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Associations of gestational and early life exposures to ambient air pollution with childhood atopic eczema in Shanghai, China

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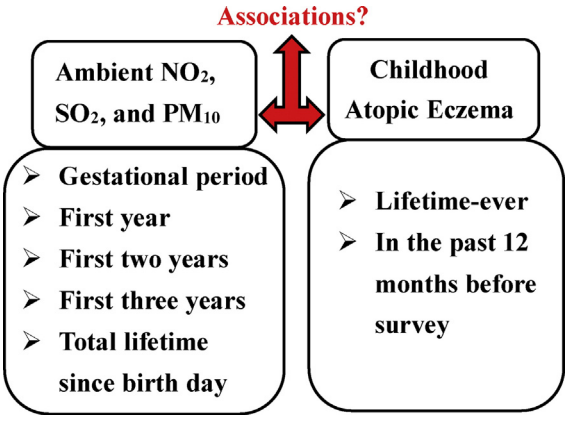
HIGHLIGHTS

- We first studied effects of ambient NO_2, SO_2, and PM_{10} on childhood eczema in China.
- We compared differences in effect of pollutants in various periods on child's eczema.
- Exposure to NO_2 in various periods were significantly associated with child's eczema.
- No significant association was found of ambient SO_2 and PM_{10} with childhood eczema.

GRAPHICAL ABSTRACT



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ABSTRACT

Whether ambient air pollution is associated with childhood atopic eczema is controversial. In this paper, we selected 3358 preschool children who had not altered residences since pregnancy from a cross-sectional study during 2011–2012 in Shanghai, China, and obtained parent-reported data regarding childhood atopic eczema using an improved ISAAC questionnaire. We recorded daily concentrations of SO_2, NO_2, and PM_{10} throughout the child's lifetime (2006–2012), and calculated period-averaged concentrations for each district where the child lived to represent the child's exposure levels of these pollutants during different periods. In the multiple logistic

Abbreviations: ISAAC, International Study of Asthma and Allergies in Childhood; CCHH, China, Children, Homes, Health; SO_2, sulphur dioxide; NO_2, nitrogen dioxide; PM_{10}, particulate matter with an aerodynamic diameter ≤ 10 μm; OR, odds ratio; CI, confidence interval; IQR, interquartile range; ETS, environmental tobacco smoke.

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regression analyses adjusted for potential confounders as well as for the other pollutants in the same periods, childhood atopic eczema was significantly associated with increments of NO_2 in the approximate interquartile range (20 μg/m^3) during gestational period (adjusted OR, 95% CI for eczema lifetime-ever: 1.80, 1.29–2.49; for eczema in the year prior to the survey: 2.32, 1.57–3.43) and during the first year of life (2.00, 1.40–2.84; 2.16, 1.43–3.28). Exposure to elevated NO_2 in the first two years, three years and total lifetime, as well as exposure to mixtures containing NO_2 in each of these periods, were consistently associated with increased likelihood of childhood eczema. The highest odds ratios were found between exposure to a mixture of SO_2 and NO_2 during total lifetime (increment: 35 μg/m^3) and childhood eczema (adjusted OR, 95% CI: 2.80, 1.75–4.48; 3.50, 1.98–6.19). No significant associations were found between childhood eczema and ambient SO_2 and PM_{10} individually or in mixtures. This study indicates that gestational and lifetime exposures to ambient NO_2 are risk factors for atopic eczema in childhood. Exposure to ambient SO_2 and PM_{10} may enhance the effect of NO_2 exposure on childhood eczema.

1. Introduction

Atopic eczema (also known as atopic dermatitis) is a common skin disease in childhood affecting a child's life-quality (Weidinger and Novak, 2015). Several studies have reported that the childhood prevalence of atopic eczema has been increasing world-wide (Asher et al., 2006; Duggan et al., 2012; Grize et al., 2006; Weidinger and Novak, 2015). The childhood prevalence of atopic eczema in China has greatly increased in the past 20 years (Gu et al., 2004; Xu et al., 2012; Zhang et al., 2013).

Serious outdoor air pollution is presently a hot topic in China (Kan et al., 2012; Zhang et al., 2012). Studies have not consistently found associations between air pollution and children's eczema (Ahn, 2014; Flohr and Mann, 2014; Kim et al., 2013b; Kim and Hong, 2012; Lee et al., 2008, 2013; Myers and Hershey, 2010; Song et al., 2011; Torres-Borrego et al., 2008). Several studies have found that exposure to ambient air pollutants increases the risk of atopic eczema in childhood (Hasunuma et al., 2014; Sbihi et al., 2015; Weir et al., 2013) or exacerbates atopic eczema symptoms (Brunekreef et al., 2009; Kim et al., 2013a; Song et al., 2011). However, other studies have reported that exposure to ambient air pollutants had no significant associations with atopic eczema in childhood (Aguilera et al., 2013; Anderson et al., 2010; Brauer et al., 2007; Gehring et al., 2010; Yura and Shimizu, 2001).

Few of these studies have been conducted in China (Lee et al., 2008, 2013). To our best knowledge, no studies have investigated gestational and early life exposures to ambient air pollutants and childhood prevalence of atopic eczema in China. Therefore, we used daily concentration data of outdoor SO_2, NO_2, and PM_{10} from the Shanghai Environmental Monitoring Center (SEMC), with our data for childhood atopic eczema from the questionnaire-based cross-sectional survey in the China, Children, Homes, Health (CCHH) study in Shanghai to investigate associations between pollutant exposure and the prevalence of atopic eczema. We studied exposures to outdoor SO_2, NO_2, and PM_{10} individually and in various mixtures ($SO_2 + NO_2$, $NO_2 + PM_{10}$, $SO_2 + PM_{10}$, and $SO_2 + NO_2 + PM_{10}$) during different periods of the child's life (from gestation to the survey day) and their associations with the risk of lifetime-ever atopic eczema and eczema in the year prior to the survey. We hypothesized that exposures to ambient air pollutants individually and in various mixtures are associated with childhood atopic eczema.

2. Materials and methods

2.1.1. Questionnaire and participants

During April 2011 to April 2012, we multi-stage hierarchically sampled 17,898 preschool children from 72 kindergartens in five districts (Urban: Jing-An, Zha-Bei, and Hong-kou; Suburban: Bao-Shan and Feng-Xian) selected from 18 districts of Shanghai city (phase one of CCHH). We surveyed parents or guardians at teacher-parent meetings using a standard questionnaire or *via* post to the children's teachers, who distributed questionnaires along with explanatory guidance for parents or guardians. We updated the questions for children's health status from those in the International Study of Asthma and Allergies in Childhood (ISAAC) (Asher et al., 1995), and modified questions about home environment and lifestyle behaviors from those of the Dampness in Building and Health (DBH) study in Sweden (Bornehag et al., 2004a). Our previous articles (Cai et al., 2016; Huang et al., 2015; Hu et al., 2014; Liu et al., 2013) provide more information about the questionnaire and survey method for the CCHH study in Shanghai. The ethical committee of the School of Public Health, Fudan University in Shanghai, China approved the questionnaire and detailed proposal for the CCHH study. By oral presentation or written explanation, we thoroughly informed participants of the purpose and potential concerns of the study. All participants verbally consented to respond to the survey.

For the present study, we selected data from 3358 four to six year-old children who were born during 2006–2008 in Shanghai city, provided specific date of birth, and who were living in the same residences as during their gestational period. To investigate the gestational period, data for 2527 children were selected (Fig. 1). Because questionnaires for children in Zha-Bei district and Hong-kou district did not include a question for the specific birthdate, the selected children were from the other three districts (Jing-An, Bao-Shan, and Feng-Xian) of Shanghai city. Jing-An district, in center city, has a high density of residences and traffic roads; Bao-Shan district, a suburb near downtown, has a vast iron and steel mill; and Feng-Xian district, a suburb far from downtown, has a low density of residences and population and no large industrial factories. The distribution of kindergartens and monitoring stations of outdoor air quality in these districts are described in a previous article (Liu et al., 2016).

2.1.2. Exposures and outcomes

The Shanghai Environmental Monitoring Center (SEMC) provided daily mean concentrations of SO_2, NO_2, and PM_{10}, from January 1, 2006 to April 30, 2012 for each of the 18 districts in Shanghai city. Daily measurements of outdoor SO_2, NO_2 and PM_{10} in every district were uniformly and respectively made by the Ultraviolet Fluorescence, Chemiluminescence methods, and a Tapered Element Oscillating Microbalance. We classified the child's exposure periods as gestational period, first year, first two years, first three years, and total years since birth (from the birth day to the surveyed day). We calculated the period-averaged values of daily concentrations of SO_2, NO_2, and PM_{10} during these periods in the district where the child's residence is located to represent exposure levels of ambient SO_2, NO_2, and PM_{10} during different periods. The period-averaged concentration was the arithmetically-averaged value of cumulative daily concentrations divided by number of days in the time segments. For example, assuming the child's residence is located in Jing-An district, we calculated the averaged values of daily concentrations of SO_2, NO_2, and PM_{10} individually and in various mixtures in Jing-An district from the pregnancy day to the birth day as the child's exposure level for these pollutants in gestational period. Then