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CLINICAL REPORT

Atopic Diseases Among Schoolchildren in Nikel, Russia, an Arctic Area with Heavy Air Pollution

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The objective of this study was to describe the prevalence rate of atopic diseases among schoolchildren living in the heavily polluted Arctic town of Nikel, Russia. A self-administered questionnaire was distributed to the parents of 1,800 children aged 8–17 years, 1,684 of whom (93.6%) completed and returned the questionnaire. Atopic diseases were reported in 508 (30.2%) of the children and prevalence was similar for both sexes. Atopic dermatitis occurred most frequently (15.5%), followed by allergic rhinoconjunctivitis (13.9%) and asthma (3.9%). The most pronounced influence on atopic diseases in children was having parents with asthma. Indoor dampness was a significant risk factor eliciting atopic diseases, whereas furred pets, passive smoking and carpets did not influence the prevalence of allergy. We conclude that although atopic diseases are a common health problem in Nikel, they are less prevalent than has been reported in recent studies of Northern European countries. Air pollution does not seem to be a major risk factor for the development of atopic diseases. ***Key words: atopic dermatitis; allergic rhinoconjunctivitis; asthma; children; pollution.***

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There is considerable evidence indicating that atopic diseases cluster in families (1–4). A Danish study of twins showed that the genetic impact of atopic dermatitis was more significant in identical than in non-identical twins, indicating that genetic factors play a decisive role in the development of atopic diseases (4). Recent epidemiological studies have suggested an increased prevalence of atopic diseases. The reasons for this increase are not known, but an increased awareness of symptoms, changes in indoor and outdoor environmental factors and the increased prevalence of Western living conditions and lifestyles all seem to be of importance (2, 5, 6). Several papers have reported that sulphur dioxide (SO_2), ozone (O_3), nitrogen dioxide (NO_2) and particulate matter may cause respiratory symptoms, asthma and eczema (7–9).

The purpose of the present study was to investigate the prevalence of atopic diseases among schoolchildren in the heavily polluted Arctic town of Nikel on the Kola Peninsula. In a previous study we reported the prevalence of atopic disease in adults living in Nikel (10). We are not aware of any previous studies of Russian schoolchildren in Arctic areas. Additional risk factors were investigated simultaneously.

MATERIAL AND METHODS

Nikel is a heavily polluted Russian town on the Kola Peninsula close to the Norwegian border with a population of about 23,000. The air pollution in the border areas is dominated by episodes linked to adverse meteorological conditions. The air pollution in this area is caused by emissions of sulphur dioxide (SO_2), particulate matter and heavy metals (such as nickel, copper, arsenic and poisonous aluminium compounds) from the smelter industries in Nikel and Zapolyarniy located 10 and 40 km from the Norwegian border, respectively. In 1993 the total emission of SO_2 from the smelters in Nikel and Zapolyarniy was about 250,000 tonnes. The average annual emission of SO_2 in this area was reduced by about 40% during the period 1982–92 (11). The mean SO_2 value was 43 $\mu g/m^3$ over a 6-month period during the winter of 1992–93, but maximum SO_2 concentrations close to 3000 $\mu g/m^3$ have been reported (12).

The study was conducted in the spring of 1994 and 1,800 schoolchildren aged 8–17 years from all 6 town schools in Nikel received a four-page self-administered questionnaire. Subjects were asked about symptoms of previous and/or present asthma, allergic rhinoconjunctivitis (AR) and atopic dermatitis (AD) in the whole family. Information requested included smoking habits of the family, keeping of and reactions to pets and housing and living conditions at the time of the investigation.

Cumulative incidence is here defined as past or present symptoms of atopic diseases. We have restricted atopic diseases to the three main atopic manifestations: AD, AR and asthma.

AD was diagnosed if the child had ever had an itchy rash of >4 weeks duration in at least one of the following areas: face; elbow and knee flexures; wrist and ankles; and hands. AR was defined as episodes with symptoms involving the nose or eyes (sneezing, stuffy nose, itching and lacrimation) in response to known or strongly suspected allergens (2). The asthma diagnosis was based on affirmative answers to both of the following questions: "Has the child suffered from asthma?" and "Does the child wheeze, cough, or have attacks of breathlessness (asthma) after exposure to extrinsic factors (pollen, animals, food, infections)?" The test–retest reliability (kappa) of the asthma definition when comparing the questionnaire to a clinical investigation (using the same questionnaire formulae) was found to be high (kappa 0.91; SE 0.04) (13). Symptoms of urticaria are here defined as one or more episodes of transient and migratory itchy erythema and swelling of the skin. The features of atopic diseases to look for were explained in broad terms in an accompanying informative letter.

The statistical analyses were performed using the statistical packages Epi-Info and SAS. The χ^2 test was used to compare the statistical significance between groups. Taylor series 95% confidence interval (95% CI) for relative risk (RR) was used to compare group differences and if the 95% CI did not include 1.0 the results were regarded as significant at $p < 0.05$.

RESULTS

Of the 1,800 children, 1,684 (93.6%) completed (with parental help) and returned the questionnaire. The cumulative incidence of atopic diseases was reported in 508 subjects (30.2%) and was similar for both sexes. AD occurred most frequently (15.5%), followed by AR (13.8%) and asthma (3.9%) (Table I). Asthma and AR occurred more frequently in boys than in girls whereas AD was reported more frequently in girls than in boys. Shortness of breath, either exercise-induced or during foggy or cold weather, was reported in 10.1% of the children and was equally distributed between boys and girls.

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Table I. *Frequency of atopic diseases among 1,684 schoolchildren (818 boys, 866 girls) in Nikel, Russia in relation to gender*

Atopic disease	No.	Percentage		
		Girls	Boys	Total
Atopic dermatitis	261	17.5[a]	13.4	15.5
Allergic rhinoconjunctivitis	233	13.6	14.1	13.8
Asthma	64	2.9	4.8[a]	3.9
Total atopic diseases	508	31.0	29.3	30.2

[a] Girls versus boys $p < 0.05$.

The incidence of AD was highest during the first years of life. Thus, in 23% of the children with AD the dermatitis first appeared before the age of 1 year and in 64% before the age of 5 years, whereas half of the children with AR had symptoms before the age of 7 years. Unexpectedly, only 30% of children with symptoms of AR had been prescribed treatment. Allergy tests were carried out on 9.6% of all the schoolchildren.

Urticaria was reported in 11.5% of the children (11.9% of boys and 11.2% of girls), with 105 of the 194 children (54.0%) experiencing two or more episodes of skin rash.

The correlation between parental and child histories of atopic diseases is shown in Table II. The least pronounced influence on atopic diseases in children was having an asthmatic mother or father: 33.3% of the children could be expected to have asthma, compared to 27.1% if the father was affected. AR in the mother increased the probability of the child developing the disease to 54.4%, compared to 50.0% if the father had AR ($p < 0.001$). If the mother had AD, AD could be expected in 52.6% of children, compared to 45.5% if the father had AD (Table II).

The relationship between the occurrence of different atopic diseases and trigger factors in the environment is shown in Table III. Indoor dampness was a significant risk factor eliciting all kinds of atopic diseases, with asthmatic girls being most at risk (RR = 17.1). The prevalence of asthma, AR and AD was significantly higher in children whose homes were heated by wood and oil than in those with electric heating (Table III). Likewise, indoor exposure to coal and gas heating systems significantly increased the risk of developing AD. Boys living in homes with furred pets were found to have a slightly increased risk of developing asthma (RR = 1.5), but this was not the case for girls or for children with AD asthma and AR. Surprisingly, no difference in the prevalence of atopic diseases occurred as a result of passive smoking or fitted carpets (Table III). In the total population surveyed, 55.2% of the parents were smokers (52.7% of males and 9.9% of females).

Table IV shows the residential characteristics and living conditions reported by the study group. About half of the households kept or had daily contact with furred pets (i.e. 23.8% kept dogs, 27.0% cats and 2.1% horses) and some kept birds (8.6%). Fitted carpets were common in most homes (83.4%) and damp patches on walls and/or windows and other signs of a humid indoor climate occurred in 12.8% of the homes. The standard of living was poor as almost everyone (97%) lived in blocks of flats, with most flats consisting of a kitchen, a living room and a bedroom with a total floor area of $< 55 m^2$.

Table II. *Atopic diseases in the children in relation to a maternal or paternal history of the same diseases*

Child's history positive for:	Mother's history (%)	Father's history (%)	*p*
Atopic dermatitis	52.6	45.5	0.33
Asthma	33.1	27.1	0.40
Allergic rhinoconjunctivitis	54.4	50.0	0.57

DISCUSSION

This study indicates a lower cumulative incidence of atopy than that reported in most European studies (2, 3, 13, 14). Different population-based studies are, however, difficult to compare due to the different methods used, different definitions of atopic conditions and the absence of standardized questionnaires. Russian people differ from other Northern Europeans both socially and politically, which may have influenced their replies to the questionnaires. We believe, however, that serious over- or under-reporting is unlikely as high sensitivity and specificity were found when comparing a self-reported diagnosis to a diagnosis based on a physician's clinical examination (13, 15). The International Study of Asthma and Allergies in Children (ISAAC) has recently carried out standardized international comparisons of the prevalence of atopic diseases among children. They found worldwide variations in the prevalence rate, i.e. 60-fold for AD, 30-fold for AR and 20-fold for asthma (16). Low disease prevalence was reported in China, Central Asia and Eastern Europe. Very high values were observed in western countries, such as Sweden, the UK, Australia and New Zealand. This is further evidence to support the lower prevalence of atopic diseases found among schoolchildren in former socialist European countries (6, 16).

Without doubt a strong link exists between atopic diseases and genetic factors, as reported in previous studies (3, 4). This would suggest that ethnic groups have a similar genetic predisposition to atopic diseases, although different environmental factors promote expression of the disease (17). The risk to children appeared to be higher when mothers rather than fathers had atopic diseases. This is in line with previous reports suggesting that maternal atopy carries a greater risk of inheritance (3, 18). Moreover, there seems to be a period in early life during which an infant is particularly susceptible to atopy, possibly due to contact with pollen (19), pets (20) and house dust mites (20, 21) and ingestion of foreign proteins (22). Our study showed that the number of households keeping pets, especially cats and dogs, is similar to that reported in other Northern European studies (2, 13). These findings indicate that most children were, in one way or another, exposed to animal dander, either via their own pets or by passive contact with pets. The absence of a significant relationship between direct exposure to furred pets and atopic symptoms may be due to the constant presence of these allergens, resulting in continuous exposure (5, 20). Moreover, this study confirms the findings of previous surveys suggesting an association between dampness and allergic symptoms (5, 21). In fact, domestic mite and pet allergens are more common in dust from homes with fitted carpets than from those with smooth floors (23).

It seems, however, that domestic factors in some way or

Table III. *Adjusted relative risk (RR) with 95% confidence interval (CI) of developing atopic dermatitis (AD), asthma and allergic rhinoconjunctivitis (AR) when exposed to various factors in the home environment*

Presence of:	AD		Asthma		AR	
	Boys RR (95% CI)	Girls RR (95% CI)	Boys RR (95% CI)	Girls RR (95% CI)	Boys RR (95% CI)	Girls RR (95% CI)
Passive smoking	0.8 (0.6–1.0)	1.2 (0.90–1.6)	0.5 (0.3–1.0)	0.5 (0.2–1.1)	0.9 (0.6–1.3)	0.9 (0.7–1.3)
Fitted bedroom carpet	0.5 (0.3–0.6)	0.5 (0.4–0.7)	0.2 (0.1–0.3)	0.1 (0.0–0.1)	0.4 (0.3–0.5)	0.5 (0.3–0.7)
Indoor dampness	1.7 (1.2–2.4)	1.8 (1.3–2.4)	5.5 (2.8–10.7)	17.1 (6.9–42.3)	1.8 (1.2–2.8)	2.12 (1.5–3.0)
Furred pets	1.0 (0.7–1.3)	1.0 (0.8–1.3)	1.5 (0.8–2.9)	1.1 (0.5–2.5)	1.3 (0.9–1.8)	1.2 (0.8–1.6)
Heating systems						
Electricity	1.0	1.0	1.0	1.0	1.0	1.0
Wood	4.7 (3.6–6.3)	3.4 (2.4–4.8)	38.1 (23.9–60.5)	62.4 (30.7–126.7)	7.6 (5.9–9.7)	5.8 (4.2–7.9)
Oil	1.5 (1.1–2.1)	1.7 (1.3–2.2)	2.5 (1.3–4.6)	4.6 (2.1–10.0)	1.7 (1.2–2.4)	2.1 (1.5–2.9)
Coal/gas/others	1.4 (1.0–1.9)	1.5 (1.1–2.0)	1.2 (0.7–2.3)	1.2 (0.5–2.6)	1.3 (0.9–1.8)	1.0 (0.8–1.5)

Table IV. *Residential characteristics and living conditions in Nikel, Russia (values shown are percentages)*

Residential characteristics	
Blocks of flats	97
Total floor area	
$< 33\,m^2$	50
$< 55\,m^2$	96
Bedroom floor area	
$< 12\,m^2$	60
$< 17\,m^2$	90
House built after	
1980	40
1960	75
1945	97
Fitted carpets	83
Humidity/patches of dampness	13
Down quilts	27
Heating systems	
Electric	16
Wood	3
Oil	26
Coal/gas/others	55
Home environment	
Smoking	55
Furred pets ≥ 1	52
Siblings	
0	34
1	53
2	9
≥ 3	4

other cause fewer allergy symptoms in children in Nikel. This is in line with the findings of earlier studies comparing former socialist countries with Western countries (6, 16). Thus, the Melbourne study reported an association between self-reported allergic symptoms and household conditions such as carpets, curtains and/or soft furnishings (24). In contrast, low levels of indoor mould and house dust mite were found in geographical areas in close proximity to each other, indicating that these allergens do not seem to be a major problem in Arctic regions (2, 5).

Children whose parents smoke have been found to have increased levels of serum-IgE (2), bronchial hypersensitivity and asthma (25). The effect of mothers smoking seems stronger than that of fathers smoking and indoor air pollution caused by numerous new building materials, which omit a multitude of chemical substances, may act as adjuvant factors in the development of atopy (25, 26). Thus, the low prevalence of atopic diseases in Nikel may to some extent be due to the low number of female smokers. Moreover, most parents (including fathers) do not smoke indoors as this is not socially acceptable in Russia.

In contrast to a previous study we found that AD, asthma and AR were less frequent among children living in homes with electric heating than in those using other energy sources (27). We therefore suggest that factors directly or indirectly related to the use of coal, gas, oil and wood for heating and/or cooking interfere with the immune system and elicit an increased risk of atopic diseases. The use of wood as a heat source was responsible for the highest risk of atopy. Furthermore, coal and wood burning increase the risk of indoor air pollution by SO_2 and particulate matter. Gas stoves were more common in homes without electric heating systems and may be responsible for increasing background levels of NO_2 to $> 50\,\mu g/m^3$ if an extractor fan is not used (28). Exposure to indoor air pollution by SO_2, NO_2 and particulate matter has been associated with increased sensitization, respiratory hypersensitivity, asthma and dermatitis (8, 9, 28, 29).

Outdoor air pollution in Nikel is dominated by episodes of high levels of SO_2, particulate matter and heavy metals, which may exceed international guideline values by a factor of > 10 (i.e. SO_2 concentrations of up to $3000\,\mu g/m^3/h$) (12). Studies in former socialist countries with heavy outdoor air pollution and the American Six Cities study confirm the correlation between respiratory symptoms such as bronchitis and chronic coughs and exposure to SO_2 and particulate matter (6, 30) but, however, low levels of atopic diseases (6). Conversely, factors associated with Western lifestyles, smoking habits, housing and other associated living conditions may induce the development of allergy (31). Moreover, prevalence rates found in Nikel are comparable with those from reports prepared 20–30 years ago (14) and in children from anthroposophic families (31).

In conclusion, in our study of schoolchildren in an Arctic area with heavy air pollution the frequency of atopic diseases was less than that found in recent comparable Northern European studies. Indoor living conditions (poor standard of living, e.g. small and insufficiently insulated houses, frequent

use of fitted carpets and smoking fathers) and heavy air pollution seem to be of less importance than other factors, e.g. Western lifestyles. Although we acknowledge the limitations of a retrospective questionnaire study, we do believe that Western lifestyles interact with atopic diseases. Hence a clinical case-control study controlling environmental risk factors is necessary in order to draw further conclusions.

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