

Incidence of asthma in adults – report from the Obstructive Lung Disease in Northern Sweden Study

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Incidence studies offer a better opportunity to study risk factors for asthma than do prevalence studies. However, regular prospective follow-ups of large cohorts are difficult to perform, and that is why direct measurement of the incidence rate of asthma is almost impossible. Thus, cross-sectional follow-up studies of defined cohorts can be used to provide data on incidence. In 1986, a postal questionnaire survey on respiratory symptoms and diseases was performed in the northernmost province of Sweden. The population sample comprised all subjects born in 1919–20, 1934–5, and 1949–50 in eight representative areas of the province, which comprises 25% of the total area of Sweden. Completed answers were given by 5698 subjects (86%) of the 6610 subjects invited to the study. In 1992, the cohort was invited to a follow-up survey during the same season as in 1986, and 6215 subjects were traced. Of the 5393 subjects who answered the questionnaire, 4932 had participated in the 1986 survey, or 87% of those who participated in 1986. For the period 1986–92, the cumulative incidences of asthma were 4.9 and 5.0%, respectively, as assessed by the questions, “Have you ever had asthma?” and “Have you been diagnosed as having asthma by a physician?” Thus, the results indicate a mean annual cumulative incidence of asthma of 0.8%. After correction of the results for subjects who were diagnosed as having asthma in the clinical part later in the 1986 study, the mean annual cumulative incidence of asthma was found to be 0.5%. Risk factors were family history of asthma (OR 3.46) and current and former smoking, while female sex was a strong trend.

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Many cross-sectional prevalence studies on asthma have been reported in recent years. Most of these studies give a uniform picture of the increasing prevalence of asthma (1–3). However, cross-sectional studies are of limited interest when studying risk factors for asthma. They express relationships or associations of uncertain value in the causality of asthma. Furthermore, cross-sectional studies give no or poor information of incidence, remission, and prognosis.

Studies of incidence not only contribute to the descriptive epidemiology of asthma but also offer a better opportunity than do prevalence studies to assess risk factors for the disease. To measure an exact incidence rate in a general population is difficult and requires follow-ups of large represent-

ative cohorts of the population under study over several years.

Only a few prospective studies of asthma incidence have been reported in the literature, most of them on children and teenagers. Most published studies on adults are from the USA and include large register studies (4, 5) and conventional population-based studies (6–8), indicating annual incidence rates of 1–4/1000 person years. The Tecumseh, Michigan study, which included physicians' examinations, gave a 4-year cumulative incidence of asthma of 1% in the early 1960s (7). The Tucson, Arizona studies reported an annual incidence of 0.4/100 person years from birth to old age with the lowest incidence in adolescents (8). The low incidence in adolescents and young adults

has been reported also in a Norwegian study (9). In contrast, results from the UK (10–12) and Sweden (13) have reported relatively high incidence rates in adolescents and teenagers, 0.7% per year in England and 1.0% (males) to 1.5% (females) in Sweden. These studies indicate an increase in the incidence of asthma over the last decades.

The Obstructive Lung Disease in Northern Sweden Study (OLIN) started as a prevalence study in 1986 (14). The study base was expanded in 1992, when also the cohort for 1986 was re-examined.

This study aimed to examine the incidence of asthma and of symptoms associated with asthma in adults during the 6-year period, 1986–92. A further aim was to detect determinants of the disease.

Material and methods

The incidence data are based on the results from two cross-sectional studies in the same population sample. The first study was a postal questionnaire study performed in late autumn 1985 and winter 1986 (14). The study was followed up by structured interviews and lung-function tests (15, 16) and a validation study which showed that the validity of the postal questionnaire was appropriate in measuring the prevalence of asthma in a Swedish population (17). The second study was performed in winter 1992 with the same questionnaire, which was mailed in the same way as in the 1986 study.

The study was approved by the ethical committee at the University and the University Hospital of Northern Sweden in Umeå.

Study population

The 1986 study population consisted of all 6610 subjects born in 1919–20, 1934–5, and 1949–50, living in eight representative areas of the northernmost province of Sweden, Norrbotten, which comprises one-fourth of the area of Sweden (Fig. 1). The study areas were selected for geographic position, population density, climatic conditions, and commercial and industrial life. The study population and addresses were provided by the provincial authorities from the Swedish Population Register. Completed answers were received from 5698 subjects (86%). One reminder was sent.

In 1992, the study population comprised 6215 subjects, as 265 subjects had died and 130 subjects could not be traced. The great majority were living in the same areas as in 1986, and fewer than 6% of the identified subjects had moved outside the province of Norrbotten, and they were included in the study population. After two

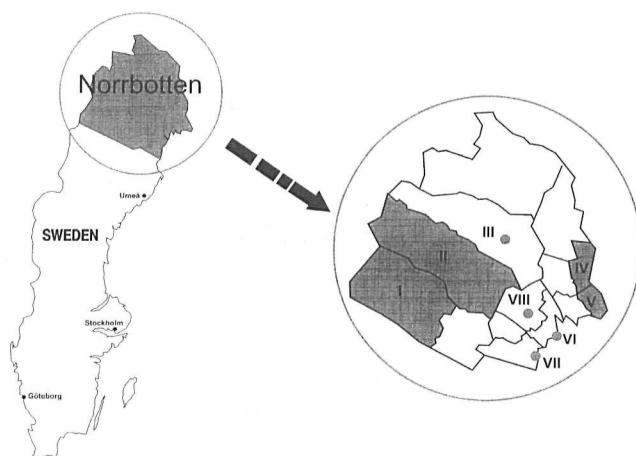


Fig. 1. Map of Sweden, province of Norrbotten, and study areas. Study samples from areas I, II, IV, and V were drawn from whole municipality, while those from areas III, VII, and VIII were from defined parts of towns of Malmberget, Piteå, and Boden, respectively, and their immediate surroundings. Sample from area VI was from defined part of city of Luleå.

reminders, the questionnaire had been responded to by 5393 subjects (87%). In total, 4932 participated in both the 1986 and the 1992 studies; i.e., 87% of the 5698 subjects who participated in 1986. The study population is described in Table 1 and Fig. 2.

Of the 5698 participants in 1986, 309 (5%) either had died or could not be traced in 1992, and another 457 (8%) subjects could be traced in 1992 but did not participate. In 1986, these 457 non-responders reported similar prevalences of asthma (5.3% vs 5.7%) and of the symptoms recurrent wheeze (11% vs 12%) and attacks of breathlessness (11% vs 11%) to the responders.

“Yes” answers to the questions, “Have you ever had asthma?” and “Have you been diagnosed as having asthma by a physician?”, were reported by 349 subjects in 1986. Of these, 316 participated at the 1992 study. Another 81 participants in the 1992 study had been classified as having asthma in the clinical part of the 1986 study, but had not answered “yes” to the questions about asthma in the postal questionnaire.

Methods

The calculations of the incidence of asthma were based on the two postal questionnaire surveys performed 6 years apart, 1986 and 1992, with the same questionnaire (14). The questionnaire had been developed from a revised version (18) of the British Medical Research Council questionnaire (19) and had been previously used in several Swedish studies (20). It included questions about respiratory symptoms and diseases, including re-current wheeze,

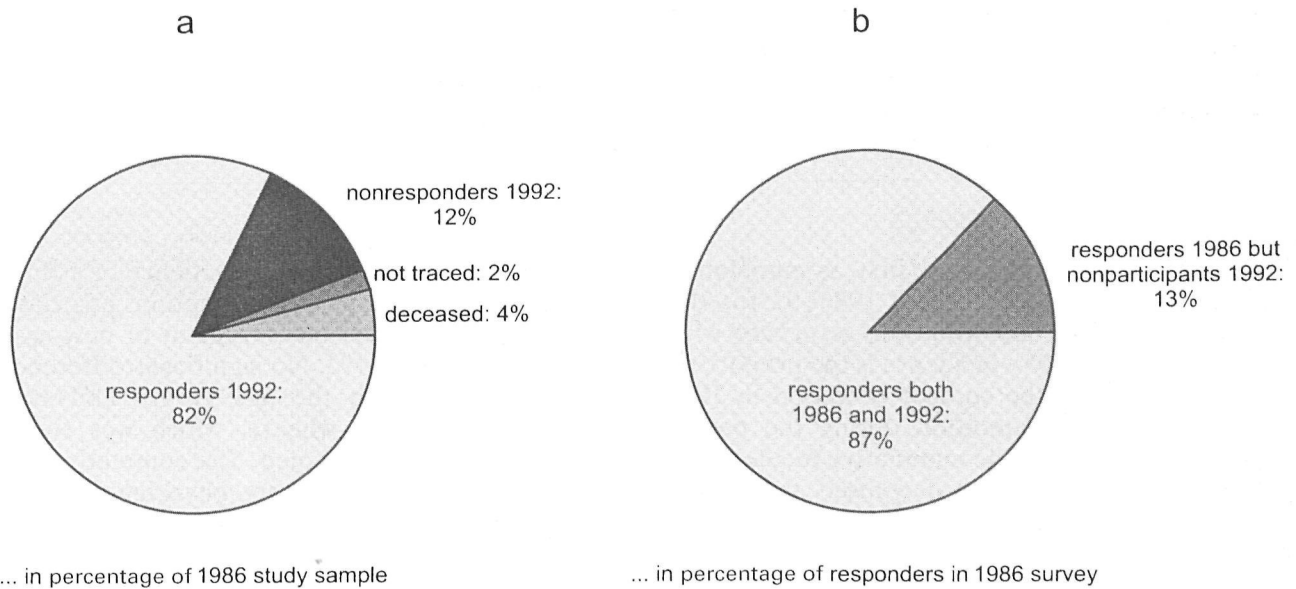


Fig. 2. a) Deceased 1986–92, not traced in 1992, nonresponders 1992, and responders 1992 in percentage of 1986 study sample. b) Responders 1986 but nonparticipants 1992 (includes nonresponders, deceased, and subjects not traced), responders both in 1986 and 1992 in percentage of responders in 1986 survey.

attacks of breathlessness, long-standing cough, sputum production, asthma, allergic rhinitis, chronic bronchitis, use of antiasthmatic drugs, and symptoms in special circumstances and varying exposures. Furthermore, the questionnaire included questions about smoking habits, occupation, and family history of the above-mentioned diseases.

Asthma was surveyed in the questionnaire by two separate questions, "Have you ever had asthma?" (self-reported asthma) and "Have you been diagnosed as having asthma by a doctor?" (physician-

diagnosed asthma). Furthermore, we calculated the incidence of users of asthma medicines, and of the symptoms recurrent wheeze, attacks of breathlessness, and the combination of recurrent wheeze and attacks of breathlessness. The questions on the symptoms were as follows:

- Do you currently use asthma medicines (permanently or as needed)?
- Do you usually have wheezing, whistling, or a noisy sound in your chest when breathing?

Table 1. Study samples. Invited and participants in 1986 and 1992, respectively; deceased 1986–92; not traced in 1992; and smoking habits in 1992 by age and sex

Study population	1919–20		1934–5		1949–50		All		Total
	M	F	M	F	M	F	M	F	
1986 study population	884	917	1041	1019	1447	1302	3372	3238	6610
Deceased	120	68	37	20	14	6	171	94	265
Not traced	9	11	14	15	46	35	69	61	130
Invited in 1992	755	838	990	984	1387	1261	3132	3083	6215
Nonresponders in 1992	77	103	115	96	261	170	453	369	822
Participants in 1992	678	735	875	888	1126	1091	2679	2714	5393
(%) of invited	(90)	(88)	(88)	(90)	(81)	(87)	(86)	(88)	(87)
Participants both in 1986 and 1992	627	666	812	829	1005	993	2444	2488	4932
(%) of participants 1986	(80)	(87)	(88)	(92)	(84)	(88)	(84)	(89)	(87)
Smoking habits in 1992									
Nonsmokers	213	459	282	459	378	393	873	1311	2184
(%)	(34)	(69)	(35)	(55)	(38)	(40)	(36)	(53)	(44)
Former smokers	284	93	297	139	258	218	839	450	1289
(%)	(45)	(14)	(37)	(17)	(26)	(22)	(34)	(18)	(26)
Smokers	92	58	205	190	352	352	649	600	1249
(%)	(15)	(9)	(25)	(23)	(35)	(35)	(27)	(24)	(25)
No information on smoking habits	38	56	28	41	17	30	83	127	210
(%)	(6)	(8)	(3)	(5)	(2)	(3)	(3)	(5)	(4)

- Do you now have or have you had asthma symptoms during the last 10 years (intermittent breathlessness or attacks of breathlessness; the symptoms may exist simultaneously with or without cough or wheezing)?

Analyses

The incidence was calculated first as cumulative incidence for the 6-year period 1986–92 for the questions on asthma and symptoms associated with asthma. The cumulative incidence is the proportion of subjects without the studied condition in 1986 who developed the condition during the period under study. Secondly, the cumulative incidence of self-reported and physician-diagnosed asthma for the period was calculated after exclusion also of the subjects who were diagnosed as having asthma in the clinical part of the 1986 study but who had not answered “yes” to the questions in the postal questionnaire about self-reported asthma or physician-diagnosed asthma. The results are given as cumulative incidences during the 6-year period. The mean annual cumulative incidence of asthma is, by definition, not identical with the annual incidence rate of the disease, but it does indicate the size of the incidence rate of asthma, as asthma is regarded as a chronic disease with a very low remission rate in adults (21).

Statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS) at the National Institute for Working Life in Umeå. The chi-square test and analysis of variance (ANOVA) were used for bivariate calculations. Determinants of disease and symptoms were calculated by multiple logistic regression analysis. The independent variables were age, sex, family history of asthma, smoking habits, area of domicile, and population density. Those who currently smoked every week or had stopped smoking within 12

months before the study were classified as smokers. Subjects who had stopped smoking more than 12 months previously were classified as ex-smokers.

Results

Incidence

Table 2 shows the cumulative incidence of asthma, use of asthma medicines, and symptoms associated with asthma by direct measurement of new cases between 1986 and 1992. No significant differences were found between the age groups and sexes except for recurrent wheeze, which was significantly more common in men. The cumulative incidences of self-reported asthma, physician-diagnosed asthma, and use of asthma medicines were greater in women, but not significantly.

The results indicated a mean annual incidence rate of asthma based on the questions on self-reported asthma and physician-diagnosed asthma of 0.8/100/year, respectively, of users of asthma medicines 1.1/100/year, of recurrent wheeze 1.1/100/year, and of attacks of breathlessness 1.5/100/year. The corresponding figure for the combination of recurrent wheeze and attacks of breathlessness was 0.5/100/year. After exclusion of the subjects who were diagnosed as having asthma in the clinical part of the 1986 study, but who did not answer “yes” at the 1986 postal questionnaire study to the questions on self-reported asthma or physician-diagnosed asthma, the calculated annual incidence rate of asthma was 0.5/100/year.

According to the question on self-reported asthma, the incident cases of asthma during the period under study were 228. Of these 228 incident cases, 85% were diagnosed as having asthma by a physician, 80% were using asthma medicines, 89% had attacks of breathlessness, 67% had recurrent wheeze, and 65% had both recurrent wheeze and

Table 2. Cumulative incidence (%) of asthma, users of asthma medicine, and respiratory symptoms associated with asthma by age and sex 1986–92. Total numbers (*n*) of incident cases 1986–92. Difference (*P* value) by age and sex. Corrected incidence refers to calculations after exclusion of all subjects who in 1986 study answered “yes” to either questions on self-reported asthma or physician-diagnosed asthma, or were classified as having asthma in clinical validation examinations

Condition or symptom	1919–20		1934–5		1949–50		All		All		Difference (<i>P</i> value) by	
	M	F	M	F	M	F	M	F	%	n	Sex	Age
Self-reported asthma	4.9	5.0	4.2	5.4	4.1	5.7	4.4	5.4	4.9	228	0.097	0.983
Self-reported asthma, corrected	3.8	3.1	2.9	3.4	2.7	3.6	3.1	3.4	3.2	147	0.479	0.873
Physician-diagnosed asthma	5.0	5.4	4.1	5.9	4.2	5.5	4.4	5.6	5.0	234	0.057	0.874
Physician-diagnosed asthma, corrected	3.6	2.8	2.6	3.6	2.6	2.8	2.9	3.1	3.0	136	0.633	0.743
Asthma medicine	6.1	5.7	6.8	8.4	5.5	6.7	6.1	7.0	6.5	306	0.203	0.108
Wheezing	8.3	5.6	8.7	5.6	5.9	6.3	7.4	5.9	6.7	289	0.043	0.490
Attacks of breathlessness	11.4	9.1	8.3	9.1	8.4	9.2	9.1	9.1	9.1	401	0.981	0.340
Wheezing and attacks of breathlessness	4.5	2.5	3.9	2.5	2.4	2.9	3.4	2.7	3.0	126	0.170	0.438

Table 3. Cumulative incidence (%) of asthma, users of asthma medicines, and respiratory symptoms associated with asthma by population density and area of domicile. Difference (*P* value) by population density and area of domicile

Condition or symptom	Population density				Area of domicile		Difference (<i>P</i> value) by	
	> 10 000	> 2000–10 000	> 200–2000	≤ 200	Coastal	Inland	Population density	area of domicile
Self-reported asthma	4.6	5.2	4.8	6.1	4.7	5.2	0.453	0.425
Self-reported asthma, corrected	3.0	3.1	3.2	4.9	3.0	3.5	0.121	0.377
Physician-diagnosed asthma	4.7	5.4	5.0	6.0	4.6	5.4	0.529	0.215
Physician-diagnosed asthma, corrected	2.6	3.3	2.9	4.4	2.6	3.4	0.132	0.103
Asthma medicine	6.4	6.8	6.1	7.2	6.3	6.8	0.874	0.556
Wheezing	5.8	7.2	8.0	8.9	6.6	6.7	0.036	0.840
Attacks of breathlessness	8.5	10.0	8.7	10.5	8.9	9.4	0.341	0.599
Wheezing and attacks of breathlessness	2.5	3.3	4.0	4.3	3.1	3.0	0.362	0.588

Table 4. Effects of different independent variables on incidence of wheezing, attacks of breathlessness, users of asthma medicine, and self-reported asthma. Odds ratios (OR) were calculated by multiple logistic regression analysis

Independent variables		Dependent variables							
		Wheezing		Attacks of breathlessness		Use of asthma medicine		Self-reported asthma	
Variables	Categories	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age	Born 1949–50	1.00		1.00		1.00		1.00	
	1934–5	1.34	0.99–1.82	1.17	0.90–1.54	1.56	1.16–2.09	1.14	0.81–1.60
	1919–20	1.43	1.01–2.03	1.45	1.07–1.95	1.29	0.91–1.83	1.29	0.88–1.90
Sex	M	1.00		1.00		1.00		1.00	
	F	0.75	0.57–0.98	0.99	0.78–1.25	1.20	0.92–1.55	1.28	0.96–1.73
Family history of asthma	No	1.00		1.00		1.00		1.00	
	Yes	2.61	1.97–3.45	3.37	2.66–4.27	3.25	2.50–4.21	3.46	2.58–4.65
Population density	> 10 000	1.00		1.00		1.00		1.00	
	2000–10 000	1.39	0.97–1.99	1.25	0.92–1.70	1.06	0.75–1.50	1.15	0.78–1.71
	200–2000	1.26	0.75–2.11	0.95	0.59–1.52	0.80	0.46–1.39	1.10	0.61–1.97
	< 200	1.57	1.05–2.34	1.13	0.79–1.62	1.00	0.67–1.50	1.31	0.85–2.04
Area of domicile	Coastal	1.00		1.00		1.00		1.00	
	Inland	0.83	0.62–1.13	1.06	0.82–1.38	1.09	0.81–1.46	1.02	0.74–1.43
Smoking habits	Nonsmoker	1.00		1.00		1.00		1.00	
	Ex-smoker	1.16	0.80–1.69	1.25	0.92–1.70	1.38	0.98–1.95	1.74	1.19–2.53
	Smoker	2.62	1.92–3.58	2.08	1.59–2.73	2.01	1.48–2.73	1.75	1.22–2.50

attacks of breathlessness. Of these 228 subjects, 97% reported that they either had recurrent wheeze, had attacks of breathlessness, or were using asthma medicines. After exclusion of those who were diagnosed as having asthma in the clinical part of the 1986 study, the number of new cases of asthma was 147. Of those 147, 97% also reported either recurrent wheeze, or attacks of breathlessness, or were using asthma medicines.

When the influence of population density and area of domicile, inland or coastal was examined, no significant differences could be shown except for wheezing, which was significantly more common in the areas with the lowest population density (Table 3). Nor could significant differences be shown in the cumulative incidence of recurrent wheeze, attacks of breathlessness, users of asthma

medicines, self-reported asthma, and physician-diagnosed asthma between the eight geographic areas.

Multivariate relationships

Odds ratios (OR) between different independent variables, which may influence the incidence of asthma and of symptoms associated with asthma, were calculated by multiple logistic regression analysis (Table 4). Significant risk factors for self-reported asthma were family history of asthma (OR 3.46), former smoking in comparison with non-smoking (OR 1.74), and current smoking vs non-smoking (OR 1.75), while female sex was a strong trend (OR 1.28). When the symptom recurrent wheeze was used as the dependent variable, current

smoking was the greatest risk factor (OR 2.62), followed by family history of asthma (OR 2.61). Furthermore, wheezing was significantly more common in men and increased significantly with increasing age. The risk pattern for both attacks of breathlessness and use of asthma medicines was between the risks for wheezing and self-reported asthma.

Between 1986 and 1992, the period under study, 78 subjects of those who were smokers in 1986 developed asthma. Of those 78 subjects, 21 had stopped smoking in 1992. If the smoking habits in 1992 were used as independent variables in the multivariate analysis, former smoking would appear as a greater risk factor for asthma (OR 1.83) (95% CI 1.28–2.63), and the influence of current smoking would decrease (OR 1.61) (95% CI 1.11–2.34).

Generally, area of domicile and population density did not significantly influence the incidence of asthma or the symptoms. However, there was one exception; rural residence was associated with an increased risk of wheezing.

When we performed the same risk-factor analysis after exclusion also of the subjects who were diagnosed as having asthma in the clinical part of the 1986 study, but who did not know they had asthma during the 1986 postal questionnaire study, the risks for asthma were similar. Former smoking and current smoking became even more pronounced risk factors with OR 2.06 (95% CI 1.30–3.28) and 2.04 (95% CI 1.30–3.19), respectively. The OR for a family history of asthma was 3.81 (95% CI 2.66–5.45).

Discussion

Whereas numerous prevalence studies of asthma have been reported in recent years, incidence studies are still scarce. When one studies diseases with a relatively low incidence, it is necessary to follow large population samples of subjects without having the disease under study for a long time to get a sufficient number of incident cases to make it possible to calculate risk factors for the disease. When one calculates risk factors which are not constant over a lifetime, a study of incidence gives more valid data than does a prevalence study. It entails less bias caused by patients forgetting what the situation was at the time of the onset of the disease and bias caused by the "healthy worker effect". A disadvantage when studying asthma is that incidence studies take a long time and generate fewer cases of the disease than do prevalence studies.

As there is no generally accepted epidemiologic diagnosis of asthma, we have measured different variables expressing incidence in order to ensure

that the results were as valid as possible. To get a more detailed picture, we also assessed the incidence of symptoms which are associated with asthma and of the use of asthma medicines.

As described, the calculations of the incidence of asthma were made in two different ways. We believe that the calculations after exclusion of those who were not aware of their asthma when they answered the 1986 postal questionnaire, but who were diagnosed as having asthma in the clinical part of the 1986 study (15, 22), more correctly reflect the real incidence of asthma. These calculations may underestimate the incidence, as some of those with a new onset of the disease were not aware of it, and may have answered "no" in the postal questionnaire to the questions on asthma. On the other hand, there may be bias, caused by the news media together with an increased public awareness of asthma, which may result in overreporting. However, although factors other than pathology are related to the identification of asthma in society, we confirm the internal validity of the results in view of the size of the population sample, the high participation rate, the identical methods, and the fact that several variables expressing the incidence gave results in concordance with each other. The fact that we have succeeded in keeping a large proportion of the cohort within the study contributes to the study's internal validity. Furthermore, the proportion of nonresponders in the second survey was low, and, in 1986, the prevalences of symptoms among the subjects were similar to those of the responders; therefore, the influence of the nonresponders on incidence could only be limited.

We found the cumulative incidence of asthma for the 6-year period to be 3%, which corresponds to an annual incidence rate of 0.5/100/year. The incidence rate must be considered high when compared with earlier studies on adults (4–8, 23). In the USA, the incidence rate of asthma was found during the 1960s, 1970s, and 1980s to be 0.1–0.4/100/year in adults (4–8). In the Tucson studies (8), which found an incidence rate of 0.4/100/year, the calculations of the incidence were based on the question, "During the past year, have you seen a doctor for asthma?" Generally, register studies tend to give lower incidence rates than population-based studies. In a study performed at the Mayo Clinic, Rochester, Minnesota, the annual incidence rate increased from 1.8/1000 in 1964 to 2.8/1000 in 1983 (4). Our results on incidence may reflect the increase in the prevalence of asthma (1–3).

Outside the USA, only a few population studies have been published in which incidence of asthma in adults was calculated, two of them from the Scandinavian countries (23, 24). In Finland, the

incidence rate was calculated as 1.5/1000/year between 1975 and 1981 in two cross-sectional surveys in the same population (23). A small 1-year follow-up study in Denmark resulted in an incidence rate of 5/1000/year in the late 1970s (24), results similar to ours. In Lebanon, the incidence of asthma was measured between 1972 and 1978, resulting in an incidence rate of 2–3/1000/year (25).

The incidence of asthma has been followed in the UK during childhood, adolescence, and young adulthood, revealing much higher incidences than studies in adults (10–12). The very high incidence rates in Swedish adolescents (13) may partly be explained by bias caused by the news media and increased public awareness of asthma and allergy.

The incidence of wheezing in our study, approximately 1/100/year, is similar to that found by a study in Lebanon (25) and slightly lower than that found in the Normative Aging Study (Boston, MA, USA) (26). The incidences of the symptoms recurrent wheeze and attacks of breathlessness, respectively, were twice as high as the incidence of asthma in our study. The differences between the incidence of asthma and the incidence of symptoms may partly be explained by the age composition of the study population, in which chronic bronchitis and chronic obstructive pulmonary disease (COPD) are common. This may also contribute to the high incidence of users of asthma medicines.

The most important risk factor in our study was family history of asthma, followed by current and former smoking. If we had used a conventional cross-sectional design when performing the risk factor analysis in our study, the influence of former smoking as a risk factor for asthma would increase and the influence of current smoking would decrease. According to the literature, the relationship between asthma and smoking is controversial. Several studies, mainly cross-sectional, have shown ever smoking or former smoking to be associated with asthma (23, 27–30), while only a few studies – in particular, the studies in teenagers and young adults – have shown current smoking to be associated with asthma (8, 12, 13). Some studies show no or a poor relation between smoking and asthma (5, 6, 31, 32). In the Tucson studies, smoking was significantly more common in subjects who later developed asthma than in those who remained free from respiratory diseases (8). The strong relationship between wheezing and smoking – in our study, OR 2.6 – was shown in the early British studies (33) and confirmed in more recent studies (26, 32).

The incidence of asthma was slightly higher in women, as has been shown in some of the above-mentioned studies (6, 8, 23). In this adult population sample, we could not see any significant differences in the incidence of asthma between the

age groups. For wheezing, the risk pattern was different. Wheezing increased with age and was more common in men, probably because the symptom is common also in COPD.

In conclusion, the annual incidence rate of asthma calculated from cumulative incidence over 6 years was 0.5/100/year. The incidence of symptoms associated with obstructive airways diseases and use of asthma medicines were two to three times greater. Family history of asthma and both current and former smoking were significant risk factors for asthma, while female sex was associated with a slightly elevated risk.

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