

Exposure to environmental tobacco smoke and respiratory tract infections in pre-school children – a cross-sectional study in Poland

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Abstract

Introduction and objective. Knowledge of the harmful influence of environmental tobacco smoke (ETS) has a positive impact on changing social behaviours worldwide. In many homes smoking is totally prohibited; in some others, partial limitations of tobacco consumption have been introduced.

Objective. To study the correlation between the adopted rules of tobacco use in homes of 3-year-olds, and the kind and frequency of acute respiratory system infections within a 6-month period of attending pre-schools.

Materials and methods. The study was performed among children attending municipal pre-schools in Białystok, Poland. The data was collected by anonymous questionnaires completed by the parents of 302 children aged 3 years chosen randomly from 1,200 children attending 51 pre-schools. The exposure of children to tobacco smoke was measured by determining cotinine to creatinine ratio (CCR) in urine.

Results. In the 150 families of children who were surveyed, 210 were smokers. Every day, the smokers consisted of fathers (37.3%) and mothers (23.6%). The 3-year-old children were divided into 3 groups according to smoking habits in their homes: 28.5% of the children under examination came from homes where tobacco smoking was forbidden (mean CCR – 15.21 ng/mg, SD=11.86), 26.2% came from homes where tobacco was smoked in separate rooms (mean CCR – 65.75 ng/ml, SD=81.51), 45.4% lived in homes where no rules connected with smoking had been established (mean CCR – 61.75 ng/ml, SD= 70.29). During the analyzed period of 6 months, 85% of the children had at least 1 respiratory tract infection (60% – upper, 16.9% – lower, 16.5% – upper and lower, 7.1% – otitis media).

Conclusions. The majority of the 3-year-old children who had lower respiratory tract infections required antibiotics and hospitalization. Living in a home where no tobacco rules were established may cause an increase of respiratory tract infections.

Key words

children, respiratory tract infections, tobacco smoke pollutions

INTRODUCTION

Acute respiratory system diseases in pre-school children are a significant problem in the practice of a GP, especially when the infections are recurrent. The moment of first contact with infectious factors in a large group of children is often the turning point in a child's medical history, but the kind and frequency of respiratory system infections are influenced by various endo- and exogenous factors. Tobacco smoke is one of the main elements of indoor air pollution, and is a factor inducing and modifying the course of respiratory system diseases [1, 2]. It is highlighted in literature that children of parents who smoke are grow up in worse living conditions and become ill more frequently, compared to their peers not exposed to environmental tobacco smoke [3, 4].

Currently, 38% of adult males and 27% of females in Poland smoke every day; 53% of citizens are exposed to

environmental tobacco smoke (ETS) at home and 40% at work [5]. Smoking one cigarette in a closed room produces 30.4 mg of dry substance, pollutes 3–4 m³ of space, and 50 m³ of air needs to be exchanged in order to remove the smell [6]. Knowledge about the harmful influence of ETS has a positive impact on changing social behaviours around the world. In many homes smoking is totally prohibited; in some others, partial limitations of tobacco consumption are introduced [7].

OBJECTIVE

To study the correlation between the adopted rules of tobacco use in homes of 3-year-old children, and the kind and frequency of acute respiratory system infections within a 6-month period of attending pre-schools. The rate of exposure to ETS was measured on the basis of survey data, objectified by determination of a marker of tobacco smoke exposition – cotinine to creatinine ratio (CCR) in urine of the studied children.

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MATERIALS AND METHOD

3-year-old children from families living in the city of Białystok, the capital of a province located in north-eastern Poland, with a population of 294,200 people were included in the study [8]. Its total surface area is 102 km², including 4,1% of green areas [9]. There are 354.7 cars to every 1,000 residents [10]. On the basis of data from the Provincial Fund for Environmental Protection concerning air cleanliness in Białystok, it was found that the norms of P10 suspended dusts were exceeded every year between 2004–2007, and 2011–2012 (D24=50µm³ 35days/year); the norms for P2,5, SO₂, NO₂, CO, CO₂ and O₃ were not exceeded. [11].

From among the 1,200 children aged 3 years attending 51 municipal pre-schools, 390 were randomly chosen (every third or fourth child from the alphabetic attendance registers).

The study tool was an original survey questionnaire entitled 'The environment of my three-year-old', anonymously filled-in by the caregivers of the randomly chosen children. The questionnaire was composed of 3 modules to evaluate the environmental conditions, incidence of respiratory system diseases among the children, and the structure of tobacco use in their families. The module devoted to previous respiratory system diseases included questions referring to the medical history and treatment in the first 3 years of life before attending pre-school and in the period of attending pre-school between January – June 2004.

302 completed questionnaires were received, and 153 girls (50.5%) and 149 boys (49.5%) were included in the study.

The exposure of children to tobacco smoke was measured by determining the cotinine to creatinine ratio (CCR) in urine [12]. 15 ml samples of morning urine were obtained from 284 children. Among the received samples, 140 were randomly chosen for determination of cotinine and creatinine concentration. The urine samples were stored at the temperature of -70°C. The extraction and quantitative analysis of cotinine was performed by high-performance liquid chromatography method (HPLC). The limits of linearity (LOL) were in the range 5–1,000 ng/ml; limit of determination (LOD) – 3 ng/ml; limit of quantification (LOQ) – 5 ng/ml. The coefficient of variation of cotinine in concentrations 20 and 100 ng/ml did not exceed 10% and amounted up to 4.8% (inter-day CV) and 7.8% (intra-days CV).

Creatinine was determined by the kinetic colorimetric method with alkaline picrate without deproteinization, with the use of Creatinine kinetic reagent set (CREA) and a biochemistry analyzer (Konelab 60i).

Statistical methods. The obtained results were subject to statistical analysis in which the arithmetic mean, standard deviation (SD), minimum and maximum values were calculated for the measurable features, whereas quantity and percentage distribution was calculated for the non-measurable values.

For the features conforming to normal distribution, evaluated with the Shapiro-Wilk test, the one-way analysis of variance (ANOVA) was applied for comparisons between the analyzed groups, and for the features non-conforming to that distribution, the Kruskal-Wallis test was applied. The qualitative variables between groups were compared with the Chi² test. For the calculations, the significance level $p < 0.05$ was assumed as statistically significant. The calculations were carried out with the use of the SPSS statistical packet.

RESULTS

In 47.9% of the analyzed families (150), 210 smokers were found: 37.3% were fathers (112), 23.6% were mothers (71), and 27 other household members (grandfathers, grandmothers, relatives). The fathers smoked 14 cigarettes a day, on average (SD=10.23), smoking mothers – 8 cigarettes, on average (SD=8.18), and other household members – 15 cigarettes, on average (SD=11.14).

On the basis of the rules of tobacco use at home provided by the parents, the children were divided into 3 groups:

1. Group 0 (Gr0) – children from families where smoking is totally forbidden
2. Group 1 (Gr1) – children from homes where smoking is permitted in separated rooms (kitchen, bathroom or hall).
3. Group 2 (Gr2) – children from homes where there are no rules concerning tobacco use.

The number of children in individual groups and the CCR values are presented in Table 1.

Table 1. Number of children classified according to ETS exposure and CCR values

Group	No. of children	Cotinine/creatinine (CCR) [ng/mg]				No. of analyzed urine samples
		Highest value	Lowest value	Mean value	SD	
Group 0	86	45.7	0.0	15.2	11.9	43
Group 1	79	350.3	0.5	65.8	81.5	40
Group 2	137	379.1	0.2	61.8	70.3	57
Total	302					140
p				Gr0-Gr1 $p < 0.001$		
				Gr0-Gr2 $p < 0.001$		
				Gr1-Gr2 $p = 2.824$		

The groups differed significantly with regards to the parents' level of education, income per person in the family and living conditions.

The highest number of children from Gr0 and the lowest number of children from Gr2 had parents with higher education. The differences between education levels of parents of children from particular groups were statistically significant (Tab. 2).

Table 2. Educational level of parents in each group of ETS exposure

Group	Mother's educational level			Father's educational level		
	higher	secondary	elementary	higher	secondary	elementary
Gr0	54 62.8%	29 33.7%	3 3.5%	43 50%	35 40.7%	8 9.3%
Gr1	34 43%	39 49.4%	6 7.6%	30 38.0%	42 53.2%	7 8.9%
Gr2	43 31.4%	88 64.2%	6 4.4%	31 23.0%	89 65.9%	15 11.1%
Total	131 43.4%	156 51.7%	15 5.0%	104 34.7%	166 55.3%	30 10.0%
p				Gr0-Gr1 $p = 0.034$	Gr0 - Gr1 $p = 0.25$	
				Gr0-Gr2 $p < 0.001$	Gr0 - Gr2 $p < 0.001$	
				Gr1-Gr2 $p = 0.094$	Gr1 - Gr2 $p = 0.063$	

The average annual net income per person amounted to:
Gr0 – PLN 12,317 (SD=15.83);
Gr1 – PLN 9,210 (SD=8.31);
Gr2 – PLN 7,034 (SD=8.66) ($p = 0.008$).



Most of the studied children – 79.1% (239) – lived in blocks of flats, 5% (15) in terraced houses, and 15.9% (48) in detached houses. In detached houses lived 25.6% of the children (22) in Gr0, 15.2% (12) in Gr1 and 10.2% (14) in Gr2; in terraced houses – 7% (6) in Gr0, 1.5% (1) in Gr1 and 5.8% (8) in Gr2; in blocks of flats – 67.4% (58) in Gr0, 83.5% (66) in Gr1 and 83.9% (115) in Gr2 (Gr0: Gr1 $p=0.008$; Gr1: Gr2 $p=0.160$; Gr0: Gr2 $p=0.008$).

The average total surface of the flats in which the studied 3-year-olds lived was: Gr0–81.6 m², Gr1–67.2 m², Gr2–62.5 m² $p=0.013$; the average number of m² in the flat was: Gr0–21.75 (SD=15.83), Gr1–17.67 (SD=8.31), Gr2–13.21 (SD=8.66), ($p=0.005$).

During pregnancy, none of the mothers of children from Gr0 used tobacco products, but 7% of the fathers smoked. In Gr1–10.1% of mothers and 47.4% of fathers smoked, and in Gr2–16.1% of mothers and 62.8% of fathers smoked (Tab. 3).

The occurrence of at least one acute respiratory system infection in the subjects over 6 months of attending pre-schools was reported by 87.2% of parents of children from Gr0, 78.5% in Gr1 and 87.6% in Gr2 (Tab. 4). The number of acute infections in children from particular studied groups

Table 3. ETS prenatal exposure

Group	Mothers smoking during pregnancy		Fathers smoking during pregnancy	
	Yes	No	Yes	No
Gr0	0% (0)	100% (86)	7% (6)	93% (80)
Gr1	10.1% (8)	89.9% (71)	47.4% (37)	52.6% (41)
Gr2	16.1% (22)	83.9% (115)	62.8% (86)	37.2% (51)
Total	9.9% (30)	90.1% (272)	42.9% (129)	57.1 (172)
p	Gr0-Gr1 $p=0.002$		Gr0-Gr1 $p<0.001$	
	Gr0-Gr2 $p<0.001$		Gr0-Gr2 $p<0.001$	
	Gr1-Gr2 $p=0.22$		G1-Gr2 $p=0.028$	

is presented by the following categories: upper respiratory tract infections (acute rhinitis, pharyngitis, laryngitis), lower respiratory tract infections (bronchitis, pneumonia) and otitis media (Tab. 5).

In all the groups, recurrences of acute upper respiratory tract infections prevailed – the biggest number of them occurred in children from Gr2. Acute lower respiratory tract infections were also the most common among children from

Table 4. Children by frequency of occurrence of acute respiratory tract infections

Infection type	Group	No. and percentage of children with number of acute infections									p
		1	2	3	4	5	6	7	8	10	
Pneumonia	0	10 11.6%	2 2.3%								0.098
	1	1 1.3%	2 2.5%								
	2	11 11.6%	3 2.2%								
Bronchitis	0	10 11.6%	1 1.2%	1 1.2%							0.228
	1	6 7.6%	4 5%			1 1.3%					
	2	21 15.3%	18 13.1%	5 3.6%	4 2.9%		1 0.7%				
Laryngitis	0	4 4.6%	2 2.3%								0.558
	1	4 5%									
	2	6 4.3%	1 0.7%	1 0.7%							
Pharyngitis	0	12 14%	7 8.1%	9 10.4%		1 1.2%	1 1.2%	1 1.2%			0.228
	1	17 21.5%	7 8.9%	6 7.6%	1 1.3%	1 1.3%					
	2	19 13.6%	16 11.7%	10 7.3%	1 0.7%	6 4.3%		1 0.7%	1 0.7%	1 0.7%	
Acute rhinitis	0	6 8%	13 15.1%	5 5.8%	2 2.3%	1 1.2%	3 3.4%	1 1.2%	2 2.3%		0.558
	1	6 7.6%	11 13.9%	4 5%	2 2.5%	4 5%			2 2.5%		
	2	10 7.3%	8 5.8%	5 3.6%	3 2.2%	4 2.9%	3 2.2%	2 1.4%	3 2.2%	1 0.7%	
Otitis media	0	3 3.4%	2 2.3%								0.558
	1	3 3.8%	1 1.3%	1 1.3%	1 1.3%	1 1.3%					
	2	5 3.6%	1 0.7%								



Table 5. Number and percentage of children with frequency of occurrence of acute respiratory tract infections

Group	Types of acute respiratory tract infections	No. and percentage of children with specific number of acute infections								
		1	2	3	4	5	6	7	8	10
0	Infections of lower respiratory tract	20 23%	3 3.4%	1 1.2%						
	Infections of upper respiratory tract	22 25.5%	22 25.5%	14 16.2%	2 2.3%	2 2.3%	4 4.7%	2 2.3%	2 2.3%	
	Otitis media	3 3.4%	2 2.3%		1 1.2%					
1	Infections of lower respiratory tract	7 8.9%	6 7.6%			1 1.3%				
	Infections of upper respiratory tract	27 34.1%	18 25.3%	10 12.7%	3 3.8%	5 6.3%	1 1.3%		2 3.8%	
	Otitis media	3 3.8%	1 1.3%	1 1.3%	1 1.3%	1 1.3%				
2	Infections of lower respiratory tract	32 23.3%	21 15.3%	5 3.6%	4 2.9%		1 0.7%			
	Infections of upper respiratory tract	35 25.5%	25 18.2%	26 11.7%	4 2.9%	10 7.3%	3 2.1%	3 2.1%	4 2.9%	2 1.5%
	Otitis media	5 3.6%	1 0.7%							

Gr2, whereas they were least frequently found in children from Gr1. Between the number of children in Group 1 and 2 who had up to 4 lower respiratory tract infections within 6 months, statistically significant differences ($p=0.001$) were found.

In the analyzed 6-month period, 77.2% of children from Group 2, 64% of children from Group 0 and 59.5% of children from Group 1 ($p=0.014$) needed antibiotic treatment, which proportionally reflects the quantitative distribution of frequency of occurrence of lower respiratory tract infections in the respective studied groups. 9.5% of children from Group 0, 7.6% of children from Group 1 and 15.7% of children from Group 2 needed hospitalization for different reasons: Gr2: Gr0 – $p=0.04$, Gr1: Gr2 – $p=0.015$.

DISCUSSION

Nearly half of the studied 3-year-old children lived in families where at least one person smoked. Nearly 1/3 of the children lived in households with a total prohibition of smoking. Most of the parents of those children had higher education. The group of 3-year-olds whose parents reported that smoking was permitted in allocated rooms of their flats (from which the children were absent) included 26.1% of the subjects. The rest of children, 45.4%, lived in families where no regulations concerning smoking had been established, which indicates that the awareness of the harmful impact of exposure to ETS among parents of the studied children is low, and is ignored by nearly half of the respondents. A study by Jung et al. [13] established the smoking statuses of parents of children aged 6–11 years in Anyang City, Gyeonggi Province, South Korea, proved that 40.9% of the children were not exposed to smoking at home, 18.5% were exposed to second-hand smoking and 40.6% exposed to third-hand smoking (THS) (smoke that lingers after the extinguishing of a cigarette, present in furniture, clothes or hair) [14].

CCR values in the urine of children potentially protected from exposure to ETS (Gr1) were similar to values occurring in children whose parents allowed smoking in their presence

(Gr2). Jurado et al. [15] obtained similar results in a study carried out in Granada, Spain, among 3–6-year-old pre-school children. The results indicate that smoking in allocated rooms in flats with a small cubic capacity (prevalent among the respondents) did not accomplish the purpose intended by the parents, and did not protect the children from the impact of smoke [16]. Protano et al. showed a clear correlation between cotinine concentration in the urine of the studied children and exposure to tobacco smoke, depending on the habit of tobacco smoking and the number of cigarettes smoked by the parents [17].

The observed discrepancy between the survey outcome and biochemical results might have been caused by dishonesty of the respondents – they may have provided false but socially desirable answers in the questionnaire about regulation of smoking in their households. It seems unlikely that a large group of subjects were exposed to tobacco smoke outside their home, although that possibility must also be considered. Indirect passive smoking (THS) must also be taken into consideration. Its toxic influence is described in detail by Matt et al. [18].

According to Dove et al. [19], the legal restriction of smoking in public places results in a lower cotinine concentration in blood serum of children. Dempsey et al. [20] observed a significant discrepancy between survey data received from parents, reporting that 13% of the hospitalized children were exposed to ETS, and the fact that cotinine was found in 55% of blood serum of the studied children. Sabanty et Brózdziak [21], who assessed CCR in the urine of elementary schools students in Łódź, Poland, observed that among those exposed to smoke, the CCR value was lower in children who had their own bedrooms. The study concerned older children who could consciously avoid the smoke and ventilate their bedrooms. The 3-year-old children considered in the presented were not able to do so because of their lack of autonomy due their young age.

During 6 months of attending pre-schools, 85% of the subjects had at least one respiratory tract infection. Some children repeatedly suffered from the same and different infections. The biggest number of sufferers recruited from

families where ETS exposure was not controlled, whereas the children not exposed to tobacco smoke were the smallest group of sufferers. The difference between those groups, however, was not significant. Irrespective of the studied group, the children most often suffered from acute upper respiratory tract infections. The highest number of recurring infections of that type was observed in children from GR2, but the differences between particular groups were not significant. Acute lower respiratory tract infections also mostly repeated in children from GR2 and least often in GR1. A significant difference between the 2 groups concerned the number of children who had up to 4 lower respiratory tract infections ($p=0.0001$). It is curious that the children from homes where smoking was prohibited were ill nearly as often as the children from the exposed group, whereas the children who were potentially protected from smoke had the fewest acute lower respiratory tract infections. In that group, however, recurrent otitis media occurred most frequently.

Cook et al. [22] analyzed 50 studies evaluating the relation between exposure to ETS and increased rate of lower respiratory tract infections in young children. The results of 29 publications confirmed a relationship between second-hand smoke and increased morbidity rate of bronchitis, bronchiolitis and pneumonia, as well as an increased number of related stays in hospital. The meta-analysis carried out by Li et al. [23] indicates that there is an increased risk of lower respiratory tract infections in children exposed to ETS, especially in those aged less than 2 years of age. Złotowska [24] published a study conducted as part of the international study project CESAR (Central European Study of Air pollution and Respiratory Health), which covered children aged 9–11. In it, she noted a statistically significant correlation between exposure to ETS and the occurrence of pneumonia in medical history. Krzywicka et al. [25], having interviewed parents of children hospitalized for respiratory tract infections, observed that more than 3 recurrences of bronchitis and pneumonia within a year occurred in 69.4% of children aged 2–4 exposed to ETS, and in 21.1% of children not exposed to second-hand smoke. The statistically significant relationship between second-hand smoke and the rate of acute bronchitis and dysphonia incidents in hospitalized children aged 0–7 was proved by Mania et al. [26].

In the presented study, it was found that statistically more children from Gr2 were exposed to ETS before birth due to their mothers and fathers smoking. However, when conducting the study in the groups mentioned in the current study, no relationship was shown between that exposure and the number of respiratory tract infections.

Jones et al. [4] concluded that prenatal exposure to ETS significantly increased morbidity of infections, especially of the lower respiratory tract. The risk is still greater with additional exposure to ETS after birth. Baker et al. [27] proved a relationship between mothers who smoked, especially when breast-feeding, and increased risk of lower respiratory illness in the first 3 years of life.

The results of the ISAAC (International Study of Asthma and Allergies in Childhood), carried out in populations of schoolchildren in Poland, Germany, the Netherlands and Switzerland, also did not show any influence of pre-natal second-hand smoke regarding increased occurrence of bronchitis and pneumonia in the studied children in any of the countries [28].

Badeńska & Czerwionka-Szaflarska [29] proved in their study that 87.3% of repeatedly hospitalized children were exposed to second-hand smoke at home, and the most frequent reasons for their hospitalization were acute respiratory tract infections and otitis media.

The results of the presented study are consistent with those quoted above regarding the higher number of hospitalizations of children who were not protected from smoke at home, in relation to those who were protected ($p=0.04$) and potentially protected ($p=0.015$).

CONCLUSIONS

Exposure to tobacco smoke in the population of 3-year-old children attending public pre-schools in Białystok does not differ significantly from the average exposure estimated in Poland.

3-year-olds who have less educated parents are more exposed to passive smoking at home.

The method of partial limitation of the exposure of children to ETS at home is ineffective.

Children living in a home environment polluted with tobacco smoke more often have respiratory tract infections, and significantly more often need antibiotic treatment and hospitalization.

Conflict of Interest

The authors have no financial or other relationships that might lead to a conflict of interest.

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