ORIGINAL ARTICLE

Annals of Agricultural and Environmental Medicine 2015, Vol 22, No 2, 265–270
www.aaem.pl

Association between PM10 air pollution and birth weight after full-term pregnancy in Krakow city 1995–2009 – trimester specificity

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Merklinger-Gruchala A, Kapiszewska M. Association between PM10 air pollution and birth weight after full-term pregnancy in Krakow city 1995–2009 – trimester specificity. Ann Agric Environ Med. 2015; 22(2): 265–270. doi: 10.5604/12321966.1152078

Abstract

Introduction and objective. The results of epidemiological studies indicate that the higher maternal exposure to air pollution, especially with particulate matter during pregnancy, the lower the infant's birth weight. The aim of this study was to estimate entire pregnancy and trimester-specific exposure of pregnant women in the city of Krakow, southern Poland, to fine particulate matter [≤10 µg (PM10)], and to assess its effect on the birth weight of boys and girls separately.
Material and methods. The study group consisted of 85,000 singleton, live, full-term births in Krakow city during a 15-year period (data from the birth registry). The mean concentrations of the pollutant for each month of gestation were estimated using continuous municipal monitoring data.
Results. Multiple linear regression analyses indicated that the mean PM10 concentration during entire pregnancy was inversely associated with birth weight in girls and the group of boys and girls combined, after adjusting for maternal age, gestational age and year of birth; in boys the relationship was not statistically significant. Maternal exposure to PM10 during the first trimester was negatively associated with birth weight separately in girls and boys, and the group of boys and girls combined. However, the PM10 exposure during the second and third trimester of pregnancy was not associated with birth weight.
Conclusions. PM10 air pollution at levels currently encountered in Krakow city adversely affect infant birth weight; however, the effect seems to be very small. The influence of particulate air pollution on foetal growth in early gestation is one of several possible explanations for the results, but further research is needed to establish possible biological mechanisms explaining the observed relationship.

Key words
air pollution, birth weight, particulate matter, infant sex, pregnancy trimesters

INTRODUCTION

Many epidemiological studies indicate adverse effect of particulate matter on foetal development; this is reflected in premature birth [1, 2], impaired intrauterine growth (intrauterine growth retardation – IUGR, or intrauterine hypotrophy) [3]; infant mortality [4] and congenital birth defects (atrial septal defects) [5]. The unfavourable infant health conditions as the result of airborne PM10 may also manifest as low birth weight, defined as birth weight ≤2,500 g. However, results regarding the relationship between air pollution and birth weight are inconclusive, especially the exposure periods. For example, the estimated reduction in birth weight was 6.9 g for each 100 pg/m^3 increase in total suspended particles during the third trimester of pregnancy, after adjustment for gestational age, residential areas, maternal age, year of birth, and infant gender [6]. Similarly, the results of a study conducted in northern Nevada, USA, from 1991–1999 [7], showed that a 10-µg/m^3 increase in the 24 h PM10 level in the third trimester of pregnancy could have been associated with a birth-weight reduction of 11 g, after controlling for infant gender, maternal residential city, education, medical risk factors, active tobacco use, drug use, alcohol use, prenatal care, mother's age, race and ethnicity of mothers, and weight gain of mothers. A study on term infants who were born in California showed that a 20-µg/m^3 difference in levels of PM10 during the third trimester was associated with a 21.7g lower birth weight, but this association was reduced and not significant after adjusting for ozone levels [8].

The results of some studies, however, indicate that the effect on birth weight is strongest if the exposure to air pollution occurred during the first trimester of pregnancy. A study conducted on all singleton live births registered by the Czech national birth register in 1991 showed that odds ratios of low birth weight were 1.15 for a 50 µg/m^3 increase in total suspended particles in the first trimester, after adjustment to socio-economic factors and the month of birth [1]. In a study on singleton full-term live infants born in Brazil, a 13.7 g reduction in birth weight for a 10 mg/m^3 change in PM10 was noted, after standardization to infant gender, maternal age and education, antenatal care, type of delivery, month of birth, and seasonal patterns [9]. A monthly analyses carried out on a sample of full-term singletons in Seoul, South Korea, suggested that the risks for low birth weight tended to increase with exposure to particles <10 mm in months 2 and 4 [10]. The findings of a study conducted in the USA also support the hypothesis that exposure to PM10 in the first trimester is associated with increased levels of term low birth weight [11].

Because the results of studies are not consistent, particularly regarding the effect period of air pollutant, for the presented study it decided to investigate Polish neonates and to estimate

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Received: 16 May 2013; accepted: 28 October 2013

entire pregnancy and trimester-specific exposure of pregnant women to fine particulate matter [≤10 µg (PM10)], and to assess its effect on birth weight. The hypothesis that male foetuses are more sensitive to prenatal environmental conditions than female ones as regards birth weight was also tested.

The recommendation of Environment Commission relating to the study period set limit values for PM10 exposure covering both an annual concentration value (40 µg/m³), and a daily concentration value (50 µg/m³), that must not be exceeded more than 35 times in a calendar year. That such a limit value was commonly exceeded proved to be the greatest problem posed by air pollution by particulate matter. Several causes for exceeding the limit values have been indicated: unfavorable climate conditions and spread of local air pollution, traffic, industrial and residential heating emissions widely using coal.

One of the most vulnerable to PM10 and other air pollutants group are foetuses, because of their physiological immaturity and intensive cell proliferation, or changing metabolic capabilities. These are the grounds for the presented study examining the association between maternal exposure to particulate matter in outdoor air during pregnancy with birth weight, which represents an endpoint of intrauterine growth, depending on maternal, placental, and foetal factors, as well as a sequence of constitutional and environmental influences [6].

MATERIALS AND METHOD

A population based study was carried out within the municipality of Krakow, where annual life births per 1,000 population rate equals 10.7, and infant deaths per 1,000 of live births rate equals 3.7 [12]. The city is located in southern Poland, in a valley in the in Malopolska Region, which is currently listed as one of the regions with the highest air pollution in Poland, especially for particulate matters.

The study was based on individual data on singleton live, full-term births who were born by mothers who at the time of the infants' births resided in the city of Krakow. All live birth data in Krakow (city area) were obtained from the birth registry data maintained by the Central Statistical Office in Poland for the period 1 January 1995 – 31 December 2009. The registration records included: date of birth restricted to month and year, birth weight (in grams), infant gender, maternal and paternal age (in years), gestational age (in weeks) and parity (number of children born by the mother, including still birth during the last delivery in mothers who delivered more than once). The date of birth was approximate by using the recorded year and month of birth and assigning 15th day of a given month to each newborn.

The season of conception was calculated by using the approximate date of birth minus the gestational age. The season of birth was defined as non-heating (N-HS) when a neonate was delivered between 1 April 1 and end of September, and heating (HS) when delivered between October – March. Similarly, the season of conception was defined as non-heating (N-HS) when a foetus was conceived between April – September, and heating (HS) when conceived between October – March.

To asses exposure to ambient air pollution, municipal ecological monitoring data was used. The data for particles with an aerodynamic diameter of ≤10 µm PM10 [µg/m³], from January 2004 – December 2009, were obtained from the State Environmental Monitoring, the system maintained by the Inspector for Environmental Protection of the Malopolska Region.

The aggregated data (monthly averages) from six monitoring stations located in the city of Krakow were used in the analysis. The mean monthly PM10 pollution in Krakow were calculated and used for analysis when monthly averages were available from at least two monitoring stations. Among the 180 available monthly averages (12 months multiplied by 15 years of study) that represented the monthly PM10 pollution in Krakow city during the study period, only four were missing (2.2%) – May, August, September and October 2004. These monthly averages were not calculated because for these months there were no monthly average measurements for at least 2 (out of 6) monitoring stations located in the city of Krakow.

By using recorded gestational age and approximate date of birth, the average PM10 pollution level was calculated during the entire pregnancy period for each mother residing in the city of Krakow. The mean level of PM10 during the entire pregnancy was estimated if completed monthly averages of PM10 levels during each month of pregnancy were available. In addition, the effects of average air pollution levels during the first, second and third trimester of gestation were assessed. The mean level of PM10 during the trimesters of pregnancy for each newborn was estimated if completed monthly averages of PM10 levels during each month of the particular trimester were available.

Statistical analysis. Difference between boys and girls in mean birth weight, gestational age, maternal age and paternal age was investigated using t test for independant samples (preceded by Levene's test to verify the homogeneity of variances and Shapiro-Wilk test or graphical assessment to test the normality of distribution). Because paternal age had skewed distribution, natural logarithmic transformation was applied. The t test was also used when testing the difference in mean levels of PM10 between N-HS and HS months from 1995–2009.

To examine the association between maternal exposure to PM10 and birth weight, univariate (in order to estimate the crude effect of exposure) was used first, followed by multivariate linear regressions, in which the birth weight was analyzed as a dependant continuous variable. Multivariate linear models included PM10 as an independent variable, and additional variables, such as: gestational age, maternal age and year of birth. The multivariate linear regressions were then repeated, after replacement the of the variable 'maternal age' by 'parity' in order to avoid colinearity when taking them both to the model. An α level of 0.0042 (with the Bonferroni correction) was used to indicate statistical significance in univariate regression models.

In order to identify potential confounders (such as: gestational age, maternal and paternal age, parity and year of birth) and select variables for the multivariate models, Pearson's correlation analysis was used. Correlation analysis was also used in order to verify whether maternal age and parity were correlated. For additional verification of the hypothesis that birth weight differ according to the years of birth, the one-way ANOVA was conducted. These analyses were repeated separately in boys and girls.

In order to check the seasonal effects on birth weight, t tests for independent samples (preceded by Levene's test) were used to verify if birth weight differed according to the season of conception or season of birth (in separate analysis). These tests were also used to verify the difference in mean PM10 levels during the entire pregnancy between heating (October – March) and non-heating (April – September) season of birth and season of conception (in separate analysis). Statistical analyses were performed with Statistica (version 10) computer software (StatSoft, Poland).

RESULTS

Characteristics of air pollution in Krakow. The levels of air pollutants are characterized by large variation during the year. As noted in many previous studies, in the heating season, especially in the coolest months, the PM10 rises. Observations made during the presented study indicate that mean PM10 levels during N-HS during 1995–2009 was 43.1μg/m³, while mean PM10 levels in HS equaled 72.0 μg/m³, t test, t for separate variance estimates = 6.24, df = 28.P < 0.0001. Mean exceeding for the yearly average PM10 limits in Krakow city between 1995–2009 equaled 36.5 percentage points. Only in 2001 the yearly average PM10 was below 40 [μg/m³] in the city (Fig. 1).

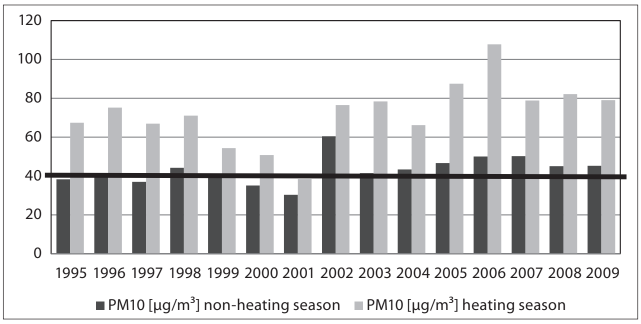

Figure 1. Mean PM10 [μg/m³] levels in Krakow city between 1995–2009 by season. Dotted line represents yearly average PM10 limits (40 μg/m³)

Characteristics of the study group. Of the 93,336 singleton births registered in Krakow city between 1 January 1995 – 31 December 2009, the current study was limited to live and full-term births (gestational age 37 – 41 weeks). These exclusions left N=84,842 newborns for study (N=43,558 boys, N=41,284 girls). The gender ratio at birth for singleton live, full-term births was 106 males per 100 females. During the study period, 137 full-term, still births were noted.

Newborns' mean birth weight was 3,402 g (SD=452.1) and was higher among boys than girls (t = 46.99, separate variance estimates, df = 84,829, P < 0.0005). The difference in gestational age between boys and girls was also statistically significant; however, it was very small. Boys gestational age was shorter (39.36 weeks) than girls (39.42 weeks), P<0.001 (Tab. 1). Among the study group, 2.3% of newborns (N = 1974) had low birth weight, i.e. below or equal to 2,500 g. The birth order was as follows: 54% of newborns were delivered as the the first child, 33.5% of newborns as the second, 8.7% newborns as the third, and 4.0% newborns as fourth or more (including stillbirth during the last delivery). Among newborns delivered as the second child (N=27,112), 171 were full-term, stillbirth siblings, being born during last delivery. Among those delivered as the third child (N=7,029), 72 were full-term, stillbirth siblings being born during the last delivery, while among those delivered as the fourth child or more (N=3,208), 36 were full-term, stillbirth sibling born during the last delivery.

Of the 84,842 newborns, 48.8% (N=41,360) were conceived during the HS (October – March), and 51.3% (N = 43,482) during N-HS (April – September). Among the study group, 48.1% (N=40,774) were born during HS and 51.9% (N=44,068) were born during N-HS.

Characteristics of study group according to birth weight, gestational age, maternal and paternal age, with comparison between boys and girls are presented in Table 1.

Table 1. Characteristics of study group according to birth weight, gestational age, maternal and paternal age

variable		all	boys	girls	t	df	p
birth weight [g]	*N*	84,842	43,558	41,284	46.99*	84,829	<0.001
	Mean	3402.2	3472.2	3328.3			
	SD	452.06	455.33	436.57			
gestational age [weeks]	*N*	84,842	43,558	41,284	-7.29	84,840	<0.001
	Mean	39.4	39.4	39.4			
	SD	1.12	1.12	1.12			
paternal age [years]**	*N*	81,325	41,730	39,595	0.54	81,161	0.59
	Mean	30.5	30.5	30.5			
	SD	5.86	5.89	5.83			
maternal age [years]	*N*	84,842	43,558	41,284	-0.24	84,840	0.81
	Mean	28.1	28.1	28.1			
	SD	5.20	5.20	5.19			

* t-test with separate variance estimates
** t-test on natural logarithm transformed data
SD – standard deviation; *df* – degree of freedom

Testing the effect of potential confounders. The following were tested: infant gender, year of birth, gestational age, maternal age, parity, season of birth and season of conception as potential confounders. A positive but very weak correlation was noted between year of birth and birth weight (r =0.01; P =0.035). Moreover, birth weight between groups of neonates born in each year of the study was compared in one-way ANOVA (F 14, 84,827=2.6; P <0.001). Because boys were heavier than girls (3472.2 g vs. 3328.3 g, respectively), ANOVA was conducted separately in each gender group. This analysis revealed that in boys birth weight did not differ between groups of neonates born in each year of study (F14, 43,543=1.5; P=0.12); however, in girls, the association was statistically significant (F14, 41,269=2.0; P=0.02).

Taking this observations into account, it was decided to include the year of birth into the multivariate models. In addition to the year of birth, the adjustments for gestational age and maternal age were included into the multivariate linear models, because these variables showed positive correlations with birth weight (r=0.32; P<0.0001; r = 0.05; P< 0.0001; respectively). Because maternal age and parity were positively correlated (r=0.46; P<0.001), they were taken separately into the multivariate models as the covariates. Thus, in the second step of the analytical process, the variable maternal age was replaced by parity, which was also positively correlated with birth weight (r =0.05; P<0.0001).

Neither the season of birth nor the season of conception were included, because the preliminary analyses showed that neither season of conception nor season of birth were associated with dependent variable – birth weight (t = -1.71; P = 0.09; t for separate variance estimates = 1.77; P = 0,08; respectively).

PM10 exposure during pregnancy and relationship with birth weight. The mean PM10 maternal exposure during entire pregnancy in newborns born between 1995–2009 equalled 58.19 [µg/m³] (SD = 11.040). Mothers of newborns who were born in N-HS had higher exposure to PM10 levels during the entire pregnancy than mothers of newborns delivered in HS (60.1 vs. 56,1; t test for separate variance estimates = -51.2; df = 76631; P<0.001). Similarly, mothers of newborns who were conceived during N-HS had higher exposure to PM10 levels during the entire pregnancy than mothers of newborns conceived in HS (60.3 vs. 55.7; t test for separate variance estimates = -64.23; df = 76155; P<0.001). All such associations between seasonality and PM10 concentrations indicated co-linearity between these variables. Thus, it was decided not to include the season of birth nor the season of conception into the final multivariate models.

Exposure during entire pregnancy. The mean level of PM10 during entire pregnancy was inversely associated with body weight in girls (β = -0.68; P<0.001), and also in the group of boys and girls combined (β = -0.58; P<0.001), after adjusting for maternal age, gestational age and year of birth (Tab. 2). The negative relationship between maternal exposure to PM10 during entire pregnancy and birth weight of boys did not reached statistical significance after controlling for potential confounding factors (β = -0.44; P<0.06).

Exposure in trimesters. The trimester-specific exposure to PM10 on birth weight of singleton, life, term infants was next investigated. The multiple linear regression model indicated that the higher mean levels of PM10 during the first trimester of pregnancy, the lower the birth weight (P<0.001) after controlling for potential confounders, such as maternal age, gestational age and year of birth (Tab. 2). Moreover, maternal exposure to PM10 during the first trimester was negatively associated with birth weight separately in girls (β = -0.46; P<0.001) and boys (β = -0.45; P<0.001). However, the effect of PM10 exposure during the second and third trimester of pregnancy were not associated with birth weight, neither in boys and girls, nor in both infant gender groups combined. Multivariate linear regression analyses in which 'maternal age' was replaced by 'parity', were also repeated. The results of all analyses remained unchanged.

DISCUSSION

The city of Krakow was selected to study the effect of maternal exposure to particulate pollution on birth weight for several reasons. Geographically, Krakow is located in a valley, which tends to concentrate pollutants and experiences a low number of windy days, which means pollutants are not readily dispersed. The major sources of Krakow's pollutants are domestic solid fuel furnaces and motor vehicles. Local industry and air-borne pollutants from other parts of Poland (Silesia) and the neighbouring city of Skawina also contribute. The most representative measurement for general air pollution is particulate matter of less than 10 micrometres. Its harmful effect on human health, especially on respiratory and cardiovascular diseases, has been proved in many studies. Lately, more and more studies focus on the impact of air pollution on maternal and foetus condition.

The presented study comprises full-term live births in order to obtain complete PM10 exposure assessment for each trimester of pregnancy, and secondly, to test the hypothesis of a correlation between air pollution and birth outcome in a more homogeneous population. The results obtained showed that the mean level of PM10 during entire pregnancy was inversely associated with body weight overall, after adjusting for maternal age, gestational age and year of birth. For each inter-quartile range increase of prenatal exposure to fine particles (PM10) by about 15.4 µg/m³, i.e. from the 25th percentile (50.9 µg/m³) to the 75th percentile (66.2 µg/m³), the average birth weight deficit equaled 9.2 g.

Because of the occurrence of the critical period during foetal development, the exposure to airborne PM10 during

Table 2. Relationship between birth weight and mean maternal exposure to PM10 during entire pregnancy and during particular trimester by infant gender, crude effects and after controlling for maternal age, gestational age and year of birth

			Unadjusted			*Adjusted**				
	infant gender	*N*	*β*	*SE*	*p*	*β*	*SE*	*p*	*R2*	*p* for model
Entire pregnancy	boys	39267	-0.104	0.208	0.617	-0.440	0.230	0.056	0.121	<0.0001
	girls	37369	-0.132	0.205	0.517	-0.678	0.228	0.003	0.108	<0.0001
	all	76636	-0.131	0.148	0.376	-0.581	0.165	<0.001	0.109	<0.0001
First trimester	boys	40728	-0.181	0.120	0.131	-0.452	0.118	<0.001	0.121	<0.0001
	girls	38742	-0.160	0.118	0.174	-0.456	0.117	<0.001	0.109	<0.0001
	all	79470	-0.176	0.085	0.039	-0.459	0.085	<0.001	0.109	<0.0001
Second trimester	boys	42029	0.064	0.111	0.561	-0.021	0.109	0.847	0.121	<0.0001
	girls	39897	0.050	0.110	0.648	-0.110	0.108	0.307	0.108	<0.0001
	all	81926	0.064	0.079	0.420	-0.059	0.078	0.451	0.109	<0.0001
Third trimester	boys	42136	0.005	0.110	0.966	0.154	0.108	0.152	0.121	<0.0001
	girls	39954	0.044	0.109	0.687	0.151	0.107	0.156	0.108	<0.0001
	all	82090	0.017	0.079	0.833	0.141	0.077	0.068	0.109	<0.0001

* adjusted for: maternal age, gestational age and year of birth
Abbreviations: *β*, regression coefficient, *SE*, standard error

various stages in the gestational period was also investigated. It was found that PM10 exposure in the first trimester of pregnancy was a predictor of the birth weight of newborns; however, the identified effect was marginal. The overall average increase in first trimester prenatal exposure to PM10 by about 30.2 µg/m^3, i.e. from the 25th percentile (42.7 µg/m^3) to the 75th percentile (72.9 µg/m^3), resulted in an average birth weight deficit of 13.9 g. However, the effect of PM10 exposure during the second and third trimester of pregnancy were not associated with birth weight, neither overall nor assessed separately in boys and girls.

The revealed associations are comparable with the results of other studies. The first trimester of pregnancy seems to be the critical period when the foetus is most vulnerable to environmental factors, air particulates among others. The manifestation of such vulnerability can be low birth weight, below 2,500 g [1, 9, 11] which represents an endpoint of retarded intrauterine growth, depending on unfavourable maternal, foetal and placental factors occurred in early pregnancy [3]. The higher foetal susceptibility to maternal environmental PM10 exposure in early stages of development may also be seen as pre-term birth, often associated with low birth weight [1, 2].

The presented findings are also in accordance with previous studies in which lack of association between birth weight and maternal exposure to airborne particulate matters in the second and third trimesters of pregnancy have been found [1, 11, 15, 13].

However, the current study did not support the hypothesis tested in some other studies [16,17], that male foetuses are more sensitive than female foetuses to prenatal environmental conditions, which may be reflected in their lower birth weight. The relationship between maternal exposure to PM10 during entire pregnancy and birth weight of girls was inverse, while in boys did not reached statistical significance. The negative effect of exposure to PM10 during the first trimester on birth weight was similar when assessed separately in each gender.

When studying the relationship between air pollution and birth weight it has to kept in mind that certain factors contribute to birth weight more than other. Birth weight is affected, for example, by maternal nutrition, pre-pregnancy weight, weight gain during pregnancy [14], maternal height, socio-economic status, occupational exposures [15], and maternal passive and active smoking [16, 17]. However, due to the unavailability of such data they could not be included into the regression models. Nevertheless, the analysis controlled several important factors, such as gestational age, maternal age, parity, infant gender and year of birth.

A second methodological problem that can be identified in the semi-individual study design is a misclassification of maternal exposure. This may have occurred, for example, because of the assumption that women do not move from their residential area and change the place of residence during pregnancy, or due to the distance between maternal residence and the air monitoring stations used to assign exposure. However, the quality of the network of air pollution stations in the Malopolska Region and its appropriate coverage of the Krakow residency area is satisfactory (six monitoring stations), which was proved by the cohort study conducted on pregnant women in Krakow city [20]. This demonstrated that personal exposure to particulate matters (measured by personal monitor over 48 hours) correlated well with the PM10 concentrations obtained from the monitors of the municipal air pollution network of Krakow. This finding suggests that the extrapolation of ambient measurements to personal exposure may be reasonably approximated.

In spite of all of these weaknesses, ecological studies, such as presented here, are useful because they can be carried out quickly, easily and inexpensively using data generally already available. Moreover, the results from ecological studies can provide the opportunity for later, more carefully designed (although likely more expensive and time-consuming) studies to build on these initial observations. This method is especially more appropriate than other designs when studying the impact of an exposure on a community level. Correlation studies also enable the comparison with a single population over a period of time, which are known as secular trend studies. By contrast, with this approach when comparing many populations in different cities at the same time, the reason why such secular trend studies are valuable is because they may avoid some of the socio-economic confounding, which is a potential problem in ecological design. However, the ranges of intra-population variation in air pollution levels are much narrower than inter-population ranges, which may explain why the association between particulate matter and birth weight is so weak. However, the revealed changes in birth weight during the 15 years of study may suggest that environmental factors may pose a possible explanation for this kind of adverse pregnancy outcomes.

Possible biological explanations. The effect of air pollutants can be mediated by multiple mechanisms which affects newborn conditions, either directly, by passing across the placenta, or indirectly by impairing maternal health or decreasing efficiency of the transplacental function, with consequent deterioration in foetal growth and development. Thus far, several biological mechanisms linking the effects of particulate air pollution on birth outcomes have been pointed out. For example, maternal exposure to particulate matters during pregnancy can contribute to systemic oxidative stress-induced DNA damage, and disrupting DNA transcription which, in turn, may increase the number of placental DNA adducts. Particulate matters may also bind receptors for placental growth factors, which result in decreasing foetal-placental exchange of oxygen and nutrients [21]. Disturbances in the supply of nutrients and oxygen to the foetus can lead to adverse foetal growth patterns [22]. Another mechanism, which has been less investigated, is inducing acute placental and pulmonary inflammation by inhalation of particles during pregnancy [23]. Other potential mechanisms of PM toxicity comprise: blood coagulability and whole blood viscosity, endothelial dysfunction and haemodynamic response, including raising blood pressure [21].

Studies on exploring a biologic plausibility for the exposure to airborne particulate matter and adverse perinatal outcomes raises acute adverse neonatal health effects of air pollution. Beside these effects, as current evidence suggests, prenatal exposure to air pollution may also cause long-term consequences in adult life. Many studies worldwide have confirmed that low birth weight, a crude marker of disturbed foetal growth, strongly associates with features of metabolic syndrome, and may be responsible for type 2 diabetes, obesity, hypertension, cardiovascular disease, and also some types of nepolasm, e.g. breast cancer [22]. Laboratory studies on animal models indicate that prenatal exposure to air pollution can also impair the future male and female reproductive functions, by diminishing sperm production and lowering testosterone levels [24] or lowering protein (BMP-15) concentrations pertinent to bone morphogenetic proteins, which may play a role in oocyte and follicular development [25]. This concept of a developmental programming (termed also as the developmental origins of health and disease) had been suggested prior to the work of Barker [26] and assumes that stimulus during a critical period of growth triggers off long-term anatomical and physiological changes in key tissues or organ systems. Thus, exposure to PM10 during the particular prenatal period of development may by more dangerous than adult exposure, as regards serious health consequences.

Over the last decades, there has been growing evidence that air pollution affects human health. Many epidemiological and reproductive biological findings point to the greater sensitivity of foetuses and newborns to environmental toxins, compared with adults. The pregnancy is considered the most vulnerable period of life for the developing organism, mainly due to intensive cell proliferation and changes in hormonal metabolism. The impact of air pollutants such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), carbon dioxide (CO_2), and fine particulate matters (PM) on birth outcomes, have previously been reported.

The results of the presented study showed a weak negative association between PM10 maternal exposure during the first trimester of pregnancy and entire pregnancy period, and birth weight reduction, but this hypothesis needs further testing on divergent populations and datasets. Only when these findings have been confirmed, and when biological mechanisms have been better understood, they would provide an important contribution to the debate on reducing the air particulate matters exposures.

Acknowledgement

This study was carried out within the framework of Project No. N N404 055 136, financed by the Ministry of Science and Higher Education in Warsaw.

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