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Is Air Pollution a Risk Factor for Low Birth Weight in Ulaanbaatar, Mongolia?

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Abstract

Ulaanbaatar (Mongolia) is one of the most air polluted capital cities in the world, with ambient sulfide dioxide (SO_2) and particulate matter PM_{10} and $PM_{2.5}$ levels > 23 times World Health Organization (WHO) standards in winter. Several studies have examined the effects of air pollution on pregnancy, providing that exposure to ambient air pollutants is associated with poor birth outcome, such as low birth weight. Our study goal was to study the associations between air pollution exposures during pregnancy and low birth weight among all full-term births (gestational age 37 - 42 weeks) for a 6-year period (January 2008 through December 31, 2013) in Ulaanbaatar, Mongolia. In the study we recruited 160,676 singletons. We used a logistic regression adjusting for gestational age, parental education level, parity and infant age. The adjusted relative risk of low birth weight was 1.06 (95% CI = 1.01 - 1.12) for each inter-quartile increase in NO_2 concentrations. The risk of low birth weight was increased to 1.04 (95% CI = 0.93 - 1.15) for CO, 1.02 (95% CI 0.97 - 1.05) for SO_2 and 1.03 (95% CI 1.01 - 1.08) for PM_{10}. Each inter-quartile increase of NO_2 concentration during the first trimester reduced 10.74 gm of birth weight. SO_2, CO and PM_{10} also decreased birth weight 7.62, 7.49, and 8.72 gm, respectively. Each inter-quartile increase of pollutants decreases baby weight up to 11 grams.

Keywords

Low Birth Weight, Carbon Monoxide, Nitrogen Dioxide, Sulfur Dioxide, Particulate Matter, Ulaanbaatar, Pollution

Subject Areas: **Clinical Trials, Epidemiology, Evidence Based Medicine, Gynecology & Obstetrics, Public Health**

1. Introduction

More than 20 million low birth weight infants are born per year in developing countries [1]. Low birth weight is

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caused by genetic, demographic, and environmental factors. In last decade the environmental factors, including air pollution contribute to reducing the birth weight and it is becoming a great public health concern.

According to a previous survey conducted in 255 world countries, the average global birth rate was 18.9 per every 1000 total birth or 4.3 births were registered per minute [2].

According to the population census of 2012, Mongolia's total population reached 2,867,700. As of 2012, the capital city's population was 1,318,100. The birthrate growth has also been increasing in recent years; the birthrate which was 1.74 in 2011 increased to 2.0 in 2012 [3] [4].

Over the last ten years, numerous studies have determined a positive association between air pollution and pregnancy outcomes. Several studies have examined the effects of air pollution on pregnancy, providing that exposure to ambient air pollutants is associated with poor birth outcome, such as low birth weight [5]-[7]; small for gestational age [8]-[10]; preterm birth [11]-[14]; congenital malformations [15]-[17] and pregnancy complications such as preeclampsia [18].

Ulaanbaatar (Mongolia) is one of the most air polluted capital cities in the world, with ambient sulfide dioxide (SO_2) and particulate matter PM_{10} and $PM_{2.5}$ levels > 23 times World Health Organization (WHO) standards in winter. The main sources of air pollution in Ulaanbaatar are household heating systems including stoves, coal burning, industrial boilers, power plants, public and private vehicles and dust emissions. The air pollution in Ulaanbaatar City is particularly severe in the winter months, due to natural constraints in the layout of the city, surrounded by mountains, and the meteorological conditions with low temperatures and low mixing heights for most part of the year, which limits the dispersion of pollutants and enhancing their concentrations.

Despite its extraordinarily high air pollution concentrations, UB has received very little research attention, where 623 deaths attributable to air pollution representing 4.0% of the annual deaths for the entire country. Moreover, a recent World Bank report relates that these noxious levels of winter air pollution are associated with adverse health effects including cardiovascular events as well as pulmonary diseases that are estimated to cost as much as 19% of UB's GDP.

The low birth weight infants are more prone to various infant diseases or infant mortality. Furthermore, the low birth weight is the risk factor or underlying cause for hypertension, diabetes and other metabolic syndromes later in life [19].

In view of such facts, the present study focuses to examine the association between air pollution exposures during pregnancy and low birth weight among all full-term births, weight of newborn babies and cases involving child deliveries between 2008 and 2013.

2. Material and Methods

The study team applied the retrospective descriptive model. The data attributable to births were extracted from the database operated by the National Center for Maternal and Child Health (formerly, the Maternal and Infant Health Center), and the First, Second and Third Maternity Homes after obtaining an official written permission. Additional data were taken from the Information Database of the Center for Health Development as well as the Health Info-2 System. Data pertaining to total births delivered at private clinics in Ulaanbaatar in the years 2008-2013 are also included in the study. In addition, relevant data and information covering the years 2008-2013 were collected including total births, live births, stillbirths, number of newborn infants, their birth weight and length, basic birth diagnosis, demographic indicators attributable to pregnant mothers, reproduction related information, prenatal care and chronic diseases common among childbearing women. Ethical approval was obtained from Ethical Committee of Health Sciences University in January, 2012. In the study we recruited 160,676 singletons. The low birth weight (LBW) is defined as a birth weight of live born infant of less than 2500 g (5 pounds 8 ounces) regardless of gestational age.

The association between ambient air pollution and low birth weight was evaluated using SPSS 20, with a logistic regression adjusting for gestational age, maternal age, maternal education level, maternal pregnancy order, and infants' gender. Pearson's correlation coefficients were used to examine the relation among air pollution concentrations.

3. Results

The overall prevalence rate of low birth weight is 4.49%, excluding preterm birth, and mean birth weight is 3403.4 gm (standard deviation = 70.263) for 160,676 singletons. Birth weight varied with maternal age, maternal education level, maternal pregnancy order, season and infant's gender after adjusting covariates. Young maternal age, maternal less education level, early and older birth order, spring season, not married status, higher number of pregnancy order and female gender of infant are risk factors for low birth weight (**Table 1**).

The average concentrations of air pollutants for the first, second and third trimester of pregnancy of study subjects for each quartile changes are presented in **Table 2**. There was a difference of air pollutant levels of first and second trimesters of pregnancy.

Table 1. Means of birth weight after adjusting other covariates, Ulaanbaatar, 2008-2013.

Covariates	N	Birth weight means (g)	95% CI		Low birth weight (%)	Number of live births
			Lower	Upper		
Maternal age (years)						
<20	15,705	3307	3300	3315	**4.6%**	15,705
20 - 24	43,135	3396	3391	3401	3.5%	43,135
25 - 29	47,873	3456	3452	3461	3.1%	47,873
30+	53,963	3446	3441	3451	**4.6%**	53,963
Maternal education (years)						
<1	214	3320	3248	3393	**7.0%**	214
1 - 4	777	3225	3186	3264	**8.3%**	779
4 - 12	77,360	3383	3379	3387	4.3%	77,468
12 - 14	21,936	3472	3465	3479	3.8%	21,975
14+	60,170	3467	3463	3471	3.2%	60,240
Not married	2317	3279	3257	3302	**6.9%**	2325
Married	158,140	3428	3425	3430	3.8%	158,351
Pregnancy order (number)						
1 - 3	123,725	3411	3408	3414	3.7%	123,870
4 - 6	33,919	3478	3472	3484	**4.3%**	33,989
7+	2813	3448	3426	3470	**5.6%**	2817
Season						
Spring	36,577	3414.82	3409.52	3420.12	**4.0%**	36,623
Summer	40,234	3429.01	3423.94	3434.08	3.8%	40,284
Fall	42,212	3423.86	3418.96	3428.77	3.7%	42,272
Winter	41,434	3433.97	3428.99	3438.95	3.8%	41,497
Infant sex						
Female	78,076	3373.27	3369.75	3376.79	**4.0%**	78,184
Male	82,381	3475.40	3471.81	3478.99	3.7%	82,492
Total		3403.4*			4.49%	

*Standard deviation: 70.263.

Table 2. Twenty-fifth, 50^{th} and 75^{th} percentiles of air pollution concentrations of the first, second and third trimesters.

Pollutants	**The first trimester percentile**			**The second trimester percentile**			**The third trimester percentile**		
	25^{th}	**50^{th}**	**75^{th}**	**25^{th}**	**50^{th}**	**75^{th}**	**25^{th}**	**50^{th}**	**75^{th}**
SO_2	5.7	14.9	38.4	4.4	11.1	33.1	5.6	12.8	32.6
NO_2	22.8	28.5	40.5	25.3	36.7	62.1	22.3	28.9	46.6
CO	525.8	1158.8	**1847.4**	525.8	1162.2	**1825.0**	527.3	1146.1	**1767.3**
PM_{10}	59.7	112.7	**243.2**	60.9	115.9	**240.2**	61.8	118.8	**231.5**

The concentrations of CO, NO_2, SO_2 and PM_{10} were positively correlated with each other ($0.54 \le r \le 0.69$) (**Table 3**).

Concentrations of air pollutants showed seasonal patterns in international studies. To avoid seasonal confounding we also used a smooth function of time trend in the logistic regression model for low birth weight using the generalized additive model [20] [21]. In the models CO, NO_2, SO_2 and PM_{10} were risk factors for low birth weight (**Table 4**).

Table 4 shows adjusted relative risks for each inter-quartile change of air pollutants. The adjusted relative risk was 1.06 (95% CI = 1.01 - 1.12) for each inter-quartile increase in NO_2 concentrations. The risk of low birth weight increased to 1.04 (95% CI = 0.93 - 1.15) for CO, 1.02 (95% CI 0.97 - 1.05) for SO_2 and 1.03 (95% CI 1.01 - 1.08) for PM_{10}.

Table 5 describes the reduction of birth weight for inter-quartile changes of each air pollutant. Each inter-quartile increase of NO_2 concentration during the first trimester reduced 10.74 gm of birth weight. SO_2, CO, PM_{10} also decreased birth weight 7.62, 7.49, and 8.72 gm, respectively.

Table 3. Correlation matrix of air pollutant concentrations during study period (2008-2013).

Pollutants	SO_2	NO_2	CO
NO_2	0.6556**		
CO	0.653**	0.545**	
PM_{10}	0.696**	0.677**	0.597**

CO = carbon monoxide, NO_2 = nitrogen dioxide, SO_2 = sulfur dioxide, PM_{10} = particulate matter.

Table 4. Relative risk of LBW for each inter-quartile change of CO, NO_2, SO_2, and PM_{10} of the first and second trimester of pregnancy.

Pollutant	First and second trimester separately	
	RR	**95% CI**
CO		
First	**1.04**	**0.93 - 1.15**
Second	**1.01**	**0.81 - 1.08**
NO_2		
First	**1.06**	**1.01 - 1.12**
Second	**0.96**	**0.91 - 1.09**
SO_2		
First	**1.02**	**0.97 - 1.05**
Second	**0.93**	**0.83 - 1.19**
PM_{10}		
First	**1.03**	**1.01 - 1.08**
Second	**0.96**	**0.57 - 1.03**

Table 5. Reduction of birth weights for inter-quartile increase of CO, NO_2, SO_2, and PM_{10} of the first trimester.

Pollutant	Coefficients	Reduction of birth weight	95% CI, inter-quartile change	
SO_2	−0.017	7.62	5.37	9.87
NO_2	−0.023	10.74	8.49	12.99
CO	−0.016	7.49	5.24	9.74
PM_{10}	−0.019	8.72	6.47	10.97

4. Discussion

We found that ambient air CO, NO_2, SO_2 and PM_{10} concentrations during the first trimester and second trimester of pregnancy were associated with low birth weight after adjusting for gestational age, parental education level, parity and infant age. In Chinese study [22], there was strong evidence between third trimester maternal exposures to SO_2, TSP and low birth weight. Rogers and Thompson showed air pollution exposures, especially TSP and SO_2 without considering specific trimester had association with very low birth weight ($\leq$1500 gm) [23]. A Czech study of birth outcomes found that the risk of intrauterine growth retardation was increased in full-term births when mothers were exposed to high levels of PM_{10} in the first months of pregnancy after controlling for maternal characteristics [24]. Ritz and Yu showed exposure-response relations between third trimester exposure to CO and birth weight [25]. In our study NO_2, SO_2, CO and PM concentrations of the first trimester are also associated with low birth weight.

The main limitation of the study was the lack of information to adjust some personal risk factors for low birth weight such as smoking, alcohol consumption and income. Another limitation was the using of environmental monitoring data, which could not represent individual exposures.

5. Conclusion

The study of the associations between air pollution exposures during pregnancy and low birth weight among all full-term births (gestational age 37 - 42 weeks) for a 6-year period (2008-2013) in Ulaanbaatar, Mongolia was performed and the logistic regression adjusting for gestational age, parental education level, parity and infant age was used for the study. The results showed that the adjusted relative risk of low birth weight was 1.06 (95% CI = 1.01 - 1.12) for each inter-quartile increase in NO_2 concentrations. The risk of low birth weight was increased to 1.04 (95% CI = 0.93 - 1.15) for CO, 1.02 (95% CI = 0.97 - 1.05) for SO_2 and 1.03 (95% CI = 1.01 - 1.08) for PM_{10}. Each inter-quartile increase of NO_2 concentration during the first trimester reduced 10.74 gm of birth weight. SO_2, CO and PM_{10} also decreased birth weight 7.62, 7.49, and 8.72 gm, respectively.

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