

Title page*Article title:*

Increasing prevalence of asthma, allergic rhinoconjunctivitis and eczema among schoolchildren: Three surveys during the period 1985-2008.

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Short title:

Asthma, allergic rhinoconjunctivitis and eczema prevalence in schoolchildren in a subarctic population.

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Authors Contributions

TEH: Designed the study, collected data, analyzed data and wrote the article.

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JH: Designed the study analyzed data and revised the article critically.

Conflict of interests

The authors declare no conflicts of interest in respect to the authorship and/or publication of this article.

Abstract

Aim: The prevalence of asthma, allergic rhinoconjunctivitis (AR) and eczema among children has increased worldwide in the last four decades, but recent studies disagree as to whether the prevalence is continuing to rise or is leveling off or declining. The aim of this study was to assess time trends in a subarctic population.

Methods: A cross-sectional, questionnaire-based survey was carried out in 2008 among children aged 7-14 years in random selected schools in Nordland County, Norway (n=4150). The results are compared with results from identical studies in 1985 (n=4870) and 1995 (n=4456).

Results: The main findings were an increasing prevalence of asthma ever (7.3% in 1985 to 17.6% in 2008, p for trend < 0.001) and AR ever (15.9% in 1985 to 24.5% in 2008, p for trend < 0.001), while the prevalence of eczema ever, after an increase between 1985 and 1995, remained unchanged in the last time period. The prevalence of current disease doubled and trebled between 1995 and 2008 for all three diseases.

Conclusion: A repeated cross-sectional survey between 1985-2008 documented an increasing prevalence of asthma ever and AR ever among schoolchildren (7-14 years), together with a considerably increase in current asthma, AR and eczema between 1995-2008.

Keywords: allergic rhinoconjunctivitis, asthma, prevalence, schoolchildren, time trends

Keynotes:

Repeated cross-sectional surveys between 1985-2008 demonstrated an increase in the prevalence of asthma and allergic rhinoconjunctivitis ever among school children (7-14 years) in a subarctic population, while the prevalence of eczema ever leveled off. Between 1995-2008 the prevalence of current disease increased substantially in all three diseases.

Introduction

In recent decades the prevalence of asthma and allergic diseases has increased substantially, and today asthma is the most frequent chronic disease among children in developed countries (1). This imposes a considerable burden of disease on patients, health care systems and society. Whereas some studies still demonstrate an increasing prevalence of asthma and allergic disease (2-4), other reports indicate a leveling off or even a decrease in the prevalence (5-7). Results from the ISAAC phase III study (2000-2003) indicate that the difference in asthma symptom prevalence between developed and developing countries has fallen (8). In spite of this change, the prevalence of asthma, allergic rhinoconjunctivitis (AR) and eczema shows wide global variation (9). The diverse global trends make regional repeated investigations important to assess time trends. Local surveys provide information about geoclimatic variables and topographical factors that may affect disease prevalence (10). In the northern part of Norway a questionnaire-based, cross-sectional survey of asthma and allergic disease was performed in 1985 (11) and repeated 10 years later: The lifetime prevalence of asthma and allergic diseases increased over this period (12). Thus, the objective of the current study was to explore whether or not the prevalence of asthma, AR and eczema continued to increase in a population of children in a subarctic area.

Subjects and Methods

Study area

The Northern part of Norway consists of three counties: Nordland, Troms and Finnmark, with a subarctic population of 468251 inhabitants (13). Nordland County,

which covers an area of 37000 km², has a unique geography with a long coastline, half of it located north of the Arctic Circle. The subarctic climate in Nordland displays an average yearly temperature of 5-6 degrees Celsius and a yearly amount of precipitation (rainfall) of 3000 millimeters.

The questionnaire

A questionnaire focusing on diagnosis and symptoms of asthma, AR and eczema was created in 1985 to assess disease among schoolchildren in northern Norway.

Questions covered gender, age, family history of atopy, socio-economic conditions, passive smoke exposure and household animals. The questionnaire was completed by parents/guardians who also signed a written consent for their children's participation. The questionnaire has been used in other Norwegian studies (14,15), and its validity has been evaluated. The questionnaire-based diagnosis of asthma was found to have a sensitivity of 0.96 and a specificity of 0.88 (14).

The 1985 and 1995 studies

The questionnaire was distributed to schoolchildren aged 7-13 years in randomly selected schools in northern Norway in 1985 and 1995. The local school nurse distributed the questionnaires and passed a new questionnaire to those not responding. The questionnaires were completed by 95% in 1985 and by 87% in 1995. The 1995 study included additional questions concerning symptoms and diseases during the last 12 months (current diseases), but was otherwise identical. The 1985 and 1995 surveys are described in detail elsewhere (11,12).

The 2008 study

In 2008, we used identical questions to those used before adding questions about physical activity, medical diagnose of asthma and asthma medication. The additional questions did not change the definition of the diseases. Schoolchildren aged 7-14 years from 65 randomly selected schools out of a totally 244 schools in Nordland County were invited to participate. These 65 schools represent 31 of 44 municipalities (local authorities) in the County. The pupils received the questionnaire between February and May. This time we were not allowed from the Regional Committee for Medical and Healthcare Research to send personal reminders. Thus all participants received one reminder. The study closed four weeks after the reminder was distributed.

Definitions

'Asthma ever' was considered if the parent answered 'yes' to the question: *Has the pupil ever had asthma (question 1)?* and/or to the question: *Does the pupil experience wheeze, periods of coughing or acute shortness of breath (asthma) due to external factors (question 2)?*

'Allergic Rhinoconjunctivitis (AR) ever ' was estimated on the basis of a positive answer to the question: *Has the pupil ever had hay fever (runny or blocked nose, sneezing, itching of the nose and/or eyes, or swollen or red eyes)?*

'Eczema ever' was recorded if the pupils reported an itchy rash lasting at least four weeks combined with lesions on the face, elbows or knee flexures, or a high degree of itching and lesions elsewhere.

'Current disease' was considered among those answering yes to the main questions about asthma, AR or eczema and reporting symptoms the last 12 months.

Atopic disease among family members was defined when answering yes to the question: *Does anyone in the family suffer from asthma, hay fever, eczema, urticaria or other diseases you believe are caused by allergy?* The answers specified which family members (parents and or siblings) and which disease they were suffering from.

Statistical analyses

The main outcome was differences in prevalence between the periods 1985-95 and 1995-2008. The analyses were performed using chi-square statistics, and the differences in secular prevalence were quantified with odds ratios (OR). For values measured three times, chi-square test for trend (linear-by-linear associations) was calculated. P-values below 0.05 were considered statistically significant in all analyses, and they were accompanied by a 95% confidence interval (95% CI). Only a few missing values to the main questions about asthma, AR and eczema (0.3%, 1.0% and 0.7% respectively) were found. The missing values were considered to be non-confirmative. The statistical analyses were performed using Graph Pad Prism version 5 (Graphical Software, San Diego Ca, USA) and Statistical Package for Social Science (SPSS) software version 19.0 (SPSS Inc. IBM, Chicago, IL, USA).

Ethical approval

The study protocol was approved by the Regional Committee for Medical and Healthcare Research, Northern Norway and The Norwegian Data Inspectorate.

Results

Of 6505 pupils invited to participate, 4150 (64%) were enrolled in the study (49.1% boys). The demographic data of all three surveys are given in Table 1.

Asthma

The prevalence of asthma ever increased from 7.3% in 1985 to 17.6% in 2008 (p for trend < 0.001) (Table 2). The prevalence of asthma ever was significantly higher among boys compared to girls in all three surveys: In 1985 8.9% vs. 5.5% (OR 1.68, 95% CI: 1.34-2.10), in 1995 14.5% vs. 10.3% (OR 1.48; 1.23-1.77) and in 2008 21.4% vs. 13.9% (OR 1.68; 1.43-1.98). Current asthma increased from 4.8% to 9.9% between 1995 and 2008 (Table 3). In 2008 doctor diagnosed asthma ever was reported by 13.8% of the participants, asthma medication ever by 18.5% and asthma medication used the last year by 8.2% of the participants.

Allergic rhinoconjunctivitis (AR)

The prevalence of AR ever increased between 1985 and 2008 (p for trend < 0.001) (Table 2). The prevalence of AR ever was significantly higher among boys compared to girls in all three surveys: In 1985 18.2% vs. 13.4% (OR 1.43; 1.23-1.68), in 1995 24.6% vs. 18.3% (OR 1.48; 1.28-1.71) and in 2008 27.9% vs. 21.2% (OR 1.43; 1.24-1.65). Current AR increased threefold between 1995 and 2008 (Table 3).

Eczema

The prevalence of eczema ever increased in the first time period and remained unchanged in the last period (Table 2). The prevalence of eczema ever was approximately similar between girls and boys in 1985 (12.8% vs. 11.7%, OR 1.1; 0.93-1.32), but higher among girls in 1995 and 2008 (OR 1.43; 1.23-1.68 and OR 1.48; 1.28-1.71, respectively). The prevalence of current eczema was more frequent in 2008 in both genders (Table 3).

The atopic burden and potential confounding factors

An increasing part of the responders reported a family history of atopy, parental asthma and parental allergy (Table 1). In 1985 21.8% of the children reporting atopic disease in the family had asthma, AR and/or eczema. This proportion increased to 50.6% in 2008 (p for trend < 0.001). Passive smoke exposure decreased from 60.7% to 31.9% (p for trend < 0.001), while the number of households keeping pet animals remained unchanged (56.3% in 1985 vs. 56.0% in 2008).

Co-morbidity

The proportion of children reporting at least one disease (asthma, AR or eczema) increased from 26.2% in 1985 to 43.3% in 2008 (p for trend < 0.001). The proportion of children with all three diseases and the proportion of children with both asthma and eczema increased during the study period (Table 4). The proportion of children reporting the combination of asthma and AR or AR and eczema increased in the first time period, but stayed unchanged in the last period (Table 4).

Discussion

The main findings in the present study were an increasing prevalence of asthma ever and AR ever, while the prevalence of eczema ever, after increasing between 1985 and 1995, stayed unchanged in the last time period. The prevalence rates found in 2008 are similar to those shown in the Norwegian birth cohort study, Oslo (2), but somewhat higher compared to results in the OLIN studies (Obstructive Lung Disease in northern Sweden) (16,17). In spite of an increasing prevalence of asthma ever, data from the last time period indicated a peak in asthma symptoms. The divergent prevalence of asthma symptoms and asthma diagnosis are consistent with data from other Nordic reports (7,18). In contrast to several prevalence studies in comparable populations (2,9,19) we demonstrated a substantial increase in the proportion of children reporting current diseases in the last time period.

Atopic disease in the family is an important risk factor for developing asthma, AR and/or eczema (16,20,21). Increased atopic burden among family members is evident. Two-thirds of the children in the 2008 survey had parents and/or siblings with atopic diseases, along with a doubling of parental asthma and allergy between 1985 and 2008. The proportion of children suffering from asthma, AR and/or eczema confirming atopic disease in the family more than doubled during the study period. Asthma, AR and eczema are closely related (2,22). Still we found a leveling off in the co-morbidity of asthma and AR, while the co-morbidity of asthma and eczema increased. This pattern is in line with the findings in a recent report from the ISAAC study (23).

Male gender is a risk factor for asthma and allergy among children (7,24). We detected a male predominance, which is in line with the results found by Anthracopoulos et al. (25). Whereas the results for asthma and AR revealed a male dominance through the study period, the results for eczema demonstrated a higher proportion of girls in the last two surveys. A study from Larsson et al. (21) supports these findings. Thus the unchanged prevalence of eczema ever in the last time period might be due to an unchanged prevalence in girls.

Local environmental factors might be important contributors to different disease prevalence (9). Passive smoke exposure decreased sizeable from 1985 to 2008. Since second hand smoke exposure is associated with both the development of asthma and more severe disease, the decrease might be expected to lower the prevalence of asthma (26). Most of the study population lives in a cold, coastal climate. During wintertime the amount of indoor time is higher in a subarctic population. Weiland and colleagues have proposed a negative effect of the annual variation of temperature and relative humidity outdoors on asthma and eczema symptoms (27).

The use of identical study design and questionnaires in three surveys has allowed us to assess a valid estimate of time trends for self-reported atopic diseases. The reliability of the results of studies based on questionnaires can be questioned. However self-reported symptom history conducts the necessary basis for defining asthma in epidemiological studies (10,28). Repeated surveys in the same population are as close a proxy, as it was possible to attain of longitudinal data. In contrast to the ISAAC studies, we compared data from the same population during three decades,

which formed the basis of more valid time trends. Still the time interval between the last two surveys might have been too long to detect a plateau in disease prevalence. Thus, the need of follow-up surveys in due time is evident. Questions about current symptoms are more reliable than questions about symptoms ever due to less recall bias and might give a better estimate of time trends. The proportions of children reporting use of asthma medication ever and last year are not different from the prevalence of asthma ever and current asthma, which strengthen the results.

Allergic diseases are given significant public health and media attention in Western societies. The impact of increased general awareness has been proposed in several papers to explain the increasing trend in the prevalence of allergic diseases (10). Increased awareness among health professionals and parents might have influenced the time trends in our study, and the increased atopic burden might represent a selection bias. Parents suffering from these diseases are expected to be more positive to participate and to be more aware of symptoms and diseases. Thus it is a possibility that the increase in heredity and disease prevalence might partly be due to this selection bias. The response rate of 64 % in 2008 is lower than in the previous surveys, and might entail a potential selection bias. In 2008 we were not allowed to give personal reminders to the participants. We believe this represent the main cause of the lower response rate compared to the earlier surveys. It was not possible to perform any analysis of the non-responders. However a large postal survey in Sweden by Rönmark et al concluded that non-responders did not differ significantly in the prevalence of airway diseases or symptoms compared with responders (29). Thus response bias is unlikely to have seriously affected the results. As we included

a large, representative fraction of the population from randomly selected schools in Nordland we believe the external validity of our study to be high.

In conclusion the prevalence of asthma ever and AR ever in a subarctic children population increased substantially between 1985 to 2008, while the prevalence of eczema ever reached a plateau. The doubling and tripling of current asthma, eczema and AR in the latest study period raises questions why and provide the basis of further investigation.

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