Science of the Total Environment 609 (2017) 815–821

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Estimation of disease burdens on preterm births and low birth weights attributable to maternal fine particulate matter exposure in Shanghai, China

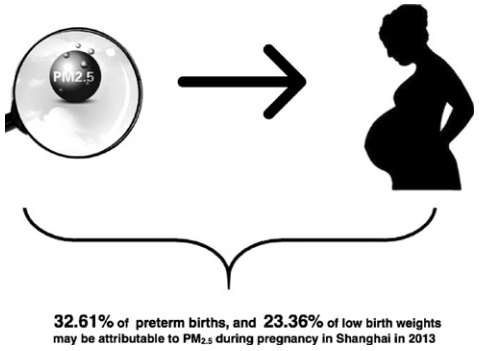
Anni Liu [a], Naisi Qian [b], Huiting Yu [b], Renjie Chen [a,c,*], Haidong Kan [a]

[a] School of Public Health, Key Lab of Public Health Safety of the Ministry of Education, Fudan University, Shanghai 200032, China
[b] Shanghai Municipal Center for Disease Control and Prevention, Shanghai 200336, China
[c] Shanghai Key Laboratory of Meteorology and Health, Shanghai 200030, China

HIGHLIGHTS

- This is one of few studies evaluating the burdens of $PM_{2.5}$ on PTB and LBW in China.
- 32.61% of PTB and 23.36% of LBW may be attributable to $PM_{2.5}$ in Shanghai, China.
- Considerable benefits could be achieved by reducing $PM_{2.5}$ exposure in pregnancy.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 11 March 2017
Received in revised form 18 July 2017
Accepted 20 July 2017
Available online 30 July 2017

Editor: D. Barcelo

Keywords:
Air pollution
$PM_{2.5}$
Preterm birth
Low birth weight
Disease burden

ABSTRACT

Background: Studies have shown that maternal exposure to particulate matter ≤2.5 μm in aerodynamic diameter ($PM_{2.5}$) was associated with adverse birth outcomes such as preterm birth (PTB) and low birth weight (LBW). However, the burdens of PTB and LBW attributable to $PM_{2.5}$ were rarely evaluated, especially in developing countries.

Objectives: To estimate the burdens of PTBs and LBWs attributable to outdoor $PM_{2.5}$ in Shanghai, China.

Methods: We collected annual-average $PM_{2.5}$ concentrations, concentration-response relationships between $PM_{2.5}$ exposure during pregnancy and PTBs and LBWs, rates of PTB and LBW, number of live births, and population sizes in grids of 10 km × 10 km in Shanghai in 2013. Then, they were combined to estimate the odds ratios (ORs), relative risks (RRs), attributable fractions (AFs), and numbers of PTBs and LBWs associated with $PM_{2.5}$ exposure.

Results: The population-weighted annual-average concentration of $PM_{2.5}$ in Shanghai was 56.19 $\mu g/m^3$ in 2013. According to the first-class limit of $PM_{2.5}$ (15 $\mu g/m^3$) in the Ambient Air Quality Standards of China, the weighted RRs of PTBs or LBWs associated with $PM_{2.5}$ in Shanghai were 1.49 [95% confidence interval (CI): 1.16–1.80] and 1.31 (95% CI: 1.04–1.67), respectively. There might be 32.61% (95% CI: 13.93%–44.42%) or 4160 (95% CI: 1778–5667) PTBs and 23.36% (95% CI: 3.86%–40.02%) or 1882 (95% CI: 311–3224) LBWs attributable to $PM_{2.5}$ exposure. The estimates varied appreciably among different districts of Shanghai.

Abbreviations: PTB, preterm birth; LBW, low birth weight; $PM_{2.5}$, particulate matter less than or equal to 2.5 μm in aerodynamic diameter; OR, odds ratio; CI, confidence interval; RR, relative risk; AF, attributable fraction; GBD, Global Burden of Disease; Class I standard, the first-class limit of $PM_{2.5}$ in the Ambient Air Quality Standards of China; Class II standard, the second-class limit of $PM_{2.5}$ in the Ambient Air Quality Standards of China.

* Corresponding author at: School of Public Health, Fudan University, P.O. Box 249, 130 Dong-An Road, Shanghai 200032, China.
E-mail address: chenrenjie@fudan.edu.cn (R. Chen).

http://dx.doi.org/10.1016/j.scitotenv.2017.07.174
0048-9697/© 2017 Published by Elsevier B.V.

Conclusions: Our analysis suggested that outdoor $PM_{2.5}$ air pollution might have led to considerable burdens of PTBs and LBWs in Shanghai, China.

© 2017 Published by Elsevier B.V.

1. Introduction

Outdoor fine particulate matter (particulate matter less than or equal to 2.5 μm in aerodynamic diameter, $PM_{2.5}$) air pollution is widely regarded as a major public health problem worldwide. In particular, several systematic literature reviews and meta analyses have shown that maternal exposure to $PM_{2.5}$ during pregnancy could increase the risk of preterm birth (PTB, <37 weeks of gestation) and low birth weight (LBW, <2500 g at birth) (Li et al., 2017; Zhu et al., 2015), although some individual studies found null or insignificant effects of $PM_{2.5}$ (Gehring et al., 2011; Pereira et al., 2014). Globally, it was estimated that 2.7 million (1.8–3.5 million) PTBs, corresponding to 18% (12%–24%) of PTBs worldwide were attributable to maternal exposure to $PM_{2.5}$ during pregnancy in the low cut-off of $PM_{2.5}$ concentration of 10 μg/m^3 (Malley et al., 2017). PTBs and LBWs can bring huge health care costs and economic productivity losses because of a number of postnatal complications (Institute of Medicine, 2007; Trasande et al., 2016). These complications include respiratory distress syndrome, sepsis, intraventricular hemorrhage, serious bacterial infection, and other diseases later in life such as asthma, cerebral palsy, neurodevelopmental delay, hypertension, diabetes, and stroke (Caudri et al., 2007; Norman, 2013; Saigal and Doyle, 2008).

As the largest developing country in the world, China is facing severe air pollution problems. In China, significant associations between $PM_{2.5}$ exposure and PTBs or LBWs have been detected in a retrospective analysis based on the World Health Organization Global Survey on Maternal and Perinatal Health (Fleischer et al., 2014) and in a prospective cohort including 95,911 live births conducted in Wuhan, China (Qian et al., 2016). Understanding of the fractions and numbers of PTBs and LBWs attributable to ambient $PM_{2.5}$ can be very helpful to design the regulatory strategies aiming to mitigate the disease burdens due to maternal $PM_{2.5}$ exposure. However, few estimates in this regard were currently available in this country.

Therefore, we evaluated the disease burdens on PTBs and LBWs attributable to maternal $PM_{2.5}$ exposure in Shanghai, one of the most developed and populous cities in China.

2. Materials and methods

2.1. Data collection

We collected population-weighted annual-average concentrations of $PM_{2.5}$ in grids of 10 km × 10 km within Shanghai in 2013, respectively, from the Global Burden of Disease 2013 (GBD 2013) database (Brauer et al., 2016; Institute for Health Metrics and Evaluation, 2013). These data were estimated by combining population sizes with $PM_{2.5}$ concentrations estimated from a global calibration model based on satellite data, results of GEOS–Chem chemical transport model and ground measurements (Brauer et al., 2016). We collected population sizes in the central urban area and 9 suburban districts (Fig. 1) of Shanghai in 2011, 2012, 2013 from the Shanghai Statistical Yearbooks. We obtained the number of live births and corresponding PTB rates in the permanent resident populations of Shanghai in 2013 from the Shanghai Major Statistical Data of Health and Family Planning (Shanghai Municipal Health and Family Planning Commission, 2015). We also collected the number and rate of LBWs classified by term LBW and preterm LBW among live births in 2013 from the same source.

The concentration-response relationships linking $PM_{2.5}$ exposure during pregnancy to the occurrences of PTBs and LBWs are crucial to calculate the fraction and number of PTBs or LBWs attributable to maternal $PM_{2.5}$ exposure. According to our brief literature review, no studies have explored the concentration-response functions in Shanghai. We thus relied on a pooled analysis on PTB and LBW using data across 21 clinics in China (Fleischer et al., 2014), which derived an OR of 1.11 [95% confidence interval (CI): 1.04–1.17] for PTBs and an OR of 1.07 (95% CI: 1.01–1.14) for LBWs associated with a 10 μg/m^3 increase of maternal $PM_{2.5}$ exposure. These estimates were generally consistent with other meta-analyses (Sapkota et al., 2012; Sun et al., 2016; Zhu et al., 2015; Lamichhane et al., 2015), but we did not use the results of these meta analyses because they had incorporated none or only one Chinese study. Besides, considering that no epidemiological studies reported the associations between $PM_{2.5}$ exposure and term-LBW in China, and huge disparities existing (for example, $PM_{2.5}$ levels and compositions) between China and developed countries, we still used the China-specific ORs of total LBW derived in Fleischer's study (Fleischer et al., 2014).

2.2. Estimation of ORs of PTBs or LBWs associated with $PM_{2.5}$

For each 10 km × 10 km grid in Shanghai, ORs (and 95% CIs) of PTBs or LBWs associated with a 10 μg/m^3 increase of $PM_{2.5}$ exposure during pregnancy in 2013 were calculated by the formula shown in Eq. (1) (Trasande et al., 2016).

$$OR_{10\ km\times 10\ km} = OR_{ref}^{\frac{C_{10\ km\times 10\ km}-C_s}{10}\ \mu g/m^3} \quad (1)$$

In Eq. (1), $OR_{10\ km\ \times\ 10\ km}$ is the OR (and 95% CI) of PTBs or LBWs associated with $PM_{2.5}$ in each 10 km × 10 km grid; OR_{ref} is the OR (and 95% CI) of PTBs or LBWs associated with a 10 μg/m^3 increase of $PM_{2.5}$ exposure obtained from Fleischer's study (Fleischer et al., 2014); $C_{10\ km\ \times\ 10\ km}$ is the population-weighted annual-average concentration of $PM_{2.5}$ in each 10 km × 10 km grid; C_{s1} is the first-class limit of $PM_{2.5}$ in the Ambient Air Quality Standards of China (Class I standard, 15 μg/m^3); C_{s2} is the second-class limit of $PM_{2.5}$ in the Ambient Air Quality Standards of China (Class II standard, 35 μg/m^3). The estimations were conducted at grid level and were further aggregated at district and city levels.

2.3. Estimation of RRs of PTBs or LBWs associated with $PM_{2.5}$

Because ORs might overestimate the true relative risks (RRs) and attributable fractions (AFs) due to potential misclassification, we applied the formula shown in Eq. (2) to estimate the RR (and 95% CI) in each 10 km × 10 km grid (Zhang and Yu, 1998).

$$RR_{10\ km\times 10\ km} = \frac{OR_{10\ km\times 10\ km}}{1-Rate_{PTB/LBW}+Rate_{PTB/LBW}\times OR_{10\ km\times 10\ km}} \quad (2)$$

In Eq. (2), $RR_{10\ km\ \times\ 10\ km}$ is the RR (and 95% CI) of PTBs or LBWs associated with $PM_{2.5}$ in each 10 km × 10 km grid; $Rate_{PTB/LBW}$ is the rate of PTB (6.53%) or LBW (3.87%) in Shanghai in 2013. The estimations were conducted at grid level and were further aggregated at district and city levels.

Download English Version:

https://daneshyari.com/en/article/5750808

Download Persian Version:

https://daneshyari.com/article/5750808

Daneshyari.com