denmark compared to Nuuk. Dogs were held indoor with a similar frequency in Denmark and Nuuk, but much less frequently in Uummannaq. In Denmark, house dust mites were found in 72% of house holds (>10/0.1 g dust). Less than 15% of households in Greenland had measurable levels of house dust mites. The prevalence of sensitization to aeroallergens in Inuit Greenlanders differed significantly between Denmark, Nuuk and Uummannaq. These findings correlated with the observed differences in population allergen exposure in the three regions. Furthermore, differences in lifestyle factors such as educational level, stress and ethnic self-identification seemed to be associated with the risk of allergic sensitization in Greenland. © 2002 Elsevier Science Ltd. All rights reserved.

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INTRODUCTION

For reasons that still remain unclear, allergen sensitization, with or without symptoms of rhinoconjunctivitis and asthma have increased in prevalence during recent decades in both developed and developing countries (1–7).

Although heredity has been shown to play an important role in allergic sensitization, evidence suggests that environmental factors in general, and allergen exposure in particular, are essential to the development of allergic diseases (8,9).

Furred pets are kept in more homes than a century ago, and house dust mite exposure has increased (10). In Denmark, the season for birch pollen begins earlier than previously, and total pollen counts have increased (11). However, increasing allergen exposure cannot fully explain the increasing allergen sensitization.

Other factors associated with the development of an allergic and clinically important condition are only poorly understood (12,13). Age, gender and month of birth are associated with sensitization, but other, less-defined endo- and exogenous factors, also seem to be associated with allergic sensitization (12–16).

The aim of this cross-sectional study was to describe the relationship between the frequency of allergen sensitization in Greenland Inuit living in three climatically and culturally very different areas with allergen exposure as well as lifestyle factors, in order to further

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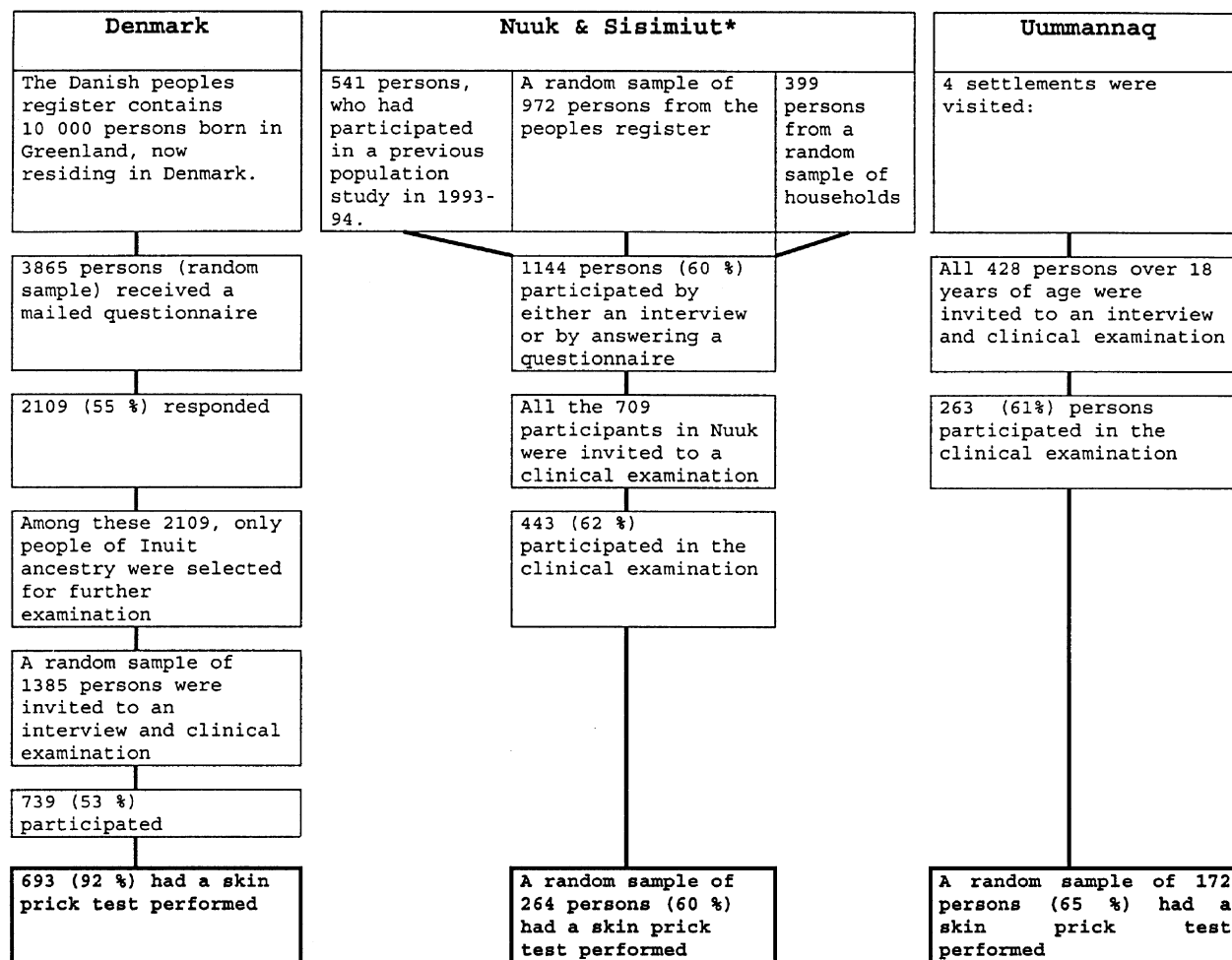


FIG. 1. Flowchart of study population.

describe possible important environmental factors causing allergic sensitization.

MATERIAL AND METHODS

Subjects

The study population and response rate is described in Fig. 1. Only subjects who were Inuit by ancestry were invited to participate in the study. The participation rate was quite low, which is something often seen in studies of Inuit Greenlanders, where participation rates around 50% are common.

Climate and site description

Denmark is a typical western society of 5 million inhabitants, whose lifestyle resembles that of the rest of Europe with regard to housing (modern, centrally heated and well-insulated houses), dietary habits (a large variety

of foodstuffs and large amounts of additives), occupation, day care (most children are in day care) and health care (easily accessed and highly specialized).

Copenhagen (Capital of Denmark) (55°43'N, 12°34'E) has a temperate climate dominated by westerly winds generally with mild winters and relatively cold summers and yearly precipitation of 600 mm. The yearly mean temp. is +8.0°C and average temp. in July is +16.5°C.

The average concentration of nitrogen dioxide outdoors was 40 ppbv reaching peak concentrations of 50 ppbv during the period between 1993 and 1999 (17).

Nuuk is the main city of Greenland with a population 13 500 inhabitants with a lifestyle in some ways that resembles that of Denmark or other developed countries, with regard to housing, diet, occupation and health care.

Nuuk (64°10'N, 51°45'W) is situated about 250 km south of the Polar Circle. The Gulf Stream reaches this part of Greenland, preventing the sea from freezing during winter. The climate is arctic/polar with a mean

yearly precipitation of 750 mm and mean yearly temp. of -1.9°C and monthly average of $+6.5^{\circ}\text{C}$ in July. The average concentration of nitrogen dioxide outdoors was 5.5 ppbv reaching peak concentrations of 18 ppbv during the period between June 1998 and July 2000 (18).

Uummannaq consists of a small town and six rural settlements and is a very typical dog-sledge district. The inhabitants live mainly as hunters and fishermen and their lifestyle is traditional with regard to housing, diet and health care. Uummannaq is only reachable by boat or helicopter.

Uummannaq ($70^{\circ}40'\text{N}$ and $52^{\circ}08'\text{W}$) is situated about 500 km north of the Polar Circle on an island, which covers 12 km^2 and is dominated by the 1175 m high mountain. The climate is arctic with a mean yearly precipitation of about 250 mm and a mean yearly temp. of -5.7°C and a monthly average of $+4.8^{\circ}\text{C}$ in July. The average concentration of nitrogen dioxide outdoors was 4 ppbv with peak concentrations reaching 14 ppbv during the period of September 1998 till July 2000 (18).

Questionnaire

The questionnaire was a general health questionnaire including respiratory symptoms and factors of possible importance for development of allergic diseases. In addition, questions on ethnic background, length of residency in Denmark, education, employment and smoking were included.

All questions in the mailed questionnaire were written in Danish and translated into Inuit. Then the questions were retranslated back to Danish to secure the meaning of the questions. All Inuit living in Denmark were questioned in both languages, but were asked only to answer one version. Inuit in Greenland were only given the Inuit version.

Participants were interviewed about symptoms of rhinoconjunctivitis, using a questionnaire adapted from the ISAAC study (19) ("When not having a cold, have you ever experienced having—itchy eyes, sneezing, a runny nose, a blocked nose or a diminished sense of smell"), and family history of atopic diseases ("Do your parents have allergy/hay fever/asthma?"). Questions were asked about present living conditions, indoor factors, smoking habits of the patient and parents, drinking habits, education ("Have you finished an education?" (After finishing school and high school)), family size, sports activities, stress ("Do you have a stressful every day life?"), and whether pets were kept in the house. Complete answers were received from 1060 (94.7%) of the 1119 individuals who had a skin prick test performed.

Skin prick test

Subjects were tested on the volar surface of the distal forearm, using standard dilutions (10 HEP, moulds 1:10 w/v) of allergens in 50% glycerol (ALK-Abello, Hørsholm, DK). Skin prick tests (SPTs) were done in duplicate according to the EAACI guidelines (20) with a histamine standard of 10 mg/ml and the diluent as a negative control (21). The allergens used were birch, Timothy grass, mugwort, horse, dog, cat, *Dermatophagoides pteronyssinus* and *D. farinae* and two moulds (*Alternaria alternata* and *Cladosporium herbarum* at 1:10 w/v). A positive reaction was defined as a reaction of at least 3 mm in diameter and at least half the size of the reaction to histamine.

Allergen sensitization was defined as a positive skin prick test to at least one of the 10 aeroallergens in the standard panel.

Pollen sampling

As a part of the study, airborne pollen measurements were carried out in Nuuk during the season of 1997–99, with a Burkard Volumetric 7-day Spore Trap (Burkard Manufacturing Co. Ltd.). The trap was placed at the Queen Ingrid Hospital ($64^{\circ}10'\text{N}$, $51^{\circ}45'\text{W}$, 19 m above mean sea-level) at 1.5 m above ground level.

The pollen data for Copenhagen were obtained from official recordings utilizing a Burkard Trap placed at the Danish Meteorological Institute ($55^{\circ}43'\text{N}$, $12^{\circ}34'\text{E}$, 8 m above mean sea-level) 15 m above ground level. For counting pollen standard methods were used (22).

Dust sampling

In order to assess the general exposure to HDM, dust samples were collected from a total of 117 homes (Denmark $n = 72$, Nuuk $n = 19$ and Uummannaq $n = 30$). All dust samples were collected in a new vacuum cleaner bag with separate sampling from the mattress and bedroom floor. Bags were sealed in a plastic bag and stored at room temperature until preparation. Domestic mites were counted, identified by microscopy, and recorded as number of mites per gram dust, as previously described (23).

Ethics

The study was approved by the local ethic committees and all subjects gave informed consent to participate.

Statistics

The data were analysed using the statistical pack SPSS. Logistic regression analysis was used to assess commonly accepted risk factors primary to the presence of allergen

sensitization at any time. Non-significant variables were deleted by backward elimination. Differences in mean (SD) values between subjects with and without sensitization were tested with non-parametric analysis. A P -value < 0.05 was considered significant. Prevalence rates were calculated for the entire group and the subgroups and differences were tested using Chi-square analysis.

RESULTS

Demographic factors

The populations in the three areas differed with regard to age, sex, education and ethnic self-identification as described in Table I.

More females (72.6%) (Table I) than males participated in Denmark with a similar trend in Greenland. The mean age of the three populations was not comparable, as the study population in Uummannaq was younger ($P < 0.001$, Table I).

The majority of the Inuit residing in Greenland considered themselves Inuit when answering the question "Would you define yourself as Inuit, Inuit and Danish or Danish?" A significantly lower proportion of the Inuit living in Denmark considered themselves Inuit. All participants in this study fulfilled the inclusion criteria of either being Inuit by self-identification or having at least one Inuit parent.

More than 45% of Inuit living in large cities in Denmark and Nuuk reported a stressful everyday life. In contrast, only 29% of the Inuit living in the rural setting of Uummannaq felt stressed (Table I).

In Denmark and Nuuk the majority of the subjects had finished an education, compared to Uummannaq, where only 14% had finished an education (Table I).

Diet

Fish was a regular part of the diet in both Denmark and Greenland, whereas a daily intake of fish oils was more common in Denmark.

Indoor factors

Significant differences in in-door factors such as use of carpets, in-door drying of clothes and damp in dwellings were observed between the three areas. In Greenland, most households lacked fitted carpets in the bedroom. In contrast, in Denmark almost 50% of the households reported fitted carpets in their bedrooms (Table I).

Washed clothes were air-dried indoor more often in Denmark and Uummannaq (Table I). Signs of dampness indoors was reported more frequently in Greenland than in Denmark ($P < 0.05$). Finally, a high proportion (more than 50%) of the Inuit was smoking.

Pollen exposure

Birch and grass pollen counts were much higher in Denmark compared to Nuuk and the pollen seasons longer (Table I).

In 1997–1999, the three birch pollen seasons in Denmark started at the end of April. The seasons continued approximately 1 month and the total birch pollen counts for the entire seasons ranged from 3103 to 9060 m^{-3} air (Table I).

In Nuuk, the birch seasons began approximately 1 month later and went to from 3 days to 1 month. The birch pollen count ranged from 9 to 80 during the three seasons.

In Denmark, grass pollen occurred between June and August and the grass pollen counts were 1386 to 1723. In Nuuk the grass pollen season was of similar length but began 1 month later. The total pollen counts ranged from 56 to 103.

Pet exposure

Pets were kept more frequently in Denmark compared to both Nuuk and Uummannaq.

Almost 20% of homes in Denmark kept dogs or cats. In rural Uummannaq $< 2\%$ kept a cat or a dog indoors. Many dogs, however, are kept outside and used as sleigh dogs. In Nuuk a few homes (12%) kept indoor dog and cat was rare (3%) (Table I).

House dust mite exposure

In Denmark, house dust mites were found in most households and frequently in large amounts, whereas house dust mites were rare in Greenland (Table I).

Dermatophagoides house dust mites were found (any amount) in dust samples from 87% of the Danish households. Seventy-two per cent of the Danish households demonstrated dust samples with significant levels of house dust mites ($> 10/0.1$ g dust, which corresponds to $2 \mu\text{g}$ Der PI allergen/g of dust).

In Greenland single specimen of *Dermatophagoides* mites per 0.10 g of dust was found in 15% of Nuuk households and 3% of Uummannaq households. (Table I).

The highest level of dust mites in a sample of 0.1 g dust was 1 house dust mite (*Dermatophagoides* spp.) and 22 storage mites in the dust samples from Greenland.

When *Tarsonemus* mites and storage mites were included, mites were found in 26.7% of Nuuk households and 13.3% of Uummannaq households (Table I).

Interestingly, the *D. farinae* mites from Greenland differed morphologically from the Danish mites and represents a Greenland subspecies rather than mites imported from Denmark.

TABLE 1. Demographics, smoking habits, indoor factors and allergen exposure in 1119 Greenland Inuit living in Denmark or Greenland (%)

	Denmark <i>n</i> = 683	Nuuk <i>n</i> = 264	Uummannaq <i>n</i> = 172
<i>Demographics</i>			
Age (years, median (range))	42 (19–78)	39 (18–59)	34 (18–56)*
Women	72.2	61.7	59.9*
Education ^a	65.2	69.0	14.1*
Current smoker	59.7	66.9	65.6
Passive smoking in childhood	84.8	87.6	93.5*
Stress in everyday life	52.9	45.7	29.4*
Ethnicity (% Inuit) ^b	30.9	87.4	90.7*
<i>Allergic disposition</i>			
Parents hay fever	12.0	3.9	5.7**
Parents allergy	20.0	13.3	14.8***
<i>Diet</i>			
Fish intake ≥ 1 week	47.5	45.3	52.5
Fish oils daily	12.5	4.2	4.7
<i>Indoor factors</i>			
Fitted carpet in bedroom	47.0	14.3	12.4*
Indoor drying of clothes	64.6	71.6	45.5*
Damp on windows	20.5	44.2	31.9*
Damp on walls	7.0	19.0	13.9*
<i>Allergens</i>			
Birch pollen (total)	3103–9060	9–80	—
Grass pollen (total)	1386–1723	56–103	—
Birch pollen season	April	June	—
Grass pollen season	June–August	July–September	—
Cat in home now	18.6	3.1	1.7*
Dog in home now	18.6	11.6	0.9*
Pet in childhood	53.9	44.7	12.1**
House dust mites ^c	72.0	15.0	3.9*

* $P < 0.001$.*** $P < 0.05$.** $P < 0.001$.^aHave you finished an education?^bWould you call yourself Inuit, Inuit and Danish or Danish? (self-identification; all participants were by definition of Inuit heredity).^c*Dermatophagoides* species: Denmark; HDM counts $> 10/0.1$ g dust. Greenland; occurrence of any number of HDM.

Childhood risk factors and heredity

The majority ($> 80\%$) of all the Inuit was exposed to passive smoking during childhood (Table 1).

Inuit in Greenland were less frequently born into families with symptoms of hay fever and allergy than Inuit in Denmark (Table 1). In addition, more than 45% of Inuit living in Denmark and Nuuk reported childhood exposure to pet animals. The exposure to pet animals was approximately five times more frequent in those regions compared to subjects living in Uummannaq.

Frequency of positive skin prick test

A positive reaction to one or more of 10 inhalant allergens was found in 22.8% of Inuit residing in Denmark compared to 10.6% in Nuuk and 6.4% in Uummannaq (Table 2).

Sensitization to birch and grass pollen was far more frequent in Denmark compared to Greenland ($P < 0.05$), where sensitization to birch was rare (Table 2). Sensitization to cat and dog was twice as frequent in Denmark compared to Nuuk, and rare in Uummannaq. The frequency of positive skin test reactions to both dust mites were twice as frequent in Denmark compared to Nuuk, and four times more frequent than in Uummannaq (Table 2).

Sensitization to moulds was uncommon in all regions.

Frequency of rhinitis symptoms

In Denmark, 82.7% of atopic Inuit reported one or more symptoms of rhinitis (itchy eyes, runny nose, blocked nose or diminished sense of smell, when *not* having a

TABLE 2. Prevalence of positive skin prick test in 1119 Greenland Inuit living in Denmark or Greenland (%)

	Denmark <i>n</i> = 683	Nuuk <i>n</i> = 264	Uummannaq <i>n</i> = 172
Atopy ^a			
All ages	22.8	10.6	6.4*
Age 18–24 years	36.4	20.0	15.0
Age 25–34 years	30.2	8.6	6.1
Age 35–59 years	20.8	10.9	4.7
Age 59+ years	12.5*	10.6	0
Birch (<i>Betula v.</i>)	7.9	1.1	0.6*
Grass (<i>Phleum p.</i>)	11.1	3.4	3.5*
Mugwort	4.1	0.8	0*
Horse	1.9	0.8	0*
Dog	6.7	3.8	0.6*
Cat hair	7.6	5.3	0.6*
<i>D. farinae</i>	6.1	2.7	1.7*
<i>D. pterynussinus</i>	6.3	3.0	1.2*
<i>Cladosporium</i>	1.3	0.8	0
<i>Alternaria</i>	1.0	0.4	0
Allergic rhinitis (%) ^b	82.7	64.3	54.5

^aAtopy; positive allergen skin prick reaction to one or more of the allergens used in the skin prick test.

^bSymptoms of rhinoconjunctivitis among subjects with one or more positive SPT.

**P* < 0.05.

cold), in Nuuk and Uummannaq, similar figures were 64.3 and 54.5%, respectively (Table 2).

Factors associated with a positive skin prick test

Sensitization to one or more aeroallergens was positively associated with young age (18–24 years) in subjects living in Denmark, whereas this association was less clear in Greenland (Table 3). This was probably due to the low number of sensitized allergic subjects in Greenland.

Subjects who identified themselves as Inuit tended to have a lower prevalence of allergic sensitization, but this association was only significant in Nuuk.

Inuit living in Denmark more often had a parent or grandparent born in Denmark, but there was no association between the place of birth of parents or grandparents and the risk of allergic sensitization.

For Inuit in Denmark, a stressful everyday life was associated with a higher prevalence of allergic sensitization, as was smoking (Table 3).

Regular fish intake did not apparently affect the risk of allergic sensitization apart from in Uummannaq, where it seemed to have a protective effect (Table 3).

In Denmark and Nuuk, subjects who reported that their parents had hay fever symptoms, were more often

sensitized than subjects, who did not report that their parents had hay fever (Table 3).

The age where subjects were exposed to high amounts of allergen was associated with the risk of allergic sensitization: In Denmark, subjects who lived in Denmark already at the age of five had an increased risk of being sensitized compared to subjects who still lived in Greenland at the age of five (*P* < 0.05) (Table 3). For Inuit in Nuuk, having lived in Denmark at an age of 5 years also increased the risk of allergic sensitization, but this association was not significant. Furthermore, for Inuit residing in Greenland, there was no association between having ever lived outside Greenland and being sensitized to aeroallergens (Table 3). These findings may reflect the importance of the length of time of allergen exposure.

Current or previous exposure to animal dander was not associated with sensitization (Table 3).

Binominal logistic regression analysis

A binominal forward logistic regression analysis was performed for the three areas of study separately and for the study population as a whole. A positive skin prick test to one or more aeroallergens was the dependent variable and independent variables were the following; gender, age, smoking, smoking in childhood, education, indoor drying of clothes, wall-to-wall carpeting, ethnicity, stress, parents with hay fever symptoms, intake of fish and fish oils, and current or previous pet keeping (Tables 4 and 5). Community of study (Denmark, Nuuk, Uummannaq) was a variable in the total analysis of the population as a whole (Table 5).

When analysing the three areas separately, allergic sensitization seemed to be associated with young age, smoking and parental disposition to hay fever in Inuit living in Denmark. Whereas in Nuuk, young age, but also stress and ethnic self-identification were associated with allergic sensitization, as was having an education for the Inuit living in Uummannaq (Table 4).

In the regression analysis for all three communities of study, only the community of study remained significantly associated with allergic sensitization to one or more allergens after regression analysis. (Table 4).

DISCUSSION

In this cross-sectional study of adult Greenland Inuit residing in three geographically and climatically very different regions (Denmark, Northern and Southern Greenland), we found major differences in the prevalence of allergic sensitization to aeroallergens, that reflected the differences in the population exposure levels to aeroallergens.

TABLE 3. Prevalence of allergic sensitization^a in subjects with or without certain variables in 1119 Greenland Inuit living in Denmark or Greenland (%)^b

	Allergic sensitization (positive SPT to one or more of ten aeroallergens)					
	Denmark		Nuuk		Uummannaq	
	Yes	No	Yes	No	Yes	No
Female	22.6	23.5	6.9	12.9	7.2	5.8
Smoker	31.0	23.0*	10.0	14.0	7.0	4.8
Education	24.7	21.6	11.2	10.5	21.4	3.5**
Ethnic self-identification (Inuit)	17.2	25.6	8.7	26.7*	6.0	0
Stress	24.0	16.4*	8.7	5.0	3.8	3.0
Fish intake > = 1 week	21.0	26.0	13.0	10.0	4.4	7.4**
Fish oils daily	18.8	24.2	18.2	11.5	0	7.5
Parents hay fever	36.1	16.9	10.0	4.7	11.1	6.9
Ever lived outside Greenland	—	—	12.8	10.8	9.1	7.1
Lived in Denmark at age 5	29.4	17.8**	0	11.9	0	7.1
Lived in Denmark at age 10	23.0	18.8	22.2	11.4	0	7.1
Pet in childhood	21.0	25.4	15.5	7.8**	21.4	3.9**
Dog now ^c	6.9	7.2	3.3	3.9	—	—
Cat now ^d	8.4	7.1	0	5.6	—	—

^a To one or more of to aeroallergens: Birch, grass, ragweed, horse, dog, cat, house dust mites (*D. farinae* & *D. pterynussinus*) & moulds (*Cladosporium* & *Alternaria*).

^b Example: 22.6% of women living in Denmark had allergic sensitization as opposed to 23.5% of men.

^c As to dog.

^d As to cat.

* $P < 0.05$.

** $P < 0.001$.

TABLE 4. Binominal forward regression analysis of risk factors for allergic sensitization to one or more of 10 aeroallergens in 1119 Greenland Inuit analyzed for each area of study separately. (Only variables included in the final analysis are presented)

	Allergic sensitization (positive SPT to one or more of ten aeroallergens)					
	Denmark		Nuuk		Uummannaq	
	OR	CI	OR	CI	OR	CI
Age < 30	1.59	0.43–1.73	1.25	0.30–5.2	—	—
Smoker	1.19	0.74–1.90	—	—	—	—
Stress	—	—	2.18	0.19–24.73	—	—
Education	—	—	—	—	7.55	1.03–55.07
Ethnic self-identification (Inuit)	—	—	0.07	0.01–1.22	—	—
Parents hay fever	2.30	0.81–29.43	—	—	—	—

Dependent variable; positive skin prick test to one or more of 10 aeroallergens. Independent variables; gender, age, smoking, passive smoking in childhood, education, ethnicity, stress, parents with hay fever symptoms, in-door drying of clothes, wall-to-wall carpeting, current or previous pet keeping, living in Denmark at age 5 and 10 years and having lived outside Greenland (only Nuuk and Uummannaq).

The association between allergen exposure and the risk of allergic sensitization is well known from previous studies (9,14,15).

However, it seems that other environmental factors are of importance to the development of allergic

sensitization and allergic disease. In von Mutius' studies of East and West German children immediately after and 5 years after the reunion of Germany, a large increase in the prevalence of allergic sensitization was observed in children from former East Germany over the 5

TABLE 5. Binominal forward regression analysis of risk factors for allergic sensitization to one or more of 10 aeroallergens in 1119 Greenland Inuit—analysis of entire study population. (Only variables included in the final analysis are presented)

	OR	95% CI
Living in Denmark vs Uummannaq	3.62	1.64–8.22*
Living in Nuuk vs Uummannaq	1.92	1.23–3.02*
Parents hay fever	6.87	0.59–79.87
Smoker	1.30	0.88–1.91

* $P < 0.005$.

Dependent variable: positive skin prick test to one or more of 10 aeroallergens. *Independent variables:* gender, age, smoking, passive smoking in childhood, education, ethnicity, stress, parents with hay fever symptoms, fish intake $>= 1$ week, daily fish oils intake, in-door drying of clothes, wall-to-wall carpeting and current or previous pet keeping.

year period. Allergen exposure did not, however, increase simultaneously (14,15). These findings have, among others, led to the conclusion that factors associated with a "Western Lifestyle" must play a role for the development of allergic sensitization (diets including a large number of different foods, recurrent infections in childhood due to more children in day care and kindergartens, increased air pollution from motor vehicles, increased stress and smoking).

In the present study, we investigated a genetically homogenous population exposed to widely differing amounts of allergen, presumably eliminating the effects of genetic variation and observed a correlation between population allergen exposure and allergic sensitization.

This was the observation with sensitization to pollens, where the prevalence of sensitization differed between Denmark and Nuuk in equivalence with the differences in pollen counts.

As an exception from this correlation between allergen exposure and sensitization, we found that allergic sensitization to cat was similar in prevalence in Denmark and Nuuk, despite the finding that few cats were currently kept in Nuuk. This could perhaps be explained by the finding that pets had been kept in similar numbers during childhood in the two areas. Also, as previous studies have shown, cat allergen adheres well and for a long time to clothes and can be detected far away from areas where cats are kept even in amounts sufficient to provoke an allergic reaction (24).

The finding of allergic sensitization to house dust mites in Inuit in Greenland, who had never lived outside the country, was surprising. The arctic climate of Greenland was expected to disfavour the living conditions of dust mites, as shown in the generally low exposure levels in the collected dust samples. However, the finding of a

morphological Greenland subspecies mite indicates, that whole populations of mite are in fact able to survive and reproduce in Greenland houses, and some people in Greenland must be exposed to large amounts of mites.

In the present study, some lifestyle factors potentially signifying a western lifestyle seemed to be associated with the risk of allergic sensitization: stress, level of education and self-identification as Inuit/Danish rather than Inuit. These associations were only observed for the Inuit who lived in Greenland, and may reflect that most Inuit living in Denmark had assimilated to a western lifestyle. The relative impact of a western lifestyle would only be expected to be visible in a society where not all inhabitants have a western lifestyle. This is the case in Greenland, where a mixture of traditional and western lifestyle is found; some people live traditionally, and others have assimilated more or less completely to a western lifestyle.

However, when a regression analysis was performed for the study population as a whole, only the current place of residency (community of study) remained significant, suggesting that in this population, environmental factors rather than lifestyle factors were of major importance to the prevalence of allergic sensitization.

To elucidate the relative importance of allergen exposure and lifestyle factors, a follow-up study is planned to describe, whether the ongoing westernization of Inuit in Greenland will result in a higher prevalence of allergic sensitization.

In conclusion, we found major differences in the frequency of allergic sensitization to aeroallergens in Inuit living in Denmark, northern Greenland (Uummannaq) and southern Greenland (Nuuk), reflecting large difference in population allergen exposure to aeroallergens, as well as lifestyle factors.

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REFERENCES

- Ulrik CS, Backer V. Atopy in Danish children and adolescents; results from a longitudinal study. *Ann Asthma Immunol* 2000; **85**: 293–297.

2. Schoenwetter WF. Allergic rhinitis: epidemiology and natural history. *Allergy and Asthma Proc.* 2000; **21**: 1–6.
3. Jones NS, Carney AS, Davis A. The prevalence of allergic rhinosinusitis: a review. *J Laryngol Otol* 1998; **112**: 1019–1030.
4. Upton MN, McConnachie A, McSharry C, Hart CL, Smith GD, Gillis CR, Watt GC. 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.
5. Plaschke P, Janson C, Norrman E, Björnsson E, Lundbäck B, Lindholm N, Rosenhall L, Järvholm B, Boman G. Skin prick tests and specific IgE in adults from three different areas of Sweden. *Allergy* 1996; **51**: 461–472.
6. Warner JO, Pohunek P, Marguet C, Clough JB, Roche WR. Progression from allergic sensitization to asthma. *Pediatr Allergy Immunol* 2000; **11** (Suppl 13): 12–14.
7. Lau S, Illi S, Sommerfeld C, Niggemann B, Bergmann R, von Mutius E, Wahn U and The Multicentre Allergy Study Group. Early exposure to house-dust mite and cat allergens and development of asthma—a cohort study. *The Lancet* 2000; **356**: 1392–1397.
8. Smith JM, Cadoret RJ, Burns TL, Troughton EP. Asthma and allergic rhinitis in adoptees and their adoptive parents. *Ann Allergy Immunol* 1998; **81**: 135–139.
9. Wahn U, Lau S, Bergmann R, Kulig M, Forster J, Bergmann K, Bauer CP, Guggenmoos-Holzmann I. Indoor allergen exposure is a risk factor for sensitization during the first three years of life. *J Allergy Clin Immunol* 1997; **99** (Part 1): 763–769.
10. Korsgaard J. Epidemiology of house dust mites. *Allergy* 1998; **53** (Suppl 48): 36–40.
11. Rasmussen A. The Birch Pollen Season in Denmark. Trend analysis and model for start of the season, peak date and annual total. *Vejret* 2001 **86**: 6–16 (Danish) (ISSN 0106-5025).
12. Eriksson NE, Holmen A. Skin prick tests with standardized extracts of inhalant allergens in 7099 adult patients with asthma or rhinitis; cross-sensitizations and relationships to age, sex, month of birth and year of testing. *J Invest Allergol Clin Immunol* 1996; **6**: 36–46.
13. Kulig M, Klettke U, Wahn V, Forster J, Bauer CP, Wahn U. Development of seasonal allergic rhinitis during the first 7 years of life. *J Allergy Clin Immunol* 2000; **106**: 832–839.
14. Von Mutius E, Martinez FD, Fritsch C, Nicolai T, Roell G, Thiemann HH. Prevalence of asthma and atopy in two areas of West and East Germany. *Am J Respir Crit Care Med* 1994; **149** (Part 1): 358–364.
15. Von Mutius E, Weiland SK, Fritzsche C, Duhme C, Keil U. Increasing prevalence of hay fever and atopy among children in Leipzig, East Germany. *Lancet* 1998; **351**: 862–866.
16. Gislason D, Björnsson E, Gislason T, Janson C, Sjöberg O, Elfman L, Boman G. Sensitization to airborne and food allergens in Reykjavik (Iceland) and Uppsala (Sweden)—a comparative study. *Allergy* 1999; **54**: 1160–1167.
17. Jensen FP, Hansen AB, Berkowicz R, Skov H. Benzene from traffic—fuel content and ambient air concentrations. Faglig rapport from DMU 309, 221 Danish Environmental Protection Agency 2000.
18. Stroyer Hansen T, Kruse M, Nissen H, Glasius M, Lohse C. Measurements of nitrogen dioxide in Greenland using Palmes tubes. *J Environ Monit* 2001; **3**: 139–145.
19. Asher I, Keil U, Anderson HA, et al. International study of asthma and allergies in childhood (ISAAC): rationale and methods. *Eur Respir J* 1995; **8**: 483–491.
20. Dreborg S. Skin tests used in type I allergy testing (position paper). *Allergy* 1989; **44** (Suppl 10): 22–30.
21. Dreborg S. The skin prick test: methodological studies and clinical applications. Medical Dissertation No. 239, Linköping, Sweden, 1987; 1–148.
22. Käpylä M, Penttinen. An evaluation of the microscopical counting methods of the tape in Hirst-Burkard pollen and spore traps. *Grana* 1981; **20**: 131–141.
23. Korsgaard J, Hallas TE. Tarsonemid mites in Danish house-dust. *Allergy* 1979; **34**: 225–232.
24. Berge M, Munir AK, Dreborg S. Concentrations of cat (Fel d), dog (Can f1) and mite (Der f1 and der p1) allergens in the clothing and school environment of Swedish children with and without pets at home. *Pediatr Allergy Immunol* 1998; **9**: 25–30.