Prevalence and Correlates of Asthma Among Children in Central St. Petersburg, Russia: Cross-sectional Study

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Aim To estimate the prevalence of asthma among children in central St. Petersburg and to evaluate associations between asthma and socio-demographic, biological, and environmental factors.

Methods A cross-sectional study included 1464 children aged 0-18 years from two central districts of St. Petersburg. Parents filled out a questionnaire on children's respiratory health, characteristics at birth, socio-demographic data, housing situation, and their own history of asthma and allergies. The diagnosis of asthma was based on the results of spirometry in children aged ≥5 years and on questionnaire data as reported by parents of younger children. Independent effects of the investigated factors on asthma were assessed by multiple logistic regression analysis. Crude and adjusted odds ratios (OR) with 95% confidence intervals (CI) were calculated.

Results The estimated prevalence of asthma was 7.4% (95% CI, 6.2-8.8). A history of allergies (OR, 1.6; 95% CI, 1.0-2.6), bronchitis, bronchiolitis, or pneumonia in infancy (OR, 12.2; 95% CI, 7.3-20.5), and self-reported parental allergies (OR, 3.6; 95% CI, 2.2-5.8 for one parent and OR, 7.1; 95% CI, 3.0-17.0 for both parents) were associated with childhood asthma. Children whose mothers were out of work also had higher prevalence of asthma than the reference group (OR, 3.4; 95% CI, 1.1-10.4).

Conclusion The prevalence of asthma is several times higher than what is officially reported for St. Petersburg's inner city children population. Early life events and socio-demographic and biologic factors were associated with asthma in children.

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> **Received:** October 8, 2007
> **Accepted:** May 7, 2008

> **Croat Med J. 2008;49:741-50**
> doi:10.3325/cmj.2008.49.741

Asthma is one of the most common childhood diseases in industrialized countries and the third leading cause of hospitalization in children in the USA, exceeded only by pneumonia and injuries (1). One-third of asthma patients experience restrictions in daily life activities and absence from school, which represents a considerable public health problem (2).

Epidemiological studies have found a higher prevalence of current asthma among schoolchildren in Western than in Eastern Europe. Leonardi et al (3) has reported the prevalence of asthma to be 2.8% in Bulgaria, 2.7% in the Czech Republic, 5.7% in Hungary, 2.3% in Poland, 8.3% in Romania, and 1.3% in the Slovak Republic. At the same time, the prevalence of asthma in Germany was 4.9% (4), 10.8% in Norway (5), and 10.3% in the UK (6). The trends in the occurrence of asthma across Europe are conflicting. While in Germany and the UK during the 1990s the prevalence increased from 4.9% to 5.6% and from 10.3% to 13.0%, respectively (4,6), in Poland, the increase was more pronounced, from 3.4% in 1995 to 9.6% in 2001 (7). Whether this increase is real or it is a consequence of the more accurate diagnostic routines implemented since 2001 remains unclear. However, it is suggested that the prevalence of asthma in the Western Europe has reached a plateau, while it is still increasing in the East (8).

Childhood asthma has been associated with challenging social circumstances, such as single-parent families (9), low income (10), poor living conditions, and house dust (11). Carpets, down pillows, and pets have also been shown to increase the risk of developing asthma in children (12,13). Among early life factors, exposure to tobacco smoke, high birth weight, formula feeding from birth, and a history of atopy or respiratory infections in infancy have been associated with higher risk of developing asthma later in life (14-17). Family history of asthma and allergies has been consistently shown to increase the risk of asthma in the offspring, suggesting the important role of genetic factors (15-18).

According to the official data, the prevalence of asthma in Russia is 1.1% in 0-14-year-old children and 1.8% in 15-17-year-old adolescents (19). In Moscow and St. Petersburg, the reported prevalence of childhood asthma is 1.2% and 1.5%, respectively (20). The International Study of Asthma and Allergies by Childhood Steering Committee (ISAAC) has estimated the prevalence of asthma in children living in Moscow to be 2.4% (21). Jaakkola et al (22) have reported the prevalence of asthma in 8 Russian cities to be 1.5%. However, in the latter study, the estimates were based on a history of doctor-diagnosed asthma during the past 12 months as recorded in medical documentation.

Most Russian studies investigating the development of asthma have focused on the effect of environmental pollution and proximity of industrial plants or highways (23,24). However, it has been recognized that the role of environmental factors in Russian research is exaggerated (23). International studies conducted in Russia have documented that smoking during pregnancy, exposure to tobacco smoke in infancy, presence of mold, and using gas as a cooking fuel were associated with higher risk of asthma (25,26).

Given the profound social and economical changes in Russia after the break-up of the Soviet Union, accompanied by considerable increase in income inequalities, social determinants of health in children may also be important. However, to our knowledge, there have been no studies specifically addressing social determinants of childhood asthma in Russia.

The aims of this study were to estimate the prevalence of asthma among children in central St. Petersburg and to evaluate associations between asthma and socio-demographic, biological, and environmental factors.

Subjects and methods

Subjects

The study involved all children aged 0-18 years from two adjacent offices out of 1232 pediatric district offices in Vasiljevski Island, one of the central parts of St. Petersburg. According to Russian regulations, all children have to be registered in local polyclinics and each district pediatric office serves approximately 800 children. According to the medical records, the district offices selected for this study served a total of 1521 children. St. Petersburg, with the population of over 4.5 million in 2002, is the fourth largest city in Europe. The study area is highly urbanized and has a well-developed infrastructure and transport network.

Data collection

The data on the diagnosis of asthma in children prior to the study and children's age and sex were obtained from the medical records at the local polyclinic during 2003.

Parents of all 1521 registered children were asked to complete a non-anonymous questionnaire, which included items on child's respiratory health, parental age at childbirth, current education and occupation for both parents, family income, history of asthma and allergies in both parents, maternal parity, duration of pregnancy, type of delivery (vaginal or Cesarean section), breastfeeding history, child's weight at birth, and a history of bronchitis, bronchiolitis, pneumonia, and allergies in infancy. The questions about child's respiratory health were as follows: 1) Has your child had an attack or recurrent attacks of high-pitched whistling sounds (wheezing) when breathing out? 2) Does your child have a persistent cough, which gets worse particularly at night time? 3) Does your child wheeze or cough after physical exercise? 4) Does you child wheeze and have chest tightness or cough after exposure to airborne allergens or pollutants? 5) Do your child's colds "go into the chest" or take more than 10 days to clear up?

Data on parental smoking and presence of carpets, pets, and down pillows or blankets in the flat at the time of the study were also collected. The questionnaire was not validated, but district pediatricians and trained interns assisted the parents in filling it in. Informed consent was obtained from the parents of all children. The distance between the family home and industrial plants and highways was estimated using detailed maps of the area.

If any of the questions on child's respiratory health was answered positively or asthma or allergies were reported by either or both parents, the child was referred to a pulmonologist. Airflow limitation was measured by spirometry in all referred children aged 5 or older. Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) were measured and a ratio of FEV_1 to FVC was calculated. The highest value of three measurements was taken. Asthma was diagnosed if FEV_1/FVC ratio was below 0.85. In children younger than 5 years, no instrumental examination was performed and the diagnosis was made by the pulmonologist based on the questionnaire data combined with anamnestic data obtained from the medical records.

Children were divided into four groups according to age as follows: 0-4, 5-9, 10-14, and ≥15 years. Maternal age at birth was categorized in four groups: <20, 20-24, 25-29, and ≥30 years. Paternal age was categorized in three groups: <25, 25-29, and ≥30 years old. A separate category "unknown" was created for parents who did not report their age. According to employment status, parents were divided into blue-collar workers, white-collar workers, and the "out of work" group. The "out of work" group included students, military servants, pensioners, and the unemployed. Monthly income per person in the household was calculated by summing up

monthly income of both parents and dividing it by the number of people in the household. Three groups were created for the monthly income per person: <1000 roubles, 1000-2999 roubles, and ≥3000 roubles (1000 roubles = € 28 = US $38). Families were described as complete if both parents lived together with the child. Birth weight was classified as <2500 g, 2500-2999 g, 3000-3499 g, 3500-3999 g, ≥4000 g, and unknown. Self-reported parental allergy was grouped as follows: no allergy in any of the parents; allergy in one parent; and allergy in both parents. The type of allergy was not specified. Type of housing was either private apartments or room(s) in a hostel/communal flat. The area per person in the household was classified as <6 m^2 or ≥6 m^2. The distance between the household and the nearest highway and between the household and the nearest industrial plant was categorized according to the Russian hygienic norms: <15 m and ≥15 m or more for the former and <300 m and ≥300 m for the latter. The history of breastfeeding was classified as breastfeeding or no breastfeeding from birth. Preterm birth was defined as the birth before the 37th completed week of pregnancy. Threatened preterm labor in the index pregnancy, Cesarean section, allergies in infancy, bronchitis, bronchiolitis and/or pneumonia in infancy, parental asthma, and presence of pets, carpets, down pillows, or blankets in the house at the time of the study were used as dichotomous variables.

Statistical analysis

Bivariate relationships between the outcome variable and covariates were assessed by Pearson χ^2 test and Fisher exact test. Individual effects of the studied characteristics were studied by multiple logistic regression. Prevalence ratios of asthma were approximated by odds ratios (OR) with 95% confidence intervals (CI). Independent variables were included in the model only if associated with outcomes at $P < 0.15$ in the bivariate analyses, as recommended by Katz (27). All analyses were performed with Statistical Package for the Social Sciences, version 12.0 (SPSS Inc., Chicago, IL, USA). The level of statistical significance was set at $P < 0.05$.

Results

According to the medical records, 12 of 1521 children registered in the two pediatric district offices had asthma, which makes the prevalence of registered asthma 0.8% (95% CI, 0.5-1.4). Parents of 1464 children (96%) filled out the questionnaire. Eight of 1464 children whose parents filled out the questionnaire were diagnosed with asthma prior to this study. Four of 57 children whose parents did not fill out the questionnaire had asthma according to the medical records. After the children who had at least one respiratory symptom or whose parents reported having asthma or allergy, except 8 children already diagnosed with asthma, were examined by the pulmonologist (n = 644), the total number of asthma cases amounted to 112 (Figure 1). The prevalence of asthma amounted to 7.4% (95% CI, 6.2-8.8).

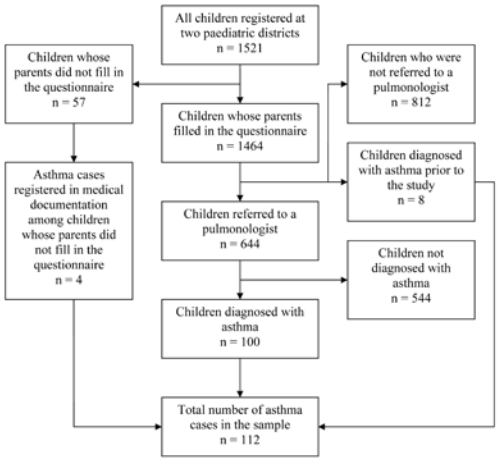

Figure 1. Flow of the participants through the study.

Table 1. Prevalence of asthma with 95% confidence intervals (CI) by age and sex

Age group (years)	Prevalence of asthma in (%, 95% CI)						*P**
	No.	boys	No.	girls	No.	both sexes	
0-4	206	3.9 (1.7-7.5)	177	5.1 (2.4-9.4)	383	4.4 (2.6-7.0)	0.569
5-9	167	13.8 (8.9-20.0)	190	9.5 (5.7-14.6)	357	11.5 (8.4-15.3)	0.211
10-14	265	9.4 (6.2-13.6)	216	5.6 (2.9-9.5)	481	7.7 (5.5-10.5)	0.112
15-18	127	7.1 (3.3-13.0)	116	3.4 (1.0-8.6)	243	5.3 (2.9-9.0)	0.208
Total	765	8.5 (6.6-10.7)	699	6.2 (4.5-8.2)	1 464	7.4 (6.1-8.8)	0.086

**P* value for sex differences were calculated by Pearson χ^2 test.

Boys were more likely to have asthma than girls, but the difference was not significant ($P = 0.086$) (Table 1). The greatest proportion of children diagnosed with asthma was in the 5-9 age group (Table 1).

In the univariable analysis, the prevalence of asthma was found to be higher among children living in single-parent families ($P = 0.001$). We also observed negative associations between asthma and presence of pets ($P = 0.014$), carpets ($P < 0.001$), and down pillows or blankets ($P = 0.021$) in the apartments at the time of the study. Given that these associations are likely to reflect the reverse causality phenomenon, they were not included in the multiple models. Detailed information on the associations between socio-demographic factors and childhood asthma are presented in Table 2.

Among the factors related to children's early life events, threatening preterm labor ($P = 0.041$), no history of breastfeeding ($P < 0.001$), allergies in infancy ($P < 0.001$), and a history of bronchitis, bronchiolitis, or pneumonia in infancy ($P < 0.001$) were positively associated with asthma. Moreover, positive relationship between birth weight and asthma was observed ($P = 0.027$). More than 30% of children born in families where both parents reported having allergy were diagnosed with asthma, while the prevalence in the families where none of the parents reported having allergy was only 4.2% ($P < 0.001$). However, no association between asthma in children and self-reported parental asthma was found (Table 3).

Table 2. Sample characteristics and the prevalence of asthma by parental socio-demographic characteristics and living conditions

Characteristics	No. (%)	Prevalence of asthma (%)	*P**
Maternal age at childbirth (years):			0.608
<20	49 (3.3)	14.3	
20-24	633 (43.2)	6.8	
25-29	441 (30.1)	5.9	
≥30	275 (18.8)	8.7	
unknown	66 (4.5)	12.1	
Maternal occupation:			0.093
blue-collar worker	133 (9.1)	3.0	
white-collar worker	715 (48.8)	7.3	
out of work	616 (42.1)	8.4	
Paternal age at childbirth (years):			0.788
<25	534 (36.5)	7.5	
25-29	423 (28.9)	5.4	
≥30	421 (28.8)	7.6	
unknown	86 (5.9)	15.1	
Paternal occupation:			0.227
blue-collar worker	253 (17.3)	7.9	
white-collar worker	696 (47.5)	6.2	
out of work	515 (35.2)	8.7	
Monthly income per person (roubles):			0.271
<1000	128 (8.7)	7.8	
>1000-2999	1 080 (73.8)	6.8	
≥3000	256 (17.5)	9.8	
Smoking in the family:			0.739
no	723 (49.4)	7.6	
yes	741 (50.6)	7.2	
Family situation:			0.001
complete family	1 295 (88.5)	6.6	
incomplete family	169 (11.5)	13.6	
Type of housing:			0.647
separate apartment	1 377 (94.1)	7.3	
room in a hostel/municipal flat	87 (5.9)	9.2	
Living area per person (m^2):			0.504
<6	174 (11.9)	8.6	
≥6	1 290 (88.1)	7.2	
Presence of pets:			0.014
no	595 (40.6)	9.4	
yes	869 (59.4)	6.0	
Presence of carpets:			<0.001
no	179 (12.2)	15.6	
yes	1 285 (87.8)	6.2	
Presence of down pillows or blankets:			0.021
no	260 (17.8)	10.8	
yes	1 204 (82.2)	6.6	
Distance to a highway (m):			0.678
<15	733 (50.1)	7.1	
≥15	731 (49.9)	7.7	
Distance to an industrial plant (m):			0.222
<300	337 (23.0)	8.9	
≥300	1 127 (77.0)	6.9	

*Pearson χ^2 test.

Table 3. Sample characteristics and the prevalence of asthma by early life events and parental health.

Characteristics	No. (%) of children	Prevalence of asthma (%)	*P**
Threatening preterm labor:			0.041
no	1 333 (91.1)	6.9	
yes	131 (8.9)	12.2	
Preterm birth:			1.000
no	1 411 (96.4)	7.4	
yes	53 (3.6)	7.5	
Cesarean section:			1.000
no	1383 (94.5)	7.4	
yes	81 (5.5)	7.4	
Parity:			0.670
1	1 114 (76.1)	7.5	
≥2	350 (23.9)	6.9	
Birth weight (g):			0.027
≤2500	51 (3.5)	3.9	
2501-3000	212 (14.5)	7.1	
3001-3500	740 (50.5)	6.4	
3501-4000	308 (21.0)	9.1	
>4000	89 (6.1)	12.4	
unknown	64 (4.4)	7.8	
History of breastfeeding:			<0.001
never breastfed	151 (10.3)	14.6	
ever breastfed	1 313 (89.7)	6.5	
Allergies in infancy:			<0.001
no	765 (52.3)	5.0	
yes	699 (47.7)	10.0	
Bronchitis and/or pneumonia in infancy:			<0.001
no	1 099 (74.4)	1.9	
yes	365 (25.6)	23.1	
Self-reported parental allergies:			<0.001
none	1 149 (78.5)	4.2	
one parent	272 (18.6)	17.3	
both parents	43 (2.9)	30.2	
Asthma in at least one parent:			0.571
no	1 453 (99.2)	7.4	
yes	11 (0.8)	9.1	

*Pearson χ^2 test or Fisher exact test.

In multivariable analysis, children aged 5-9 (OR, 2.5; 95% CI, 1.3-5.0), with a positive history of allergy (OR, 1.6; 95% CI, 1.0-2.6) and bronchitis, bronchiolitis, or pneumonia (OR, 12.2; 95% CI, 7.3-20.5) in infancy, with mothers out of work (OR, 3.4; 95% CI, 1.1-10.4) and from families where one (OR, 3.6; 95% CI, 2.2-5.8) or both (OR, 7.1; 95% CI, 3.0-17.0) parents reported having allergy were more often found to have asthma after adjustment for other variables. Asthma was also more prevalent in children whose mothers were white collar workers (OR, 2.2; 95% CI, 0.7-6.7) and who lived with only one parent (OR, 1.8; 95% CI, 1.0-3.2), but the associations did not reach the level of statistical significance (Table 4).

Discussion

The prevalence of childhood asthma in two central pediatric districts of St. Petersburg found in our study was greater than the estimates based on medical records data for this area. Our study also suggests that maternal occupation, history of allergies and bronchitis, bronchiolitis, or pneumonia in infancy, as well as parental self-reported allergies, are associated with asthma in children in central St. Petersburg. The differences between the estimated and reported prevalence of asthma in the study area may raise concerns about potential underestimation of the burden of asthma in Russia. Other results are in line with the current knowledge on childhood asthma. The findings should be interpreted with caution taking into account the study limitations.

One of the limitations is a relatively small sample size. Although retrospective calculation of the statistical power suggests that the number of study subjects was sufficient for estimating the observed prevalence of asthma with a precision of 1.5%, generalization of the findings strongly depends on representativeness of the sample. While the high response rate (96%) leaves little space for random error within the studied districts, the districts themselves may not be representative of all districts in St. Petersburg. Therefore, our prevalence estimate could be generalized only to the central parts of the city.

Another limitation is that the data on all studied characteristics, including children's respiratory complaints, were based on parental reports. While some factors, such as parental age, education, and occupation generally have high validity, other data, such as smoking, parental asthma, or early life events could be prone to information bias. Parents of patients with asthma may be more likely to report exposures that could lead to the disease resulting in overestimation of the effect. How-

Table 4. Crude and adjusted odds ratios (OR) with 95% confidence intervals (CI) for the association between the explanatory factors and childhood asthma

Explanatory factors	Crude OR	95% CI	Adjusted OR*	95% CI
Sex:				
male	1	reference	1	reference
female	0.71	0.47-1.05	1.16	0.72-1.86
Age group (years):				
0-4	1	reference	1	reference
5-9	2.79	1.56-5.01	2.52	1.28-4.95
10-14	1.79	0.99-3.24	1.62	0.82-3.18
≥15	1.22	0.58-2.55	0.83	0.36-1.94
Maternal occupational:				
blue-collar worker	1	reference	1	reference
white-collar worker	2.53	0.90-7.12	2.22	0.74-6.71
out of work	2.97	1.05-8.37	3.40	1.11-10.4
Family situation:				
complete family	1	reference	1	reference
incomplete family	2.24	1.37-3.67	1.78	0.98-3.23
Threatening preterm labor in the index pregnancy:				
no	1	reference	1	reference
yes	1.88	1.07-3.30	1.20	0.61-2.38
Birth weight (g):				
≤2500	1	reference	1	reference
2501-3000	1.87	0.41-8.43	1.48	0.30-7.30
3001-3500	1.66	0.39-7.04	1.26	0.28-5.78
3501-4000	2.45	0.57-10.6	1.73	0.37-8.16
>4000	3.46	0.74-16.2	1.90	0.37-9.82
unknown	2.08	0.44-11.1	3.29	0.52-20.9
History of breastfeeding:				
never breastfed	1	reference	1	reference
any breastfed	0.41	0.25-0.68	0.71	0.39-1.30
Allergies in infancy:				
no	1	reference	1	reference
yes	2.13	1.41-3.21	1.62	1.00-2.61
First bronchitis and/or pneumonia in infancy:				
no	1	reference	1	reference
yes	15.09	9.28-24.54	12.21	7.29-20.45
Self-reported parental allergies:				
none	1	reference	1	reference
one parent	4.79	3.13-7.34	3.55	2.16-5.82
both parents	9.94	4.88-20.3	7.14	2.99-17.0

*Adjusted for all variables in the table.

ever, the questionnaires were completed prior to the examination by the pulmonologist, thus potentially reducing recall bias. Moreover, the assistance of trained interns and district pediatricians in filling in the questionnaire could have also contributed to reduction of the information bias.

The strength of the study is that all children with respiratory complaints and all children whose parents reported having asthma or allergies were examined by a pulmonologist and the final prevalence estimate was based on the results of this examination. However, we do not know whether the children whose parents did not report any respiratory problems would have been diagnosed with asthma if they had taken similar examination. Thus, there is a possibility that the prevalence of asthma in this study may still be underestimated, but the underestimation is likely to be small given that all parents were informed about the aims of the study and were offered a free visit to the pulmonologist for their children. The diagnosis was based only on reduced FEV_1/FVC ratio in children aged 5 years or older. In younger children, only parental answers on the questionnaire items about respiratory symptoms combined with anamnesis data were used, which might result in a slight overestimation of the prevalence of asthma in this age group. Other examinations, such as peak flow monitoring, tests with bronchodi-

lators, and bronchial challenge tests, were performed only in a limited number of patients; therefore, only spirometric results were used in this study, thus compromising the validity of the results.

Although the diagnostic criteria of asthma used in this study can be criticized and the validity of our prevalence estimate may be questioned, the discrepancy between the prevalence of childhood asthma recorded in medical documentation and our estimates is unlikely to be attributed to misclassification of asthma cases. One can speculate that this underestimation may be partly associated with general mistrust in public health care system during transition, resulting in more and more people attending private clinics and/or "traditional practitioners," which are not included in the official statistics. Children with mild disease may not be diagnosed with asthma because of unavailability of the diagnostic equipment in public health care centers and insufficient competence of medical personnel employed there. The combination of all mentioned factors could result in the observed difference between the official data and our estimates.

The association that we found between asthma and a history of respiratory diseases such as bronchitis, bronchiolitis, or pneumonia in infancy is in line with most of other studies (28-31). Infants from the neighboring Finland who had had severe bronchiolitis or pneumonia were more likely to develop asthma later in life (28). The observed associations between parental allergies and childhood asthma are also in accordance with findings from other countries (29). Interestingly, the risk of asthma was exactly twice as high when both parents had allergy as when only one parent had allergy, supporting the hypothesis that the genetic mechanisms responsible for the predisposition to asthma may have additional effects (30). The association between a history of allergies in infancy and asthma later in life is well established (31).

At the same time, we could not find any association between parental and childhood asthma. We speculate that the prevalence of asthma in Russian adults may also be underestimated, similarly to childhood asthma.

Children whose mothers were out of work had the highest risk of asthma. Most of these women were either unemployed or students. While positive associations between social advantage and asthma were reported in the UK, Hermann et al (32) observed the opposite in Denmark. Unemployed, low-educated, and single mothers could be more likely to live in suboptimal living conditions with dampness, mold, or cockroach infestations, which are in turn associated with asthma in children (25,26).

Children who were not breastfed had more than twice higher prevalence of asthma in crude analysis. The evidence on the protective effect of breastfeeding on the development of asthma and allergies is inconclusive (33). However, most studies demonstrated a modest protective effect (34). Our results are similar, but low power and absence of data on exclusivity or duration of breastfeeding do not permit conclusions on the role of breastfeeding.

Smoking has been consistently shown to increase the risk of childhood asthma (1,33). We used the variable "smoking in the family" as a surrogate for children's exposure to tobacco smoke. Surprisingly, smoking in the family was not associated with asthma in our study. More than a half of the children in our sample live in families with at least one parent who is smoking. Similarly, Jaakkola et al (25) reported no association between current parental smoking and asthma in Russia, probably due to almost universal exposure to tobacco smoke, although the children whose mothers smoked during pregnancy had higher prevalence of the disease.

In conclusion, the prevalence of childhood asthma in central St. Petersburg was 7.4%, which is many times higher than what is registered in the medical records (0.8%) or presented in the official data (1.5%). History of allergies, bronchitis, bronchiolitis, or pneumonia in infancy, maternal occupation, and parental allergies were associated with higher prevalence of childhood asthma. The results should be interpreted and generalized with due caution given the limitations of the study.

Acknowledgment

Dr Glushkova was supported by the Norwegian Research Council (Scholarship IS Rus 06/07-31).

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