

The prevalence of respiratory symptoms and asthma among school children in three different areas of Norway

Nystad W, Magnus P, Røksund O, Svidal B, Hetlevik Ø. The prevalence of respiratory symptoms and asthma among school children in three different areas of Norway

Pediatr Allergy Immunol 1997; 8: 35–40. © Munksgaard 1997.

The role of exposure to ambient air pollution has been a topic of interest as a potential risk factor for respiratory symptoms and asthma. We expected that the prevalence rates would vary in Norway between the capital, Oslo, the mountainous area Hallingdal and the industrial area Odda. Surveys were conducted in school children, aged 6–16 years, in; Oslo ($n=2577$), Hallingdal ($n=1177$) and Odda ($n=831$). The parent-reported prevalence of wheeze in past year was almost similar in Oslo (13.1 (95% CI 11.7–14.5)) and Upper Hallingdal (14.2 (13.1–15.3)), but lower in Odda (9.0 (7.0–11.0)). The findings for severe respiratory symptoms were almost equal. The age patterns within each area differed. The risk of wheeze ever ($p<0.001$) and wheeze in past year ($p=0.04$) decreased with increasing age in Odda, while there was an increase in the risk of exercise induced wheeze in Oslo ($p=0.02$) and Hallingdal ($p<0.001$). The lifetime prevalence of asthma was lowest in Odda (5.4 (3.8–7.0)) compared to Oslo (9.4 (8.2–10.6)) and Hallingdal (8.5 (6.8–10.2)). There was a positive association between physical activity and wheeze in past year. The results do not support the hypothesis that respiratory morbidity is more common in urban than rural areas, age and physical activity can influence the prevalence rates of respiratory symptoms in school children.

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Key words: childhood asthma; epidemiology; ISAAC regional differences

Received October 1, 1996
Accepted March 23, 1997

In recent years the role of exposure to ambient air pollution has been a topic of interest as a potential risk factor for respiratory symptoms and asthma. A report indicates that symptoms can occur at levels of exposure previously considered safe (1). The most common air pollutants in an urban environment include sulphur dioxide (SO_2), suspended particulate matter (SPM), nitrogen oxides (NO_x), carbon monoxide (CO), and ozone (O_3). Reported effects of exposure to environmental chemicals relevant for respiratory disorders include reductions in lung function, increased airway hyperresponsiveness and symptom exacerbation (1,2).

Most areas in Norway have little air pollution. One exception is the capital Oslo, where, on cold winter days, motor vehicle emissions and other sources are captured beneath an inversion layer which causes a high impact of air pollution (3). One would therefore expect that the prevalence rates of respiratory symptoms and asthma were higher in Oslo than more sparsely populated areas. Other

mechanisms that could cause differences in the prevalence rates are factors such as climate, allergen exposure and life style. Some people may also be more likely to report symptoms.

The objective of the present study is first to compare the prevalence of respiratory symptoms, asthma, hay fever and eczema among school children in Oslo, a rural sparsely populated mountainous area, and a small industrial area on the western coast. Second, to look upon age patterns of respiratory symptoms, and third, to estimate whether there is an association between physical activity and reported wheeze.

Subjects and methods

Areas

The areas are described in Table 1. The city Oslo is the area with the highest population density. The Upper Hallingdal valley is a mountainous area with a low population density located in mid Norway

with an inland climate. The area is free from heavy industry, and except for a few local places the traffic density is low. Odda has a coastal climate. The population is concentrated in a small city. Within the area there is heavy industry with emissions of sulphur dioxide (SO₂), suspended particulate matter (SPM) and fluoride (Odda Smelteverk, Norzink and Tinfoss Titane and Iron A/S).

Population

The target population was school children in the first to ninth grade, 6–16 years old. In Oslo school classes were selected randomly from the current list of school classes belonging to the municipality. In Upper Hallingdal and Odda all school children in the first to ninth grade were included in the study. The mean age and gender distributions are described in Table 1.

Variables

The ISAAC-questionnaire, the International Study of Asthma and Allergy in Children, was distributed to the children at school and completed by the parents at home (4). The ISAAC questionnaire relies on the parental recall of asthma and respiratory symptoms in their children aged 6–7 years and on self-response in 13–14 years (4). In the present study we have used parental responses to the ISAAC questionnaire for children in all ages so that we could make comparisons independent of age. In addition, questions on eczema and hay fever based on the American Thoracic Society (ATS) (5) and the Medical Research Council (MRC) 1976 questionnaire (6) used in other cross-sectional studies of childhood asthma were included (7,8). Physical activity level

was assessed by using a question of physical activity level from the "WHO cross-national survey of health behaviour in school-aged children" (9). The items defining each measure, beyond the ISAAC-questionnaire, are presented in the Appendix 1.

Statistical analysis

Lifetime and current prevalence rates were calculated and are presented with 95% confidence interval (CI). The most common symptoms are presented in three age groups; 6–8 years, 9–12 years and 13–16 years. Logistic regression was used to estimate the odds ratios (ORs) with 95% confidence intervals for the association between age and respiratory symptoms, and the association between physical activity level and wheeze in past year. Missing values were excluded from analysis. All data were analysed using the Statistical Products of Service Solution package (SPSS) for Windows (Release 6.1).

Results

Response rates of 85% or more were obtained in all three areas, the mean ages were almost similar and approximately 50% of the respondents were female (Table 1).

Wheezing

Table 2 shows that the parent-reported prevalence of respiratory symptoms was similar in Oslo and Hallingdal, but lower in Odda. The prevalence of wheeze ever and wheeze in past year tended to decrease with increasing age in Oslo and Odda, while the prevalence rates tended to increase with increasing age in Hallingdal. The prevalence of exercise in-

Table 1. A description of the population and areas under study

	Oslo	Hallingdal	Odda
Study population <i>n</i>	2577	1177	831
Response rate % (<i>n</i>)	85 (2188)	89 (1045)	95 (788)
Gender			
male% (<i>n</i>)	52 (1128)	48 (497)	52 (405)
female% (<i>n</i>)	48 (1060)	52 (548)	48 (383)
Age, mean (SD)	10.6 (2.4)	11.5 (2.6)	11.1 (2.6)
Month of data collection	January	May	October
Number of schools	59	18	5
Area	Urban area, the capital of Norway	Mountainous area, >470m above sea level	An industrial area on the western coast
Size - km ²	427	3492	1584
Population density (persons per km ²)	1130.1	2.9	5.1
Normal temperature (°C)			
January	−4°	−9°	−3.5°
July	+16.0°	+11.0°	+14.5°

Table 2. Parent-reported prevalence of wheeze among school children divided into three age groups, 6–8, 9–12 and 13–16 years old

Question	Oslo		Hallingdal		Odda		Total		
	Sample <i>n</i>	Symp**% (95% CI)	Sample <i>n</i>	Symp**% (95% CI)	Sample <i>n</i>	Symp**% (95% CI)	Sample <i>n</i>	Symp**% (95% CI)	(95% CI)
Wheeze ever									
6–8 years	590	25.3	171	18.1	163	27.0	914	24.2	(21.4–27.0)
9–12 years	1046	22.2	478	20.3	353	20.1	1877	21.3	(19.4–23.2)
13–16 years	548	20.8	394	22.1	271	15.5	1213	20.0	(17.7–22.3)
Total	2184	22.7 (20.9–24.5)	1043	20.6 (18.1–23.1)	787	19.9 (17.1–22.7)	4014	21.6	(20.3–22.9)
Wheeze in past year									
6–8 years	590	15.3	171	10.5	163	11.0	924	13.6	(11.4–15.8)
9–12 years	1046	12.0	478	12.1	353	8.8	1877	11.4	(10.0–12.8)
13–16 years	548	11.7	394	16.8	271	6.6	1213	12.2	(10.4–14.0)
Total	2184	12.8 (11.4–14.2)	1043	13.6 (11.5–15.7)	787	8.5 (6.6–10.4)	4014	12.2	(11.2–13.2)
Exercise induced wheeze									
6–8 years	582	10.5	171	7.6	161	6.2	914	9.2	(7.1–11.1)
9–12 years	1038	8.8	476	9.2	349	6.9	1863	8.5	(7.2–9.8)
13–16 years	547	14.7	394	17.0	269	7.4	1209	13.8	(11.8–15.8)
Total	2167	10.7 (9.4–12.0)	1041	11.9 (10.1–13.9)	779	6.9 (5.1–8.7)	3986	10.3	(9.4–11.2)

* symp = symptom

duced wheeze increased with increasing age in all three areas.

Table 3 describes the sex-adjusted ORs for the association between respiratory symptoms and age when age increase with three years. In Odda, the adjusted OR decreased with increasing age for wheeze ever ($p < 0.001$) and wheeze in past year ($p = 0.04$). In Oslo and Hallingdal, the aOR increased with increasing age for exercised induced wheeze, $p = 0.02$ and $p < 0.001$, respectively.

The prevalence for symptoms of severe asthma, >12 attacks of wheezing in past year, sleep disturbed

by wheezing at least once per week, and attacks of wheezing limiting speech were almost equal in all three areas (Table 4). The parent-reported prevalence of at least one of these severe symptoms were 3.4% (2.6–4.2) in Oslo, 3.3% (2.2–4.4) in Hallingdal and 2.9% (1.7–4.1) in Odda (not tabulated).

There was a positive association between physical activity and reported wheeze in past year. See Table 5 gives the age-, sex- and area-adjusted ORs for the association between reported wheeze and the indicator of physical activity level. None of the potential confounding variables had an effect on the relation between measures of physical activity and respiratory symptom.

Asthma

Odda had the lowest prevalence of lifetime asthma, while there were minor differences between the urban and rural area (Table 4).

The median ages of onset for children with asthma were 2.0 years in Oslo, 4.0 years in Hallingdal and 2.0 years in Odda. Seventy-five percent of the asthmatic children had been diagnosed at 6 years of age in Oslo, at 10 years in Hallingdal and at 5 years in Odda (not in Table).

Other atopic diseases

There were no differences between the areas in the prevalence of hay fever and eczema (Table 4).

Table 3. Adjusted odds ratios (aORs) with 95% confidence intervals (CI) for the association between respiratory symptoms (wheeze) and asthma and age when age increase with three years

Question	Oslo	Upper Hallingdal	Odda
	aOR* 95% CI	aOR* 95% CI	aOR* 95% CI
Wheeze ever			
Three years increase in age	0.9 (0.8–1.0)	1.1 (0.9–1.3)	0.7 (0.5–0.8)
Wheeze in past year			
Three years increase in age	0.9 (0.8–1.1)	1.2 (1.0–1.5)	0.7 (0.5–1.0)
Exercise induced wheeze			
Three years increase in age	1.2 (1.0–1.5)	1.5 (1.2–1.9)	1.1 (0.8–1.5)

* adjusted for sex

Table 4. Parent-reported prevalence of attacks of wheezing, sleep disturbed by wheezing and other respiratory symptoms, hay fever and eczema

Question	Oslo		Upper Hallingdal		Odda	
	%	(95% CI)	%	(95% CI)	%	(95% CI)
Attacks of wheezing in past year						
None	87.3	(85.9–88.7)	86.7	(84.6–88.2)	91.3	(89.3–93.3)
1–3	7.7	(6.6–8.8)	7.2	(5.6–8.8)	5.2	(3.6–6.8)
4–12	3.0	(2.3–3.7)	4.0	(2.8–5.2)	2.3	(1.2–3.4)
>12	2.0	(1.4–2.6)	2.3	(1.4–3.2)	1.2	(0.5–1.9)
Sleep disturbed by wheezing						
Never	92.7	(91.6–93.8)	94.1	(92.1–96.1)	94.2	(92.5–95.7)
<1 per week	6.2	(5.4–7.0)	5.1	(3.8–6.4)	4.3	(2.9–5.7)
1+ per week	1.0	(0.7–1.3)	0.7	(0.2–1.2)	1.6	(0.7–2.5)
Other respiratory symptoms						
Severe attack of wheezing limiting speech in past year	1.3	(0.9–2.7)	1.3	(0.6–2.0)	0.9	(0.3–1.6)
Night cough	15.4	(13.9–16.9)	10.6	(9.1–12.1)	12.1	(9.8–14.4)
Asthma						
Lifetime asthma	9.4	(8.2–10.6)	8.5	(6.8–10.2)	5.4	(3.8–7.0)
Other atopic diseases						
Hayfever*	7.8	(6.7–8.9)	9.3	(7.5–11.1)	8.5	(6.6–10.4)
Eczema*	17.1	(15.5–18.7)	15.5	(13.3–17.7)	15.6	(13.1–18.4)

Not included in the ISAAC questionnaire; Appendix I.

Seventy-one percent of the children in Upper Hallingdal and 76% in Odda had lived in the areas since birth. In Hallingdal, the lifetime prevalence of asthma among those who had moved to the area was 9.4% (6.4–12.4) compared to 8.0% (6.0–10.0) among the others. In Odda, the lifetime prevalence of asthma among those who had moved to the area was 4.2% (1.4–7.0) compared to 5.8% (3.7–7.7) among the others.

The populations are different regarding the proportion of children with another ethnic origin than Norwegian (Oslo $n=274$, Hallingdal $n=17$, Odda $n=13$). Non-Norwegians tended to report less asthma and respiratory symptoms. Analysing the data without children with another ethnic origin than Norwegian resulted in minor differences in the results, but no changes in the main trend in the differences between the areas.

Discussion

The main findings in the present study are that there are minor differences in the parent reported prevalence of respiratory symptoms and asthma between the city, Oslo and the mountainous area, Upper Hallingdal, while the prevalence rates were lowest in Odda on the western coast. The age patterns within each area tend to be different, and there was a positive association between physical activity and reported wheeze in the past year.

Information obtained by questionnaires may be subject to recall bias. There is an area of uncertainty concerning the use of questionnaires in diagnosing asthma (10). In addition, the ISAAC questionnaire has mainly been validated for an English-speaking population (11–13). In the comparison of asthma morbidity symptoms are preferable to diagnoses. A question of asthma seems, however, to be remarkably specific in that people who claim to have the disease nearly always seem in fact to have it (14). The item asthma is also widely used in other studies of childhood asthma and are thus included to make comparisons within and between countries. Using the same procedures, it is unlikely that the differences in the findings in the present study could be attributed to a methodological bias.

Seasonal differences in data collection may account for some of the differences observed between the areas. The findings of regional differences are, however, consistent for lifetime and current prevalence rates, which support the findings despite a possible differential measurement bias. May is before the pollen-season in the mountainous area, and one could expect that the prevalence rates were highest in Oslo in January due to the cold climate and possible effects of air pollutants (3,15,16).

Theoretically, one can assume that people moving out of the city had an increased risk of developing atopy, which could result in a “healthy worker effect”. If atopic parents moved from the polluted ar-

ea, the prevalence of respiratory symptoms of children in that zone, who are potentially less susceptible, will be low. The prevalence of asthma among children who changed municipality in the present study do not, however, differ significantly from the other children.

What factors that may cause differences in prevalence rates remain a question of speculation. The present study was not designed to elucidate factors that may cause regional differences.

An interesting finding is that age is associated with the parental report of symptoms during such a small age range as school age. The effect of age on the reporting of respiratory symptoms is a relatively poorly explored area. Age patterns can reflect the effect of risk factors through childhood. However, age patterns can also be a result of changing awareness of symptoms both among children and parents. A decrease in prevalence rates with increasing age is inconsistent with such a hypothesis.

The finding of a positive association between wheeze in past year and physical activity suggest that children's physical activity level does influence the prevalence rates of respiratory symptoms. Physically active children can have an increased perception of respiratory symptoms, and exercising under different climatic conditions as in cold weather may influence the environmental exposure. Exercise is an important provoking factor for wheezing (17,18). The present study is, however, the first study to assess the influence of this exposure. Cultural differences in life style such as physical activity may thus effect comparisons within and between countries. The finding needs to be confirmed.

There were minor differences between the areas in the prevalence of more severe respiratory symptoms and other atopic diseases. Presumably more severe attacks of wheeze are less easily misclassified. Wheeze in general may reflect more unspecific respiratory symptoms, and thus be more easily influenced by public awareness, perceptions of symptoms and diagnostic routines. Local traditions among physicians in the three regions as regards diagnostic practice may therefore, on the one hand, partly explain the difference in the prevalence of asthma. On the other hand, the prevalence rates of respiratory symptoms are consistent with the prevalence of asthma in Odda, suggesting that there may be regional differences in asthma morbidity within Norway.

Previously published Norwegian cross-sectional studies of childhood asthma have shown minor interregional differences in asthma morbidity (19,20). In contrast, Søyseth et al. have reported an increased bronchial hyperresponsiveness in school children living in an industrial area with high levels of sulphur dioxide compared to that of children living in a relatively unpolluted area in Norway (2). There is,

however, no difference in the prevalence of childhood asthma between an urban and rural area in the Highlands of Scotland (21). In Belfast there is a higher prevalence of asthma among rural compared to urban first year students (22). A Swedish study shows approximately similar prevalence of asthma and wheeze, except for exercise-induced coughing, in urban and rural Sundsvall (23). A recent study has indicated that self-reported traffic exposure is related to self-reported wheezing and symptoms of allergic rhinitis (24). The findings are thus not consistent. There is no exposure assessment in the present study. The areas do, however, represent three very different regions of Norway, which reflect differential environmental exposures. More than urbanisation climate and life style can, however, influence the prevalence rates.

Compared to other ISAAC-studies, the reported prevalence of respiratory symptoms and asthma in the present study are lower than previously published studies from England, New Zealand and Australia (13,25). The results are, however, more consistent with findings from Germany and Spain (25,26). The ISAAC protocol has been used in several countries and possible explanations for the observed differences may include differences in exposure to risk factors and differences in asthma management. Other factors may be cultural and language differences, which can influence the comparisons between English speaking countries and others. The influence of language and culture on the reporting of respiratory symptoms are poorly understood.

The present study does not support the hypothesis that asthma is more common in urban than rural areas. In conclusion, we suggest that epidemiological studies of respiratory morbidity in school children can be influenced by age and physical activity.

Table 5. Reported prevalence of wheeze in past year by physical activity and the adjusted odds ratios (aORs) with 95% confidence intervals (CI) for the association between wheeze in past year and physical activity

Physical activity level	Wheeze in past year			
	Sample n	Symp *	aOR*	(95% CI)
Hours a week				
None	361	8	1.0	
about ½ hour	222	13	1.6	(0.9–2.8)
about 1 hour	675	12	1.5	(0.9–2.3)
about 2–3 hours	1391	13	1.6	(1.0–2.4)
about 4–6 hours	924	12	1.6	1.0–2.4)
7 hours or more	358	15	1.9	(1.2–3.1)
Hours a week				
None	361	8	1.0	
≥ ½ hour a week	3573	13	1.6	(1.1–2.3)

*adjusted for age, sex and area

Appendix

- * *Asthma*. "Has the child been treated by a doctor or admitted to hospital for asthma?" * If "Yes", "Age of onset?"
- * *Other diseases associated with atopy*. "Has the child been treated by a doctor or admitted to hospital because of: a. eczema b. hay fever?"
- * *Physical activity level*.
Hours a week. "Outside of school hours: How many hours a week does the child engage in sports or exercise so much that it is out of breath or sweat?" Seven categories were possible ranging from "7 hours or more" to "None".
Frequency. "Outside of school hours: How often does the child engage in sport or exercise so much that it gets out of breath or sweats?" Seven categories were possible ranging from "Every day" to "Never".

Acknowledgement

Our thanks to the Norwegian Research Council and the Norwegian Asthma and Allergy Society for help with funding.

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