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ANALYSIS OF THE IMPACT OF LONG-TERM EXPOSURE TO AIR POLLUTION ON WOMEN'S HEALTH IN NIS (SERBIA)

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Abstract. *The aim of this study was to investigate the impact of long-term exposure to air pollution on women's health through the analysis of studies dealing with this problem in Niš (Serbia). This chapter provides an overview of the methodology used in the studies carried out in the city of Nis. We analyzed the period of long-term exposure to air pollution, air pollution exposure measures, type of pollutants, study population and its characteristics and the criteria for specific health effects which had been investigated. The studies included in this paper have shown that long-term exposure of women to low concentration of outdoor air pollutant is associated with prevalence of respiratory symptoms and diseases. Also, the results suggest that long term exposure before pregnancy to relatively low levels of some air pollutants is not associated with a pregnancy-induced hypertension but is strongly associated with anemia.*

Key words: *air pollution, women, pregnant women, health*

1. INTRODUCTION

Health and environmental problems which occur due to all human activities in the area are often connected with air pollution, either as a greater or lesser extent changes in the normal composition of air. Direct effects of human exposure to air pollutants occur in the respiratory tract, and after absorption through the blood, they could enter to other organs, where it can also sustain injury [8,12].

Health effects that occur at the same time can be acute or chronic, depending on the amount of pollutant concentration, duration of exposure, and the person's current health status, as well as of the meteorological conditions, etc. Health effects of these pollutants are provided by laboratory testing (animal and volunteers), as well as a number of epidemiological studies. The results of these tests are not completely reliable for a number of reasons (different degree of sensitivity of individuals of the same or different

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species of animals, exposure conditions, test methods, etc.). Epidemiological studies provide much more specific information than laboratory testing [11].

Of the population, which includes children, pregnant women, the elderly and the chronically ill people, especially sensitive to high concentrations of pollutants in the air, long-term exposure to low concentrations can impair their health. Also, long-term exposure to air pollution, especially in people who live in the most polluted towns, reduces life expectancy [6,7].

General health of the female population is an essential question and essential condition for the quality of life of women. Health status of women is further endangered by pregnancy, childbirth, motherhood, on the one hand and economic dependence and inadequate measures of health and safety at work, in traffic and at home, on the other hand.

The aim of this study was to investigate the impact of long-term exposure to air pollution on women's health through analysis of studies dealing with this problem in Niš (Serbia).

2. METHODS

This chapter provides an overview of the methodology used in the studies carried out in the city of Nis.

Study area. The studies were conducted in the city of Niš, situated in the south of Serbia. In 2011, Niš had a population of 381.757 inhabitants in an area of 596.71 m^2. Dominant air pollution source is traffic.

Air pollution exposure measures. Monitoring of air pollution was carried out at the Institute of Public Health in Nis in all studies. Outdoor air pollutants were monitored during a five-year period. The pollutants were measured daily, during the whole year in and out of heating season, at two measuring points. First measuring point in Nis (Knjeginje Ljubice Square) was located in the center of town, and the second measuring point is in Niska Banja in the peripheral area of the town. Long lasting examinations in Institute for Public Health Niš have shown that the quoted measured sites were significantly different from high concentration of measured pollutants so they have been chosen for this studies. The concentrations of black smoke (BS), sulfur dioxide (SO_2) and lead (Pb) in sediment matter were determined in twenty-four hour's samples of air.

Sampling equipment was placed at 1.5 m above floor level at two sampling sites. The sampling sites were selected to ensure diversity in terms of the outdoor environment.

The ambient level of black smoke concentrations was measured by reflectance. The sampling was performed by means of a pump operating with flow rate of 1 L/min through Whattman No1 paper filters. At the same time, the air concentration of sulfur dioxide is measured. The measured volume of air was bubbled through a solution of potassium tetrachloromercurate. The sulfur dioxide present in the air stream reacts with the solution to form a stable monochlorosulfonatomercurate complex. During the subsequent analysis, this complex is brought into reaction with acid-bleached pararosaniline dye and formaldehyde yielding intensely colored pararosaniline methyl sulfonic acid. The optical density of this species is determined spectrophotometrically at 548 nm and was directly related to the amount of sulfur dioxide collected. 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 is 1.7 $\mu g/m^3$.

Lead in sediment matter was collected with absorbed solution of sulfur acid and is detected by graphic furnace atomic absorption spectrometry. The lowest limit of detection was 0.5 µg/m3.

The ratio of air pollutants was determined and commented upon in accordance with the Regulation of Guideline Values of Emission (Official Gazette of the Republic of Serbia No. 54/92).

The Air Quality Index for sulphur dioxide and black smoke was calculated as recommended by European Commission, by using emission marginal values and average yearly concentrations. The five AQI categories are used for air quality description: values <0.4 is ”good“, 0.4-0.6 is ”moderate“, 0.6-0.8 is ”unhealthy for sensitive groups“, 0.8-1.0 is „unhealthy“ and value >1.0 is ”very unhealthy“.

Study population. Two studies have included more than 650 women, aged 20 to 40 years, from two areas with different levels of common outdoor air pollutants. One group lived in residential area, whereas another group lived in suburban area. Women of both groups were no smokers and they were not professionally exposed to air pollution. They had lived for at least five years on those locations, at the distance of 1km from measured place.

The other two studies included over 300 pregnant women, aged 20 to 30 years, divided into two groups on the basis of the exposure to air pollution. Pregnant women of both groups had been fully healthy before gravidity, nonsmokers, and they were not professionally exposed to harmful materials. All subjects had been living more than five years in the same location, living at the distance about of 25 km from air monitoring station. All of pregnant women were in early pregnancy All of these pregnant women were enrolled in early pregnancy (gestational age <10 weeks). Data on pregnancy were collected on the basis of physical examinations, fetal ultrasounds and hospital registrations. The subjects were of the same ethnicity and were not alcohol consumers.

Data on age, educational level, parity, passive smoking, and genetic predisposition were collected by an interview. They had been informed about the aims of the study, the performance and the expected results of the study.

Health effects. Studies have dealt with the investigation of the impact of long-term exposure to air pollution on the occurrence of respiratory symptoms and diseases, anemia and high blood pressure.

The data of the women's prevalence of respiratory symptoms in the last 12-month period of life and lifetime prevalence of respiratory illnesses as diagnosed by their doctors were obtained through questionnaires. Training physicians filled out questionnaires during the interview with women. The questionnaire was adapted from the American Thoracic Society questionnaires adjusted for Serbian language [3]. Respiratory symptoms were defined based on yes/no responses to the questions about the symptoms stated in the questionnaire.

Blood pressure was measured at each trimester of pregnancy in the Gynecological and Obstetrics Clinic, Niš (Serbia). Pregnancy-induced hypertension is defined according to criteria described by the International Society for the Study of Hypertension in Pregnancy (ISSHP): development of systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg without proteinuria after 20 weeks of gestation in previously normotensive women [2].

Venous blood was analyzed in the laboratory of Primary Health Care Center Niš. Anemia in pregnancy has been defined by criteria from the Centers of Disease Control and Prevention. Hemoglobin Hb level should be less than 11g per dL during the first and third trimesters and less than 10.5g per dL during the second trimester, and the values of hematocrit Ht <34%.

Statistical methods. Statistical analysis has been performed on a computer, according to the standard principles of descriptive and analytical statistical methodology, using standard programs for processing data such as Excel and software package SPSS in version 10.0. The comparison between the frequency of modality and occurrence of the tested characteristics has been performed by nonparametric Pearson chi-squared test. Comparison of the average values is done by t-test. Testing of correlation of individual characteristics is performed by regression analysis (SPSS), which determines the type and the strength between the tested characteristics.

3. RESULTS

Considering the results of the analyzed studies, it can be seen that the average annual concentrations of sulfur dioxide, black smoke and lead in sediment matter at both measuring locations do not show higher concentrations than allowed maximums in the corresponding year according to the Regulation Book of Serbia. The average pollutant levels also remained below the current WHO Guidelines. However, one should notice that both measured pollutant values in suburban area are significantly lower in reference to the same measured values in residential area (Table 1). Differences between average annual values for all pollutants are statistically significant for the level $p < 0{,}01$.

Table 1 Pollutant concentration in Niš and Niška Banja during 1998 – 2008 period

Measure station	Pollutant	$\bar{X}$	SD	C_{50}	C_{98}	Min	Max
Knjeginje	SO_2 ($\mu g/m^3$)	17.95	11.13	13.4	31.6	0	86.8
Ljubice	BS ($\mu g/m^3$)	37.31	26.91	25.5	144	0	227
Square	Pb ($\mu g/m^2$)	66.17	24.51	37.9	-	4.1	81.84
	SO_2	8.48	11.82	2.7	26.0	0	41.8
Niška Banja	BS	3.29	4.95	0	19.9	0	29.8
	Pb	27.91	21.59	12.3	-	0	79.54

Table 2 shows AQI2 variation in Niš and Niška Banja. In Niška Banja, the index values were always „good", while in Niš, the index values were „unhealthy" and „very unhealthy".

Table 2 The quality of air in Niš and Niška Banja in terms of air quality index values (AQI2)

Year	Knjeginje Ljubice Square		Niška Banja	
	AQI2	Air quality	AQI2	Air quality
1998	0.86	Unhealthy	0.26	Good
1999	0.98	Unhealthy	0.34	Good
2000	1.02	Unhealthy	0.07	Good
2001	1.08	Very Unhealthy	0.16	Good
2002	1.12	Very Unhealthy	0.17	Good
2003	0.52	Moderate	0.07	Good

In the period between 1998 and 2008, several epidemiological studies were performed in the city of Niš. The aim of these studies was to monitor prevalence of lower and upper respiratory symptoms, lower and upper respiratory illnesses and prevalence of anemia and high blood pressure (Table 3).

The studies showed statistically significant higher frequency of anemia, respiratory symptoms and illnesses inhabitants living in the city area with AQI2 values over 1.

Table 3 Main characteristics of epidemiological studies in Niš

Population	Outcome	OR	95%CI	χ^2	p	Pollutants included in studies	Year of investigation; no. of participants (references)
Women	Cough with cold	2.10	1.04 - 4.25	5.13	0.023*	SO_2, BS	1999-2003;663
	Cough apart from cold	1.26	0.67 - 2.37	0.58	0.466		
	Cough longer than 3 months	1.16	0.63 - 2.13	1.14	0.286		
	Phlegm	3.48	1.38 - 9.02	3.60	0.038*		
	Fit of coughing	1.12	0.63 - 2.40	0.20	0.657		
	Breath with difficulty	1.42	0.60 - 2.70	0.63	0.428		
	Wheezing	1.27	0.61 - 2.87	0.51	0.474		
Women	Sinus trouble	1.43	0.95 - 2.15	3.2	0.213	SO_2, BS	2000-2004; 653
	Bronchitis	1.66	1.23 - 2.23	11.89	0.022*		
	Pneumonia	1.18	0.83 - 1.67	0.9	0.521		
	Asthma	1.35	0.98 - 1.84	3.74	0.674		
Pregnant women	Anemia	2.32	1.02 -.4.53	11.18	0.038*	SO_2, BS, Pb	1998.- 2002;327
Pregnant women	High blood pressure	1.44	0.94 - 24		0.325	SO_2, BS, Pb	2004 - 2008; 654

* statistical significance

4. DISCUSSION

The previous researches in the world follow the acute exposure of people to the high concentrations of pollutants in the air. It has been discovered that being acute exposed to the air pollutants can provoke higher incidence of symptoms and diseases of the respiratory system. Also, it has been assumed that being chronically exposed to air pollution can provoke symptoms and diseases of the respiratory system because of lung functions` disorder.

Fine particulate air pollution is a risk factor for cause-specific cardiovascular disease mortality via mechanisms that likely include pulmonary and systemic inflammation, accelerated atherosclerosis, and altered cardiac autonomic function [9].

Long-term exposure to combustion-related fine particulate air pollution is an important environmental risk factor for cardiopulmonary and lung cancer mortality [5,10].

The overall epidemiological evidence suggests that adverse health effects are dependent on both exposure concentrations and length of exposure, and that long-term exposures have larger, more persistent cumulative effects than short-term exposures [1]. Although proximity in time matters, with most recent exposure having the largest health impact, there is evidence that the short-term exposure studies capture only a small amount of the overall health effects of long-term repeated exposure to PM.

The effects of air pollution on red blood cells have been investigated mostly on children. Anemia in pregnancy may be initiated by numerous integrated risk factors, and air pollution can quite clearly be one of the reasons for their occurrence.

The study of tested pregnant women exposed to air pollution revealed the relation between the frequency of anemia during pregnancy and the exposure to concentrations of certain air pollutants. However, these subjects live more than five years in the same place and the long term exposure to air pollutants had influence on occurrence of anemia. Naturally, other factors (genetic dispositions, nutrition habits, etc.) contributed to the described low concentrations of hemoglobin and hematocrit.

One study has not shown that long-term exposure to air pollution positively corresponds to the occurrence of high blood pressure among pregnant women. The study has several limitations. First, the study did not examine the relationship between pregravid body mass index (BMI) and the development of hypertensive disorders of pregnancy. Second, the study could not control lipid level of pregnant women. Throughout the study, it is not examined how other factors such as population density, household income and life stiles in two different locations affect our two examined groups. Another limitation is that there is a possibility of the different concentration of air pollutants even in the same location. For example, the examined women living in the city of Nis close to a road may have very high air pollution levels, whereas women living further away may have low levels of air pollution.

In adults, the evidence for long-term air pollution effects is mostly based on cross-sectional comparisons. These limit the comparability of studies and impede quantitative summaries. New studies should use individual-level exposure assessment to clarify the role of traffic and to preclude potential community-level confounding. Further research is needed on the relevance of specific pollution sources, particularly with regard to susceptible populations and relevant exposure periods throughout life [4].

5. CONCLUSION

Based on the analysis of the studies that followed the impact of long-term exposure to air pollution on health in the city of Nis it can be concluded that air pollution monitoring is very important in making assessments of the exposure of the population. The studies included in this paper have shown that among women long-term exposure to low concentration of outdoor air pollutant is associated with prevalence of respiratory symptoms and diseases. Also, the results suggest that long term exposure before pregnancy to relatively low levels of some air pollutants was not associated with a pregnancy-induced hypertension but is strongly associated with anemia.

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ANALIZA UTICAJA DUGOTRAJNE IZLOŽENOSTI ZAGAĐENJA VAZDUHA NA ZDRAVLJE ŽENA U NIŠU (SRBIJA)

Cilj ovog rada je bio da se ispita uticaj dugotrajne izloženosti zagađenju vazduha na zdravlje žena kroz analizu studija koje se bave ovim problemom u gradu Nišu (Srbija). Ovo poglavlje daje pregled metodologije koja se koristi u studijama koje su sprovedene u gradu Nišu. Analizirali smo period dugotrajne izloženosti zagađenju vazduha, metode merenja zagađujućih materija u vazduhu, vrste polutanata, ispitanike i njihove karakteristike i kriterijumima za specifične zdravstvene efekte koji su istraživani. Studije uključene u ovom radu pokazali su da među ženama dugotrajna izloženost niskim koncentracija zagađiujućim materija iz vazduha je povezana sa prevalencom respiratornih simptoma i bolesti. Takođe, rezultati sugerišu da dugotrajno izlaganje polutantima iz vazduha pre nije bio povezan sa porastom krvnog pritiska u trudnoći ali je značajno bio povezan sa nastankom anemije.

Ključne reči: *aerozagađenje, žene, trudnice, zdravlje*