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A Survey of Atopic Diseases among School Children in Sør-Varanger Community

Possible Effects of Subarctic Climate and Industrial Pollution from Russia

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The occurrence of atopic diseases in school children in the community of Sør-Varanger was studied on the basis of a questionnaire sent to the parents of all the 575 children aged 7–12 years. 551 children (95.8%), 266 girls and 285 boys, completed the questionnaire. Atopic diseases were reported to be present or to have occurred in 249 (45.2%) of the 551 children, more frequently in girls (50.4%) than in boys (40.4%) ($p < 0.02$). Asthma occurred in 68 cases (12.3%), with almost the same frequency in girls (13.2%) and boys (11.2%). Allergic rhinoconjunctivitis was detected in 113 children (20.6%); it was slightly more frequent in boys (21.8%) than in girls (18.9%) but did not reach statistical significance. Urticaria occurred in 72 cases (13.1%), more frequently in girls (17.7%) than in boys (8.8%) ($p < 0.002$), while atopic dermatitis occurred in 130 cases (23.6%), again more frequently in girls (27.6%) than in boys (19.6%) ($p < 0.03$). Ninety-four (37.8%) of the children experienced more than one atopic symptom. In 75% of the children with dermatitis the age at onset was under 5 and more than 50% of the children with asthma had experienced symptoms before the age of 3. Parental history of atopic diseases was reported by 35.6% of all children, more frequently in mothers (30.2%) than in fathers (20.1%). On the other hand, 30.6% of children with no parental history of atopic diseases appeared to develop some kind of atopic disease; this increased to 48.0% with a single and to 56.1% with a double parental history. A strong, cumulative effect in both single and double parental history was seen for dermatitis, asthma and allergic rhinoconjunctivitis with identical symptoms in parents and children. Smoking in the family and keeping of furred pets occurred irrespective of whether the children had atopic symptoms or not. 17.2% of the children reported reactions to foods, 8.9% to animal dander, 7.1% to grass pollen and 5.3% to birch pollen. Possible explanations for the high frequency of atopic diseases in this area may be sought in the subarctic climate and in industrial pollution. ***Key words: Asthma; Allergic rhinoconjunctivitis; Atopic dermatitis; Urticaria; Air pollution.***

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Atopic dermatitis, bronchial asthma and allergic rhinoconjunctivitis as well as certain forms of gastrointestinal allergy and urticaria are usually referred to as atopic diseases (1). One of the concepts underlying the atopic concept, the inherited constitution as expressed by the tendency to familial clustering, is also one of the main background factors for atopic disease. Pollen is the most common allergen causing allergic rhinitis (2, 3) even when the screening procedure has included skin testing to multiple allergens such as animal dander, moulds and house dust mite (4).

The phenomenon of altered reactivity was called "atopy" by Coca & Cooke in 1923 (5), and in 1933, after the atopic concept was established, the term "atopic dermatitis" was suggested to distinguish the disorder from other forms of dermatitis (6). An inherited disposition was stated to be a major background factor. The immunological classification of allergic reactions by Gell & Coombs (7) and the subsequent discovery of immunoglobulin E (IgE) in the 1960's (8, 9) provided the basis for an immunological approach to the atopic concept. The frequency of atopic diseases shows wide variations in different parts of the world with prevalence figures from 10 to 25% for total atopic diseases (10). Genetic predisposition and environment have been discussed as underlying factors (11); however, the studies performed have been of different designs and comparisons are therefore difficult. The variations may be attributed to a multitude of factors such as ethnic differences, inclusion criteria, climate and other environmental factors. Studies also vary in the epidemiological definitions they apply and it is not always clear whether the symptoms are present or past.

Atopic diseases are common in childhood, and cross-sectional surveys of the Norwegian population indicate that 14–20% of children under the age of 15 have had some kind of atopic disease (12–14). One particular feature of the disorder is the apparent increase over time, and it is generally agreed that the prevalence of all atopic diseases has increased world-wide in the last decades (15–17), although the methods used in various surveys are not strictly comparable. A recent Swedish study demonstrated that the prevalence of atopic diseases increases the further north you go (15), and two further studies indicated a high occurrence of atopic diseases in Northern Sweden (Sandberg, K., personal communication; Norrman, E. et al., personal communication).

In Norway there has been a lot of interest in the considerable level of air pollution found in the areas close to the Russian border. The air pollution is caused by emissions from Russian smelting plants on the Kola peninsula and especially from the town Nikel where 300,000 tons of sulphur dioxide are emitted annually in addition to heavy metals such as nickel, copper, arsenic and poisonous aluminium compounds. Measurements taken from air, water and vegetation have shown high levels of pollution (18).

In addition, since the 1950's, an increasing number of new building materials emitting a multitude of chemical substances have been introduced. Pollution from such materials concentrates indoors where ventilation is low and has been related to the "sick building syndrome" since the 1980's. Moreover, in-

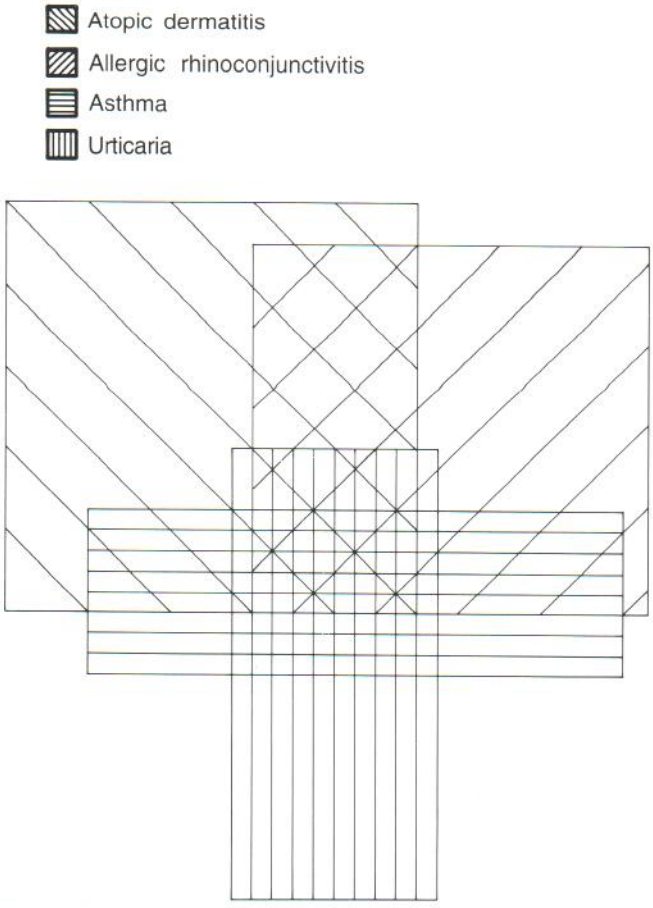

Fig. 1. Relative prevalence and overlap of symptoms of atopic dermatitis (overlap 52%), allergic rhinoconjunctivitis (overlap 66%), asthma (overlap 75%) and urticaria (overlap 50%).

creased relative humidity has implications of allergen occurrence such as mould and house dust mite.

The present study is the first in a series of studies which will be undertaken in order to determine the prevalence of atopic diseases among children in a rural community in Northern Norway close to the Russian border. Future investigations will seek to clarify if the occurrence of atopic diseases can be related to heredity or environmental factors such as climate, allergens and air pollution.

MATERIAL AND METHODS

In order to study the occurrence of atopic diseases a questionnaire was compiled and distributed to all the 575 school children aged 7–12 in the community of Sør-Varanger (population 9,800) in Northern Norway. People were asked about symptoms of previous and/or present asthma, allergic rhinitis and/or conjunctivitis, dermatitis, urticaria and food intolerance, age when first and last symptoms occurred, family history of atopic diseases, keeping of furred pets and other animal-related activities including horse-riding, smoking habits in the family, duration of breast feeding and housing and living conditions.

Atopic dermatitis was diagnosed if the child had ever had itching lesions of more than 4 weeks duration in at least one of the following areas: face, elbow and knee flexures, side of the neck, wrist and ankles and/or fingers and hands.

Asthma was diagnosed if the child confirmed previous and/or present asthma or recurring attacks of wheezing, coughing or heavy breathing due to external factors such as animal dander, pollens, house dust or food.

Allergic rhinoconjunctivitis was defined as episodic rhinorrhea associated with nasal stuffiness and sneezing in response to known or strongly suspected allergen(s) and often accompanied by lacrimation.

Urticaria is here defined as one or more episodes of transient erythema and swelling of the skin with or without pruritus. Atopic urticaria can be suspected in cases where urticaria occurs in patients with other atopic manifestations.

Cumulative incidence is here defined as the total proportion of children with past or present symptoms.

The statistical analyses were performed using the statistical package SAS. The χ^2-test was used to evaluate group differences.

The investigation was approved by the Ethical Committee of Tromsø University.

RESULTS

551 children (95.8%), 266 girls and 285 boys, completed the questionnaire. Atopic diseases were found to be present or to have occurred in 249 (45.2%) of the 551 children, significantly more frequently in girls (50.4%) than in boys (40.4%) ($p < 0.02$). Asthma occurred in 68 children (12.3%) with no significant difference between girls (13.2%) and boys (11.2%). Allergic rhinoconjunctivitis occurred in 113 cases (20.6%), slightly more frequently in boys (21.8%) than in girls (18.9%) without, however, reaching statistical significance. Urticaria occurred in 72 cases (13.1%) and was significantly more frequently in girls (17.7%) than in boys (8.8%) ($p < 0.002$), while atopic dermatitis occurred in 130 cases (23.6%), likewise more frequently in girls (27.6%) than in boys (18.7%) ($p < 0.03$).

A single atopic symptom was found in 155 children, of which atopic dermatitis accounted for 63 (11.4%), allergic rhinoconjunctivitis for 39 (7.1%), asthma for 17 (3.1%) and urticaria for 36 (6.5%). In 94 (37.8%) of the 249 affected children more than one atopic symptom was reported. Atopic dermatitis combined with allergic rhinoconjunctivitis occurred in 40 cases (7.3%) with no significant difference between boys (7.7%) and girls (6.8%). The combination of atopic dermatitis and asthma occurred in 29 (5.3%) and was similar in both sexes (boys 5.4%, girls 5.2%). Atopic dermatitis in combination with asthma and allergic rhinitis occurred in 25 (4.6%) with the same frequency in boys (5.0%) and girls (4.1%). Seven (1.3%) of the children (boys 1.1%, girls 1.5%) had symptoms of all four atopic manifestations (atopic dermatitis, allergic rhinoconjunctivitis, asthma

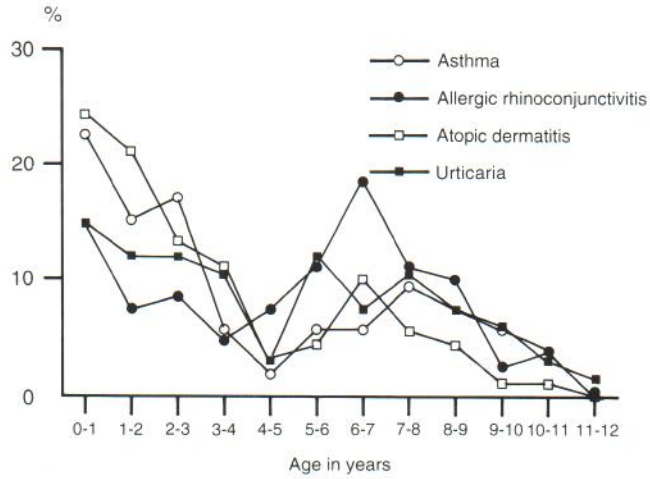

Fig. 2. Age at onset of atopic dermatitis, allergic rhinoconjunctivitis, asthma and urticaria in school children in Sør-Varanger community.

Table I. *Atopic diseases in children in relation to parental history*

Parental history of atopic diseases	Child history				
	Asthma %	Allergic rhinoconjunctivitis %	Atopic dermatitis %	Urticaria %	Total atopic diseases %
None	9.6	13.7	17.8	11.8	30.6
Single	13.8[a]	27.6[a]	28.6[a]	15.3	48.0[a]
Double	24.4[a]	40.0[a]	43.9[a]	12.2	56.1[a]

[a] $p < 0.05$.

and urticaria). Allergic rhinoconjunctivitis combined with asthma occurred in 15 cases (2.7%), more often in boys (3.5%) than in girls (1.9%), whereas the remaining 35 cases (6.4%) were divided between other combinations (boys 4.5%, girls 8.3%). The proportion of associated allergic symptoms was highest in asthma (75%), followed by allergic rhinoconjunctivitis (66%), atopic dermatitis (52%) and urticaria (50%), but with no significant differences between the sexes (Fig. 1).

The age at onset of the different atopic diseases was widely distributed. The incidence of atopic dermatitis and asthma was highest during the first years of life, whereas allergic rhinoconjunctivitis showed a peak in the age group 6–7 and urticaria was fairly constant throughout (Fig. 2). Thus, in 25% of the children dermatitis first appeared before the age of 1 and in 75% before the age of 5, whereas more than half of the asthmatic cases had symptoms before the age of 3. From the age of 7 all atopic manifestations decreased.

Parental history of atopic diseases was reported in 35.6% of all children, more frequently in mothers (30.2%) than in fathers (20.1%). In families with no parental history of atopic diseases, 30.6% of the children appeared to develop some kind of atopic disease. Where single parental history of atopic diseases occurred, atopic diseases in the children accounted for 48.0%; this figure increased to 56.1% (Table I) with double parental history. The influence of parental history was also analysed for each specific disease (Table I). If one or both parents had asthma, asthma could be expected in 13.8% and 24.4% of the children respectively, compared to 9.6% when the parents had no history of asthma. Allergic rhinoconjunctivitis in one or both parents

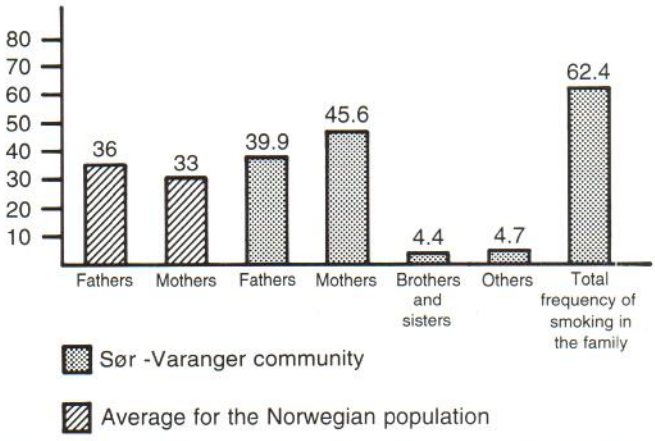

Fig. 3. Smoking habits in the Norwegian population as a whole and in families living in Sør-Varanger community.

increased the probability of the children developing the same disease to 27.6% and 40.0% respectively, compared to 13.7% with no parental history. Atopic dermatitis occurred in 17.8% of children with no parental history of the disease compared to 28.6% if one and 43.9% if both parents had atopic dermatitis. Urticaria patients did not show the pattern described above (Table I).

According to the questionnaires smoking in the family occurred in 62.4% of the total population surveyed, which appears to be higher than the average for the country, as surveyed via telephone (Fig. 3). The frequency of smoking in families with children having present allergic symptoms with or without asthma was virtually the same (64.3%) as in the study group as a whole (62.4%) (Fig. 3). Other factors, such as keeping of domestic animals and horse-riding, were confirmed by 299 (54.3%) of the 551 children and were not lower in families with allergic children, particularly not in families where children had asthma.

Pollen (grass 7.1% and birch 5.3%) allergy was the dominating allergy in children with rhinoconjunctivitis, whereas animal dander and food intolerance occurred in 8.2% and 1.8% of the children respectively. Not unexpectedly, allergic rhinoconjunctivitis symptoms showed seasonal variations with high spring (34.0%) and summer (47.3%) peaks and an autumn (14.3%) and winter (4.4%) dip.

Of the 12.3% asthmatic children, 4.5% experienced asthmatic attacks when in contact with animal dander and 1.1% when consuming certain foods, whereas the final 6.7% appeared to have attacks brought on by house dust mite, pollens etc.

Worsening of atopic dermatitis due to foods was reported in 6.7% of the children, whereas urticaria due to food intolerance was reported in 4.9%. In 86 (90.5%) of the 95 children with food allergy, two or more incidents for each type of food had occurred.

DISCUSSION

The difficulty of establishing a diagnosis is well known in atopic research (19). In this study the frequency of atopic diseases is based on the information given by the parents and the figures are, of course, subject to errors. Questionnaire-based studies always have inherent limitations with respect to exactness. The accuracy of figures obtained from a questionnaire depends both on the precision of the questions, the standard of knowledge of those completing the questionnaires and their willingness and conscientiousness in replying. Serious under-reporting is not

likely, as most parents in Norway today are well informed about atopic diseases through attending child health clinics during the child's first years of life and later at the school health examination. However, atopic dermatitis is usually the first sign of atopy in childhood and many cases have their onset in infancy. Thus, episodes of atopic dermatitis in infancy can, in some cases, have been misunderstood by general practitioners or even forgotten by the parents. On the other hand, if cases of contact dermatitis have accidentally been included, this may have led to overestimation of atopic dermatitis. A diagnosis of bronchial asthma is often established in children of 1–6 years of age, whilst allergic rhinoconjunctivitis symptoms usually begin between the age of 5 and 19. As a consequence, some underestimation is possible regarding transient wheezing, coughing or heavy breathing in early age due to less distinct symptoms. On the other hand, some overestimation regarding asthma may have occurred since some cases of wheezing included in the asthma population could be non-atopic cases. The figures given for urticaria may be encountered with great uncertainty. Episodic urticaria may have several causes and it is not possible on the basis of a questionnaire to obtain a correct answer as to whether the skin congestion is caused by an atopic allergen or not. Urticaria appearing in children with overlapping atopic manifestations may be regarded as atopic (Fig. 1). On the other hand, cases of atopic urticaria may occur in children with no other atopic symptoms.

The present investigation gives figures for both past and present symptoms of atopic diseases for children aged 7–12. The cumulative incidence obtained for each atopic condition was even higher than in a similar study of school children in Northern Sweden (15). A significantly higher prevalence of atopic dermatitis and urticaria in girls than in boys resulted in a total higher frequency of atopy in girls.

Multiple symptomatology was found in more than one third of the cases; it was slightly more common in girls than in boys and therefore opposite to Åberg (15). The high proportion of multiple symptoms probably contributes to the high total frequency of atopic diseases found in this study.

A high incidence of atopic dermatitis and asthma in early life is a general finding (20–22). This pattern was pronounced in the present material with approximately 75% of all children with dermatitis getting their first symptoms during the first 5 years of life, and more than 50% of the children with asthma during the first 3 years of life (Fig. 2). The relatively low occurrence of allergic rhinoconjunctivitis through childhood, except for a peak when starting school (6–7 years of age), explains the increasing prevalence figures of this disease with age during childhood and adolescence reported in cross-sectional studies (2, 15).

Inherited disposition is a major background factor in allergic diseases (23). A strong cumulative effect in both single and double parental history was seen for dermatitis, asthma and allergic rhinoconjunctivitis with identical symptoms in parents and children, whereas no such influence could be seen for urticaria (Table I).

About two thirds of the children in the study were exposed to tobacco smoke and more than half of them to animal dander in their homes, irrespective of whether or not they had a diagnosis of atopic disease, asthma included (Fig. 3) (24). No causal relationship between exposure and disease could be confirmed from our data which are, however, based only on current exposure and not the more important period of early childhood (25, 26). Investigations indicate that people in the three northernmost counties smoke more than in any other part of the country (National Council on Tobacco and Health, Oslo, Norway; personal communication). Thus despite health education and good public medical services in this area, the lifestyle of the people is different from the rest of the country.

House dust mite is the most common allergen source related to asthma, especially in warm and humid climates (27, 28), and also a major provocative factor for allergic rhinitis. Mould, pollen, and animal dander are also important sources of allergens. In the northern part of the country all these allergens have been found to cause allergies. Neither house dust mite nor mould are among the most important provocative factors in this subarctic climate. The pollen exposure is shorter and the pollen counts lower most days during the pollen season (Bolle & Ramfjord, personal communication). Keeping of domestic animals (54.3%) is similar to that reported in a recent Swedish study (53.0%) (15).

Regional variations in the frequency of atopic diseases shown by a higher prevalence in the northern than in the southern areas of Scandinavia (15) may be due to ethnic or environmental factors as well as variations in the criteria used for diagnosis. There are, however, no striking differences, e.g. with respect to HLA-patterns, between the study group and the Norwegian population as a whole (29).

It seems likely that the prevalence of atopic diseases has increased in the last few decades and this has been confirmed by several reports published in recent years (15–17). Moreover, in a recent Swedish study it was found that the frequency of all atopic conditions increases with increasing latitude (15), but also that the frequency of atopic diseases in parents of children living in the north was even lower than that found in southern areas. Thus, the geographically related increase in atopic diseases over recent decades must be due to factors present mainly during childhood.

It is more difficult to identify the exact reasons for the gradual increase in the prevalence of common diseases in young children over many years than to detect substances causing acute discomfort during exposure. It is also quite possible that concentrations necessary for a harmful long-term effect on young children may be lower than those causing direct airway irritation. If so, a further increase in atopic diseases can be expected for many years to come.

We know that certain chemicals and/or irritants can damage both the skin and the mucosa, thereby lowering its resistance to allergens. Thus, the latency period required for the development of allergic reactions can be shortened if influenced by pollutants. About 70% of the population in Sør-Varanger are exposed to high SO_2-concentrations caused by emissions from Russian smelting plants situated close to the Norwegian border. SO_2 concentrations of more than 100 times (3000 $\mu g/m^3$) the normal annual average with unfavourable wind conditions have been measured. Moreover, heavy metals such as nickel, copper and arsenic have been found 100 km from the smelting plants on the Norwegian side of the border with particularly high concentra-

tions during the winter, e.g. nickel deposition of 3 mg/m^2 or more have been measured annually in two thirds of this area (18).

Consideration must also be given to how the indoor environment is influenced by the outdoor temperature. Due to the cold climate in a subarctic area, the buildings, in an effort to save energy, generally have more efficient insulation. Pollutants, therefore, tend to concentrate indoors. The build-up of mixtures of such pollutants, usually in low concentrations, has been related to the "sick building syndrome".

Mucous irritation in the upper respiratory tract usually gives the impression of dry air; investigations, however, have shown that there is no relationship between this symptom and relative humidity measured. In fact, electrically heated homes designed for maximum energy efficiency are especially tight, and relative humidity in these homes can reach levels in excess of 75% during even subzero winter weather (30).

In addition to skin and mucous irritation environmental chemicals can act on the immune system, possibly resulting in an immune deficiency facilitating sensitization to both foods and environmental pollutants.

A further consequence of inadequate ventilation and increased air humidity is an increased exposure to viral, bacterial and fungal agents. The epidemiological importance of this in atopic diseases has not been clarified, but may be substantial. Pollutants released by microorganisms can probably act as sensitizing agents in susceptible hosts, whereas some cause infectious disease and other produce toxins with both acute and chronic health effects.

In conclusion, the high frequency of atopic diseases found in this study may be explained by both the subarctic climate and the environmental (indoor and outdoor) air pollution. Hence, further studies are needed to confirm the present findings. Such studies are currently under way.

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