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Pet exposure in utero and postnatal decreases the effects of air pollutants on hypertension in children: A large population based cohort study[☆]



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ABSTRACT

The effect of ambient air pollution exposure on childhood hypertension has emerged as a concern in China, and previous studies suggested pet ownership is associated with lower blood pressure (BP). However, limited information exists on the interactive effects pet ownership and air pollution exposure has on hypertension. We investigated the interactions between exposure to pet ownership and air pollutants on hypertension in Chinese children. 9354 students in twenty-four elementary and middle schools (aged 5–17 years) in Northeastern China were evaluated during 2012–2013. Four-year average concentrations of particulate matter with aerodynamic diameter of $\leq 10 \mu\text{m}$ (PM₁₀), SO₂, NO₂, and O₃, were collected in the 24 districts from 2009 to 2012. Hypertension was defined as average diastolic or systolic BP (three time measurements) in the 95th percentile or higher based on height, age, and sex. To examine effects, two-level regression analysis was used, controlling covariates. Consistent interactions between exposure to pet and air pollutants were observed. Compared to children exposed to pet, those not exposed exhibited consistently stronger effects of air pollution. The highest odds ratios (ORs) per 30.6 $\mu\text{g}/\text{m}^3$ increase in PM₁₀ were 1.79 (95%confidence interval [95%CI]: 1.29–2.50) in children without current pet exposure compared to 1.24 (95%CI: 0.85–1.82) in children with current pet exposure. As for BP, only O₃ had an interaction for all exposure to pet ownership types, and showed lower BP in children exposed to pet. The increases in mean diastolic BP per 46.3 $\mu\text{g}/\text{m}^3$ increase in O₃ were 0.60 mmHg (95% CI: 0.21, 0.48) in children without pet exposure *in utero* compared with 0.34 mmHg (95%CI: 0.21, 0.48) in their counterparts. When stratified by age, pet exposure was more protective among younger children. In conclusion, in this large population-based cohort, pet ownership is associated with smaller associations between air pollution and hypertension in children, suggesting pet ownership reduces susceptibility to the health effects of pollutants.

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1. Introduction

Over the past decade, growing body of research have suggested a causal relationship between ambient air pollution exposure and adverse cardiovascular health (Brook et al., 2017; Pope et al., 2015). Prior studies and a report by the World Health Organization found children are more vulnerable to the effects of air pollution, where exposure as early as *in utero* is associated with future cardiovascular morbidity (Buka et al., 2006; Huang et al., 2017; Special Programme on Health and Environment, 2005). Currently, developing countries such as China are experiencing an increased prevalence of childhood high blood pressure (BP) and hypertension (Tian et al., 2017; Zhang et al., 2015). Elevated BP beyond normotensive in children are associated with early onset hypertension and poor cardiovascular health in early adulthood (Falkner et al., 2010). In addition to air pollution being a chief concern in China, the current trend of high BP in children raises apprehension for the future population's health. For this reason, identifying preventative interventions to lower BP and modify disease progression in children is a public health priority.

Published literature have found sociological and genetic factors to be contributors to high BP in children such as sedentary lifestyle, obesity, poor sleep quality, family history, susceptibility loci, and excess sodium intake (Falkner et al., 2010; Juhola et al., 2012; Poulter et al., 2015; Xi et al., 2013). In a study among children ages 5–17 years in China, found a positive association between exposure to short-term ambient air pollution (exposed for two years) and elevated BP (Zeng et al., 2017). Similar studies among Chinese school aged children and adults (18–74) also revealed an elevated odds of high BP and hypertension when exposed to long-term ambient air pollution (Dong et al., 2014; Yang et al., 2017). Among these studies, an association was generally observed when exposed to ambient particles with diameter $\leq 10 \mu\text{m}$ (PM₁₀), sulfur dioxide (SO₂), nitrogen dioxide (NO₂) and ozone (O₃) on BP and/or hypertension which can be generalized to urban areas in China.

Over the past three decades, several published studies including a clinical trial have revealed an association between pet exposure on heart rate and hypertension, as well as lowered mental-stressors associated with elevated BP in majority adult populations (Allen et al., 2001; Nagengast et al., 1997). A recent study by Xu et al. (2017) examined *in utero* and postnatal exposure to pet ownership on BP and hypertension in China. The study found that among school age children, exposure to pet ownership reduces the odds of elevated BP and hypertension. A scientific statement by the American Heart Association suggested pet exposure has positive cardiovascular effects, however, stated a need for further studies to explore risk factor modification and pet acquisition (Levine et al., 2013).

Previous research showed that the biological effects of long-term exposure to air pollution on BP and hypertension is plausible due to stimulating local and systemic inflammation and oxidative stress, autonomic imbalance, and vasoconstriction (Coogan et al., 2017; Fuks et al., 2014; Yang et al., 2017). Additionally, current evidence has shown pet companions are inhibitors of sympathetic nervous system activity including physiological arousal and behavioral distress (Hansen et al., 1999; Nagengast et al., 1997). For instance, studies have suggested that pet exposure acts as a buffer against physiological responses to stress and provides social support that enhances ability to adapt to stress (Allen et al., 2001; Nagengast et al., 1997). These findings suggest that both exposure to pet and air pollution may effect BP, where pet exposure can potentially mitigate the effects of air pollution on elevated BP and hypertension.

Though studies have shown exposure to air pollutants is associated with elevated risk of hypertension, while exposure to pets

lowers BP, the interaction of both exposures on arterial BP and hypertension risk remains unclear. Examining the MEDLINE database, we observed limited epidemiologic evidence on the evaluation of the effect of exposure to air pollution and pet ownership on hypertension and BP in children, who are most vulnerable to the effects of air pollution. A potential reasoning for lack of evaluation is due to the large sample needed of individuals exposed to both pet ownership and air pollution. The Seven Northeastern Cities Chinese Children's Study (SNECC), conducted in Northeastern China provides an opportunity to investigate the synergistic effects of pet ownership and air pollution exposures on hypertension and BP. SNECC study includes children of urban areas exposed to higher levels of air pollution, and generally represents the level of air pollution exposure in China's cities.

In this study, we tested the hypothesis that exposure to pet ownership (*in utero*, first two years of life, and current exposure) would modify the association between exposure to long-term ambient air pollutants (PM₁₀, SO₂, NO₂, and O₃) and children's BP and hypertension, with a weaker association of air pollution exposure with BP among children exposed to pet ownership compared to non-exposed children. Our study aims to also examine differences by age group and whether the strength of the association differs based on when exposure to pet ownership occurred.

2. Material and methods

2.1. Study cities selection and participant recruitment

We analyzed data from the SNECC study. SNECC is a retrospective cohort study that investigates the associations between health outcomes among children and environmental pollution exposure *in utero* and postnatal, including ambient air pollution. The region which the study encompasses consists of over 20 million people residing in fourteen cities in Liaoning province located in Northeastern China. To minimize the correlation between district-specific ambient pollutants, and maximize the inter- and intra-city gradients for pollutants of interest, from April 2012 to June 2013, seven cities (Shenyang, Dalian, Anshan, Fushun, Benxi, Liaoyang, and Dandong) located in Liaoning province in Northeastern China were selected based on their mean air pollution level data recorded from 2009 to 2012 (Fig. 1). Detailed information about SNECC has previously been published (Dong et al., 2014).

In the present study, in each of the seven cities, we selected all urban districts for the study. There are five districts in Shenyang, four districts in Dalian and Fushun, three districts in Anshan, Benxi, and Dandong, and two districts in Liaoyang. In each of the twenty-four districts, there was only one available municipal air monitoring station that generated air pollution data. Each district had an elementary and middle school located within one kilometer of the air monitoring station. We randomly selected one elementary and middle school, and then from each grade, one or two classrooms were randomly selected from each grade of selected schools. Among the classrooms, children were included if they lived in the district for at least two years before the start of the study. The final sample for this study was 9354 children (4583 females and 4771 males). During the study period, the policy for admitting students into primary schools were based on geographical boundaries, forbidding selection of *trans*-regional schools for children. Therefore the air monitoring stations, which were the only monitoring station in the child's school district, was the closest station to the child's home.

Completed consent forms were obtained from the participant's parent/guardian prior to start of the study. The study received approval by the Human Studies Committee of Sun Yat-sen University and conducted in accordance with the World Medical

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