

Impact of pollution and place of residence on atopic diseases among schoolchildren in Telemark County, Norway

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For estimation of the prevalence, degree of severity, and association with outdoor pollution, a questionnaire on asthma and other atopic diseases was distributed to the parents of 4666 7–13-year-olds, comprising all the children in 36 schools in Telemark County, Norway, including 37% of the schoolchildren in the county. The response rate was 94%. In a validity study employing clinical evaluations, the questionnaire-based diagnosis of asthma was found to have a sensitivity of 0.96 and a specificity of 0.88. The lifetime prevalence of asthma in Telemark was 9% (boys 11.3%, girls 6.6%; $p < 0.001$). There was no significant difference in the lifetime prevalence of asthma by pollution zone; 8.3% in heavily, 9.3% in moderately, and 9.2% in minimally polluted zones. The asthma prevalence was significantly higher (14.2%; $p < 0.05$) among boys in the coastal area of the county than in the mountainous area (8.9%). Both of these areas were in the minimal pollution zone. Of asthma cases, 67% were categorized as mild, 29% as moderate, and 4% as severe. The lifetime prevalence was 17.8% (boys 21.3%, girls 14.2%; $p < 0.001$) for allergic rhinitis, 13.2% (boys 11.4%, girls 15.2%; $p < 0.001$) for atopic eczema, and 29.6% (boys 31.7%, girls 27.4%; $p < 0.01$) for overall atopic disease (asthma, allergic rhinitis, eczema). These findings are not compatible with the hypothesis that outdoor pollution is associated with the lifetime prevalence of asthma in school-age children. The results also show that less than 0.5% of schoolchildren suffer from severe asthma.

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Atopic diseases, particularly asthma in children, have been reported to have increased during the last few decades (1–3), and this has led to more publicity and greater professional concern regarding these diseases. Modified diagnostic criteria and greater parental awareness of respiratory symptoms may partly explain the increase in prevalence (4). A widely accepted definition of asthma for use in epidemiologic studies is lacking. Objective quantifications of asthma in children with reasonable sensitivity and specificity are also needed (5). Prevalence studies have been made using different definitions of asthma and are not readily comparable. Some studies have used identical epidemiologic methods and report increases in asthma symptoms and bronchial hyper-responsiveness (2,3,6,7). Marked differences between geographic areas have been described (8, 9). It has been postulated that ambient air pollution

might explain differences in the prevalence of asthma in children. Some studies seem to confirm this explanation (10, 11), whereas other recent studies do not support this hypothesis (12–14). Among the many prevalence studies conducted in recent years, few attempts have been made to assess the severity of childhood asthma (14–17).

Telemark County in Norway has a varied geography, ranging from low coastal areas to high mountains. A considerable concentration of industry is found in one part of the county (Grenland). Air pollution has been heavy in this area. The prevailing public opinion is that outdoor pollution in the area is responsible for an increase in atopic diseases, particularly asthma in children.

The purposes of this study were to estimate the prevalences of asthma, hay fever, and eczema in boys and girls aged 7–13 years by climatic areas

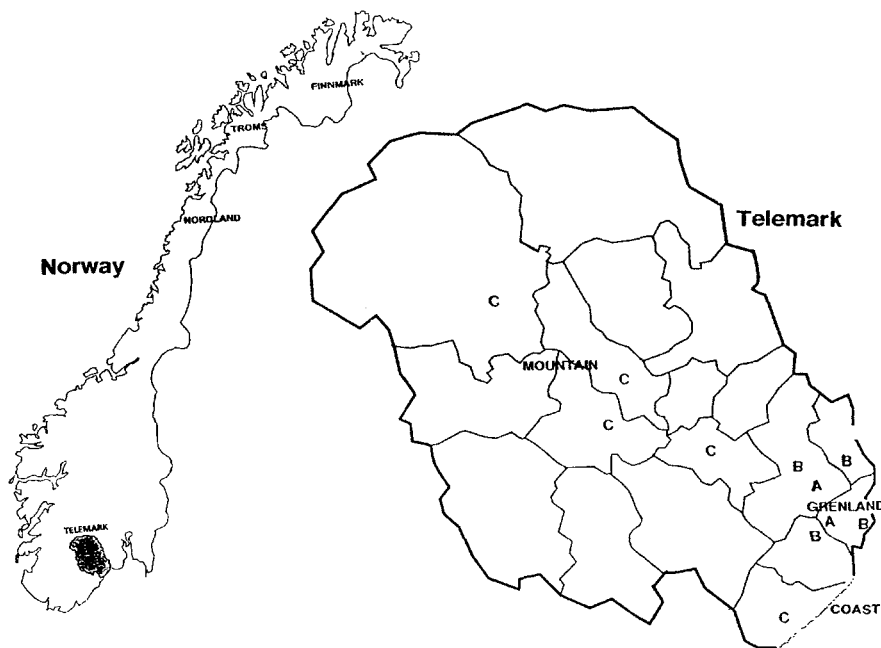


Fig. 1. Map of Norway showing location of Telemark and study areas of pollution: A = heavy, B = moderate, C = minimal pollution.

(from coastline to mountain) and by pollution zones (urban and rural) on the basis of questionnaire data, and to describe the validity of the questionnaire, as well as to assess the severity of asthma by performing a clinical examination in a subgroup of children.

Material and methods

Population

Questionnaire survey. In April 1991, 4666 questionnaires were distributed to 36 primary schools in 10 of the county's 18 municipalities. All children in classes 1–6 (7–13 years of age) at each school were invited to participate. This amounted to 37% of the total number of children in the county (12 340) in this age group. The schools were randomly selected (cluster sampling) to yield the required number of children in the three areas of defined ambient pollution (A = heavy, B = moderate, C = minimal), with the intention that 1/3 of the respondents should belong to each area (Fig. 1). A total of 4381 children responded to the questionnaire (93.9%). During the recording of the data, 268 questionnaires were lost. This lost material came from various schools and areas and did not constitute a systematic loss. Area A included 4148 children in school classes 1–6, among whom 1506 received the questionnaire and 1198 responded. In area B, with 3234 schoolchildren, 1680 received the questionnaire and 1551 responded; in area C, with 4958 children, 1480 received the questionnaire and 1364 responded.

Clinical study. In spring 1993, 125 children, defined as having asthma in the questionnaire (see below), and 125 controls, matched on an individual basis (matching criteria: same class, age, sex) and belong-

ing to randomly selected schools in areas A and B, were selected as a sampling frame for the study. Owing to limited capacity, 73 cases and 51 controls were randomly selected from this sampling frame. Fifty-nine (80%) of the invited case children and 37 (73%) of the invited controls responded and were examined.

Geographic areas

The areas of ambient air pollution were defined according to measurements performed by the Norwegian State Pollution Control Authority (L. Stige, SFT, Skien, Norway, personal communication), which had systematically recorded pollution levels for several years in representative areas of the county. Considerable differences in the mean values of

Table 1. Yearly mean and peak levels ($\mu\text{g}/\text{m}^3$) of SO_2 , NO_2 , SO_4 , and $\text{NH}_3 + \text{NH}_4$ for 1991 as measured by State Pollution Control Agency in three geographic areas of Telemark County in Norway

	Area A	Area B	Area C	Air-quality guideline
SO_2				
Yearly mean	37	3	0.4	
Peak – 24-h mean	247	–	4.6	90
Peak – 1-h mean	1798	–	–	
NO_2				
Yearly mean	35	10	1	
Peak – 24-h mean	129	–	7.3	75
Peak – 1-h mean	336	–	–	
SO_4				
Yearly mean	2.9	–	1.5	1–5
Peak – 24-h mean	30	–	10	
$\text{NH}_3 + \text{NH}_4$				
Yearly mean	2.9	–	0.7	

– No measurements.

measured pollutants in areas A, B, and C are shown for 1991 (Fig. 1 and Table 1) relating to WHO air-quality guidelines (18). Area A corresponds to the industrial region of Grenland, where the main sources of pollution are a fertilizer plant, a magnesium plant, and a pulp and paper plant. Area B consists of the surrounding municipalities, and C represents rural and coastal areas. The ambient pollution has been reduced by 10–70% in areas A and B during the last 15 years.

The climatic areas were categorized as coastline, middle area, and inland. The seaside area is a subcategory of the coastline area, and the mountainous area is a subcategory of the inland.

Variables

Questionnaire survey. The questionnaire was formulated by two of the authors (R.B., J.H.) in 1985. It was used in identical studies in northern Norway (19, 20) and consists of more than 150 questions presented as a self-administered questionnaire. The asthma diagnosis was based on the following two questions: "Has the child suffered from asthma?" and "Does the child wheeze, cough, or have attacks of breathlessness (asthma) after exposure to extrinsic factors (grass, animals, food, infection, weather)?" An affirmative answer to either one or both of the questions was defined as asthma, in accordance with previous prevalence studies in northern Norway.

The questionnaire included questions about the presence of atopic diseases (i.e., bronchial asthma, allergic rhinoconjunctivitis, eczema, urticaria) in members of the family (parents, siblings). An affirmative answer to the general question was followed by a specification of the family members who had the various diseases. The symptoms of allergic rhinoconjunctivitis and eczema were explained in a separate letter sent with the questionnaire. Past or present symptoms of these disorders were recorded for the index child. Rhinoconjunctivitis was defined as periods of symptoms involving nose/eyes (sneezing, stuffy nose, itching), and eczema as a rash lasting more than 4 weeks combined with much itching and/or localized in specific areas. Questions were included about indoor smoking, the presence of pets in the house, condensation of humidity on the walls, and the presence of carpets in the children's bedroom.

Clinical study. The 59 schoolchildren with a questionnaire-derived diagnosis of asthma and the 37 children without such a diagnosis were subjected to a structured interview, a detailed clinical history, a clinical examination, skin prick testing, blood specimen sampling for serologic allergy diagnostics, and test-

ing of lung function.

Lung function was tested by determining peak expiratory flow (Wright peak-flow meter) (Airmed Ltd, Harrow, UK), and by using the Cosmed Pony Spirometer (Cosmed S.l.r., Rome, Italy) before, and 15 min after salbutamol inhalation (0.1 mg/10 kg inhaled by vaporization). The parameters studied were FVC, FEV₁, PEF, and FEF 25–75.

The child was considered to have current asthma if the clinical history revealed three or more episodes (at least one during the last year) of bronchopulmonary obstruction (BPO) (21) or if the examination, including lung function tests, confirmed reversible obstruction (>10% reversibility of PEF or FEV₁). Previous asthma was defined as an identical clinical history, but without symptoms during the last year.

As a result of the structured interview, clinical examination, and lung-function study, the children were categorized as having no asthma or mild, moderate, or serious asthma at the time of the questionnaire survey. A modification of Aas's system (22), as proposed by Norwegian pediatric allergologists, was employed for the evaluation of severity. This classification differs slightly from advice given by an international pediatric consensus group (23) and gives more details on frequency and duration of episodes:

Mild: Fewer than six episodes of BPO/year lasting less than 1 week. Normal lung function without medication during long periods even in season. Exercise-induced asthma (EIA) alone belongs to this group.

Moderate: More than six episodes of BPO/year lasting 1 week or more. Symptom-free periods of less than 1 month during the season. Optimal treatment leading to normal lung function. No dramatic attacks during the last 3 years.

Severe: Prolonged obstructive episodes (>1 month), lack of normalization of lung function in spite of optimal treatment. All children with dramatic attacks during the last 3 years.

Compared to the Aas classification, mild asthma is grade 1, moderate is grades 2–3, and severe is grades 3–5.

Skin prick tests (SPT) for common allergens were performed by an allergy nurse and measured on the forearm. The Phazet system (Pharmacia) was used with six allergens (*Dermatophagoides pteronyssinus*, *Cladosporium*, cat dander, dog dander, and birch and timothy pollen). Histamine was used as a positive control. Wheal size was recorded after 15 min, and a wheal of half the size of histamine or

Table 2. Adjusted odds ratios (with 95% confidence intervals) for having asthma by pollution area, climatic zone, familial atopic disease, and occurrence of smoking, carpet in bedroom, dampness, and animal in home for 2016 boys and 1872 girls aged 7–13 years

Variables	Boys		Girls	
	Percentage of boys having asthma	Adjusted odds ratios (95% CI)	Percentage of girls having asthma	Adjusted odds ratios (95% CI)
Pollution area				
Heavy	10.1 (60/597)	1.0	6.9 (36/523)	
Moderate	12.4 (94/756)	1.17 (0.80–1.71)	6.1 (44/718)	0.87 (0.53–1.43)
Minimal	10.9 (72/663)	1.34 (0.75–2.42)	7.4 (47/631)	1.05 (0.49–2.26)
Climatic zone				
Coastline	13.6 (88/649)	1.82 (1.08–3.06)	6.8 (42/618)	1.02 (0.54–1.93)
Middle area	10.5 (95/901)	1.51 (0.79–2.87)	6.4 (54/843)	0.95 (0.41–2.16)
Inland	9.2 (43/466)	1.0	7.5 (31/411)	
Atopic disease in family				
Yes	15.6 (177/1136)	3.08 (2.21–4.30)	9.3 (102/1095)	3.06 (1.95–4.81)
No	5.6 (49/880)	1.0	3.2 (25/777)	1.0
Carpet in bedroom				
Yes	9.4 (112/1187)	1.0	5.8 (68/1167)	1.0
No	13.8 (114/829)	1.59 (1.19–2.13)	8.4 (59/705)	1.34 (0.91–1.95)
Dampness in home				
Yes	12.7 (8/63)	1.0	4.7 (2/43)	1.0
No	11.2 (218/1953)	1.09 (0.50–2.37)	6.8 (125/1829)	1.59 (0.38–6.76)
Smoking at home				
Yes	13.0 (131/1011)	1.61 (1.20–2.15)	7.7 (72/934)	1.53 (1.05–2.21)
No	9.5 (95/1005)	1.0	5.9 (55/938)	1.0
Animals at home				
Yes	9.5 (103/1081)	1.0	5.6 (65/1165)	1.0
No	13.2 (123/935)	1.39 (1.04–1.85)	8.8 (62/707)	1.65 (1.14–2.39)

more was considered positive for allergic sensitization. Blood specimens for Phadiatop Cap (Pharmacia) were taken and tested according to the instructions given by the manufacturer. Positive Phadiatop and/or positive SPT were interpreted as representing allergic sensitization in the child.

For assessment of the reliability of the questionnaire, the parents of the children who were examined clinically, filled in the respiratory part of the original questionnaire in 1993 for a second time.

Statistical analysis

Chi-square tests were used to study contingency tables, and multiple logistic regression was employed to estimate the odds ratios, adjusted for the effects of other variables, with the SPSS program package (SPSS release 6.1, Chicago; SPSS, Inc, 1994). The odds ratio was interpreted as a relative risk of having asthma, given a certain exposure as compared to a reference exposure level.

The reliability of the questionnaire was assessed by the kappa statistic (24). Standard errors for sensitivity and specificity and for corrected prevalences were computed, under an assumption of binomially distributed variables.

The investigation was approved by the ethics

committees of Health Region IV (questionnaire survey) and Region II (clinical study).

Results

Questionnaire survey

Nine percent of all children reported asthma (369/4113). Asthma was reported more often by boys (11.3%, 238/2115) than by girls (6.6%, 131/1992). In the most polluted area, 8.3% (99/1198) were asthmatic, while the percentages were 9.3 (145/1551) and 9.2 (125/1364) in the less polluted areas. This difference was not statistically significant (chi square = 1.1, 2 d.f.; $p = 0.59$).

For both sexes combined, the climatic area showed a slight, but not significant, association with asthma (chi square = 3.4, 2 d.f.; $p = 0.18$). However, a significant effect was observed for boys (chi square = 6.0, 2 d.f.; $p < 0.05$), with the highest prevalence (13.6%, 92/677) in the coastal area. When the two most extreme climatic zones (seaside versus mountain) were compared for the boys, the prevalences were 14.2% and 8.9%, respectively (chi square = 5.7, 1 d.f.; $p < 0.05$). The corresponding prevalences for the girls were not different (seaside, 7.3% and mountain, 7.7%, chi square = 1.88, 1 d.f.; $p = 0.39$).

The relationships between the occurrence of

Table 3. Adjusted odds ratios (with 95% confidence intervals) for having allergic rhinitis by pollution area, climatic zone, familial atopic disease, and occurrence of smoking, carpet in bedroom, dampness, and animal in home for 2016 boys and 1872 girls aged 7–13 years

Variables	Boys		Girls	
	Percentage of boys having rhinitis	Adjusted odds ratios (95% CI)	Percentage of girls having rhinitis	Adjusted odds ratios (95% CI)
Pollution area				
Heavy	20.2 (120/595)	1.0	16.3 (85/523)	1.0
Moderate	20.5 (155/756)	1.02 (0.76–1.37)	17.3 (124/717)	1.09 (0.78–1.51)
Minimal	23.9 (158/662)	1.55 (0.97–2.49)	10.2 (64/629)	0.53 (0.29–0.97)
Climatic zone				
Coastline	21.6 (140/648)	1.24 (0.83–1.84)	13.9 (86/617)	0.84 (0.48–1.48)
Middle area	20.8 (187/900)	1.37 (0.83–2.27)	17.0 (143/843)	0.89 (0.46–1.72)
Inland	22.8 (106/465)	1.0	10.8 (44/409)	1.0
Atopic disease in family				
Yes	28.6 (325/1135)	2.88 (2.26–3.67)	19.0 (208/1093)	2.58 (1.91–3.47)
No	12.3 (108/878)	1.0	15.5 (65/776)	1.0
Carpet in bedroom				
Yes	19.1 (226/1185)	1.0	14.1 (164/1167)	1.0
No	25.0 (207/828)	1.33 (1.06–1.67)	15.5 (109/702)	1.14 (0.86–1.50)
Dampness in home				
Yes	30.2 (19/63)	1.0	18.6 (8/43)	1.0
No	21.2 (414/1950)	0.74 (0.41–1.31)	14.5 (265/1826)	0.74 (0.33–1.64)
Smoking at home				
Yes	23.6 (238/1009)	1.41 (1.13–1.76)	14.8 (138/933)	1.14 (0.88–1.49)
No	19.4 (195/1004)	1.0	14.4 (135/936)	1.0
Animals at home				
Yes	19.5 (210/1079)	1.0	13.2 (153/1162)	1.0
No	23.9 (223/934)	1.30 (1.04–1.62)	17.0 (120/707)	1.23 (0.94–1.61)

asthma and the pollution zones and climatic areas did not change when variables were included in a multivariate, logistic regression model (Table 2). Among the variables, there was a clear effect of familial atopic disease (ORs > 3). An association with smoking and with not having animals at home was also found for both sexes. Smoking at home was reported in 57.3% of the homes with asthmatic children versus 50.3% among nonasthmatics (chi square = 6.64, 1 d.f.; $p < 0.01$). Of families with asthmatic children, 48.4% had animals versus 58.9% in families without such children (chi square = 14.98, 1 d.f.; $p = 0.001$).

Allergic rhinitis was reported for 21.3% (449/2112) of the boys and for 14.2% (282/1989) of the girls (chi square = 35.1, 1 d.f.; $p < 0.001$). Table 3 shows no association with the pollution area for boys, but a reduced prevalence among girls in the least polluted area. Again, the presence of atopy in the family was the strongest predictor. There was a positive association with smoking at home for boys with rhinitis. A tendency to have pets in the home and carpets in bedrooms less frequently could also be noted for children with rhinitis.

Eczema was reported for 11.4% (241/2115) of the boys and for 15.2% (302/1992) of the girls (chi square = 12.7, 1 d.f.; $p < 0.001$). No association with

the pollution area was found (Table 4). The direction and strength of the associations with the other variables were much the same as for allergic rhinitis.

Atopic diseases in the family (asthma, allergic rhinitis, eczema, urticaria) were present in 56% (2315/4113) of all families, in 79% (289/364) of families with asthmatic children, and in 55% (2026/3675) of those without (chi square = 79.7, 1 d.f.; $p < 0.001$). Forty-two percent (155/369) of the mothers and 29% (106/369) of the fathers of asthmatic children had either asthma, allergic rhinitis, or eczema.

If the past or present occurrence of asthma, allergic rhinitis, or eczema is called atopy, the overall lifetime prevalence of atopy in this sample was 29.6% (1217/4113). Among the boys, 31.7% (670/2115) had atopy compared to 27.4% (545/1992) among the girls (chi square = 9.2, 1 d.f.; $p < 0.01$).

Clinical study

Of the children categorized as having asthma according to the questionnaire, 8.5% (5/59) did not have asthma (false-positive) and 5.4% (2/37) were false-negative. The sensitivity of the questionnaire was $54/56 = 0.96$ (standard error (SE) 0.02). The specificity was $35/40 = 0.88$ (SE 0.05). Assuming

Table 4. Adjusted odds ratios (with 95% confidence intervals) for having eczema by pollution area, climatic zone, familial atopic disease, and occurrence of smoking, carpet in bedroom, dampness, and animal in home for 2016 boys and 1872 girls aged 7–13 years

Variables	Boys		Girls	
	Percentage of boys having eczema	Adjusted odds ratios (95% CI)	Percentage of girls having eczema	Adjusted odds ratios (95% CI)
Pollution area				
Heavy	10.1 (60/597)	1.0	17.4 (91/523)	1.0
Moderate	12.3 (93/756)	1.22 (0.83–1.78)	15.6 (112/718)	0.85 (0.61–1.19)
Minimal	11.9 (72/663)	1.20 (0.64–2.22)	12.8 (81/631)	0.94 (0.56–1.60)
Climatic zone				
Coastline	11.7 (76/649)	0.98 (0.58–1.66)	16.2 (100/618)	1.69 (1.04–2.73)
Middle area	11.1 (100/901)	0.99 (0.51–1.90)	16.6 (140/843)	1.69 (0.93–3.07)
Inland	12.0 (56/466)	1.0	10.7 (44/411)	1.0
Atopic disease in family				
Yes	15.8 (179/1136)	2.85 (2.07–3.94)	19.9 (218/1095)	2.73 (2.03–3.67)
No	6.0 (53/880)	1.0	8.5 (66/777)	1.0
Carpet in bedroom				
Yes	9.9 (117/1187)	1.0	15.3 (179/1167)	1.0
No	13.9 (115/829)	1.41 (1.06–1.88)	14.9 (105/705)	0.98 (0.74–1.28)
Dampness in home				
Yes	12.7 (8/63)	1.0	11.6 (5/43)	1.0
No	11.5 (224/1953)	1.05 (0.48–2.28)	15.3 (279/1829)	1.42 (0.55–3.70)
Smoking at home				
Yes	12.5 (126/1011)	1.36 (1.02–1.80)	15.5 (145/934)	1.12 (0.86–1.45)
No	10.5 (106/1005)	1.0	14.8 (139/938)	1.0
Animals at home				
Yes	9.6 (104/1081)	1.0	14.7 (171/1165)	1.0
No	13.7 (128/935)	1.49 (1.12–1.97)	16.0 (113/707)	1.04 (0.80–1.35)

that the clinical examination represents the true diagnosis of asthma, the corrected estimate of lifetime prevalence of asthma in this cross-sectional study is the sum of the positive predictive values for both the positive and negative questionnaire replies to asthma, weighted by their relative frequencies. Thus, the corrected prevalence was $(54/59 \times 369/4113 + 2/37 \times 3744/4113) = 0.131$.

Among the 56 subjects with asthma on the basis of the clinical study, 48 (86%) had current asthma. Among these, 32 had mild, 14 had moderate, and two had severe asthma. Both asthmatic children that had been reported as not having asthma in the questionnaire suffered from mild asthma. The prevalence of current moderate and severe asthma in the whole population of schoolchildren in Telemark was estimated to be $14 + 2/59 \times 369/4113 = 2.4\%$. Severe asthma represented only 0.3%.

Testing for allergy showed that 22/32 (69%) children with mild asthma had positive skin tests or Phadiatop, whereas 9/14 (64%) of moderate cases, and both severe cases showed positive tests. Among the nonasthmatics, 17.9% (7/39) were sensitized.

The test–retest reliability (kappa) of the asthma definition (in 1991 and 1993) by questionnaire was 0.91 (SE 0.04). If only the first question (“Has the child suffered from asthma?”) was used, kappa was 0.86

(SE = 0.05). If the other question was used (“Does the child wheeze, etc.”), kappa was 0.81 (SE 0.06).

Discussion

The clinical study shows the sensitivity and the specificity of the questionnaire to be high, making it a useful epidemiologic tool.

We were not able to detect any significant difference between the three areas of ambient air pollution in Telemark. This agrees with several studies (12–14, 25, 26), but it contradicts some other studies showing an increased prevalence of asthma in polluted areas (10, 11, 27). We saw, however, a trend toward slightly more asthma in the area of least pollution, which included both mountainous and coastal parts of the county. The prevalence of asthma was higher in the coastal area, particularly for boys, and this may explain the higher figure in the minimally polluted area. As the prevalence figure is marginally higher outside the polluted area, one might speculate that families have moved away with their asthmatic children as a consequence of the possible deleterious effects of industrial pollution, but this possibility could not be verified by us (data not shown).

The cumulative prevalence of asthma was high (9%) and nearly twice as high for the boys (11.3%)

than for the girls (6.6%), this difference being a usual finding (28). The clinical study revealed that 7.7% of the children currently have asthma. In 1980, Skarpaas & Gulsvik (29) found a prevalence of 3.1% physician-diagnosed asthma in schoolchildren in Oslo, while 9% reported symptoms of wheezing and occasional breathlessness. At the same time in Sweden, Åberg et al. (30) found the lifetime prevalence of asthma to be 5.1% in schoolchildren. Seventy-five percent of them had physician-diagnosed asthma. Owing to different study methods, it is not possible to determine whether our prevalence figures represent more asthma than these 10-year-old reports.

A clear difference in asthma prevalence in boys was detected between the mountainous areas (8.9%) and the seaside region (14.2%). No such difference could be noted for girls. Marked differences in the prevalence rates for wheezing and asthma between mountainous areas and coastal regions have been reported (9). A feasible explanation might be more exposure to allergens in the humid and milder coastal area (2, 11). However, our observation that these differences occur particularly in boys is not mentioned in the literature, and we have no explanation for the interaction with sex.

We found that 2/3 of our current asthmatic children had a mild form of disease. Converted to population prevalences, only 2.1% had moderate asthma and 0.3% had severe asthma. This is in accord with a US survey by Taylor & Newacheck (16), who reported an asthma prevalence of 4.9%, 59% of these cases being characterized as mild, giving 2% of children suffering from moderate to severe asthma. Among the 13.1% of children found to have asthma in the UK in 1994 (27), more than half (8%) had fewer than three wheezing episodes a year, and only 2.2% had experienced more than 12 wheezing episodes. In their study from 1988, Bråbäck & Kälvesten (17) stressed that most of the asthmatic children (prevalence 4%) had mild symptoms. In recent years, very high asthma prevalence rates have been reported in children (26), and more children than before are probably being included as asthmatics in many of the reports all over the world. Our results may indicate that asthma in schoolchildren is at about the same level as reports during the past 10–20 years. In a recent report from the UK, Anderson et al. (4) conclude that the proportion of asthma cases which are severe seems to have been reduced, judging by the level of disability and the number of acute episodes.

Among the girls with allergic rhinitis, a significant association with the pollution zone was found. This was not the case with the boys. The lifetime prevalence of eczema was 13.2% with an expected sex ratio of 1.3, which are about the same figures as

reported from Sweden by Åberg et al. 10 years ago (30). The pollution zones or climatic areas did not seem to have any significant influence on this prevalence in the boys, but the lifetime prevalence of eczema in girls appears to be significantly higher in pollution area A than in the nonpolluted area C. Girls may be more vulnerable to sensitization to aeroallergens in the polluted areas, leading to upper airway and skin problems. Further studies should be done to elucidate these sex differences not reported elsewhere.

The clinical study revealed that 67% (31/46) of the children defined as asthmatics had allergic sensitization, while 17.9% of the nonasthmatics were allergic. Kjellman & Hesselmar found a higher figure of allergy (90%) in their long-term studies of asthmatic children who were referred to hospital (31), but our group of children was unselected. In this unselected group, we assume that 1/3 of all asthmatic children have hyperreactive mucous membranes without detected allergic sensitization.

The indoor climate has deteriorated in many countries as a consequence of extensive energy-conserving measures, less ventilation, and the introduction of new building materials. Probably as a consequence of this, sensitization to house-dust mites has become much more common (2, 32). The asthmatic children in our study had carpets in their bedrooms and pets less often than the nonasthmatic children. However, animals are present in nearly half of the homes with asthmatic children. Humidity in the house has been reported as an important risk factor in the development of asthma (10). In our study, however, the houses seem to be of good quality, as only about 3% reported such indoor problems, with no difference in exposure between asthmatics and controls. The respiratory irritant that has received most attention is cigarette smoke. It is disturbing that indoor smoking is more common in asthma homes than in nonasthma homes. Similar results have been shown previously (33). The increasing amount of respiratory disease and asthma has coincided with a high rate of smoking among young women.

In conclusion, this study indicates that there was no association between air pollution (as approximated by place of residence) and the occurrence of asthma in schoolchildren. The prevalence of asthma among boys was particularly high in the seaside areas of Telemark.

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