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Effects of particulate matter exposure during pregnancy on birth weight: A retrospective cohort study in Suzhou, China

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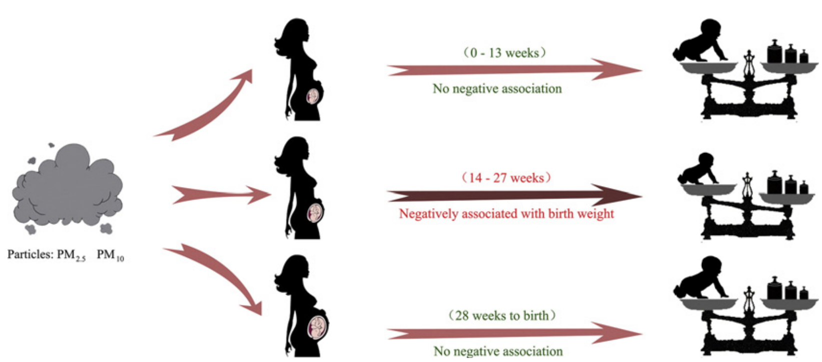
HIGHLIGHTS

- Birth weight was reduced by $PM_{2.5}$ and PM_{10} exposure during second trimester.
- Particle exposure was not associated with birth weight in the other two trimesters or the whole gestation.
- No significant association was observed between particle exposure and gestational age of term neonates.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: Recent studies have identified that exposure to particulate matter during pregnancy could result in adverse birth outcomes, but the effects of exposure at trimester-specific intervals are inconsistent.
Objective: Our primary goal was to investigate whether particulate matter exposure during pregnancy could affect birth weight and gestational age of neonates.
Methods: A retrospective cohort study was conducted to examine the relationship between maternal particulate matter exposure and neonatal birth weight. We collected 14,455 births records linked to hospital admission records (delivery and antenatal) from January 2013 to December 2015 in Suzhou Municipal Hospital. Air monitoring data in the same timeframe were also collected from Suzhou Environmental Protection Agency. The risk of low birth weight due to the exposure to $PM_{2.5}$ (with median aerodynamic diameter ≤ 2.5 μm) and PM_{10} (with median aerodynamic diameter ≤ 10 μm) at each trimester and throughout the entire pregnancy were assessed. Linear regression models were applied and potential confounding factors were adjusted for data analysis. Gestational age, which was another important birth outcome, and its association with maternal particulate matter exposure were also studied.

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Results: The final analysis included 10,915 singleton live births. Using multiple linear regression models, we found that gestational exposure to $PM_{2.5}$ and PM_{10} at 10 μg/m^3 increments in the second trimester led to decreases in birth weight of 4.94 g (95% confidence interval: −9.828, −0.046) and 5.65 g (95% confidence interval: −10.110, −1.188), respectively. However, gestational age was not significantly associated with maternal particulate matter exposure in term neonates.

Conclusion: These findings indicate that pregnant women might be more susceptible to particulate matter during the second trimester which may lead to decreased neonatal birth weight.

1. Introduction

Air pollution has become one of the world's biggest health risk. Pollution-caused problems have drawn more attention along with the development of technology and industry. Ambient air pollution has caused heavy burden on economy and human society (Trasande et al., 2016) and resulted in a variety of adverse effects on human body such as diabetes mellitus, asthma, respiratory diseases (Coogan et al., 2012; Middleton et al., 2008; Pollock et al., 2017) and even Alzheimer's disease (Yan et al., 2016). Particulate matter is the primary pollutants of air pollution. It's ubiquitous as hybrids of solid particles and liquid droplets floating in the atmosphere. Usually, they were emitted from construction sites, unpaved roads, fields, smokestacks and fires in different sizes and forms. It can be made up of hundreds of different chemicals. Particle pollution includes PM_{10}, which are inhalable particles with diameters that are generally smaller than 10 μm; and $PM_{2.5}$, which are fine inhalable particles with diameters that are <2.5 μm. Some studies have shown that particulate matter is a major cause of mortality (Jacobson, 2008) and ranked as the fourth leading cause of death in China (Lim et al., 2012).

Several studies have reported the adverse pregnancy outcomes related to particulate matter, including low birth weight (Laurent et al., 2014b; Morakinyo et al., 2016; Sapkota et al., 2012), premature delivery (Ha et al., 2004; Lamichhane et al., 2015; Leem et al., 2006), intrauterine retardation (Vrijheid et al., 2011), birth defects (Girguis et al., 2016; Yao et al., 2016) and stillbirth (Green et al., 2015; Siddika et al., 2016). Birth weight loss is a common adverse birth outcome, which has been proved to have impacts on infant health and even long-term health (Sappenfield et al., 1987; Wilcox, 2001). It is often used as an important indicator for neonatal survival (Mathews and MacDorman, 2008; Osmond and Barker, 2000) (Valla et al., 2017). Previous evidence suggested that complex toxic particulate matter constituents, especially zinc, nickel, vanadium, organic carbon and nitrate, cause adverse birth outcomes. The combination of various types of metal elements may cause maternal inflammatory response and decrease blood oxygen carrying capacity, which may further lead to intrauterine growth retardation (Basu et al., 2014; Laurent et al., 2014a).

Although trimester-specific analysis of relationship between particulate matter exposure and birth outcomes has been conducted extensively, the findings were inconsistent across studies. Some studies observed association between particulate matter exposure and adverse birth outcome during first trimester of pregnancy (Hansen et al., 2006; Lee et al., 2013; Medeiros and Gouveia, 2005), while others indicated the relationship in late trimester (Bell et al., 2007; Gray et al., 2010; Yitshak-Sade et al., 2016). The inconsistent results may be attributed to heterogeneous sources, different statistical methods, racial and ethnic differences, pollutant components, sample size and regional variation. Our research was conducted in Suzhou, which is a relatively developed city in eastern China with a large population and rapid industrial development. The concentration of airborne particulate matter in Suzhou is relatively stable and at the national average. Thus, it's suitable for us to explore the association between particle pollution and adverse birth outcomes such as low birth weight and gestational age.

2. Methods

2.1. Study population

A retrospective cohort study was conducted to examine the relationship between maternal particulate matter exposure during pregnancy and neonatal birth weight. The study population was recruited at Suzhou municipal hospital (Suzhou, China) from January 2013 to December 2015 and hospital-based records of all participants were obtained. The records include both the neonates (e.g. birth weight, gestational age and sex) and the mothers (e.g. pre-pregnancy body mass index (BMI), age, education level, pregnancy complications and if assisted reproduction techniques were used). Women with smoking or alcohol history or give birth elsewhere were excluded from this study. Other exclusion criteria, which were referred from a previous study (Ebisu et al., 2014), including non-singleton births ($n = 1679$), birth defects such as sexual deformity, congenital malformation, hydrocephalus, hydronephrosis and congenital heart disease, assisted reproduction techniques used ($n = 577$) and maternal age <15 years old or >50 years old ($n = 411$). Gestational age was estimated based on the first day of last menstrual period and date of birth. For women whose gestational age <37 weeks were also excluded ($n = 873$). As a result, 10,915 pregnant women were included in this study (Fig. 1). The study protocol was approved by the institute review board of Nanjing Medical University and complied with the principle outlined in the Helsinki Declaration. The written inform consent provided by the institute review board was also obtained from each participant.

2.2. Exposure assessment

Data on these two pollutants were collected at Suzhou Environment Agency from January 1, 2013 to December 31, 2015. Daily 24-hour average concentrations of the pollutants $PM_{2.5}$ and PM_{10} were measured by eight fixed-site monitoring stations in Suzhou, namely Shangfangshan, Nanmen, Wuzhong, Caixiang, Xiangcheng, Zhagangchang, Xingqu, and Gongyeyuan. The residential address of each pregnant woman registered in medical record was converted into longitude and latitude using Google Maps software. The map coordinates of the air monitoring stations and a geographic information system (ARCGIS, version 10.3; ESRI, Redlands, CA, USA) (Lin et al., 2015) was used. In this study, the first trimester was defined as 0–12 weeks, while the second trimester was 13–27 weeks, and the third trimester spanned from 28 weeks to birth. The average particle concentrations of the eight air monitoring stations were calculated based on different trimesters for each participant and clustered pregnant woman with similar gestational age. Monthly average particle concentration of each air monitoring station was used as a reference. Then, the exposure value of each pregnant woman was calculated using inverse distance weighting approach on the basis of reference concentration, longitude and latitude of individual residential site and air monitoring stations.

2.3. Covariates

Clinical information that were considered in the analyses include maternal delivery age (categorized into <20, 20–34 and >34 years