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AIR POLLUTION AS A RISK FACTOR FOR PNEUMONIA

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Abstract. *Air pollution has been shown to exacerbate respiratory diseases such as pneumonia. The aim of this research was to investigate the relationship between the longterm exposure to air pollution, as a risk factor, and the development of pneumonia in the population. The observed sample consisted of Niš citizens of different age groups who lived in the area with high concentrations of air pollutants (investigated group) such as the Square of the October Revolution, as well as the citizens of Niška Banja (control group) which is the zone with the lowest concentration of air pollution. The investigation was carried out in the Public Health Institute in Niš, in the period between 2000 and 2012. A sample of 500 participants from Niš and Niška Banja was split into three age groups: up to 25, between 26 and 50, and above 51. Modified WHO, British MRC and American Thoracis Society questionnaires were run among the investigated and contol population sample group. A significance test was performed using a Mantel-Haenszel chi square (χ^2) statistic. This test was used to check for a statistically significant difference in the prevalence of pneumonia between the investigated group and the control group across all age groups. The odds ratio (OR) and relative risk (RR) were determined. The statistical significance between measured concentrations in the air at observed measured spots was determined using the Student's t-test.*

The highest value of the chi square test was determined in the age group up to 25 (RR = 8,00, OR = 8,87, p<0,05), in the group 26-50 years RR = 4,83, OR = 6,66, p<0,05 and in the group above 51 years RR = 1.11, OR = 1,15, p>0,05.

The obtained results prove that the prevalence of pneumonia is significantly higher in the exposed population than in the non-exposed, especially among younger than 25 years old.

Key words: *air pollution, pneumonia*

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1. INTRODUCTION

Air is the most important need of our existence and its composition certainly affects the quality of life and health of people of all ages.

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution.

Air pollution is one of the most significant aspects of contamination of the living space of urban areas. The highest concentrations of air pollutants were measured in large cities and industrial centers [1, 2]. According to WHO data, urban outdoor air pollution is estimated to cause 1.3 million deaths worldwide per year.

Pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide [3, 4]. Outdoor and indoor air pollution causes respiratory and other diseases that can be fatal [5, 6].

Long-term exposure to air pollution, even to the normally low levels, can increase the risk of acute respiratory disease and lead to worsening of chronic obstructive pulmonary disease in the general population [7].

One of the first studies that showed an association between indoor air pollution and pneumonia in infants was done in 1968 [8].

Numerous studies have shown that prolonged exposure to higher levels of air pollution is significantly associated with the hospitalization of patients with community acquired pneumonia [9].

2. RESEARCH OBJECTIVE

The aim of this research is to investigate the potential relation between the long term exposure to air pollution as a risk factor and the development of pneumonia in the population.

3. MATERIALS AND METHODS

The investigated population sample in Niš has been chosen from different age groups and locations. Dwellers in the areas with high concentrations of pollutants in the air (the Square of the October Revolution) are called the investigated group, and citizens of Niška Banja, which represents a zone with the lowest concentration of pollutants in the air, are called the control group. The above mentioned residential area of Niš has similar urban characteristics - this is an area with intense traffic, without significant migrations of the population. On the other hand, Niška Banja (spa) is an area with very low traffic intensity and also without significant migrations of the population (Table 1).

Table 1 Observed population sample structure by age

Age (years)	Niš (the Square of the October Revolution)	Niška Banja	Total
Up to 25	80	80	160
26-50	90	90	180
above 51	80	80	160
Total	250	250	500

This research is based on a retrospective five-year air pollution study on the above mentioned observed areas. The air pollution was monitored during the period between 1996 and 2000 by observing the concentrations of SO_2 and soot in the air, in accordance with the Serbian Regulations on emission limit values [10]. Modified WHO, British MRC and America Thoracis Society questionnaires [11] were run among the investigated and the control population sample group. Statistics parameters such as arithmetic mean, median and standard deviation were employed in the assessment process. The existence of the statistically significant difference between the incidence of the exposed and diseased and the incidence of the non-exposed and non-diseased was tested using the Mantel-Haenszel chi-square test (χ^2). The odds ratio and relative risk were also determined. The statistical significance between measured concentrations in the air at observed measured spots were determined using the Student's t-test. The investigation was carried out at the Public Health Institute in Niš, in the period between 2000 and 2012.

4. Results

The results of air pollution by the common air pollutants SO_2 and soot at the places of measurement observed during the five-year period are given in Table 2.

Using the T-test statistic, it was proved that during those five years, there were statistically significantly higher average annual concentration of SO_2 and soot at investigated places of measurement compared to the control ones (Table 3).

Table 2 Annual concentrations of SO_2 and soot and in the air (μg/m^3) around the Square of the October Revolution (Niš) and Niška Banja

	SO_2								Soot							
	Niš				Niška Banja				Niš				Niška Banja			
Year	$\bar{x}$	C_{50}	C_{98}	% above GVI	$\bar{x}$	C_{50}	C_{98}	% above GVI	$\bar{x}$	C_{50}	C_{98}	% above GVI	$\bar{x}$	C_{50}	C_{98}	% above GVI
1996.	35	25	128	1.09	24	17	102	1.20	35	27	109	19.17	1	0	11	0
1997.	52	33	242	6.02	30	9	256	3.21	21	14	86	6.30	1	0	7	0.36
1998.	19	15	64	-	7	0	45	0	24	16	101	10.13	1	0	12	0.30
1999.	12	8	46	-	8	6	25	0	37	28	137	14.79	2	0	15	0
2000.	10	8	32	-	2	1	18	0	41	26	179	22.19	0	0	9	0

Table 3 Statistically significant difference between average annual concentrations of SO_2 and soot at investigated places of measurement

	SO_2			Soot		
Year	Niš	Niška Banja	p	Niš	Niška Banja	p
1996.	35	24	<0.001	35	1	<0.001
1997.	52	30	<0.001	21	1	<0.001
1998.	19	7	<0.001	24	1	<0.001
1999.	12	8	>0.05	37	2	<0.001
2000.	10	2	<0.001	41	0	<0.001

Taking into account the statistically significant difference between average annual concentrations of all air pollutants, the observed places of measurements were found to be appropriate for tackling chronical effects of air contaminants on the health of the population exposed to them.

The results obtained by investigating the exposure to air pollution and the prevalence of pneumonia in the observed population are shown in Table 4.

Table 4 Exposure to risk factors from polluted air and the development of pneumonia in the population of all ages

Age (years)	Up to 25				26-50				Above 51			
Exposure	Diseased		Healthy		Diseased		Healthy		Diseased		Healthy	
	number	%	number	%	Number	%	number	%	number	%	number	%
Yes	8	10,00	72	90,00	29	32,22	61	67,78	20	25,00	60	75,00
Ne	1	1,25	79	98,75	6	6,67	84	93,33	18	22,50	62	77,50
Total	9	5,63	151	94,37	35	19,44	145	80,56	38	23,75	122	76,25

Using the chi square statistic, the significant difference between the prevalence of pneumonia in the exposed population compared to the non-exposed was obtained. The term non-exposed refers to the population exposed to very low concentrations of air pollutants (Table 5).

Table 5 Statistical significance of the difference in development of pneumonia

Age (years)	χ^2	RR	OR	p
Up to 25	4,24	8,00 0,63<RR<6,36	8,87 1,07<OR<191,68	<0.05
26-50	17,17	4,83 2,11<RR<11,07	6,66 2,44<OR<19,14	<0.05
Above 51	0,03	1,11 0,64<RR<1,94	1,15 0,52<OR<2,53	>0.05

The results concerning exposure to other risk factors are given in Table 6.

Table 6 Statistical significance of the difference in the exposure to other risk factors

Risk Factors	χ^2	p
Hazardous materials at work place	2.35 $< \chi^2_{(1\ i\ 0.05)} = 3.841$	> 0.05
Indoor smoking	0.92 $< \chi^2_{(1\ i\ 0.05)} = 3.841$	> 0.05
Driving a motor vehicle	3.20 $< \chi^2_{(1\ i\ 0.05)} = 3.841$	> 0.05
Heating with wood or coal	2.05 $< \chi^2_{(1\ i\ 0.05)} = 3.841$	> 0.05
Living room positioned near to the crossroads	2.90 $< \chi^2_{(1\ i\ 0.05)} = 3.841$	> 0.05
Hereditary predisposition	0.01 $< \chi^2_{(1\ i\ 0.05)} = 3.841$	> 0.05

5. Discussion and Conclusions

Based on the average annual concentrations of the percentile values of C_{50} and C_{98}, it can be said that the population in Niš (Square of the October Revolution) has been exposed to the moderately high concentrations of the observed pollutants. As opposed to them, the inhabitants of Niška Banja were exposed to significantly lower concentrations of air pollutants.

Since research shows that long-term exposure of the population can have a significant impact on the occurrence of respiratory infections, we examined the effect of air pollution on the population in the period 2000-2012, and displayed the results of air pollution in the past due period (1996-2000) to show that the population had been exposed to air pollution for years. Otherwise, this trend of air pollution values continued in the period after 2000, as evidenced by the reports of the Public Health Institute in Niš, which are publicly available on the official site of the Institute.

It is known that even small increases in the average annual concentrations of air pollutants (for soot only $10\mu g/m^3$) can cause health problems despite the fact that there is no sufficient evidence that these concentration have been above their limit values [12].

These results are in compliance with the results of similar studies in the literature. The study from [9] Canada, points to the fact that long-term exposure to higher levels of nitrogen dioxide and fine particulate matter (PM 2.5) was significantly associated with hospitalization of patients with community-acquired pneumonia (odds ratio (OR), 2.30; 95% confidence interval (CI), 1.25 to 4.21; $p = 0.007$ and OR, 2.26; 95% CI, 1.20 to 4.24; $p = 0.012$, respectively, over the 5^{th} to 95^{th} percentile range increase of exposure. Sulfur dioxide did not appear to have any association (OR, 0.97; 95% CI, 0.59 to 1.61; $p = 0.918$). In our study, statistically significant link between air pollution and pneumonia in the elderly (above 51) has not been proven. Our study, as well as other research, confirmed the fact that the youngest were the most sensitive to air pollution. It seems that the relative risks are likely to be significant for the exposures considered here. Since acute lower respiratory infection is the leading cause of death in children in less developed countries, and exacts a larger burden of disease than any other disease category for the world population, even small additional risks due to such a ubiquitous exposure as air pollution have important public health implications. In the case of indoor air pollution in households using biomass fuels, the risks also seem to be fairly strong, presumably because of the high daily concentrations of pollutants found in such settings and the large amount of time young children spend with their mothers doing household cooking. Given the large vulnerable populations at risk, there is an urgent need to conduct randomized trials to increase confidence in the cause-effect relationship, to quantify the risk more precisely, to determine the degree of reduction in exposure required to significantly improve health, and to establish the effectiveness of interventions [13]. Reduction of indoor air pollution exposure from solid fuel use is a potentially important intervention for childhood pneumonia prevention [14, 15].

For adults, a more immediate predisposition to pneumococcal pneumonia and bacteremia because of viral infection or air pollution was suggested [16].

Based on the results, it can be concluded that long-term exposure to pollutants in the air adversely affects the health of the population and is a risk factor for development of pneumonia.

The results of research can contribute to laying the foundation for controlling and managing the health risks of air pollutants in exposed population.

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AEROZAGAĐENJE KAO FAKTOR RIZIKA ZA NASTANAK PNEUMONIJE

Aerozagađenje može uticati na pogoršanje respiratornih bolesti kao što je pneumonija. Cilj istraživanja bio je utvrđivanje međuzavisnosti između dugogodišnje izloženosti aerozagađenju, kao faktoru rizika i pojave pneumonije kod eksponiranog stanovništva. Ispitanici su bili stanovnici Niša, svih uzrastnih kategorija, koji žive u zoni sa visokim koncentracijama zagađujućih materija u vazduhu (Trg Oktobarske revolucije)– ispitivana grupa, kao i stanovnici Niške Banje (najčistije zone Niša), takođe svih uzrastnih kategorija – kontrolna grupa. Istraživanje je urađeno u Institutu za javno zdravlje u Nišu u periodu između 2000 i 2012. god. Uzorak od 500 ispitanika iz Niša i Niške Banje bio je podeljen u tri uzrastne grupe: do 25, između 26 i 50 i iznad 51 god. Kod stanovnika ispitivane i kontrolne grupe izvršeno je anketiranje po modifikovanoj anketi WHO, British MRC i American Thoracis. Postojanje statistički signifikantne razlike u oboljevanju od pneumonije između ispitivane i kontrolne grupe i to u svim uzrastnim kategorijama testirano je

Mantel-Hanszel-ovim χ^2 testom. Utvrđen je unakrsni i relativni rizik. Statistička značajnost između izmerenih koncentracija polutanata u vazduhu na ispitanim mernim mestima utvrđena je Studentovim t-testom.

Najveće vrednosti χ^2 testa utvrđene su u uzrastnoj grupi do 25godina (RR = 8,00, OR = 8,87, p<0,05), dok je u grupi 26-50 godina RR = 4,83, OR = 6,66, p<0,05, a u grupi iznad 51 god RR = 1.11, OR = 1,15, p > 0,05.

Dobijeni rezultati ukazuju da je prevalenca pneumonije značajno veća kod eksponirane populacije u odnosu na neeksponiranu, posebno kod mlađih od 25 godina.

Ključne reči: *aerozagađenje, pneumonia*