



# Parental stress and air pollution increase childhood asthma in China

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## ABSTRACT

**Background:** Although air pollution and social stress may independently increase childhood asthma, little is known on their synergistic effect on asthma, particularly in China with high levels of stress and air pollution.

**Objectives:** To examine associations between exposure to a combination of parental stress and air pollution and asthma prevalence in children.

**Methods:** We conducted a cohort study of 2406 preschool children in Changsha (2011–2012). A questionnaire was used to collect children's lifetime prevalence of asthma and their parental stress. Parental socioeconomic and psychosocial stresses were respectively defined in terms of housing size and difficulty concentrating. Children's exposure to ambient air pollutants was estimated using concentrations measured at monitoring stations. Associations between exposure to parental stress and air pollution and childhood asthma were estimated by multiple logistic regression models using odds ratio (OR) and 95% confidence interval (CI).

**Results:** Life time prevalence of asthma in preschool children (6.7%) was significantly associated with parental socioeconomic and psychosocial stresses with OR (95% CI) respectively 1.48 (1.02–2.16) and 1.64 (1.00–2.71). Asthma was also associated with exposure to air pollutants, with adjusted OR (95% CI) during prenatal and postnatal periods respectively 1.43 (1.10–1.86) and 1.35 (1.02–1.79) for SO<sub>2</sub> and 1.61 (1.19–2.18) and 1.76 (1.19–2.61) for NO<sub>2</sub>. The association with air pollution was significant only in children exposed to high parental stress, the association with parental stress was significant only in children exposed to high air pollution, and the association was the strongest in children exposed to a combination of parental stress and air pollution. Sensitivity analysis showed that the synergistic effects of parental stress and air pollution on childhood asthma were stronger in boys.

**Conclusions:** Parental stress and air pollution were synergistically associated with increased childhood asthma, indicating a common biological effect of parental stress and air pollution during both prenatal and postnatal periods.

## 1. Introduction

Asthma is the most common chronic disease in children and the leading cause of pediatric hospitalization worldwide and leads to a heavy economic burden on the family and poor quality of the life (Eder et al., 2006). A rapid increase in the prevalence of childhood asthma has been observed in developing countries, including China (Zhang et al., 2013). Identifying the key causal factors is important to develop prevention measures so as to reduce the rapidly increasing childhood asthma in China.

Although both genetic and environmental factors are responsible for the development of asthma, environmental factors are likely responsible for the rapid increase in the prevalence (London, 2007).

Ambient air pollution has been suggested to be linked with childhood asthma (Guarnieri and Balmes, 2014). Mounting evidence indicates that early-life exposure to traffic-related air pollution (TRAP) in developed countries contributes to the development of asthma in children (Anderson et al., 2013; Brunst et al., 2015; Gasana et al., 2012; Nishimura et al., 2013; Tétreault et al., 2016). Several recent studies in China have showed that exposures to both TRAP and industry-related air pollution (IRAP) were associated with childhood asthma (Deng et al., 2015, 2016a; Liu et al., 2016).

Social environment is another important contributor to childhood asthma (Sandberg et al., 2000). Family or parental stress, such as socioeconomic and psychosocial stresses, may play an important role in their children's health (Shalowitz et al., 2006). Exposure to stress

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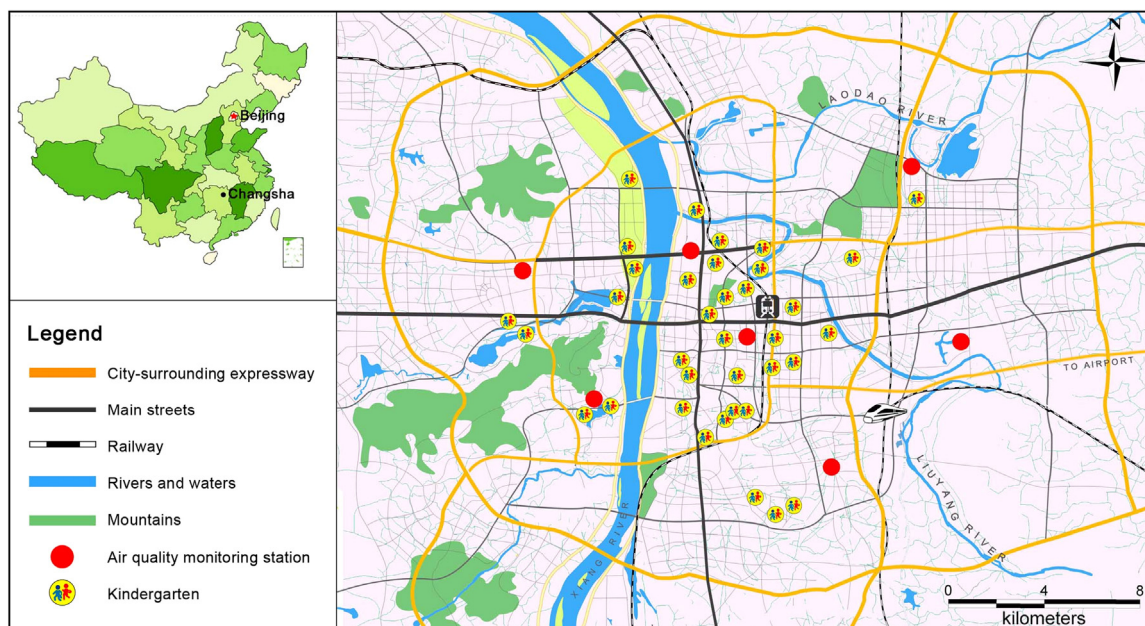


Fig. 1. Distributions of kindergartens and air pollution monitoring stations in Changsha, China.

during pregnancy and early childhood can result in permanently altered changes in stress-response systems, which are thought to play a key role in the programming of respiratory disorders that result in asthma in the later childhood (Lee and Wright, 2016). A growing number of epidemiological studies over the past decade have demonstrated significant associations between prenatal maternal stress and early asthma phenotypes in the children (Cookson et al., 2009; Heinrich, 2015; Lee et al., 2016). Recent systematic reviews and meta-analyses confirmed the link between prenatal stress and the subsequent development of asthma in early childhood (Flanigan et al., 2018; Van De Loo et al., 2016). However, the role of parental stress in childhood asthma in China is lacking and further investigation is warranted to fill the knowledge gap.

Although exposures to air pollution and social stress may increase susceptibility to childhood asthma, there is growing concern about their potential interaction (Chen et al., 2008). Social stress and air pollution often co-exist (O'Neill and Schwartz, 2003), and a recent review found that stress is very likely associated with air pollution, such as low socioeconomic communities face higher levels of air pollution (Hajat et al., 2015). Several recent studies have also observed that children from stressed households are more susceptible to the effects of air pollution on the development of asthma or other respiratory diseases (Bose et al., 2017; Chiu et al., 2014; Clougherty and Kubzansky, 2009; Lee et al., 2018; Shankardass et al., 2009). Strikingly, coinciding with the rapidly increased prevalence of childhood asthma, an increase in air pollution (especially the air pollution episode or haze events) and social stress in China also has been reported (Chen et al., 2014; Huang et al., 2014). Whether the “double exposure” to high air pollution and high parental stress in China contributes to the rapidly increasing of childhood asthma is the focus of this research.

We hypothesize that there is a synergistic effect between exposures to parental stress and air pollution on childhood asthma. To test the hypothesis, we examined not only the role of parental stress in the association between exposure to air pollution and childhood asthma but also the role of air pollution in the association between exposure to parental stress and childhood asthma. We carried out a cohort study in Changsha as part of nationwide multi-center “China-Children-Homes-Health (CCHH)” study (Deng et al., 2015; Zhang et al., 2013). In the present study, parental stress includes socioeconomic stress and psychosocial stress, ambient air pollution includes both traffic- and industry-related air pollutants, and the exposure window includes both

prenatal and postnatal periods.

## 2. Materials and methods

### 2.1. Study population

Between September 2011 and January 2012, we conducted a survey for childhood asthma and allergies in the kindergartens in Changsha (Fig. 1). The cohort study protocol was described in detail elsewhere (Deng et al., 2016a). Briefly, we used a self-administered Chinese questionnaire to collect information on health status, exposure to indoor environment risk factors, and lifestyles of the children and their family members. A total of 4988 questionnaires were distributed to the children in 36 randomly selected kindergartens. Children were instructed to have the questionnaire completed by parents and to return it to kindergartens within one week. We received 3897 completed questionnaires (78% response rate). We excluded the following children: 745 children from kindergartens having response rates lower than 50%; 162 children with low birth weight and preterm birth and 10 children with multiple births; 15 children older than 6 years of age; and 65 children younger than 3; and 494 children without information about health outcome were excluded. In total, 2406 questionnaire responses from children aged 3–6 years were used.

### 2.2. Exposure windows

We considered both prenatal and postnatal exposure windows for each child. Prenatal exposure window was from the conception month to the birth month, and postnatal window spanned from the first month of the first year of life to the last month of last year before survey.

### 2.3. Exposure to parental stress

Parental stress in the present work was classified into 2 types: socioeconomic stress and psychosocial stress, which were obtained from the parent administered questionnaires. We used housing size to describe parental socioeconomic stress. Housing size has recently become a useful index of socioeconomic status (SES) to predict health outcomes (Butterfield et al., 2011; Juhn et al., 2011), and we further considered it as a kind of socioeconomic stress, as a lower SES is usually related to

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