ORIGINAL ARTICLE

Prevalence and Risk Factors for Asthma in Poland: Results From the PMSEAD Study

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Abstract

Background: The prevalence of asthma depends on both hereditary and environmental factors. Knowledge of the effects of environmental and congenital factors on the frequency of occurrence of asthma may provide important clues to its pathogenesis and prevention.
Objectives: The Polish Multicentre Study of Epidemiology of Allergic Diseases was designed to obtain estimates representative of the entire Polish population to assess asthma prevalence and risk factors.
Methods: Thirty-three areas were selected in 11 regions of Poland. Epidemiologic diagnoses of asthma were verified by a single recognized expert in each region on the basis of collected data as well as available medical documentation, in accordance with the1997 guidelines of the Global Initiative for Asthma. Ambient air concentrations of sulfur dioxide and suspended particulates (black smoke) were measured directly or estimated by statistical modelling.
Results: Results were obtained for asthma in 16 238 subjects, including 3268 children (aged 3 to 16 years) and 12 970 adults (17 to 80 years). The overall prevalence of asthma was 8.6% (95% confidence interval [CI], 7.7% – 9.6%) among children and 5.4% (95% CI, 5.0% – 5.8%) among adults. Several risk factors for asthma were identified: family history of asthma, black smoke, residential exposure to traffic-related air pollution in both children and adults, and damp or overcrowded housing in adults. No statistically significant association was observed for passive smoking in the home, use of gas stoves, pet ownership, or exposure to ambient air pollution with sulfur dioxide.
Conclusion: Our results show that the prevalence of asthma is associated with several host and environmental factors in the Polish population.

Key words: Asthma. Prevalence. Risk factors. Poland.

Resumen

Antecedentes: La prevalencia del asma depende tanto de factores hereditarios como medioambientales. El conocimiento de los efectos de los factores congénitos y medioambientales en la frecuencia del asma puede proporcionar claves importantes en lo relativo a su patogenia y prevención.
Objetivos: El objetivo del Estudio Multicéntrico de la Epidemiología de las Enfermedades Alérgicas polaco fue obtener datos representativos de toda la población polaca para evaluar la prevalencia del asma y los factores de riesgo.
Métodos: Seleccionamos 33 zonas de 11 regiones de Polonia. Los diagnósticos epidemiológicos de asma los verificó un solo experto reconocido de cada región, basándose en los datos compilados y en la documentación médica disponible, de acuerdo con las directrices de 1997 de la Iniciativa Global para el Asma. Se midieron directamente o se calcularon mediante modelado estadístico las concentraciones en el aire de dióxido de azufre y las partículas en suspensión (humo negro).
Resultados: Se obtuvieron resultados sobre el asma en 16.238 sujetos, de los cuales 3.268 eran niños (de 3 a 16 años de edad) y 12.970 adultos (de 17 a 80 años de edad). La prevalencia general del asma fue de un 8,6% (intervalo de confianza [IC] de un 95%, 7,7% – 9,6%) entre los niños y de un 5,4% (intervalo de confianza [IC] de un 95%, 5,0% – 5,8%) entre los adultos. Se identificaron varios factores de riesgo del asma: antecedentes familiares de asma, humo negro, exposición residencial a contaminación ambiental relacionada con el tráfico tanto en niños como en adultos, y la humedad o la convivencia en domicilios superpoblados, en adultos. No se observó una relación estadísticamente significativa con la exposición pasiva al tabaco, el uso de cocinas de gas, la presencia de animales domésticos o la contaminación del aire por dióxido de azufre.
Conclusión: Nuestros resultados demuestran que la prevalencia del asma se relaciona con factores medioambientales y congénitos en la población polaca.

Palabras clave: Asma. Prevalencia. Factores de riesgo. Polonia.

** The names of the PMSEAD members are provided at the end of the article.*

Introduction

In the late 20th century we witnessed enormous progress in the epidemiology of asthma and allergic diseases. Two very large international studies—the European Community Respiratory Health Survey (ECRHS) and the International Study of Asthma and Allergies in Childhood (ISAAC)—provided very valuable information about the spread of these diseases worldwide, as well as their potential risk factors [1-3]. However, it should be remembered that the first phases of the ECRHS I and the ISAAC projects (designed mainly to assess geographical variations) used a simple standard approach to attain high response rates at minimum cost in as wide a range of centres as possible. Therefore, despite their unquestionable achievements, both projects have left some problems unsatisfactorily resolved. The very simplified phase I screening questionnaires did not ensure an acceptably high reliability of diagnoses, while phase II was burdened with some "cooperation" bias (persons with allergy-like symptoms were more willing to come for specialist tests). Moreover, selected areas mostly situated nearby academic centres cannot be considered truly representative samples of the general population of an entire country. Thus, further studies are still needed.

A multicenter study of the epidemiology of allergic diseases in Poland, the Polish Multicentre Study of Epidemiology of Allergic Diseases (PMSEAD), was designed under the auspices of the Polish Society of Allergology. The study protocol was constructed in such a way as to obtain results that are not only comparable but also complementary to those of the ISAAC and ECRHS studies. In contrast to both of those studies, particular emphasis was placed on diagnosis verification and selection of a wide range of individuals aged 3 to 80 years from both urban and rural areas with varying climate and different levels of air pollution, and on minimizing cooperation bias in the assessment of risk factors. Data collection was started in 1998 and completed in 1999.

Here we present the results of the PMSEAD study concerning the prevalence of asthma and associated risk factors.

Material and Methods

The study was approved by the Ethics Committee of the Wroclaw Medical University, Poland.

Study Population

The study population encompassed individuals of both sexes, including children (3–16 years) and adults (17–80 years).

Study Territory

To obtain a sample representative of the whole country, 11 regions were selected throughout Poland. They were located in such a way as to cover the whole country including east–west, north–south, and coastal–mountain regions (figure). Research teams were located in the following regions: 1) Bialystok, 2) Bydgoszcz, 3) Gdansk, 4) Krakow, 5) Lublin, 6) Lodz, 7) Poznan, 8) Rabka, 9) Warszawa, 10) Wroclaw, and 11) Zabrze. Each center covered a region corresponding to an administrative unit (a province according to the divisions existing before 1999). In each region, 3 areas with high, moderate, and low levels of environmental pollution were defined on the basis of black-smoke concentrations in ambient air. One of these 3 areas was rural. In this way, 33 areas were included in the study. Their distribution is shown in the figure.

Map showing the distribution of regions (provinces) investigated in the study.

Assessment of Ambient Air Pollution

In Poland, ambient air pollution concentrations of sulfur dioxide (SO_2) and suspended particulates (black smoke) are routinely measured through the network of sanitary-epidemiological stations. The measurements are taken in more than 500 fixed sampling sites placed all over the country based on the smallest administrative units (SAUs). In SAUs where more than 1 sampling site was operating, the average value from all measurements was used. Since in some SAUs where the study was carried out there were no air pollution sampling sites, it was necessary to use statistical modelling to estimate air pollution. For that purpose we used the kriging method in the ARC/INFO system [4]. The spherical method was used to obtain predicted semivariance. The estimated values of a given air pollutant concentration were averaged over the area of an SAU. Although these values allow only approximate assessment of air pollution, it is nevertheless possible to clearly identify areas with different levels of population exposure to black smoke and SO_2.

Black smoke concentrations were measured in 20 SAUs selected in this study and estimated for 13, while SO_2 concentrations were measured in 16 and estimated for 17 areas.

Sampling

Cluster random sampling [5] of the study subjects was applied in each selected area. Home addresses were drawn by lot in such a way as to obtain a total number of residents of around 600 in a sample that included individuals of both sexes, aged 3 to 80 years and who lived there permanently. Assuming that around 20% of selected persons may refuse to participate in the study, the planned number of individuals examined in each region containing 3 areas was equal to 1500 and the total sample size 16 500. Such a sampling strategy was applied in order to reflect the very wide range of ages in the examined population.

Instruments

Five different questionnaires were used: 1) residential questionnaire (24 items), 2) screening questionnaire for adults (23 items), 3) detailed questionnaire for adults (115 items), 4) children's questionnaire (48 items), and 5) questionnaire for subjects not examined, determining reasons for absence or refusal (7 items). The questionnaires were completed by trained personnel (medical students or nurses) at the homes of selected subjects, after prior information was provided on the time of the visit and its purpose. The residential questionnaire and the screening questionnaire for adults or the children's questionnaire were filled in for all individuals. A detailed questionnaire for adults was completed after receiving an affirmative answer to any of the designated questions of the screening questionnaire. In this way, the "cooperation" bias of phase II was avoided. Any available medical documentation was taken into account and notified.

Asthma Diagnosis

Diagnoses were established by a single countrywide recognized expert in each region in accordance with international guidelines [6], on the basis of collected data as well as available medical documentation. Since there is no precise, commonly accepted gold standard for asthma diagnosis, some between-expert variation has to be taken into account. However, assessment of this factor is complex and will be the subject of a separate report that will consider the within-country variation in asthma prevalence with respect to between-expert variation and adjustment for risk factors.

Risk Factors

The potential risk factors considered in the analysis were gender, family history of asthma (one or both parents having asthma), residential exposure to traffic (determined by the question "Do you complain at your home of fumes or noise caused by traffic?"), dampness in the home (assessed by questions about the presence of dampness or mould on the wall), environmental tobacco smoke (assessed by the question "Is there anyone who smokes in your apartment?"), use of a gas stove for cooking, overcrowding of the house (defined as 5 or more persons living in an apartment), and pet ownership, as well as exposure to ambient air pollution with black smoke or with SO_2, defined in the statistical analysis as present when a person was living in an area where pollutant concentrations were above the median value.

Statistical Analysis

Data are presented as prevalences and odds ratios (OR) with corresponding 95% confidence intervals (CI), and as arithmetic means (SD). Differences between proportions were assessed by χ^2 test. Risk factor analyses were performed by multivariate logistic regression with the exception of family history of asthma, which for adults had to be assessed by univariate analysis because the relevant question was only included in the detailed questionnaire for adults; thus, this information was not available for the whole sample examined. The influence of risk factors was modeled using multivariate logistic regression. The final model was built using the best subset method with score statistic. The most significant variables were selected and results were presented in the form of adjusted odds ratios together with 95% CI. All calculations were performed for children and adults separately. A value of $P < .05$ was defined as statistically significant.

Results

From 18 378 individuals living at the sampled home addresses, complete and reliable data concerning 16 238 individuals were obtained (98% of the predicted sample size). The sample included 12 970 adults (5939 men and 7031 women) with a mean (SD) age of 42.8 (17.0) years and 3268 children (1666 boys and 1602 girls) aged 9.4 (3.7) years. Mean age and sex structure in the adult sample were very similar to the total Polish population of the same age range [7] (mean age, 42.8 [16.8] years; proportion of men, 48.2% in the general population vs 45.8% in the sample). In the case of children, our sample was slightly younger than the general population (mean population age, 10.1 [4.0] years) and had a lower proportion of boys (51.0% in the sample vs 56.2% in the general population). The prevalence of asthma was higher in children than in the adult population: 8.6% (95% CI, 7.7%–9.6%) and 5.4% (95% CI: 5.0%–5.8%), respectively. Despite the presence of statistically significant between-region differences in the prevalence of asthma (Table 1), there was no geographic (climatic) relationship found in terms of east–west, north–south, or coastal–mountain regions.

We examined 10 selected risk factors for asthma. To assess their importance in children we used multivariate logistic regression for all of them in the entire sample. Because the question on family history of asthma was asked for adults in another ("detailed") questionnaire administered only in a selected part of the sample examined, we were able to assess the role of 9 factors in the entire sample, while the importance of family history of asthma had to be assessed in a subset of 3820 adults. We found as many as 4 risk factors to be statistically significant both for children and adults, as well as 2 additional risk factors that were only significant in the adult sample (Table 2). The strongest risk factor for asthma appeared to be a family history of the disease. Children from those families were over 3 times more likely to develop asthma

Table 1. Prevalence of Asthma in the Study Regions*

Region	Adults Prevalence	Adults P	Children Prevalence	Children P
Bialystok	3.6% (2.6% – 4.7%)	.022	2.8% (0.7% – 4.8%)	.004
Bydgoszcz	5.0% (3.9% – 6.1%)	.788	4.9% (2.8% – 7.1%)	.039
Gdansk	5.1% (3.9% – 6.3%)	.878	13.0% (9.6% – 16.4%)	.007
Krakow	7.6% (6.0% – 9.1%)	.005	10.9% (7.1% – 14.7%)	.409
Lublin	5.6% (4.3% – 6.8%)	.969	7.6% (4.6% – 10.7%)	.821
Lodz	7.3% (5.7% – 8.9%)	.025	8.5% (5.2% – 11.7%)	.999
Poznan	3.5% (2.5% – 4.5%)	.011	9.5% (6.5% – 12.6%)	.853
Rabka	3.5% (2.5% – 4.5%)	.015	7.0% (4.2% – 9.8%)	.603
Warszawa	6.8% (5.4% – 8.3%)	.089	11.8% (7.9% – 15.7%)	.218
Wroclaw	6.3% (5.0% – 7.6%)	.396	10.5% (7.2% – 13.8%)	.507
Zabrze	6.3% (4.5% – 8.1%)	.606	7.1% (3.0% – 11.1%)	.846
Overall	5.4% (5.0% – 5.8%)		8.6% (7.7% – 9.6%)	

*Data are shown as % (95% confidence interval). Comparisons were made between regional estimated prevalence and overall estimated prevalence for the study sample by χ^2 test.

as compared to those with no family history of the disease (OR, 3.42; 95% CI, 2.62–4.45; $P < .001$). The increased likelihood of asthma was lower in adults, but it was still highly significant (OR, 1.37; 95% CI, 1.22–1.54; $P < .001$). Among children, boys suffered from asthma more often than girls (10.9% vs 6.3%; OR, 1.81; 95% CI, 1.39–2.35), whereas in the adult population the opposite relationship was found (4.9% vs 5.8%; OR, 0.84; 95% CI, 0.72–0.98).

There were also significant outdoor environmental risk factors found. Air concentrations of black smoke in the examined areas ranged from 10.0 µg/m3 to 92.0 µg/m^3 and SO_2 from 4.0 µg/m^3 to 35.0 µg/m^3. For statistical analyses, all 33 areas were divided into 2 groups: greater than the median value or less than or equal to the median. The prevalence of asthma increased significantly with exposure to a higher level of black smoke: OR = 1.51 (95% CI, 1.17–1.94) in children and OR = 1.28 (95% CI, 1.10–1.49) in adults. In contrast, the prevalence of asthma was not significantly associated with higher exposure to ambient air pollution with SO_2: OR = 1.20 (95% CI, 0.91–1.59) in children and OR = 1.01 (95% CI, 0.85–1.20) in adults. Asthma prevalence was also significantly associated with exposure to traffic in the area of residence: OR = 1.43 (95% CI, 1.11–1.84) in children and OR = 1.35 (95% CI, 1.16–1.57) in adults.

Indoor risk factors appeared to be significant only in the adult sample. Among them were living in damp houses (OR, 1.53; 95% CI, 1.29–1.81) or in overcrowded houses (OR, 1.35; 95% CI, 1.05–1.75). There was no clear relationship found between asthma prevalence and use of gas stoves, ownership of pets, or environmental tobacco smoke either in children or adults.

Discussion

The main advantage of this study, as compared to those conducted according to the ISAAC or ECRHS protocols, is that it was based on a sample representative of the entire Polish population. The prevalence of asthma was estimated in our survey to be 8.6% among children aged 3 to 16 years and 5.4% among adults aged 17 to 80 years.

In the ISSAC and ECRHS studies, marked variations in the prevalence of asthma were found between countries. The highest prevalence rates—even exceeding 20% for children—were observed mainly in English-speaking, developed countries, as well as in some centers in Latin America [1]. The respective rates found in 2 Polish centres participating in the ISAAC study, Krakow and Poznan, were low and ranged from

Table 2. Risk Factors for Asthma Assessed by Multivariate Logistic Regression*

	Children		Adults	
Risk Factor	Adjusted OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
Family history of asthma†	3.42 (2.62– 4.45)	<.001	1.37* (1.22 – 1.54)	<.001
Male sex	1.83 (1.42 – 2.37)	<.001	0.85 (0.73 – 1.00)	.044
Traffic	1.43 (1.11 –1.84)	.006	1.35 (1.16 – 1.57)	<.001
Black smoke	1.51 (1.17 – 1.94)	.002	1.28 (1.10 – 1.49)	.002
Damp house	1.21 (0.92 – 1.60)	.180	1.53 (1.29 – 1.81)	<.001
Overcrowded house	1.25 (0.90 – 1.72)	.180	1.35 (1.05 – 1.75)	.020
Gas stove	1.36 (0.83 – 2.23)	.220	0.95 (0.74 – 1.23)	.702
Passive smoking	0.99 (0.75 – 1.30)	.917	1.01 (0.86 – 1.18)	.907
Sulfur dioxide‡	1.20 (0.91 – 1.59)	.194	1.01 (0.85 – 1.20)	.895
Pet ownership	0.89 (0.69 – 1.14)	.349	1.01 (0.87 – 1.18)	.869

*OR indicates odds ratio; CI, confidence interval.
†Assessed in the subset of 3820 individuals who completed the detailed questionnaire.
‡Statistically significant relationship in the univariate analysis: OR = 1.34 (95% CI, 1.04 – 1.72; *P* = .019) in children; OR = 1.19 (95% CI, 1.02 – 1.38; *P* = .028) for adults.

1.3% to 4.1%. Compared to the those figures, the prevalence of asthma among the entire Polish population of children was estimated in our study to be twice as high, which was nevertheless still much lower than that observed in countries at the top of the list in the ISAAC study. Furthermore, in the Krakow and Poznan centers, these estimates (10.9% and 9.5%, respectively) were very close to the average country value. This discrepancy may suggest that the evaluation through self-completed questionnaire in the ISAAC study probably reflects underdiagnosis of asthma in Polish children, as well as some tendency towards an increase in the prevalence of the disease.

There was a good correlation between the results of the ISAAC and ECRHS studies. In the adult population aged 20 to 44 years the highest prevalence rates ranging from 7.1% to 11.2% were also observed in the English-speaking centers of Australia, New Zealand, the United Kingdom, and the United States of America [1,2], but that prevalence was much lower than the prevalence observed in children. In Wroclaw, representing Poland in the ECRHS survey, the estimated prevalence of asthma at 4% was only moderately lower than that found in our study (5.4%) [8]. Significant differences in the prevalence rates between regions cannot be easily explained. Further analysis will be required and comparative studies are now underway to address this issue. The recently published results of the third National Health and Nutrition Examination Survey (NHANES III) show that the overall prevalence of current asthma in the USA is 4.5% [9], thus markedly lower than that observed for Portland, Oregon (7.1%) in the ECRHS study [2]. The NHANES III survey was performed using procedures comparable to the PMSEAD in a large sample of adults aged 20 years or more that can be considered as representative of the entire adult population of the USA. However, that study made use of self-completed questionnaires and "reported physician diagnosed asthma."

An alarming increase in the prevalence of asthma in the past few decades has focused researchers' attention on the identification of risk factors for this disease. In our study, family history of asthma was found to be the strongest risk factor for development of asthma. This is consistent with the findings of other studies, where the importance of family history has been highlighted [10-12]. We confirmed that asthma affects boys more often than girls, while the prevalence of adult asthma is higher in women. These findings are also consistent with the results of other studies conducted separately in populations of children [13] or adults [9]. However, those host factors cannot explain the increased prevalence of this condition in a relatively short period of time. Therefore, in our study particular emphasis was placed on the assessment of environmental risk factors. Our primary interest was in considering the relationship between outdoor air pollution measures and asthma prevalence at the population level.

In each area examined, we assessed data for 2 types of air pollutants: particles (black smoke) and gases (SO_2). In addition, residential exposure to traffic was analyzed. We showed that an increased prevalence of asthma was significantly associated with living in areas with higher black smoke pollution. This is the first such finding based on directly measured or estimated levels of ambient air pollution.

Numerous studies have reported weak but statistically significant associations between acute health effects and particulate air pollution of this kind, which, among other things, results in increased emergency admissions for asthma [14,15]. In contrast, there are very few population-based studies assessing the (long-term) effect of air pollution on asthma prevalence. Results of comparative epidemiological studies performed following the reunification of Germany originally seemed to suggest that exposure to higher levels of atmospheric pollution has little effect on the prevalence of asthma [16]. An analysis of data from the *Pollution Atmospherique et Affections Respiratoires Chroniques* (PAARC) survey collected in 24 areas of 7 French towns during 1974–1976 also did not indicate a role for black smoke [17]. Our observation may suggest not only irritant (short-term) but also damaging (long-term) effects of black smoke compounds on the airway epithelium.

Evidence from several studies indicates that the pollution of ambient air with SO_2 leads to the aggravation of asthma symptoms [14,15], but only a few reports show a link between the air concentration of SO_2 and the prevalence of asthma [17,18]. In the PMSEAD study, living in areas with higher SO_2 pollution was found to be a weak but significant risk factor for asthma on univariate statistical analysis; however, the significance was not maintained when assessed in a multivariate logistic regression model. This finding implies that the interpretation of this phenomenon may be biased when epidemiological studies do not take into account certain confounding factors.

Our results revealed a significant relationship between exposure to traffic-related air pollution and increased risk of asthma development, confirming the results of studies undertaken in various geographical regions [19-21]. However, we found no geographical (climatic) pattern in the prevalence of asthma in Poland.

Recently, it has often been suggested that domestic factors may be even more important than outdoor air pollution in explaining the rise in asthma cases. Among factors of this sort analyzed in this study, only living in overcrowded or damp houses were positively associated with increased prevalence of asthma, and then only in adults. Since the number of co-tenants can be considered, to some extent, as equivalent to family size, it is perhaps surprising that this did not appear as a risk factor. However, one must remember that while family size or the number of siblings have been reported almost unequivocally as risk factors for atopy, eczema, or allergic rhinitis, the data are less clear in the case of asthma, as discussed by Karmaus and Botezan [22]. Many people living in a single apartment may contribute to domestic air pollution of various types (more persons smoking cigarettes, longer use of gas stoves, etc). The possible effect of some confounding factors not analyzed in this survey should also be taken into account and should be addressed in future studies. It is generally accepted that damp housing conditions are associated with increased prevalence of respiratory symptoms and asthma [23], although few population-based, epidemiological studies have specifically assessed this potential risk factor [24, 25]. Thus, our results provide some additional evidence in this area.

The apparently surprising lack of association between the prevalence of asthma and residential environmental tobacco smoke is probably explained by the average level of exposure (assessed in this study by the question "Is there anyone who smokes in your home?") being too low to have a significant effect. Such an interpretation is justifiable in the light of the SAPALDIA study results, showing a dose-dependent relationship between exposure to environmental tobacco smoke and elevated risk of physician-diagnosed asthma [26]. Another explanation that should be taken into account is the possible impact of the so-called non-differential misclassification bias, which might weaken the true association between exposure and disease.

The use of gas stoves may contribute to domestic air pollution. Some studies have reported that women who used gas for cooking had an increased risk of asthma symptoms [3,27]. This was not confirmed in our survey for the general population of both sexes. However, we did not ask about kitchen ventilation, and so the question used may have been a rather weak indicator of exposure.

Recently, the influence of pet ownership on the prevalence of asthma has been a matter of some debate. Contrary to the NHANES III results [9], in the PMSEAD study this factor appeared not to be significant.

Despite recent reports from Switzerland [28], Italy [29], and the Netherlands [30] suggesting that the increase in prevalence of asthma among children may have ceased, worldwide trends still continue to rise [31-33]. The rapidly increasing incidence of asthma is a problem that defies easy answers. Our results confirm the hypothesis that the mechanism underlying this phenomenon is complex, without a single factor that could be identified as the principal cause.

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