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LONG-TERM EXPOSURE TO AIR POLLUTION RELATED TO ASTHMA IN SCHOOLCHILDREN

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Abstract. *The aim of this paper was to analyze the associations between long-term exposure to air pollution and asthma in schoolchildren. Exposed group of children (N=215), aged 11–14 years, were attending the school located in a city of Niš (Serbia) with a higher level of air pollution, while the children (N=139) of non-exposed group, were attending the school in the area with a lower level of air pollution. The air concentrations of black smoke, nitrogen dioxide, sulfur dioxide and lead in sediment matter were determined in ten-year period. The standardized questionnaire was completed by the parents. There was a significant difference in the prevalence of asthma (χ^2=0,720, p>0,05) and respiratory symptoms (χ^2=6,635, p < 0,01) in children exposed to higher concentrations of air pollutants when compared with the control group. We concluded that long-term exposure to background ambient air pollution was associated with an increased prevalence of childhood asthma.*

Key words: *environmental exposure, air pollution, asthma, children*

1. INTRODUCTION

Worldwide changes in the environment can potentially be associated with the remarkably increased rate of allergic diseases, particularly in countries with a western lifestyle, including rapid urbanization and high level of vehicle emissions. The development and phenotypic expression of atopic diseases depends on a complex interaction between genetic factors, environmental exposure to allergens and non-specific adjuvant factors, such as tobacco smoke, air pollution and infections [1,2].

Children have been shown to be at particular risk for these effects of air pollution. Numerous epidemiological studies have shown that long-term exposure to air pollution is associated with exacerbations of asthma [3-6], the most common chronic disorder in

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children. Despite this burden, management of childhood asthma is often substandard, even in high-income countries. Also, the epidemiological evidence of an association between long-term air pollution exposure and increased rates of asthma is limited, especially in the transitional countries. Research in European countries has shown that two-thirds of hospital admissions for asthma in children could be avoided with better preventive care [7].

The aim of the study was to analyze the relationship between long-term exposure to air pollution and asthma in sample of schoolchildren in the city of Niš, Serbia.

2. SUBJECTS AND METHODS

The study sample consisted of children aged 11 to 14 years, non-smokers, citizens of Niš (Serbia). The group of exposed children, attended school in a city area with a high level of outdoor air pollution (School 1), while the children of the comparative group, designated as the non-exposed group, attended school in an area with a lower level of outdoor air pollution (School 2). School 1 is located in an urban area with major traffic roads surrounding the school building and School 2 in a residential area, far from the main street. All children lived in the areas close to the schools and at a distance of 0.5km from the measuring site. The exclusion criteria were any acute illnesses and residence within the studied area for less than 10 years prior to the study.

Parents were informed about the aims and performance of the study and the research was approved by the Regional School Authorities of Niš (Serbian Ministry of Education). The parents agreed with involvement of their children in the study and were requested to complete fill in a standardized questionnaire. Data regarding demographic characteristics, parents' smoking habits, parents' education level, density of habitation (number of people living in one room), mold presentation in home and mode of heating were collected.

Outdoor air pollutants were monitored during the ten- year period. The concentrations of black smoke, nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) were determined in twenty-four–hour samples of air collected. Sampling equipment was placed at 1.5 m above floor level at two sampling sites near the school buildings. The sampling sites were selected to ensure diversity regarding the outdoor environment. The ambient level of black smoke concentrations was measured by reflection. Sampling was performed by means of a pump operating with a flow rate of 1 L/min through Whattman No1 paper filters. At the same time, the air concentration of sulfur dioxide was measured by bubbling a certain volume of air through a solution of potassium tetrachloromercurate [8]. The total volume of the air sample was determined from the flow rate and the sampling time. The concentration of sulfur dioxide in the ambient air was calculated and expressed in μg/m3. The lowest limit of detection was 1.7 μg/m3. Ambient nitrogen dioxide was collected with a pump containing triethanolamine in its tube with the exact amount of the reacted nitrogen dioxide using the standard spectrophotometry [8,9]. The minimum detectable limit of the method had been determined to be 2.0 μg/m3. Lead in sediment matter was collected with absorbed solution of sulfur acid and was detected by graphic furnace atomic absorption spectrometry. The lowest limit of detection was 0.5 μg/m3.

A statistical package SPSS 10.0 was used for data analysis. Descriptive statistics was computed for all variables. Mantel-Haenszel chi-square test was used to compare frequencies of categorical variables between two groups. Student's t test was used to compare values of non-categorical variables. Statistical significance was set at a level of 0.05.

3. RESULTS

Baseline characteristics of study population are reported in Table 1. There were no statistically significant differences in age between the two group of pupils.

Table 1 Distribution of the children by gender and age*

Characteristics of children	Total n=354	Exposed n=215	Non-exposed n=139
Male/Female, n	174/180	101/114	73/66
Age,yr (mean ±SD)	12.96 ± 1.54	12.78 ± 1.56	12.95 ± 1.52
11 yr, n (%)	109 (30.8)	60 (27.9)	49 (35.2)
12 yr, n (%)	107 (30.2)	54 (25.1)	53 (38.1)
13 yr, n (%)	79 (22.3)	55 (25.6)	24 (17.3)
14 yr, n (%)	59 (16.7)	46 (21.4)	13 (9.4)

*no statistically significant differences between the two investigated groups

Also, there were no statistically significant differences in parents' smoking habits, parental education level, density of habitation, wood or coal heating between the two groups (table 2).

Table 2 Characteristics of examined children

Home environment	Exposed (n=215)	Non-exposed (n=139)	Significance
Parental education level			
Elementary	15%	31%	n.s.
Above elementary	85%	69%	
Parental smoking habit			
YES	43%	45%	n.s
Density of habitation (mean ± SD)	0.82 ± 0.32	0.88 ± 0.29	n.s.
Wood or coal heating	20.0%	15.8%	n.s.

*n.s. no statistically significant

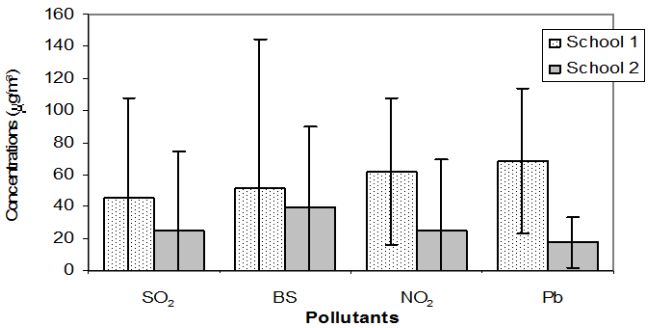

Fig. 1 Levels of air pollution in Niš between 1990-2000

The results of air pollution measurements are summarized in Figure 1. All concentrations of the air pollutants measured during the ten-year investigated period at the location in School 1 were higher when compared to the concentrations of the same pollutants measured

at the location in School 2. The differences between average annual values for all the air pollutants between two measuring sites were statistically significant for the level < 0.05. The average concentrations of monitored outdoor air pollutants are below those in current WHO guidelines.

The family history of atopy was also investigated among children and there was no statistically significant difference among two groups of investigated pupils ($\chi^2 = 0.01 < \chi^2$ (1 and 0.05) = 3.841, $p > 0.05$).

Table 3 Long-term exposure to air pollution and asthma among children between 11 to 14 years

Exposure	Children with asthma		Children without asthma (number)	Total
	number	%		
Yes	17	7,97	198	215
No	8	5,0	131	139
Total	25	6,2	329	354

In the group of children exposed to higher levels of air pollutants, almost 8% are with asthma. In school 2, the percentage of children with asthma were lower (5%) and the chi-square ($\chi^2 = 0.720 < \chi^2$ (1 and 0.05) = 3.841 and $p > 0.05$) test confirms that there is a significant difference in the frequency of asthma in children exposed to higher concentration of air pollution compared to those exposed to lower concentrations. The value of relative risk are more than 1 (R.R. = 1,38; odds ratio 1,4)

At the same time, upper respiratory symptoms: $\chi^2 = 7.8 > \chi^2$ (1 and 0.01) = 6.635, $p < 0.01$, as well as lower respiratory symptoms $\chi^2 = 0.02 < \chi^2$ (1 and 0.05) = 3.841, $p < 0.05$, were highly presented in exposed group of children.

4. DISCUSSION

During early childhood, respiratory system is still developing. This results in greater permeability of the epithelial layer in young children and they are also more susceptible than healthy adults to air pollutants. Moreover, exposure to air pollution in childhood is a special concern because their immune system is immature.

The results of the presented investigation show that even relatively low levels of air pollution, after long-term exposure, correspond positively to the occurrence of asthma in urban children. Taking into account that there are cities in Serbia with measured air pollutant levels higher than in the city of Niš [10], it would be useful to conduct similar epidemiological studies in these cities, too.

Asthma is the most common chronic disease affecting children and adolescents. The prevalence of asthma in schoolchildren is 0–30% in different population groups. In recent decades, studies have confirmed an overall increase in their prevalence, although on a smaller scale than previously thought, showing a greater increase in the poorest countries, mainly from Africa, Latin America and parts of Asia [11]. This fact suggests that genetic predisposition alone is not the only indicator of susceptibility to these diseases, and that the gene–environment interaction probably plays a greater role.

The prevalence of active asthma in adolescents in Niš was about 8%, close to those of similar national study [12]. According to this study, in the 13 485 children from five

study centers who responded to the questionnaire, the prevalence for childhood asthma ranged from 2.5% to 9.8% and the prevalence of asthma was higher in school children in the urban and largest cities of Belgrade and Niš.

Further study is needed to disentangle this interaction and underlying mechanisms by which even low levels of urban air pollution have a negative impact on respiratory health. Air pollutants appear able to induce airway inflammation and increase morbidity in children. A better definition of mechanisms related to pollution-induced airway inflammation in asthmatic children is needed in order to find new clinical and therapeutic strategies for preventing the exacerbation of asthma. Moreover, reducing pollution-induced oxidative stress and consequent lung injury could decrease children's susceptibility to air pollution. In addition, epigenetics seems to have a role in the lung damage induced by air pollution. Finally, a number of epidemiological studies have demonstrated that exposure to common air pollutants plays a role in the susceptibility and severity of respiratory infections.

Preventive measures may include both exposure to allergens and adjuvant risk/protective factors and pharmacological treatment. These measures may address the general population, children at risk for development of atopic disease (high-risk infants), children with early symptoms of allergic disease or children with chronic disease.

5. CONCLUSION

In conclusion, our study shows positive relationships between long-term background concentrations of main urban air pollutants and an increased prevalence of asthma in schoolchildren. These results support the hypothesis that not only high peaks of air pollutants concentrations, but even a moderate increase in background air pollution might have an influence on childhood respiratory and allergic health. Physicians, parents, and policy makers all have a part to play in making asthma the controllable disease for children and adults.

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REFERENCES

1. Carlsen K. H. , Håland G., Hovland V., Lødrup Carlsen K. C. , Mowinckel P., Riiser A.(2014),Lung function trajectories from birth through puberty reflect asthma phenotypes with allergic comorbidity, The Journal of allergy and clinical immunology, 134(4), 917-923, 2014 .doi: 10.1016/j.jaci.2014.05.020.
2. Shaker M.(2014), New insights into the allergic march, Current Opinion in Pediatrics, 26(4), 516-520, 2014. doi: 10.1097/MOP.0000000000000120.
3. Melly S., Perkins L., Rohr A., Sinclair A.H., Spengler J., Tolsma D., Wyzga R. (2014), Childhood asthma acute primary care visits, traffic, and traffic-related pollutants, Journal of the Air & Waste Management Association, 64(5), 561-567, 2014.
4. Cai J., Chen R., Ha S., Kan H., Wang W., Xu X., Zhao A., Zhao J. MF. (2014), Acute effects of air pollution on asthma hospitalization in Shanghai, China, Environmental pollution., 191, 139-144, 2014.
5. Esposito S., Galeone C., Lelii M., Longhi B., Ascolese B., Senatore L., Prada E., Montinaro V., Malerba S., Patria MF., Principi N. (2014), Impact of air pollution on respiratory diseases in children with recurrent wheezing or asthma, BMC pulmonary medicine, 14, 130-138, 2014. doi: 10.1186/1471-2466-14-130.
6. Nikić D., Bogdanović D., Milosević Z., Nikolić M., Stanković A. (2008), Impact of air pollution on the rate of hospital admission of children with respiratory diseases, Vojnosanitetski Pregled, 65 (11), 814-819, 2008.

7. No authors listed. (2014), Controlling asthma, Lancet, 383 (9928): 1521, 2014.
8. Manual of Analytical methods, NIOSH, CDC, IV Edition1994.
9. Standard methods for examination water and wastewater, APHA, AWWA, WEF:Atlanta, 1998.
10. Serbula S.M., Antonijević M.M., Milosević N.M., Milić S.M., Milić A.A. (2010), Concentrations of particulate matter and arsenic in Bor (Serbia). Journal of Hazardous Materials, 181(1-3): 43-51, 2010. doi: 10.1016/j.jhazmat.2010.04.065.
11. Pearce N., Aït-Khaled N., Beasley R., Mallol J., Keil U., Mitchell E., Robertson C., ISAAC Phase Three Study Group. ISAAC Phase Three Study Group. (2007), Worldwide trends in prevalence of asthma symptoms: Phase III of the International Study of Asthma and Allergies in Childhood (ISAAC). Thorax, 62, 758-6, 2007.
12. Zivković Z., Vukašinović Z., Cerović S., Radulović S. , Zivanović S. , Panić E., Hadnadjev M., Adžović O. (2010), Prevalence of childhood asthma and allergies in Serbia and Montenegro, World Journal of Pediatrics, 6(40), 331-336, 2010. doi: 10.1007/s12519-010-0207-y.

DUGOTRAJNA IZLOŽENOST ZAGAĐUJUĆIM SUPSTANCAMA IZ VAZDUHA KAO FAKTOR RIZIKA ZA POJAVU ASTME KOD ŠKOLSKE DECE

Cij rada bio je utvrdjivanje povezanosti između dugogodišnje izloženosti aerozagadjenju i pojave astme kod dece. Ispitana su anketiranjem deca nepušači, uzrasta 11-14 godina, u Nišu (Srbija). Izložena grupa dece (N=215) pohadjala je školu koja je locirana u delu grada sa višim koncentracijama zagađujućih materija u vazduhu, dok su deca iz kontrolne grupe (N=139), pohadjala školu koja je locirana u delu grada sa nižim koncentracijama zagađujućih materija u vazduhu. Procena desetogodišnje izloženosti polutantima iz vazduha rađena je na osnovu merenja sadržaja sumpor-dioksida, azot dioksida, olova u sedimentu i čadji u vazduhu. Kod eksponirane dece prevalencija astme je bila statistički značajno veća u odnosu na eksponiranu grupu dece ($\chi 2=0,720$, $p>0,05$), a utvrđena je i statistički značajna razlika između eksponirane i neeksponirane grupe dece ($\chi 2=6,635$, $p < 0,01$). Zaključeno je da dugotrajna izloženost aerozagađenju utiče na povećanje prevalencije astme u detinjstvu, kao i relevantnih respiratornih simptoma.

Ključne reči: *izloženost zagađujućim materijama ,aerozagadjenje, astma, deca*