



Associations between heavy traffic near residence and childhood health outcomes as modified by bedroom floor level and bedroom ventilation

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ABSTRACT

During 2011–2012, we conducted a cross-sectional study and collected 13,335 parent-reported questionnaires for 4–6 year-old children in Shanghai, China. In this study, we investigated associations of LC-HTRH (Living Close to High Traffic Roads or Highways within 200 m of the residence) with childhood health outcomes. In the multiple logistic regression analyses, LC-HTRH was significantly associated with lifetime-ever doctor-diagnosed asthma (adjusted OR, 95% CI: 1.40, 1.16–1.70). LC-HTRH and bedroom floor level had significant interaction effects on lifetime-ever asthma attack and eczema and past-year eczema. In the subanalyses, LC-HTRH was significantly associated with lifetime-ever asthma (1.52, 1.11–2.09) and asthma attack (1.69, 1.11–2.56) among children who lived on the 4th–6th floors. LC-HTRH was significantly associated with the increased odds of lifetime-ever asthma and past-year rhinitis in summer, autumn, and winter among children whose bedroom windows were opened often. Furthermore, more significant associations between LC-HTRH and the studied outcomes were found among children who both lived in low floor levels and came from families who often opened bedroom windows during night than others. Except for lifetime-ever asthma, no significant associations were found between LC-HTRH and all studied outcomes among children from families who did not often open bedroom windows during night in the different floor levels. This study indicates that LC-HTRH might be associated with part of childhood health outcomes. When ambient air is polluted, increasing bedroom ventilation might lead household air quality at low-medium levels worse, and thus increase odds of some childhood allergic and respiratory problems.

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1. Introduction

Numerous studies have investigated associations between exposure to ambient traffic-related air pollutants and childhood asthma, allergies, and airway diseases/symptoms [1–26], but findings in these studies are not consistent [2,3]. Several systematic reviews [4–10] concluded that exposure to ambient traffic-related

air pollutants exacerbates symptoms in asthmatic patients and may induce new-onset childhood asthma. Many regional studies have also found that long-term exposure to ambient air pollutants may induce childhood asthma, allergic rhinitis, and increase the odds of respiratory infections [11–27]. Several studies have also reported that residences close to heavily trafficked roads or highways increase the risk of these outcomes during childhood [28–34]. However, studies from Norway [35] and the United States [36] did not find that exposure to ambient nitrogen dioxide (NO₂), a widely used indicator of traffic-related air pollution, is associated with new-onset of asthma or related symptoms. A global-scale study [37] and a multi-center European study [38] found no significant

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associations between air pollution and childhood asthma.

Several studies have noted that the distribution of ambient air pollution differs according to floor levels in residential buildings [39–44]. Specifically, Jung and colleagues conducted on-site inspections for outdoor and indoor air quality in the residences of 339 five-six year-old children living in New York city, and found that indoor nonvolatile polycyclic aromatic hydrocarbons (PAH) and black carbon (BC, an indicator of heavy traffic-related pollutants) levels generally decrease with increasing floor level, whereas indoor PM_{2.5} (particulate matter <2.5 μm) concentration was not effected by floor level [41]. Accordingly, we hypothesized that the floor level of a residence may modify associations between traffic-related exposures close to the residence and the odds of childhood asthma, allergies, and airway diseases/symptoms; and those children, who lived in the higher floor level and had lower PAH and BC exposures, may have lower prevalences of these outcomes. Whereas we found no study investigating the interaction of residence floor level and traffic-related exposures close to the residence with the risk of these outcomes.

Besides, several studies have also reported that household ventilation [29,45–47] is significantly associated with childhood respiratory health. Wargocki et al. systematically reviewed peer-reviewed papers published before 2002 and concluded that low indoor ventilation rate is strongly associated with Sick Building Syndrome (SBS) symptoms, airway inflammation, infections, asthma, and allergies [45]. In another systematic review of ventilation rates and human health, Sundell et al. also concluded that lower ventilation rates are strongly and positively associated with occupants' airway inflammation, respiratory infections, asthmatic symptoms and short-term sick leave [46]. Since most studies including in the review were conducted in locations where outdoor air pollution was low, the authors also noted that further study is needed over a wider range of climate and in locations with polluted outdoor air [46]. When the residence is close to high traffic roads or highways and/or outdoor air pollution is heavy, increasing outdoor air ventilation may aggravates the indoor occupants' exposure level of traffic-related air pollutants which are produced in outdoors, thus strengthening associations of traffic-related air pollutants and increased risk of childhood asthma, allergies, and airway outcomes. However, to the best of our knowledge, there were no studies of household ventilation for residences with heavy traffic near the residence and the prevalence of childhood asthma, allergies, and airway outcomes, especially in Chinese cities where many residences are close to high traffic roads or highways and outdoor air pollution are usually heavy [1,20,24,27].

Therefore, as part of phase one of the China, Children, Homes, Health (CCHH) study in Shanghai, China [48,49], we collected data regarding the child's bedroom floor, family ventilation habits in different seasons, traffic conditions near the residence, and children's lifetime-ever health information. We then analyzed associations of traffic road/highway near the residence on history of and current status of childhood asthma, allergies, and airway diseases/symptoms among preschool children. We also studied the interaction effect of the child's bedroom floor levels and family ventilation habits in different seasons with traffic conditions near the residence on the odds of these outcomes. We hypothesized that traffic conditions near the residence could be significantly associated with increased odds of the studied outcomes; and that these associations could be stronger among children who lived in the lower floor levels of the residential buildings or among children with higher bedroom ventilation; as well as that these associations could be stronger among children who both lived in the lower floor levels of the residential buildings and had higher bedroom ventilation.

2. Materials and methods

2.1. Studied population and questionnaire

During April 2011–April 2012, we conducted a cross-sectional study in 72 kindergartens from five districts (Urban: Jing-An, Zha-Bei, and Hong-Kou; Suburban: Bao-Shan and Feng-Xian) of Shanghai, China. We surveyed 17,898 parents/guardians of preschool children during the teacher-parent meeting in these kindergartens by a standard questionnaire, or via post questionnaire to the children's teachers, who distributed them along with explanatory guidance to the parents or guardians (one family, one questionnaire). In the present study, from a total of 15,266 completed and valid questionnaires (response rate: 85.3%), we selected the 13,335 children 4–6 year-old as the studied population in analyses with regard to the child's past-year health outcomes. We excluded questionnaires for 1–3 year-old and 7–8 year-old children because the numbers in these age groups were small [48,49]. For our questionnaire, we revised questions about the child's history of asthma, allergies, and airway diseases/symptoms from those in the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire [50]. The word “eczema” was not included in the original ISAAC questionnaire. In the CCHH questionnaire, we have added this word along with a specific description to explain “eczema” to parents. We also modified questions about dwelling characteristics, ambient environment, and family lifestyle behaviors for our Chinese version from those of the Dampness in Building and Health (DBH) study in Sweden [51]. The full CCHH questionnaire has been provided as supplemental material in a previous article [52]. In the questionnaire, we had a question that “has the child been living at the present residence during the whole of his/her life (yes vs. no)”. To eliminate the effect of residence changing on our estimations of the studied associations, we further selected those children (n = 7506) who did not change their residences since birth as the studied population in the analyses with regard to the lifetime-ever health outcomes.

The ethical committee of the School of Public Health, Fudan University approved the questionnaire and detailed proposal for this study. We informed participants of the purpose, details and potential concerns of the study by oral presentation or written explanation. All participants verbally consented for themselves and the children for whom they responded to questionnaires, and voluntarily responded to the survey. Our previous articles [29,48,49,52] provide more information about the CCHH study in Shanghai.

2.2. Exposures and outcomes

As in the parallel CCHH study in Beijing, China [53], LC-HTRH (Living Close to High Traffic Roads or Highways within 200 m of the residence) was used as an indicator of for higher ambient traffic-related pollutant exposures. In our questionnaire, parents/guardians of the studied children provided information regarding traffic conditions close to the residence (near main road or a highway) via the question “Is your residence within 200 m of a main traffic road/highway (yes vs. no)”. Children were classified as having traffic exposure when this question was answered “yes”. Parents/guardians of the studied children also reported the child's bedroom floor in the residential building by responding to the question “which floor is the child's room located in the residential building”; and reported family ventilation habits in different seasons by responding to the question “how often is the window open when the child is sleeping during night? (Never vs. Sometimes vs. Often)”. Herein family ventilation habits in different seasons only indicated the ventilation status of the dwelling at night. According to data

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