

# Effects of indoor air pollution on respiratory symptoms of non-smoking women in Niš, Serbia

## Effetti dell'inquinamento nell'aria di ambienti confinati sui sintomi respiratori di donne non fumatrici residenti a Niš, Serbia

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### ABSTRACT

**Rationale:** The aim of this study was to determine the effects of indoor air pollution exposure on respiratory symptoms and illnesses in non-smoking women in Niš, Serbia.

**Materials and methods:** The study was carried out in 1,082 never-smoking females, aged 20-40 years, who were not occupationally exposed to indoor air pollution. The prevalence of respiratory symptoms and illnesses was assessed using the American Thoracic Society questionnaires. Multivariate methods were used in the analysis.

**Results:** A strong association was found between respiratory symptoms and indoor air pollution. The associations between home dampness and sinusitis and bronchitis were also found to be statistically significant.

**Conclusions:** Indoor air pollution exposure is an important risk factor for respiratory symptoms and illnesses in non-smoking women in Niš, Serbia.

**Keywords:** Indoor air pollution, non-smoking women, respiratory symptoms.

### SOMMARIO

**Razionale:** Scopo di questo studio era determinare gli effetti dell'esposizione ad inquinamento nell'aria di ambienti confinati sui sintomi respiratori e in termini patologici nelle donne non fumatrici di Niš, Serbia.

**Materiali e metodi:** Lo studio è stato condotto su 1.082 donne che non hanno mai fumato, di 20-40 anni di età, non esposte sul luogo di lavoro ad inquinamento aereo indoor. La prevalenza di sintomi respiratori e di patologie è stata valutata con i questionari dell'American Thoracic Society. Per l'analisi si è ricorsi a metodiche multivariate.

**Risultati:** È stata riscontrata una forte associazione tra sintomi respiratori ed inquinamento ambientale indoor. L'associazione tra umidità domestica, sinusiti e bronchiti è stata a sua volta individuata come statisticamente significativa.

**Conclusioni:** L'esposizione ad inquinamento ambientale in ambienti confinati è un fattore di rischio rilevante per disturbi respiratori e per patologie nelle donne non fumatrici di Niš, Serbia.

**Parole chiave:** Donne non fumatrici, inquinamento aereo indoor, sintomi respiratori.

### INTRODUCTION

Sources of indoor air pollution can exist in any home, with constant or periodical emission of pollutants. The pollutants that are emitted are different from outdoor pollutants in terms of their concentration, which can be sometimes significantly higher [1]. There are many different types of pollutants which may give rise to combined effects. The main factors related to indoor air pollution are chemicals for intended use or unintentional emissions from different sources, particles, microbes, pets, humidity, ventilation, temperature.

The presence of indoor pollutants, even at low concentrations, may have an important biological impact on account of long exposure periods [2]. In developing countries, it is typical for individuals to be exposed to very high levels of pollution for 3-7

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hours each day over many years [3]. Exposure to hazardous pollutants may have an immediate or a long-term effect, which may not become manifest for many years. The significance of the exposure depends upon the source, how much is emitted from the source, how harmful the pollutant is, and how much has accumulated within the home [4].

The respiratory system is the primary target of indoor air pollutants' effects because most frequently they enter the human organism through inhalation. Air pollution-related diseases are the most important cause of respiratory morbidity and mortality in adults. There are also indications that these effects are higher for sensitive groups of the population, such as children, women and persons with chronic diseases [5]. Respiratory health effects, such as infections and asthma, are the illnesses most closely associated with increased absenteeism from work.

Several studies have investigated the effects of indoor air pollution on the health of infants and children [6-8]. In this study, we examined the effects of indoor air pollutants on the prevalence of respiratory symptoms and illnesses in non-smoking women.

## MATERIALS AND METHODS

### Study area

The study was conducted in the city of Niš, situated in the South of Serbia. In 2008 Niš had a population of 381,757 inhabitants in an area of 596,71 km<sup>2</sup>.

### Study population

We evaluated data from a sample of 1,082 never-smoking women, aged 20-40 years, living in a part of the town with low concentrations of outdoor air pollutants and who were not professionally exposed to air pollution. They had lived for at least five years in this location, at a distance of 15 km from the sampling site. The participants of this study were recruited during a medical check up at the Health Care Center of Niš.

### Respiratory symptoms and illnesses

The study was carried out between March and September 2008. Details of the women's prevalence of respiratory symptoms (cough, phlegm, blocked/runny nose, wheezing and shortness of breath) in the last 12-month period and of the lifetime prevalence of respiratory illnesses (e.g. asthma, allergic rhinitis, sinusitis, pneumonia and bronchitis, as diagnosed by their doctors) were obtained through questionnaires. Trained physicians filled out the questionnaires during an interview with the women. The questionnaire was adapted from the American Thoracic Society questionnaires validated for Serbian language [9]. Respiratory symptoms were defined based on yes/no responses to the symptoms questions in the questionnaire. The questions about respiratory symptoms were as follows: Have you had daily coughs for > 3 weeks in the last 12 months? Have you had phlegm in your nose or throat in the last 12 months when you did not have

flu? Have you had wheezing in your chest in the last 12 months when you did not have flu? Have you ever had attacks of shortness of breath in the last 12 months? In the past 12 months, have you had a problem with a runny or a blocked nose when you did not have flu?

Our questionnaire also included items about socioeconomic status, indoor environmental determinants (e.g. environmental tobacco smoke [ETS] at home, use of biomass fuels, home dampness and the keeping of pets) and family history of respiratory illnesses.

### Outdoor air pollutants

Concentrations of outdoor air pollutants (sulfur dioxide and black smoke) were measured for 24 hours/day in the women's living area during the period 2004-2008. The sampling protocol was carried out by well trained personnel. Laboratory examination of sulfur dioxide (SO<sub>2</sub>) and black smoke was performed according to the Regulation of Guideline Values of Immission (Official Register Republic of Serbia 54/92). Concentrations of SO<sub>2</sub> were analyzed by spectrophotometry, while concentrations of black smoke (BS) were analyzed by reflectometry. For all pollutants annual averages were calculated.

### Statistical methods

Multiple logistic regression analyses were performed to analyse the relationship between respiratory symptoms and disease and exposure to different sources of indoor air pollution. Potential confounding factors such as age, education, family history of respiratory illnesses and annual average of SO<sub>2</sub> and black smoke were adjusted for. Results are presented as adjusted odds ratios (OR) with 95% confidence intervals (CI).

## RESULTS

A description of the study population is presented in Table I. More than 50% of the women had a positive family history of respiratory illnesses. Women's education was high (74% of women had ≥ 12 grades of school education). Over 30% reported exposure to ETS at home and home dampness. Use of biomass fuels was present in 357 homes (32.9%). Pets were kept in 4.7% of homes. Prevalence of respiratory symptoms in non-smoking women was from 8.2 to 33.4%, while the prevalence of respiratory illnesses diagnosed by doctors was from 1.9 to 42.1% (Table I). Table II shows annual average concentrations of SO<sub>2</sub> and black smoke in the women's living area in the period between 2003 and 2008. The average annual concentrations of SO<sub>2</sub> and black smoke do not show higher concentrations than the allowed maximums in the corresponding year according to the Regulation Book of Serbia (50 µg/m<sup>3</sup>). In much of Europe, concentrations of SO<sub>2</sub> in urban areas have declined substantially in recent years as a result of controls on emissions and changes in fuel use. Annual mean concentrations in such areas are now mainly in the range 12-45 µg/m<sup>3</sup>. Data from a study conducted in 28 European

**TABLE I: DESCRIPTION OF THE STUDY POPULATION, ALL WOMEN (N = 1,082)**

Medical characteristics	N (%) of women
Cough	362 (33.4)
Phlegm	193 (17.8)
Blocked-runny nose	177 (16.4)
Wheezing	89 (8.2)
Shortness of breath	355 (32.8)
Doctor-diagnosed asthma	211 (19.5)
Doctor-diagnosed bronchitis	132 (12.1)
Doctor-diagnosed allergic rhinitis	455 (42.1)
Doctor-diagnosed sinusitis	342 (31.6)
Doctor-diagnosed pneumonia	32 (2.9)
<b>Exposure variables</b>	
ETS at home	350 (32.3)
Use of biomass fuels	357 (32.9)
Home dampness	349 (32.3)
Keeping of pets	511 (47.2)
<b>Confounding variables</b>	
Age	
20-30 years	516 (47.7)
31-40 years	566 (52.3)
Education	
< 12 grades	405 (37.4)
> 12 grades	677 (62.6)
Family history of respiratory illnesses	397 (36.6)

*Definition of abbreviation:* ETS, environmental tobacco smoke.

locations in the winter of 1993–1994 indicated low PM<sub>10</sub> concentrations in Northern Europe, with mean urban values of around 20 µg/m<sup>3</sup>.

Higher concentrations were found in areas with high population and traffic density such as Amsterdam and Berlin (45–50 µg/m<sup>3</sup>) and central European cities such as Budapest (57 µg/m<sup>3</sup>), and even higher concentrations occurred in southern European cities such as Pisa (61 µg/m<sup>3</sup>) and Athens (98 µg/m<sup>3</sup>) [10].

Results of the multiple logistic regression analyses are presented in Tables III and IV. The associations between ETS at home and use of biomass fuels and, on the one hand, cough [OR (95% CI): 1.34 (1.11–1.61) and 1.36 (1.07–1.74), respectively] and short-

ness of breath [OR (95% CI): 1.27 (1.04–1.55) and 1.40 (1.12–1.75), respectively], on the other hand, were found to be statistically significant. There were statistically significant associations between home dampness and cough, OR (95% CI): 1.25 (1.07–1.45), and home dampness and wheezing, OR (95% CI): 1.24 (1.01–1.53) (Table III). The associations between home dampness and two illnesses - bronchitis - OR (95% CI): 1.32 (1.10–1.59) and sinusitis - OR (95% CI): 1.45 (1.07–1.98) - also were found to be statistically significant. All other ORs were close to unity (Table IV).

## DISCUSSION

The available evidence on toxicity, indoor concentrations and number of people exposed suggests that some indoor air pollutants may constitute a significant public health problem, in particular a high prevalence of respiratory symptoms and illnesses. The respiratory system has various defense mechanisms which may alleviate air pollutants' effects, since the respiratory system is the primary place where the negative influence of air pollutants is most clearly seen.

In carrying out this study on the influence of indoor air pollution on the appearance of respiratory symptoms and diseases, we focused on the research of the five most important factors of indoor air pollution - ETS at home, use of biomass fuels, home dampness, home heating and keeping of pets. Gender differences in the effects of environmental factors may be related to personal habits, the occupational environment and the home environment. Women have been found to be more susceptible than men to environmental factors [11-13].

The results of this investigation show that exposure to ETS at home, use of biomass fuels, and home dampness represent increasing factors for the prevalence of respiratory symptoms and illnesses.

Environmental tobacco smoke (ETS) is a major source of indoor air contaminants. We did not find that ETS exposure was a significant risk factor for the presence of asthma in non-smoking women (OR 0). One reason for this may be the underestimation of diagnosis of asthma by doctors. Most studies carried out around the world have demonstrated a connection between ETS exposure and the appearance of asthma [14-17]. Climatic changes and exposure to urban air pollution can affect the appearance of asthma, too [18,19]. However, there are studies that did not show such a connection [20,21]. One study from Singapore [22] confirmed the risk of asthma among non-smoking adult women residing with heavy smokers (OR 1.6; 95% CI 0.69-3.79). We also studied respiratory symptoms in relation to ETS exposure and found a significantly higher prevalence of common respiratory symptoms like breathlessness and cough among the ETS exposed individuals. Increased prevalence of respiratory symptoms has been reported in several recent studies among non-smoking women adults [23-25]. Smoke from household solid fuels is a complex mixture which

**TABLE II: ARITHMETIC MEAN CONCENTRATIONS OF SULFUR DIOXIDE AND BLACK SMOKE IN WOMEN'S LIVING AREA, 2004-2008**

Pollutants	Mean concentrations (µg/m <sup>3</sup> )				
	2004	2005	2006	2007	2008
SO <sub>2</sub>	10.01	10.32	8.34	2.22	4.05
BS	1.22	0.98	0.87	0.76	0.45
5-year mean concentrations (µg/m <sup>3</sup> )					
SO <sub>2</sub>	6.98				
BS	0.85				

*Definition of abbreviations:* BS, black smoke; SO<sub>2</sub>, sulfur dioxide.

TABLE III: MULTIPLE LOGISTIC REGRESSION ANALYSIS OF ASSOCIATIONS BETWEEN SYMPTOMS IN NON-SMOKING WOMEN AND EXPOSURE TO INDOOR AIR POLLUTION

Exposure variable	Symptom variable				
	Cough	Phlegm	Blocked/runny nose	Wheezing	Shortness of breath
ETS at home	1.34 (1.11–1.61)	0.91 (0.76–1.09)	0.98 (0.84–1.14)	0.87 (0.70–1.08)	1.27 (1.04–1.55)
Use of biomass fuels	1.36 (1.07–1.74)	0.94 (0.79–1.12)	0.96 (0.82–1.12)	0.97 (0.77–1.23)	1.40 (1.12–1.75)
Home dampness	1.25 (1.07–1.45)	0.91 (0.76–1.09)	0.98 (0.80–1.20)	1.24 (1.01–1.53)	0.87 (0.70–1.08)
Keeping of pets	0.90 (0.74–1.10)	0.99 (0.80–1.22)	0.97 (0.77–1.23)	0.99 (0.81–1.22)	0.92 (0.78–1.09)

Definition of abbreviation: ETS, environmental tobacco smoke.

contains many potentially relevant components from a toxicological point of view. According to our results, exposure to the smoke which is released by the combustion of wood and coal affects the appearance of cough and breathlessness. Air pollution due to the use of biomass fuel has been shown to be associated with chronic obstructive lung disease (COPD), especially in females [26-29]. Ekici et al. [30] compared the presence of chronic airway diseases (CAD) in two groups of nonsmoking women older than 40 years with (exposed group) and without (control group) a history of exposure to biomass cooking. The prevalence of CAD in the exposed group was found to be higher than that in the control group [28.5% vs. 13.6%, crude ORs 2.5 (1.5–4.0),  $p = 0.0001$ ]. Kiraz et al. [31] found that rural women exposed to biomass fumes are more likely to suffer from chronic bronchitis (CB) and COPD than urban women even though the prevalence of smoking is higher among the latter group. In a cross-sectional study in Mid-Anatolia [32], pulmonary function measurements of 112 cow-dung users and 153 modern energy source users, all non-smokers, were assessed and compared. For all pulmonary function test parameters [forced expiratory volume in 1 second ( $FEV_1$ ), forced vital capacity (FVC),  $FEV_1/FVC$ , and forced expiratory flow ( $FEF_{(25-75)}$ )] a highly significant ( $p < 0.0001$ ) reduction of the values was observed in biomass users.

Biological agents in indoor air are known to cause three types of human diseases: infections, hypersensitivity diseases and toxic diseases. In addition, exposure to conditions conducive to biological contamination (e.g. dampness) has been related to upper and lower respiratory symptoms. Several studies have shown that home dampness is a significant

predictor of respiratory symptoms [33-35]. Fisk et al. [36] reported the results of a quantitative meta-analysis of the studies reviewed in the US Institute of Medicine (IOM) report plus other related studies. The resulting summary estimates of ORs from random effects models based on all studies ranged from 1.38 to 1.50, with 95% CIs excluding the null in all cases. Based on the results of this meta-analysis, building dampness and mold are associated with approximately 30-50% increases in a variety of respiratory and asthma-related health outcomes. The effects of pet-keeping on life varied according to pet type, allergic sensitivity of an individual and greater environmental exposure to allergen. Biological agents in pets did not have any impact on non-smoking women's health in our investigation. Results of other studies show that dogs and cats have the strongest impact on health. In our case most of the women kept birds. It was probably the reason for the discrepancy in results.

There is a clear need for more studies on indoor pollution and health in adults, and especially in women. Future studies should address both short-term and long-term health effects related to indoor air pollutants. In conclusion, the current results in non smoking women emphasize the importance of good indoor air quality for the maintenance of health.

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TABLE IV: MULTIPLE LOGISTIC REGRESSION ANALYSIS OF ASSOCIATIONS BETWEEN ILLNESSES IN NON-SMOKING WOMEN AND EXPOSURE TO INDOOR AIR POLLUTION

Exposure variable	Symptom variable				
	Asthma	Bronchitis	Allergic rhinitis	Sinusitis	Pneumonia
ETS at home	0.97 (0.77–1.24)	0.91 (0.72–1.16)	0.98 (0.68–1.41)	0.97 (0.85–1.30)	0.94 (0.70–1.27)
Use of biomass fuels	0.90 (0.70–1.16)	0.91 (0.71–1.15)	0.94 (0.63–1.48)	0.88 (0.67–1.11)	0.99 (0.80–1.22)
Home dampness	0.91 (0.73–1.12)	1.32 (1.10–1.59)	0.92 (0.86–1.48)	1.45 (1.07–1.98)	0.88 (0.63–1.11)
Keeping of pets	0.88 (0.69–1.12)	0.89 (0.70–1.13)	0.98 (0.69–1.15)	0.86 (0.78–1.27)	0.90 (0.65–1.25)

Definition of abbreviation: ETS, environmental tobacco smoke.

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