AIR POLLUTION AND RESPIRATORY SYMPTOMS IN THE FEMALE POPULATION

ONESNAŽENOST ZRAKA IN SIMPTOMI V DIHALIH PRI ŽENSKI POPULACIJI

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Abstract

The objective of the study was to examine the relationship between the exposure to outdoor and indoor air pollutants and respiratory health of women. Outdoor concentrations of sulphur dioxide and black smoke were studied during the period 2000 –2004, in residential and suburban areas of the city of Niš, Serbia. The study population comprised 653 women, aged 33.87± 3.0 years. Data on respiratory symptoms, diseases and exposure to indoor air pollutants (passive smoking and smoke of combustion products) were collected using a questionnaire. Women living in the residential area showed a significantly higher prevalence of all respiratory symptoms. Also, a positive correlation was found between cough, congestion and bronchitis, and exposure to passive smoking. There was no statistical difference in respiratory symptoms between women exposed to combustion products compared to unexposed women.

Key words: air pollution, respiratory symptoms, respiratory diseases, women

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Izvleček

V raziskavi so želeli ugotoviti povezanost med onesnaženostjo zunanjega in notranjega zraka in boleznimi dihal pri ženskah. V obdobju od 2000 do 2004 so merili koncentracije žveplovega dioksida in črnega dima v zraku, in sicer v stanovanjskem in v predmestnem predelu Niša v Srbiji. V študijo je bilo zajetih 653 žensk, starih 33.87± 3.0 let. Podatke o simptomih in boleznih dihal ter o izpostavljenosti onesnaževalcem v zunanjem in notranjem zraku (tobačni dim, pasivno kajenje in dim iz gorljivih materialov) so zbirali s pomočjo vprašalnika. Pri ženskah v stanovanjski soseski so ugotovili statistično značilno večjo pogostnost simptomov v dihalih. Našli so tudi pozitivno korelacijo med pojavi kašlja, kongestije in bronhitisa in pasivnim kajenjem. Pri ženskah, izpostavljenih dimu gorljivih materialov, niso ugotovili statistično značilno več dihalnih težav kot pri ženskah, ki temu dimu niso izpostavljene.

Ključne besede: onesnaženost zraka, simptomi in bolezni dihal, ženska populacija

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Introduction

Air pollution has become a major concern worldwide because of its hazardous effects on human health (1). Traffic, industry and heating are the major sources of air pollution in towns. Among many natural and anthropogenic sources of air pollution, the combustion of fossil fuels is a major contributor in urban and industrial societies. People living in urban areas are permanently exposed to some level of pollutants.

The respiratory system is the primary target of air pollutants, which most frequently enter human organism through inhalation. The level of their penetration in the lungs and their remaining in the place of potential damage depend on their physical and chemical characteristics (2). Water-soluble pollutants are completely extracted in the upper respiratory tract in contrast to poorly soluble pollutants which enter the respiratory ways and alveoli to a lesser extent.

The mechanisms by which air pollutants damage the lungs are not yet completely clear, and could be roughly divided into acute irritation and inflammation, chronic inflammation with fibrous response to some agents, challenge of immune response and cancer genesis (3,4).

Health consequences of air pollution are either acute or chronic, depending on the pollutant concentration, meteorological conditions, duration of exposure to pollutants (long-term and short-term) and health condition.

Studies conducted in a wide range of cities with different levels of air pollution have reported increase in the rate of mortality and morbidity from different causes and in various age groups (5,6). Air pollution-related diseases are the most important cause of respiratory morbidity and mortality in adults. There are also indications that health effects of air pollution are stronger in sensitive population groups, such as children, women and persons with chronic diseases (7).

Sources of indoor air pollution with constant or periodical emission of pollutants can be found in any home. They differ from outdoor pollutants in their concentration, which is sometimes significantly higher.

Whether the concentration of the emitted indoor pollutants increases or decreases depends on the type of the pollutant, its character, store of its source, mechanism of spontaneous evolution, and frequency of indoor ventilation, which is of a great importance if the emitted contaminating indoor substance is not reactive. The most common indoor pollutants include: sulphur dioxide, various solvents, tobacco smoke, carbon monoxide, radon, nitric oxides, formaldehyde and asbestos. In addition to these chemical pollutants, biological contaminants, such as mites, insects, spores of fungi and animals' allergens, are also found indoors (8).

People react differently to their exposure to indoor air pollutants. Their response depends on three important factors: age, health condition and sensitivity. Respiratory tract is the first to suffer if someone is exposed to indoor pollutants, which leads to the development of respiratory symptoms and diseases (9,10).

This study was undertaken to assess the prevalence of respiratory symptoms and diseases in women exposed to significantly different quantities of outdoor air pollutants. The main aim of the study was to determine the role of indoor air pollutants in the development of respiratory symptoms and conditions, which are not caused by exposure to outdoor air pollution.

Methods

Outdoor air pollutants were measured at two measuring sites in the city of Niš, one in the residential and another in the suburban area. The two sites were selected for the study because they differed significantly in concentrations of the pollutants determined by the Institute of Public Health.

Concentrations of the outdoor air pollutants sulphur dioxide and black smoke were measured 24 hours a day, during the period 2000 - 2004. Sampling was carried out by a specially trained personnel. Laboratory tests for sulphur dioxide and black smoke were done in accordance with the Regulations of Guideline Values of Emission (The Official Bulletin of the Republic of Serbia 54/92) (11).

Ambient levels of black smoke were measured by the reflectance of a sampled filter. The sampling was preformed using a pump operating at a flow rate of 1 L/min through Whattman type N°1 paper filters.

Air concentration of sulphur dioxide was determined simultaneously with that of black smoke. A measured volume of air was bubbled through the solution of potassium mercury tetrachloride. Sulphur dioxide present in the air stream reacted with the solution to form stable monochlorosulfo-

natomercurate.This complex was brought into reaction with acid-bleached pararosaniline dye and formaldehyde, yielding intensely coloured pararosaniline methyl sulphuric acid. Optical density was determined spectrophotometrically at 548 nm, and was directly related to the collected amount of sulphur dioxide. The total volume of air sample was determined from the flow rate and sampling time. The concentration of sulphur dioxide in the ambient air was computed and expressed in μg/m^3; the lower limit of detection was 1.7 μg/m^3.

This study included 653 women, aged 33.87± 3.0, living in two areas with different levels of common outdoor air pollutants sulphur dioxide and black smoke. One group (356) lived in a residential area, and another (197) in a suburban area. Women of both groups were not smokers and were not professionally exposed to air pollution. They had lived for at least five years at those locations, at a distance of one km from the measuring site.

A standard WHO questionnaire was used for the first part of the study (12). The questionnaires were completed by physicians during the interview with the women. The survey was conducted in May 2005. The questionnaire included questions about the prevalence of respiratory symptoms (cough related/ unrelated to cold, congestion and/or phlegm- related/ unrelated to cold, runny nose lasting longer than three mounts, wheezing and respiratory diseases (sinusitis, bronchitis, asthma, pneumonia), which had been diagnosed by physicians over the previous 12 months.

Exposure to indoor air pollution was assessed using the original questionnaire. Special emphasis was placed on the women's exposure to passive smoking and to smoke of combustion products. The questions concerning the exposure to smoke of combustion products were as follows: "Do you have central heating system in your home?", "Do you heat your living room?", "Which kind of heating material do you use?". Exposure to passive smoking was assessed on the basis of answers to the following questions: "Does anyone smoke in the house?" and "How many smokers live in the house?".

The collected data were processed using a software system. Data obtained through the interview were analysed using the Epiinfo 6.0 and Microsoft Excel statistical programmes. Statistically significant levels of the measured sulphur dioxide and black smoke were determined using the Student's t-test, and differences at $p<0.01$ were considered statistically significant. Statistical significance of the difference was established with the Pearson's chi-squared test. The odds ratio and a 95%-confidence interval were calculated to evaluate the association of respiratory symptoms and diseases in women with environmental variables.

Results

Outdoor air pollutants, sulphur dioxide and black smoke, were monitored at two measuring sites, one in the residential and another in the suburban area. The average annual concentrations of sulphur dioxide and black smoke at measuring locations did not exceed Serbia's maximum allowed concentrations for the corresponding year (50 ?g/m3). Also, the average levels of the pollutants remained below the current WHO guidelines. However, the values of both pollutants were significantly lower in the suburban area than in the residential area .

The t-test statistics showed significantly higher average annual concentrations of sulphur dioxide and black smoke at the residential area measuring location, as compared to values measured in the suburban area. Differences between average annual values were statistically significant for both pollutants ($p <0.01$) (Tables 1 and 2).

Table 3 indicates the rate of respiratory symptoms and diseases in the women studied. Women from the residential area had a higher prevalence of all respiratory symptoms than women living in the suburban area (10.35 to 89.54, 8.09 to 75.14, respectively).

Bronchitis was the only respiratory disease with a statistically higher prevalence among women from the residential area. No connection was found between high outdoor pollutant concentrations and occurrence of sinus problems, pneumonia and asthma. Our study showed no statistically significant relationship between exposure to smoke of combustion products and respiratory morbidity. Respiratory symptoms, especially cough and congestion and/ or phlegm related to cold, were more common among women exposed to passive smoking, (Table 4). Bronchitis was significantly more frequently diagnosed in women whose husbands smoked at home.

Table 1. Air concentrations of sulphur dioxide (μg/m^3) in two areas studied.
Tabela 1. Koncentracije žveplovega dioksida (μg/m^3) v zraku dveh preučevanih območij.

Year / Leto	No.of measurements / Št. meritev	Residential area / Stanovanjska soseska		Suburban area / Primestno območje		t	p
		Mean ± SD	Range	Mean ± SD	Range		
2000	302	12±17.15	0 - 89	7±12.23	0 - 75	9.962	P<0.01*
2001	232	10±12.09	0 -54	8±6.75	0-25	3.954	P<0.01*
2002	325	15±8.79	0 -70	2±4.42	0-30	14.690	P<0.01*
2003	336	23±8.63	0 -47	4±5.33	0-34	20.208	P<0.01*
2004	337	22±18.88	0 -113	6±6.29	0-50	16.576	P<0.01*

*statistically significant differences / statistično značilne razlike

Table 2. Air concentrations of black smoke (μg/m^3) in two areas studied.
Tabela 2. Koncentracije črnega dima (μg/m^3)v zraku dveh preučevanih območij.

Year / Leto	No. of measurements / Št.meritev	Residential area / Stanovanjski predel		Suburban area / Primestno območje		t	p
		Mean ± SD	Range	Mean ± SD	Range		
2000	302	37±26.58	0 -224	1±4.58	0 -73	15.072	p<0.01*
2001	232	41±33.06	0 -206	2±3.82	0 -15	15.837	p<0.01*
2002	325	39±39.78	0 -249	1±1.60	0 -11	17.947	p<0.01*
2003	336	33±30.07	4 -167	1±2.09	0 -18	22.241	p<0.01*
2004	337	34±30.54	0 -289	1±11,68	0 -14	18.526	p<0.01*

*statistically significant differences / statistično značilne razlike

Table 3. Prevalence of respiratory symptoms and diseases and exposure to outdoor air pollution.
Tabela 3. Pogostnost simptomov in bolezni v dihalih in izpostavljenost onesnaženemu zunanjemu zraku.

Respiratory symptoms and diseases / Respiratorni simptomi in obolenja	Prevalence / (%) Pogostnost		χ^2	Odds ratio / Razmerje obetov (95%CI)
	Residential area / Stanovanjski predel	Suburban area / Primestno območje		
Cough related to cold / Kašelj zaradi prehlada	89.54	75.14	6.64*	1.84 (1.21-3.13)
Cough unrelated to colds / Kašelj, ki ni povezan s prehladom	45.83	26.34	14.96*	4.49 (1.89-10.96)
Congestion and/ or phlegm related to cold / Kongestija in/ali sluz zaradi prehlada	27.69	8.09	10.46*	3.03 (1.62-10.08)
Congestion and/ or phlegm unrelated to cold / Kongestija in/ali sluz nepovezana s prehladom	28.80	16.21	12.30*	3.01 (1.53-5.97)
Runny nose for more than 3 months / Nahod več kot 3 mesece	22.11	15.62	6.80*	2.43 (1.17-5.08)
Wheezing / Hropenje	10.35	8.36	7.16*	2.58 (1.22-6.89)
Sinus problems / Težave s sinusi	48.49	42.67	1.00	0.02 (0.22-1.74)
Bronchitis / Bronhitis	47.63	38.57	9.26*	3.39 (1.40-8.90)
Pneumonia / Pljučnica	15.83	14.80	0.26	1.16 (0.63-2.13)
Asthma / Astma	8.94	7.43	3.28	0.17 (0.01-1.62)

* $p < 0.01$

Table 4. Exposure to indoor air pollution and the occurrence of respiratory symptoms and diseases.
Tabela 4. Izpostavljenost onesnaženemu notranjemu zraku in pojav simptomov in bolezni v dihalih.

Respiratory symptoms and diseases / Respiratorni simptomi in obolenja	Smoke of combustion products / Dim gorljivih materialov				Passive smoking / Pasivno kajenje			
	Exposed / Izpostavljenost n=250)	Not Exposed / Ni izpostavljenosti (n=403)	χ^2	Odds ratio / Razmerje obetov (95%CI)	Exposed / Izpostavljenost (n=526)	No exposed / Ni izpostavljenosti (n=127)	χ^2	Odds ratio / Razmerje obetov (95%CI)
Cough related to cold / Kašelj zaradi prehlada	19 (7.6%)	10 (2.5%)	3.01	2.01 (0.85 - 4.84)	23 (4.4%)	6 (4.7%)	6.71*	1.48 (1.09 - 2.01)
Cough unrelated to cold / Kašelj nepovezan s prehladom	17 (6.8%)	15 (3.7%)	1.65	1.18 (0.91 - 1.53)	18 (3.4%)	16 (12.6%)	0.01	1.02 (0.78 - 1.33)
Congestion and/ or phlegm related to cold / Kongestija in/ali sluz zaradi prehlada	31 (12.4%)	25 (6.2%)	3.30	2.00 (0.89 - 4.60)	38 (7.2%)	18 (14.1%)	6.44*	1.45 (1.08 - 1.95)
Congestion and/ or phlegm unrelated to cold / Kongestija in/ali sluz nepovezana s prehladom	15 (6.0%)	2 (0.5%)	0.59	1.15 (0.79 - 1.68)	8 (1,5%)	9 (7,1%)	0.32	1.1 (0.78 - 1.56)
Runny nose for more than 3 months / Nahod več kot 3 mesece	29 (11.6%)	18 (4.5%)	1.85	1.27 (0.89 - 1.81)	25 (4.7%)	22 (17.3%)	0.3	1.26 (0.53 - 3.08)
Wheezing / Hropenje	20 (8.0%)	11 (2.7%)	3.47	1.34 (0.97 - 1.84)	15 (2.8%)	16 (12.6%)	0.79	1.2 (0.79 - 1.83)
Sinus problems / Težave s sinusi	24 (9.6%)	10 (2.5%)	0.54	1.14 (0.86 - 1.68)	17 (3.2%)	17 (13.4%)	3.2	1.43 (0.95 - 2.15)
Bronchitis / Bronhitis	12 (4.8%)	9 (2.2%)	3.06	2.02 (0.85 - 4.84)	17 (3.2%)	4 (3.1%)	11.89*	1.66 (1.23 - 2.23)
Pneumonia / Pljučnica	9 (3.6%)	5 (1.2%)	1.84	1.22 (0.79 - 1.81)	8 (1.5%)	6 (4.7%)	0.9	1.18 (0.83 - 1.67)
Asthma / Astma	6 (2.4%)	5 (1,2%)	0.05	0.91 (0.39 - 2.21	7 (1.3%)	4 (3.1%)	3.74	1.35 (0.98 - 1.84)

* $p<0.05$

Discussion

The respiratory system, which is most exposed to negative influence of air pollutants, has various defensive mechanisms which prevent or alleviate their harmful effects.

The most important defensive mechanisms of the respiratory tract are cleaning and filtrating air by upper bronchial tubes, bronchial secretion of immunoglobin, lysosomes, sneezing and coughing reflexes and antioxidants in the mucus covering the lung's surface.

Acute exposure of people to high concentrations of pollutants in the air has been investigated in previous studies (13,14). It was established that acute exposure to air pollution can increase the incidence of respiratory symptoms and diseases. There is less information about chronic effects of lower concentrations of pollutants (15). It is assumed that chronical exposure can be associated with respiratory symptoms and lung function disorders (16).

The concentration of sulphur dioxide and soot during the study did not exceed the legally allowed levels and the WHO reference values. The group of women exposed to low concentrations of sulphur dioxide had a statistically significant prevalence of some respiratory symptoms and diseases.

Studies done in Switzerland (17) confirmed this assertion and showed that particle concentrations of 10 - 53 ?g/m3 , which is considerably below the allowed limits, cause respiratory symptoms and reduce respiratory function. Forsberg and associates (18) confirmed a high risk for respiratory symptoms, such as cough, irritation of throat and nose, in individuals exposed to and average annual concentrations of sulphur dioxide of 2-16?g/m3. Researchers in Helsinki established that an increase of sulphur dioxide levels exceeding 21?g/m3 increases the rate of respiratory infections by 15 % (19).

Air pollution and the resulting chronic health problems are not related to the quality of outdoor air only, since human health is influenced by the quality of indoor air, too.

Our study of the impact of indoor air pollution on health and onset of respiratory symptoms and diseases was focused on two most important factors of indoor air pollution- heating and exposure to passive smoking.

The results showed that exposure to smoke released by wool and coal combustion is not responsible for the onset of respiratory symptoms and diseases.

Most (but not all) studies done worldwide confirmed the connection between exposure to smoke from fuel stores and respiratory morbidity. Holsein and associates (20) found no relationship between the form of heating and respiratory symptoms. Research conducted in the USA (21) revealed no positive correlation between the exposure to smoke of fuel stores and the occurrence of respiratory symptoms, asthma and allergic reactions. Other authors came to a similar conclusion (22, 23, 24).

Conclusion

Air pollution monitoring is very important for assessing the level of population exposure. This study showed a correlation between long-term exposure to low concentrations of outdoor air pollutants and the prevalence of respiratory morbidity in women, which stresses the need for following the example set by other countries, and to introduce stricter Immission Marginal Values of air pollutants in this country.

Exposure to passive smoking seems to be a significant etiological factor in respiratory morbidity. A clear effect of exposure to common outdoor air pollutants during the life has not been established.

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