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ENVIRONMENTAL RISK FACTORS FOR RESPIRATORY SYMPTOMS AND CHILDHOOD ASTHMA

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Abstract: The presented cross-sectional study, comprised a group of 1,130 children from 13–15 years of age living in Upper Silesia, Poland, was undertaken to ascertain the role of environmental factors in the development of adverse respiratory health outcomes. To estimate the prevalence of these effects, the ISAAC questionnaire supplemented by questions related to risk factors was used. Bronchial asthma was identified in 4.5% of the children, asthma diagnosed by physicians in 8.7%, and prevalence of wheezing in the previous 12 months in 12.6%. The highest probability of wheezing was found in children with maternal genetic propensity (such as asthma, allergy), exposed to maternal smoking, or was connected with household risk factors such as the presence of dampness/mould or living in 50-year-old building. Female gender and attendance at nursery school were shown to be protective factors against wheezing. The probability of asthma was nearly twice as high in children residing in damp/mouldy dwellings, heated by coal-fired furnaces and living in the immediate vicinity of a road with heavy traffic. This study revealed that exposure to indoor (tobacco smoke, coal stove emission, mould or dampness in dwelling) and outdoor (traffic pollution) air contaminants are major environmental factors responsible for adverse respiratory health effects in children.

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Key words: respiratory symptoms, childhood asthma, environmental factors.

INTRODUCTION

Childhood asthma and allergic diseases are serious problems of public health. Hitherto published data suggest that the frequency of asthma increases, which is one reason why medical care and treatment expenses have been growing constantly [1, 22, 34, 47]. It has been estimated that the social costs of asthma in Europe amount to about 3 billion EURO per year [11]. Epidemiological data collected through the International Study of Asthma and Allergies in Childhood (ISAAC) demonstrated a significant variability in the prevalence of childhood asthma, allergic rhinitis, eczema and other respiratory disorders in different countries [18, 19]. Despite the fact that the ISAAC study was based on the same standardized protocol and applied to representative population samples, the obtained results demonstrated that the frequency of asthma varied from 2.1–4.4% in Albania, Greece and Russia, to almost 32% in Australia, New Zealand, Ireland, and the United Kingdom [18, 19]. The observed variability could be partially explained by different ways of defining wheezing, dyspnea and asthma. It might also be explained by differences in socio-economic status and in life style, e.g. exposure to active and passive smoking [36, 46]. On the other hand,

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some recent studies (such as phases II and III of ISAAC or SCARPOL) revealed a certain stabilization of asthma prevalence among adolescents in Western European countries [14, 16].

The results of recent Polish studies have shown an increase of asthma and respiratory symptoms in schoolchildren [12, 28, 29]. The latest data from a cross-sectional study carried out in Chorzów (Upper Silesia, Poland) confirmed an augmentation in frequency of asthma appearance in subjects from 3.4% in 1990 to 8.5% in 2007 [8, 9]. The increase in asthma and allergic disorders during the last decades is not fully understood; however, the increase is partly attributed to better medical diagnosis, better risk perception among parents and accessibility to medical services. Although, the role of genetic propensity in development of allergic disorders is unquestionable, the significance of environmental factors has been relatively well documented for observed increase of asthma prevalence [20, 32, 44, 48, 49]. Although available published data provide a better understanding of the etiology of childhood asthma and other respiratory disorders, the control of both socio-economic determinants (such as family size or living conditions) and various environmental factors (e.g. exposure to tobacco smoke, high humidity of the air or presence of moulds indoors) should be performed [3, 27]. Several studies suggest the possible relationship between traffic-related pollution and asthma initiation [6, 7, 34, 43], but none of the possible pathways has been adequately or fully explored so far [37].

The lack of reliable data explaining the impact of environmental exposure on the development of respiratory diseases was a major inspiration to conduct this study. To estimate the prevalence of adverse respiratory health outcomes, the ISAAC questionnaire supplemented by questions related to environmental risk factors was used. The obtained results of this epidemiological survey might be useful for the introduction of preventive activities which could assist in getting control over asthma.

MATERIALS AND METHODS

The cross-sectional epidemiological study was carried out among 1,130 school children from 13–15 years of age living in Chorzów, Upper Silesia, Poland. Due to the concentration of several dozen of coal mines, steelworks, metal and chemical processing industries on a relatively small territory, the Upper Silesia region is one of the most polluted conurbations in Southern Poland. Besides, a rapid development of the road network over the last decade and consequently an increase in vehicle traffic intensity has substantially contributed to ambient air pollution in this region. Moreover, the city of Chorzów had a very high unemployment ratio (21.6% and 17.3% in 2005 and 2006, respectively) and many of the families still live in poor conditions (numerous houses were built before 1945, a high percentage of the population live in multi-family houses where coal stoves are still used for cooking and heating purposes).

The target group was recruited (at random) from children of all public gymnasia located in the town in 2005–2006. The cross-sectional epidemiological study included questionnaire questions, medical examination with interviewing patients, spirometric examination and skin prick tests. The paper presents data on respiratory symptoms, as well as asthma, resulting from the questionnaire survey in relation to environmental factors. The Polish version of the ISAAC questionnaire and the inquiry sheet from the PHARE-CESAR (Central European Study of Air Pollution and Respiratory Health) survey were used to examine the occurrence of the following respiratory disorders: wheezing, dyspnea attacks with wheezing, and doctor diagnosed asthma [3, 6, 27]. Moreover, data describing possible exposure to traffic-related pollution (such as distance between place of residence and a motorway or major road connecting the surrounding towns of the conurbation, traffic density during a day) were collected based on knowledge of the parents. Additionally, all independent variables such us: maternal allergy or asthma, paternal allergy or asthma, parents' educational background, their employment status, exposure to tobacco smoke, birth body weight, breast feeding, nursery school attendance, suffered pneumonia/bronchi inflammation before third year of life, presence of dampness or mould in dwellings, contact with animals since birth, presence of pets in dwellings, presence of coal-fired stoves and carpets in flats as well as age of building were collected by means of a questionnaire. Differences between groups (chi-square test) were verified by multivariate analysis (Proc Logistic, backward selection). The applied model is shown below:

$$\begin{aligned}\text{sickness/symptom} = a_1 + a_2 \cdot \text{gender} + a_3 \cdot \text{paternal atopy} + a_4 \cdot \text{socioeconomic status}\\ + a_5 \cdot \text{presence of mould or dampness in dwelling} + a_6 \cdot \text{exposure to tobacco smoke}\\ + a_7 \cdot \text{coal stove} + a_8 \cdot \text{pneumonia/bronchi inflammation before third year of age}\\ + a_9 \cdot \text{contact with pets} + a_{10} \cdot \text{exposure to road traffic}\end{aligned}$$

Statistical analyses. All statistical analyses were performed using SAS, version 9.1.3 (SAS Institute Inc., Cary, NC). The risk of detecting asthma in children was evaluated on the basis of adjusted odds ratio (OR) at its 95% confidence interval (95% CI). The relationships were treated as statistically significant at $p<0.05$.

RESULTS

There were 1,130 children from 13–15 years of age participated in the study, from which 55.2% ($n_1=624$) were girls and 44.8% ($n_2=506$) were boys. The complete data on demography, environmental and socio-economic status of the subjects are presented in Table 1. The prevalence of wheezing ever recorded ("wheezing ever") in the studied population was 24% ($n=271$), and the frequency was significantly higher ($p<0.01$) for boys ($n=142$; 24%) than for girls ($n=129$; 20.7%). The prevalence of wheezing, in the

Table 1. Prevalence of wheezing, dyspnea attacks with wheezing, doctor diagnosed asthma, demographic, environmental and socio-economic status.

Variable	Number of subjects	%
Child gender		
male	506	55.2
female	624	44.8
Wheezing last year	143	12.6
Dyspnea with wheezing last year	69	6.1
Doctor diagnosed asthma	86	8.7
Maternal education		
primary	126	11.4
vocational	426	38.5
secondary	455	4.1
university	100	9.0
Paternal education		
primary	89	8.2
vocational	629	5.2
secondary	290	26.8
university	73	6.8
Unemployment mother	194	17.2
Unemployment father	70	6.2
Allergy in mother	161	14.2
Allergy in father	77	6.8
Asthma in mother	35	3.1
Asthma in father	29	2.6
Smoking maternal	454	40.2
Smoking paternal	552	48.8
Birth body weight ≤ 2,500 g	179	15.9
Birth body weight > 2,500 g	951	84.1
At least 3 months breast feeding	765	67.7
Nursery school attendance	90	8.0
Kindergarten attendance	908	80.3
Contact with animals since birth	419	44.2
Coal heating	110	9.7
Carpets on floors	409	36.9
Damp stains/mould present at home	537	50.1
50-year-old building	516	45.7
Heavy road traffic exposure	418	37.8

last year before completion of the study, referred to 143 children (12.6%), more frequently to boys (n=73; 14.5%) than to girls (n=70; 11.2%); however, the difference between genders was not statistically significant. Attacks of dyspnea with wheezing ever concerned 139 children (12.3%), i.e. 12.8% (n=65) boys and 11.9% (n=74) girls, respectively. Attacks of dyspnea with wheezing in the last year before completion of the study were found in 69 children (6.1%), also more frequently in boys (n=33; 6.5%) than in girls (n=36; 5.8%). Within the studied group, there were 51 children (4.5%) identified with asthma, including 5.3% (n=27) of boys and 3.9% (n=24) of girls. Asthma was identified using a questionnaire survey in 4.5% of children, whereas asthma diagnosed by physicians was noted in 8.7% (n=86) of the same studied group. Despite gender differences, the last three relationships were not statistically significant ($p>0.05$).

Table 2 presents the results of stratification analyses considering relationships between the frequency of wheezing and various determinants of this adverse health outcome. Statistically significant relationships were recorded between wheezing for boys and girls and: pneumonia/bronchi inflammation before the child's 3rd birthday ($p<0.0001$), presence of dampness/mould in dwellings ($p<0.0001$), and the age of building older than 50 years ($p<0.001$). Additionally, in the case of girls, statistically significant relationships were also noted for maternal allergy, asthma and smoking ($p<0.01$, $p<0.001$ and $p<0.01$, respectively), exposure to passive smoking at home ($p<0.001$) and attendance at nursery school ($p<0.05$); in the case of boys, for paternal allergy and exposure to particulates derived from coal heating and road traffic (all $p<0.05$).

Table 3 shows the results of stratification analyses regarding the frequency of dyspnea attacks with wheezing with reference to several determinants of childhood health. Statistically significant relationships were obtained for dyspnea attacks with wheezing and maternal allergy and asthma, pneumonia/bronchi inflammation before the child's 3rd birthday (all: $p<0.0001$), and exposure to particulates derived from road traffic ($p<0.001$). Moreover, in the case of girls, both passive smoking ($p<0.001$) as well as contact with animals since birth ($p<0.05$) had a significant influence on the observed frequency of dyspnea attacks with wheezing. Regarding boys, paternal allergy ($p<0.01$) and asthma ($p<0.05$), as well as dampness/mould in dwellings ($p<0.001$) additionally contributed to the observed increase of dyspnea attacks with wheezing.

Finally, the results of stratification analyses for the frequency of doctor diagnosed asthma influenced by major determinants of childhood health are presented in Table 4. Based on the study, the frequency depended mainly on pneumonia/bronchi inflammation observed before the child's 3rd birthday ($p<0.0001$). The other factors having impact on the frequency of doctor diagnosed asthma were strongly gender dependent, i.e. for the girls: maternal allergy ($p<0.01$) and exposure to particulates derived from road traffic ($p<0.05$), and for the boys: birth body weight ($p<0.05$), paternal smoking ($p<0.05$), dampness/mould in dwellings ($p<0.001$), age of the building ($p<0.01$), and father's employment status ($p<0.05$).

The results of multivariate analysis (Tab. 5) confirmed that a probability of wheezing attacks was significantly higher in children with genetic susceptibility, i.e. maternal asthma and allergy (both $p<0.05$). Moreover, the study showed that an increase of risk of health disorders depends on some environmental factors such as: exposure to passive smoking, presence of dampness/mould in dwellings or

Table 2. Frequency (%) of wheezing related to environmental and socioeconomic factors.

Independent variables		Girls			Boys			Total		
		n	%	p	n	%	p	n	%	p
Maternal allergy	Yes	31	32.6	<0.01	20	30.3	NS	51	31.7	<0.01
	No	98	18.5		122	27.7		220	22.7	
Paternal allergy	Yes	6	15.4	NS	17	44.7	<0.05	23	29.9	NS
	No	123	21.0		125	26.7		248	23.6	
Maternal asthma	Yes	12	54.5	<0.001	4	30.8	NS	16	45.7	<0.001
	No	117	19.4		138	28.0		255	23.3	
Maternal smoking	Yes	66	26.1	<0.001	58	28.9	NS	124	27.3	<0.05
	No	63	17.0		84	27.5		147	21.7	
Paternal smoking	Yes	76	30.8	NS	70	22.9	NS	146	26.4	NS
	No	66	25.5		59	18.5		125	21.6	
Smoking at home	Yes	99	24.1	<0.001	97	29.3	NS	196	26.4	<0.001
	No	30	14.0		45	25.7		75	19.3	
Nursery school attendance	Yes	5	8.8	<0.05	7	21.2	NS	12	13.3	<0.01
	No	124	21.9		135	28.5		259	24.9	
Pneumonia/bronchi inflammation before 3rd birthday	Yes	69	37.5	<0.001	75	43.1	<0.001	144	40.2	<0.0001
	No	60	13.6		67	20.2		127	16.4	
Dampness/mould in dwellings	Yes	72	24.7	<0.05	81	33.1	<0.01	153	28.5	<0.0001
	No	57	17.2		61	23.4		118	19.9	
High density of road traffic	Yes	56	22.7	NS	65	33.5	<0.05	121	27.4	<0.05
	No	73	19.4		77	24.7		150	21.8	
Coal stove	Yes	48	23.6	NS	50	33.8	<0.05	98	27.9	<0.05
	No	81	19.2		92	25.7		173	22.2	
Home built before 1945	Yes	68	24.1	<0.05	77	34.1	<0.001	145	28.5	<0.001
	No	61	17.8		65	23.2		126	20.3	

NS – not significant

living in 50-year-old building (all $p<0.05$). The lowest risk of wheezing attacks was characteristic for girls ($p<0.01$) and children with nursery school attendance history ($p<0.05$). The highest probability of dyspnea attacks with wheezing was associated with maternal allergy ($p<0.0001$); also revealed was exposure to particulates derived from tobacco or traffic (both $p<0.01$) and poor living conditions (i.e. when dampness or mould were present indoors; $p<0.05$). Finally, the risk of doctor diagnosed asthma was high when the children lived in damp/mouldy dwellings, in houses with coal stoves, or close to roads where traffic intensity was high (all $p<0.05$).

DISCUSSION

The presented observations on respiratory symptoms and asthma prevalence confirm conclusions from other studies on child populations inhabiting different regions of Poland [13, 25, 50]. The majority of epidemiological studies documented an importance of maternal atopy to genetic susceptibility of children. The mother transfers her genes to the baby, and during intrauterine development is also the exclusive environment and continues to be a major environmental factor during breast-feeding [43]. The role of genetic factors, represented in this study by a positive answer to a questions from questionnaire concerning maternal allergy and asthma, was confirmed regarding attacks of wheezing and dyspnea with wheezing. Furthermore, the results of this study confirmed an influence of several environmental factors on the frequency of the examined respiratory disorders and asthma. All these adverse health problems afflicted children living in poor housing conditions more frequently, i.e. in damp or mouldy premises, exposed to tobacco smoking, in old buildings often with coal stoves, or located near roads with high traffic density.

It is well known that urban females are smokers more often than rural females, which has been proved in our surveys [36, 46]. The percentage of tobacco smokers in Upper Silesia is higher than in other regions in Poland, and exceeds the threshold of 40%. Exposure to tobacco smoke is strongly related to the frequency of various respiratory disorders and asthma, especially in the youngest children [36, 41, 53]. The Tucson Children's Respiratory Study confirmed the statistical importance of maternal tobacco smoking as a significant factor of wheezing in children. The most interesting fact was that this relationship applied

Table 3. The frequency (%) of dyspnea attacks with wheezing related to determinants of childhood health.

Independent variable		Girls			Boys			Total		
		n	%	p	n	%	p	n	%	p
Maternal allergy	Yes	24	25.3	<0.0001	14	21.2	<0.05	38	23.7	<0.0001
	No	50	9.5		51	11.6		101	10.4	
Paternal allergy	Yes	3	7.7	NS	10	26.3	<0.01	13	16.9	NS
	No	71	12.1		55	11.7		126	12.0	
Paternal asthma	Yes	2	9.5	NS	3	37.3	<0.05	5	17.2	NS
	No	72	11.9		62	12.4		134	12.2	
Maternal asthma	Yes	7	31.8	<0.001	4	30.8	<0.05	11	31.4	<0.0001
	No	67	11.1		61	12.4		128	11.7	
Maternal smoking	Yes	43	17.0	<0.001	27	13.4	NS	70	15.4	<0.001
	No	31	8.4		38	12.5		69	10.2	
Smoking at home	Yes	61	14.9	<0.001	43	13.0	NS	104	14.0	<0.01
	No	13	6.1		22	12.6		35	9.0	
Nursery school attendance	Yes	4	7.0	NS	2	6.1	NS	6	6.7	NS
	No	70	12.4		63	13.3		133	12.8	
Pneumonia/bronchi inflammation before 3rd birthday	Yes	45	24.5	<0.0001	37	21.3	<0.0001	82	22.9	<0.0001
	No	29	6.6		28	8.4		57	7.4	
Dampness/mould in dwellings	Yes	42	14.4	NS	40	16.3	<0.05	82	15.3	<0.001
	No	32	9.6		25	9.6		57	9.6	
Contact with animals since birth	Yes	22	8.8	<0.05	20	11.8	NS	42	10.0	NS
	No	52	13.9		45	13.3		97	13.6	
High density of road traffic	Yes	37	15.0	<0.05	35	18.0	<0.001	72	16.3	<0.001
	No	37	9.8		30	9.6		67	9.7	

NS – not significant

to prenatal exposure to tobacco smoke only, in the postnatal period such dependency was not observed [17, 41]. On the contrary, the results of cross-sectional research carried out among 6,420 children residing in three large cities of Southern Poland (Cieszyn, Żywiec, and Bielsko-Biała) showed that passive exposure to tobacco smoke was not connected with frequency of respiratory symptoms and asthma in subjects [48]. Nevertheless, it is highly probable that the obtained results were biased by limited reliability of evidence based on a questionnaire survey. On the other hand, if the children have ever had diagnosed asthma, the perception of environmental health risk in their parents could be higher and led them to stop smoking at home.

The results of this study have pointed out several indoor sources of air pollution, e.g. a coal stove, responsible for observed respiratory disorders in children. Such a simple system for heating and cooking was typical for old buildings, especially those built before 1945, and was a consequence of the low socio-economic status of the families. These findings correspond to the results of an other study conducted in Chorzów, in which coal burning stoves were significantly related to risk of asthma in schoolchildren [52]. It was also noted that both dampness and mould exposure in dwellings were significantly related to the occurrence of wheezing, attacks of dyspnea with wheezing and asthma in the studied group. For example, the risk of wheezing attacks was 1.4-times higher, attacks of dyspnea with wheezing 1.5-times higher, and bronchial asthma almost twice as high in children living in damp/mouldy dwellings than in the group of children not exposed to these threats. Other published data confirm these findings concerning respiratory disorders and asthma in children residing in damp/mouldy dwellings [4, 31, 37, 40, 52]. An influence of exposure to high relative humidity and moulds in the early period of child growth on increase of risk of wheezing and asthma was demonstrated for Italian children aged 7–13 years [40], as well as Swedish and German children populations aged 7–8 years [4, 31]. Other Polish data for children from the southern part of the Silesian Voivodeship confirmed the same relationship between damp/mouldy dwellings and adverse respiratory health outcomes [51]. In spite of applied treatment, an exposure to moulds in an indoor environment can lead to problems in gaining control over asthma [23]. Due to the lack of possibilities to confront the questionnaire answers with the real values of environmental measurements, the conclusions built on the

Table 4. Frequency (%) of doctor diagnosed asthma, related to determinants of childhood health.

Independent variable		Girls			Boys			Total		
		n	%	p	n	%	p	n	%	p
Maternal allergy	Yes	11	6.0	<0.01	6	5.2	NS	17	6.5	NS
	No	13	2.7		21	5.4		34	3.9	
Unemployed father	Yes	2	6.4	NS	5	12.2	<0.05	7	9.7	<0.05
	No	22	3.7		22	4.7		44	4.2	
Paternal smoking	Yes	14	4.6	NS	19	7.7	<0.05	33	6.0	<0.05
	No	10	3.1		8	3.1		18	3.1	
Smoking at home	Yes	19	4.6	NS	20	6.0	NS	39	5.3	NS
	No	5	2.3		7	4.0		12	3.1	
Birth body weight 1,501 g ÷ 2,500 g	Yes	7	7.0	NS	0	0	<0.05	7	3.9	NS
	No	93	93.0		79	100		172	96.1	
Birth body weight >2,501 g	Yes	17	3.2		27	6.3		44	4.6	
	No	507	96.8		400	93.7		907	95.4	
Pneumonia/bronchi inflammation before 3rd birthday	Yes	14	7.6	<0.001	17	9.8	<0.001	31	8.7	<0.0001
	No	10	2.3		10	3.0		20	2.6	
Dampness/mould in dwellings	Yes	13	4.4	NS	20	8.2	<0.001	33	6.2	<0.01
	No	11	3.3		7	2.7		18	3.0	
High density of road traffic	Yes	15	6.1	<0.05	13	6.7	NS	28	6.4	<0.05
	No	9	2.4		14	4.5		23	3.3	
House built before 1945	Yes	11	3.9	NS	20	8.9	<0.01	31	6.1	<0.05
	No	13	3.8		7	2.5		20	3.2	

NS – not significant

questionnaire survey should be formulated only in a very cautious manner. Some authors stress that parents with respiratory symptoms are prone to assess the observed health problems (e.g. when exposed to indoor dampness and/or moulds) in a more dramatic way [5, 51]. This might be a source of measurement errors which should not be ignored in a cross-sectional study. Such types of errors could lead to an overestimation of the real association between exposure and frequency of adverse respiratory outcomes. Nevertheless, according to World Health Organization, a subjective perception of health status can be a useful tool for the measurement of population health, and the correlation between self-reporting and other quantifiable outcomes can be successfully applied to this type of epidemiological studies [45].

The obtained results paid attention to the problem of indoor air quality. It is estimated that children spend from 70–90% of their daily activity indoors. Whereas outdoor air pollution and its impact on childhood health is quite well recognized and followed by some regulations, the knowledge and legal scarcities regarding indoor air quality are still visible. Old buildings, usually without proper ventilation and an efficient heating system, create specific microenvironments supporting microbial and/or mite colonization of construction or finishing materials. The results of this study showed that dampness and fungal contamination appeared (constantly or periodically) in 50% of investigated dwellings, while in the Netherlands in 15–18%, in Nordic countries in 15–25% and in the United Kingdom in 17–46% only [5, 45]. Fungi can affect human health in many different ways. Possible reactions fall into one of three groups: allergic reactions (sensitization and immune responses, i.e. asthma, allergic rhinitis or hypersensitivity pneumonitis), infections (e.g. aspergillosis), and toxic responses (mainly connected with the secondary fungal metabolites, i.e. mycotoxins). The role of cell wall components, such as glucans, has also been reported. In addition, exposure to volatile organic compounds produced by fungi while growing on substrates and degrading them may be responsible for nonspecific symptoms, such as headaches, eye/nose and throat irritation, and fatigue [10, 15, 35, 39]. Exposure to moulds can initiate IgE and IgG dependable reactions, including those with participation of cell response and cytotoxic reactions [10, 15]. Damp dwellings are usually contaminated by many different fungi which could produce dozens of allergens. Such allergen diversity and presence in this "biological cocktail" of joint epitopes cause cross-reactivity among related species, making both proper diagnosis as well as a connection between adverse health effects and exposure very difficult.

Although several epidemiological studies show that people living in buildings with mould problems where they are exposed to high concentrations of airborne fungal propagules, have more respiratory disorders than people in non-problem ones. The relationship between inhaled fungal spores and induction of respiratory symptoms is still

Table 5. Odds ratios (OR) and its 95% confidence intervals (CI) related to determinants of observed adverse health outcomes.

Variable	log OR	95% CI	p
Wheezing attacks			
Female gender	0.65	0.49–0.87	<0.01
Maternal allergy	1.46	1.04–2.04	<0.05
Maternal asthma	2.16	1.02–4.53	<0.05
Exposure to passive smoking at home	1.44	1.05–1.96	<0.05
Nursery school attendance	0.47	0.25–0.89	<0.05
Dampness/mould in dwellings	1.41	1.05–1.87	<0.05
50-year-old building	1.39	1.04–1.85	<0.05
Dyspnea attacks with wheezing			
Maternal allergy	2.28	1.56–3.35	<0.0001
Exposure to passive smoking/ maternal smoking	1.62	1.13–2.34	<0.01
High density of road traffic	1.76	1.23–2.53	<0.01
Dampness/mould in dwellings	1.54	1.07–2.23	<0.05
Doctor diagnosed asthma			
Coal stove	1.91	1.06–3.45	<0.05
Dampness/mould in dwellings	1.95	1.08–3.53	<0.05
High density of road traffic	1.93	1.09–3.41	<0.05

controversial [10, 15, 20, 45]. In this study, the association between fungal contamination of dwellings and respiratory disorders or bronchial asthma in children living in Chorzów was clearly visible, and the occurrence of dampness or mould indoors was recognized as an important environmental risk factor.

The obtained results also revealed that respiratory disorders and asthma were associated with traffic related air pollution. The city of Chorzów is located between main crossroads of Upper Silesia conurbation connecting neighbouring towns, i.e. Katowice, Świętochłowice, Ruda Śląska, and Bytom. For the purpose of this research, a distance between the place of residence and the road with high traffic density was used as a surrogate of exposure. The risk of wheeze attacks, dyspnea attacks with wheezing and bronchial asthma were from 1.4 to almost twice as high in children exposed to pollution derived from heavy road traffic. The impact of air pollutants emitted by road transport is a subject of numerous studies [33, 35, 43, 44, 48], but the methods applied for exposure assessment between them are very distinct. German scientists, in the model of cross-sectional study among school children aged 9–11 years, measured the number of vehicles during a school day. A number of cars above 25,000 per day was treated as a high traffic density. The obtained results of this study showed that for children exposed to such traffic emission, the lower values of spirometric parameters such as peak expiratory flow, PEF, and maximal expiratory flow at 25%, $MEF_{25\%}$, were typical. Moreover, the frequency of respiratory disorders, including cough and returning attacks of wheezing, was higher in exposed subjects and the high level of exposure was defined as a dwelling-place located in a distance less than 90 m from a busy street [48]. Japanese and British studies used a distance between place of residence and busy roads as a substitute for exposure. In both studies, the frequency of wheeze attacks and infections of the respiratory system were higher in children living close to the roads with high traffic density [32, 44]. Similar evidence was obtained for Dutch children living within a 100 m distance from a road with high traffic density [35, 43]. The presently performed observations of birth cohort in different countries confirm correlation between the exposure to traffic related air pollution and adverse respiratory system symptoms (such as wheeze, cough, infections of upper respiratory tract), a higher occurrence of asthma and increase of hospitalization in case of acute asthma exacerbation [33]. It was also documented that lung development impairment due to exposure to traffic pollutants could be treated as an additional unfavourable prognostic factor for children suffering from asthma [21].

Due to different methods applied for exposure assessment (which are often based on a direct measurement of particulate matter smaller than 2.5 µm, $PM_{2,5}$, various nitrogen oxides, NO_x, and ozone, or on application of special models taking into account several pollutants) and for evaluation of adverse health response (such as respiratory disorders, asthma, or atopy), the results of this type of study are frequently incomparable [6, 7, 30]. The relationships between exposure to traffic related pollutants and asthma, atopy or pollinosis were often confirmed in surveys evaluating the distance from a busy street [30, 35, 43]. Unfortunately, the observed relations did not always confirm a strong link between specific health outcomes and individual traffic related chemical compound or agent. This observation leads to the conclusion that the knowledge about factors which play a major role in initiation of allergy process and their mutual interactions is still insufficient. Experimental data collected during animal and volunteer studies confirm that diesel exhaust particles, DEP, can cause not only asthma aggravation but can also have an impact on the immunological system initiating the allergy process [26, 38, 39]. Moreover, some studies suggest that an increase in allergic diseases, including asthma, is not only related to the reactivity of exhaust fumes emitted by diesel engines, but depends on the biological activity of particles originating from tyre attrition or agents derived from catalytic processes as well [26].

The results of this study show that nursery school attendance had a protective effect against wheezing. The observed relationship corresponds with the concept of "hygiene hypothesis", which postulates the increase of asthma prevalence in children living in a clean modern environment. In this context, it has been proposed that an overcoming of microbial infections or exposure to microbial agents in the first years of life may lead to the response of the immune system, which is known to be skewed in Th_2 direction during foetal life, into a Th_1 direction. This protective effect may be increasingly lost as the surrounding environment becomes "cleaner". If this is true, the protective effect would apply to "atopic" diseases such as allergic asthma, allergic rhinitis, and eczema. Although, it is now appropriately recognized that non-allergic mechanisms may play a role in asthma, atopic asthma still makes up for a considerable proportion of asthma in general population and thus the identification of any protective factors that may lead to new approaches to prevent atopy and allergic asthma are of great value. The "hygiene hypothesis" is generally consistent with the epidemiological evidence, but as such is not conclusive. It thus remains unclear whether any single factor can explain the global trends, or it is the entire "package of changes", including so-called "westernization of life", that is responsible. A decrease in microbiological stimulation in the first months of life or limited exposure to infectious factors favour the survival of Th_2 lymphocyte (i.e., the phenotype dominating in uterine life) and, by that, favour the allergy [2, 24, 42]. Assuming that a nursery school environment is conductive to respiratory system infections, this phenomenon, according to the "hygiene hypothesis" concept, can protect a child from development of allergy and asthma in the future. Nevertheless, the practical conclusions resulting from the "hygiene hypothesis" must be carefully drawn due to a large diversity of microorganisms and their varied impact on immune system.

CONCLUSIONS

The findings of this study reveal that the role of environmental exposure in development of respiratory symptoms and childhood asthma is significant, apart from well known genetic factors. The exposure to indoor (tobacco smoke, coal stove emission) and outdoor (road traffic pollution) air contaminants, or contact with damp and/or mouldy materials are major environmental factors responsible for adverse respiratory health effects in children living in heavily polluted and densely populated urban areas.

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