

RELATIONSHIP BETWEEN EXPOSURE TO AIR POLLUTION AND OCCURRENCE OF ANEMIA IN PREGNANCY

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Summary. *Exposure to air pollution can lead to pathological conditions such as anemia. The aim of the study was to assess the frequency of anemia in pregnant women exposed to different and substantial quantities of air pollutants. The subjects were pregnant women (n = 327), aged 20-30, non-smokers, in good physical condition, living for more than five years in Niš and Niška Banja and not exposed to harmful agents at working place. Blood specimens were gathered from the subjects in each trimester of pregnancy in the laboratory of Niš Health Center. Anemia was diagnosed for the values of hemoglobin < 105 g/l and hematocrit < 34%. The measurement of air pollutants, sulphur dioxide (SO₂), soot and lead (Pb) in sediment matters in the air was carried out daily at two locations in Niš (Trg Knjeginje Ljubice) and Niška Banja during the period 1998-2002, as well as in each trimester of pregnancy during 2003. We calculated the Air Quality Index (AQI) for both areas. Our results show that the occurrence of anemia in pregnancy is significantly higher in pregnant women exposed to higher concentration of air pollutants.*

Key words: *Air pollution, anemia, pregnancy, pregnant women*

Introduction

The World Health Organisation has warned that chronic exposure to low concentrations of air pollutants can potentially cause anemia in humans (1). Most air pollutants reach the blood very fast without previously bio-transformed.

The hematopoietic system is highly sensitive to air pollutants as its cells renovate continually. The biological mechanisms by which air pollutants may interfere the process of red blood cells production are reflected in the synthesis of heme, the forming of red blood cells, and its life-expectancy (2,3). Toxic materials from the air lead to significant damage to red blood cells such as reduced hemoglobin concentrations, the number of erythrocytes and hematocrit, thus leading to anemia.

It is well known that anemia is the most frequent pathological condition in pregnant women. An analysis of anemia etiology in pregnancy is most important as it provides the basis for preventive care that, if adequate, can reduce the risk of pre-term delivery and infant low birth weight (4,5).

Aim

The aim of the study was to assess the frequency of anemia in pregnant women exposed to different and substantial quantities of air pollutants.

Subjects and Methods

The subjects were 327 pregnant women, divided into two groups on the basis of exposure to air pollution. The exposed group comprised 174 pregnant women, average age 28.25 ± 5.07 , living for more than five years in Niš. The control group included 153 pregnant women, average age 27.73 ± 4.76 , living in Niška Banja. The pregnant women from both groups had been fully healthy before gravidity, non-smokers, and professionally unexposed to harmful materials.

Blood specimens were gathered from the subjects in each trimester of pregnancy in the laboratory of Niš Health Center. Anemia was diagnosed for the values of hemoglobin < 105g/l and hematocrit < 34%. The levels of statistic significance of the measured hematological parameters between the exposed and control group were determined using a Student's T-test.

Outdoor air pollutants, sulphur dioxide, soot and lead in sediment matters, were monitored in the Institute of Public Health in Niš, during the period 1998-2002 and in each trimester of the subjects' pregnancy in 2003. The pollutants were measured at two locations, in the center of Niš (Trg Knjeginje Ljubice) and in the center of Niška Banja. The ratio of air pollutants was determined and commented upon in accordance with the Regulation of Guideline Values of Emission (Official Bulletin of the Republic of Serbia No. 54/92). The levels of statistic significance of the measured air pollutants concentrations in the air at the locations were determined using a Student's T-test.

The Air Quality Index (AQI) calculated for sulphur dioxide and soot is recommended by the European Commission, wherein we used Emission Marginal Values and average annual concentrations. Table 1 shows the correspondences of the Air Quality Index values to the air quality categories.

Table 1. Classification of air quality according to the Air Quality Index values

Air Quality Index Values	Air Quality
<0.4	Good
0.4-0.6	Moderate
0.6-0.8	Unhealthy for Sensitive Groups
0.8-1.0	Unhealthy
>1.0	Very Unhealthy

Statistically significant differences in anemia incidence in pregnant women exposed to different and substantial concentrations of air pollutants were determined using a Pearson's chi-squares test.

Results

All concentrations of the air pollutants measured during the period 1998-2002 at the location in Niš were higher when compared to the concentrations of the same pollutants measured at the location in Niška Banja (Table 2). This difference is statistically significant (Table 3).

Table 2. Pollutant concentration in two areas during the period 1998-2002

Measure station	Pollutant	\bar{X}	SD	C50	C98	Min	Max
Niš, Trg	SO ₂ [†]	12.91	13.11	12.4	30.6	0.0	74.6
Knjeginje	Soot [†]	35.33	31.95	24.4	140	0.0	227
Ljubice	Pb ^{††}	65.66	28.55	39.9	–	3.8	80.24
Niška Banja	SO ₂	5.35	10.82	2.6	27.0	0.0	42.8
	Soot	1.33	4.75	0.0	18.8	0.0	26.2
	Pb	25.94	22.51	13.7	–	0.0	80.94

[†]µg/m³, ^{††}µg/m²

Table 4. Pollutant concentrations in two areas during 2003

Trimester of pregnancy	Measure station in Niš						Measure station in Niška Banja					
	SO ₂	$\bar{X} \pm SD$	Soot	$\bar{X} \pm SD$	Pb	$\bar{X} \pm SD$	SO ₂	$\bar{X} \pm SD$	Soot	$\bar{X} \pm SD$	Pb	$\bar{X} \pm SD$
First	22.45	±18.21	40.66	±29.06	7.2	±11.06	4.33	±1.12	0.33	±3.09	2.09	±8.03
Second	15.33	±9.23	25.67	±30.11	5.3	±43.11	0.33	±4.71	0.01	±1.06	2.97	±5.18
Third	14.33	±16.98	29.67	±30.65	9.43	±13.64	1.20	±6.19	0.14	±2.29	3.27	±2.54

Table 5. Statistic significance of differences in pollution levels during each trimester of pregnancy in 2003

Statistics	Pollutant								
	SO ₂			Soot			Pb		
	I	II	III	I	II	III	I	II	III
t-test	9.96	3.95	14.69	20.21	16.57	9.95	2.23	2.12	8.13
p-value	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	<0.01*	<0.05*	<0.05*	<0.05*

* statistic significance

Table 3. Statistic significance of differences in pollution levels during the period 1998-2002

Pollutant	Statistic	
	T-test	p-value
SO ₂	13.07	<0.01 *
Soot	17.94	<0.01 *
Pb	3.91	<0.001*

* statistic significance

Table 4 shows the average pollutant concentrations by areas for each trimester of pregnancy. This difference is statistically significant (Table 5).

The calculated values of AQI by areas during the period 1998-2003 are shown in Table 6. AQI in Niš had values from 0.52 to 1.12 and the air quality was degraded, while AQI in Niška Banja had values from 0.07 to 0.34 and the air quality was preserved.

Table 6. Values of AQI in two areas and classification of air quality

Year	Niš		Niška Banja	
	AQI	Air quality	AQI	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

The relation between concentrations of hemoglobin and hematocrit and exposure to air pollution is given in Table 7. The average hemoglobin concentrations and hematocrit are statistically significantly higher in controls.

The occurrence of anemia during pregnancy in both groups is given in Table 8. Out of a total number of the pregnant women exposed to higher concentrations of air pollutants in Niš, 12.64% were anemic. In Niška Banja, the percentage of anemia was, however, lower (5.88%).

Table 7. Statistic significance of differences between average concentrations of hemoglobin and hematocrit

Trimester of pregnancy	Exposed group		Control group		t-test	p-value
	Hb(g/l)	Ht(%)	Hb(g/l)	Ht(%)		
First	103.43±8.62	0.31±0.03	128.72±6.57	0.39±0.02	15.07	p<0.01*
Second	89.74±5.72	0.27±0.02	113.86±5.56	0.35±0.01	15.83	p<0.01*
Third	98.81±9.53	0.30±0.03	115.23±5.38	0.36±0.01	17.95	p<0.01*

* statistic significance

Table 8. Occurrence of anemia in pregnant women as compared to exposure to air pollution

Subject	With anemia		Without anemia		Total	χ^2	p-value
	Number	%	Number	%			
Exposed group	22	12.64	152	87.36	174	11.18	p<0.05*
Control group	9	5.88	144	94.12	153		
Total	31	9.48	296	90.52	327		

* statistic significance

After statistic application of a chi-square test, it was confirmed that there was a significant difference in anemia incidence in pregnant women exposed to higher concentrations of air pollution, when compared to those pregnant women who were exposed to lower concentrations of air pollution.

Discussion

Although concentrations of sulphur dioxide and soot have been significantly decreasing worldwide in the last ten years, the present concentrations in the air are still an important threat to human health. Therefore, it is necessary to accomplish detailed analyses of the influence of these air pollutants upon sensitive groups of the population, such as children, pregnant women, old people and subjects suffering from chronic diseases.

Given our data, one should notice that the concentrations of sulphur dioxide, soot and lead in sediment matters at both of the measuring locations do not show higher concentration values than the allowed maximum according to the Regulation of Guideline Values of Emission prescribed by our country (6). However, even as such they can significantly harm human health (7,8).

The European Commission has suggested that the Air Quality Index is more representative in case the air quality date is used for health risk study (9). According to the Air Quality Index values, the air in Niška Banja was "good", which means the air quality is considered satisfactory and air pollution poses little or no risk. At the same time, the air in Niš was "unhealthy or moderate", which means that the members of sensitive groups are likely to be affected by lower levels of concentrations compared to the rest of the population, and they may experience more serious health effects.

It is well known that pregnancy is a specific condition and that pregnant women are more sensitive to the effects of all environmental factors than the rest of the

human population. An analysis of each symptom and disease in pregnancy is most important as it provides the basis for preventive care which, if adequate, can reduce the risk of miscarriage, pre-term delivery and congenital malformations of the fetus.

The effects of air pollution on red blood cells have been investigated mostly in children (10,11). Air pollutants present in the environment largely damage cell immunity and change the intensity and course of iron metabolism in the body, which results in iron-deficient anemias with very low values of hematocrit and hemoglobin. Also, lead can damage the erythrocytes' membranes, resulting in anemia.

The cause of anemia is the lack of iron, which is treated with ferrous preparations per os accompanied by mandatory monitoring of pregnant women's hematological reactions. Parenteral therapy has no advantages over oral therapy, since hemoglobin levels increase only 2-4 days later than after per os (12,13). More severe in-pregnancy anemias can be treated by recombinant erythropoietin (14). Since iron preparations are a bit harder to endure, most perinatologists suggest that this therapy, along with folic acid preparations, should be given during the second half of pregnancy (15).

This investigation has shown that a long-term exposure to air pollution positively corresponds to the occurrence of anemia among pregnant women. It was difficult to find a greater number of pregnant women due to the low birth rate in our country. However, at the time of the study, our subjects had been living for more than five years in the same place and the long-term exposure to air pollutants influenced the occurrence of anemia in pregnancy. Naturally, other factors (genetic disposition, nutrition habits, etc.) contributed to the detected low concentrations of hemoglobin and hematocrit.

Further study is needed to disentangle this interaction and the underlying mechanisms, but the balance of evidence remains that outdoor air pollution has at most a modest effect on the occurrence of anemia in pregnancy.

Conclusion

The occurrence of anemia in pregnancy was initiated by numerous integrated risk factors, and air pollution can quite clearly be one of the reasons for this occurrence.

Air pollution monitoring is highly important in order for population exposure to be assessed. Monitoring the influence of air pollution on pregnancy and its outcome should be intensively pursued in the future, too.

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POVEZANOST IZMEĐU IZLOŽENOSTI AEROZAGAĐENJU I POJAVE ANEMIJE U TRUDNOĆI

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Kratka sadržaj: Izloženost aerozagađenju dovodi do pojave različitih patoloških stanja, a jedno od njih je i pojava anemije. Cilj ovog istraživanja je bio ispitivanje međuzavisnosti između izloženosti aerozagađenju i učestalosti pojave anemije kod trudnica. Ispitivanjem je bilo obuhvaćeno 327 trudnica, nepušača, starosti od 20 do 30 godina, koje žive duže od pet godina u Nišu i Niškoj Banji, i koje su bile dobrog zdravstvenog stanja pre trudnoće, profesionalno neekspozirane štetnim noksama. Koncentracija hemoglobina i hematokrita je određivana iz uzoraka krvi trudnica u svakom trimestru trudnoće u laboratoriji Doma zdravlja u Nišu. Polutanti iz vazduha, sumpor dioksid, čađ i olovo u sedimentnim materijama, mereno je svakodnevno na dva merna mesta, u Nišu (Trg Knjeginje Ljubice) i Niškoj banji, u periodu od 1998-2002. i tokom čitave trudnoće ispitivanih trudnica, tokom 2003. godine. Za oba područja izračunavan je i indeks kvaliteta vazduha. Pojava anemije je bila statistički značajno veća kod trudnica izloženih aerozagađenju u odnosu na pojavu anemije kod trudnica kontrolne grupe. Između prosečnih koncentracija hemoglobina i hematokrita između eksponirane i kontrolne grupe takođe je nađena statistička značajnost. Dalja istraživanja u ovoj oblasti su poželjna i potrebno ih je sprovesti na većem broju ispitanica.

Ključne reči: Aerozagađenje, anemija, trudnoća