Residential environment in relation to self-report of respiratory and asthma symptoms among primary school children in a high-polluted urban area

Nawarat Apichainan
Department of Health, Ministry of Public Health

Saowanee Norkaew
Faculty of Public Health, Thammasat University (Rungsit Campus)

Nutta Taneepanichskul (nutta.taneepanichskul@gmail.com)
College of Public Health Sciences, Chulalongkorn University

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Abstract

Respiratory disease and its complication are the cause of children deaths worldwide every year. Several epidemiological studies pointed out an association between quality of residential in inner city and risk of children health. Few studies had been focused on respiratory and asthma symptoms in high-polluted urban area in low to middle income countries. We conducted a cross-sectional study to investigate the association between residential environments and respiratory symptoms including asthma among 658 primary school children aged between 6 to 10 years who have been living in high-polluted urban area of Bangkok Thailand. The International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire was modified and used for symptom self-report during the past 12 months. Binary logistic regression model was performed to find the associations. The results showed that living near garment and clothing shop is associated with shortness of breath (AOR = 1.846; 95%CI 1.034, 3.297). Vectors in home is related to dry cough at night (AOR = 1.505; 95%CI 1.052, 2.153) and phlegm (AOR = 1.414; 95%CI 1.014, 1.973). Wall dampness is increased odd of having wheezing or whistling (asthma) in the chest (AOR = 1.921; 95%CI 1.141, 3.235). Housing quality and living environments to reduce respiratory and asthma symptoms among urban children must be improved to address these risks.

Introduction

The World Health Organization (World Health Organization, 2017b) reported that unhealthy environments killed more than 25% of 5.9 million children worldwide. Among them, about 570,000 child deaths were attributed to respiratory disease and its complications. Furthermore, around 300 million children experience asthma attacks, which is another burden of respiratory disease that has continuously increased in low-to middle-income countries (The Global Initiative for Asthma (GINA), 2018). The exposure to poor-quality indoor air is an important cause of these diseases. Asthma symptoms are characterized by repeated attacks of wheezing, breathlessness, and dry cough at night, which differ in each affected person(The Global Initiative for Asthma (GINA), 2018). Asthma interrupts daily activities, sleep quality, and school attendance, and it sometimes causes death in severe cases ((D'Amato et al., 2016; The Global Initiative for Asthma (GINA), 2018). In Thailand, there is a high prevalence of respiratory disease (64.7%) and asthma (29.4%) at all ages, while a higher prevalence is found among children aged between six and seven years in the Bangkok area (Maipang, 2015; The Global Asthma Network, 2014,).

An association between residential environmental factors in relation to respiratory disease and asthma has been found in many epidemiological studies. However, the fundamental cause of asthma is still not clear. Both genetics and environments are possible risk factors (World Health Organization, 2017a). Housing environments, such as mold, dampness, pets, vectors (i.e., cockroach and rat), carpets, and curtains have been found to be significant risk factors for respiratory and asthma symptoms (Cincinelli & Martellini, 2017). Several previous findings indicated that exposure to allergens in the home, such as house dust mites, mold, and dampness, were causes of asthma exacerbation (Chen, Tsai, & Lee, 2011; Nguyen T1, 2010; Pirastu et al., 2009). Exposure to pets, including cats and dogs, in the early stages of life was found to lead to respiratory complications, including asthma symptoms, rhino conjunctivitis, and eczema among young adults (Brunekreef et al., 2012).

Inner-city homes were found to have a higher number of indoor pollutants, especially particulate matter, than non-inner-city homes (Matsui et al., 2008). Kumar et al. (2015) also found the highest indoor suspended particulate matter (SPM) in residences located in urban areas, which was significantly higher in asthmatic children's houses than in non-asthmatic children's houses ($p < 0.001$) However, few studies have focused on residential environments and respiratory and asthma symptoms in children living in the inner cities of low-to middle-income countries.

Because of the increased understanding of respiratory and asthma symptoms, it is crucial to gain better knowledge of the link between residential environments and the risk of respiratory and asthma symptoms among children living in highly polluted urban areas of Thailand.

Results

Children's characteristics and respiratory and asthma symptoms

A total of 658 primary school children, male (50.2%) and female (49.8%), were included in this study. Table 1 shows that the median age (interquartile range, IQR) was 8 (2) years. The median height of the male and female children was 122 (10.0) cm. The median weight at birth was 3 (0.3) kg, and the weight during this study was 26 (7.0) kg. Most of the children (64.6%) had exercised regularly. Only 2.3% had a family history of asthma. The highest prevalence of respiratory and asthma symptoms in the previous 12 months was running nose without cold symptoms (52.7%) (Supplement Table 1). The children stayed at their residences on weekends more than on school days. Most of the children (53.0%) were in their place of residence for approximately 24 hours during the weekend, whereas 76.0% were at home for 13–14 hours during the school day. The majority of children (69.5%) spent most of their time in their bedrooms.

Residential environment and respiratory/asthma symptoms

Table 2 presents the residential characteristics and respiratory symptoms of the primary school children who participated in this study. Most children lived in flats, apartments, or condominiums (62.9%). Average age of house was more than 30 years, which was not associated with respiratory and asthma symptoms. The majority of the participants were tenants (77.1%) rather than owners (22.9%). The type of residence was not associated with any respiratory symptoms. Among the places reported to be near the residence, the highest was garment/clothing factory (24.3%), which was associated with shortness of breath ($p = 0.008$).

Children living in an environment of cigarette smoke and with smokers in the family were associated with a dry cough at night. The presence of vectors was associated with the symptoms of dry cough at night ($p = 0.005$), phlegm ($p = 0.006$), and running nose without cold ($p = 0.009$). The presence of wall dampness in the residence was associated with the symptoms of wheezing or whistling in the chest (asthma) ($p = 0.007$), phlegm ($p = 0.024$), and shortness of breath ($p = 0.004$). Home renovation was associated with the symptoms of dry cough at night ($p = 0.029$), phlegm ($p = 0.028$), and running nose ($p = 0.021$). However, stoves used for cooking in the residence, including charcoal smoke, flowers with pollen, pets, incense, charcoal smoke, incense smoke, and insecticide use, did not show any associations with respiratory and asthma symptoms (Supplement Table S2).

A binary logistic regression model was used to assess the association between residential environments and respiratory and asthma symptoms in the previous 12 months (Table 3). The results showed that compared with the absence of wall dampness, its presence increased by 1.921-fold the likelihood of wheezing or whistling in the chest (asthma) (AOR =1.921; 95% CI 1.141–3.235; $p = 0.014$) and by 1.882-fold the likelihood of shortness of breath (AOR =1.882; 95% CI 1.047–3.386; $p = 0.035$). Compared with their absence, a garment/clothing factory near the residence increased the likelihood of shortness of breath by 1.846-fold (AOR = 1.846; 95% CI 1.034–3.297; $p = 0.038$). Compared with the absence of vectors, their presence increased by 1.505-fold the likelihood of having dry cough at night (AOR =1.505; 95% CI 1.052-2.153; $p=0.025$) and 1.414-fold the likelihood of phlegm (AOR =1.414; 95% CI 1.014-1.973; $p=0.041$). However, home renovation and the presence of flowers with pollen were possible risk

factors for respiratory and asthma symptoms (AOR>1) among children, but statistical significance was not achieved.

Discussion

Respiratory and asthma symptoms in the past 12 months among primary school children in the highly polluted area were reported at around 1 in 4. Running nose without cold was reported in the highest numbers, and shortness of breath was reported in the lowest numbers. Tenant status, living near garment and clothing shops, and living in the presence of cigarette smoke and incense smoke were indicated to be risk factors for respiratory and asthma symptoms among the primary school children in this study.

Our study evaluated the association between residential environment and respiratory symptoms in an urban area of Bangkok, where the concentration of air pollution was the highest. We found that around 11% of the children in our study had wheezing symptoms. This percentage was less than in Liu et al. (2014), which was 21.7% among children in urban Shanghai. Mathew et al. (2015) found rank between 12.7–17.7% among Delhi children. In addition, we found that dry cough at night (32.5%) and phlegm (43.3%), which was similar to Mathew et al. (2015) at 26.9% and 29.0%, respectively.

Most of the children in this study lived in flats, apartments, and condominiums (62.9%). The average length of residence was more than 30 years, which was consistent with our observation that most of the buildings in the study area were old, and there was a high density of both buildings and people. Nearly 30.0% of the children were living in single-family dwellings (16.6%) and townhouses (12.9%). They were also living in the same environment, which caused respiratory effects. They lived near a garment/clothing factory (24.3%), garage/car care facility (9.7%), furniture shop (5.9%), fresh market or restaurant (cooking smoke) (2.4%). Our study found that living near a garment/clothing factory increased the likelihood of having the symptom of shortness of breath in the children. Brender, Maantay, and Chakraborty (2011) showed that the effects of residential proximity to a source of air pollution were associated with asthma among children. However, residential proximity to environmental hazards serves as a crude proxy for exposure. It does not accurately represent the individual exposure to ambient conditions or the effects on the body or organs. The residential exposure to site contaminants also varies according to the climatic and topographic characteristics of the geographic area. Our findings showed that most of the participants were tenants (77.1%) rather than owners of their residences (22.9%), which was also positively associated with wheezing or whistling in the chest. A possible reason for this result could be that owners take better care of their houses compared with tenants. Moreover, house ownership may be related to better health outcomes because it could indicate higher income, wealth, better housing infrastructure, and healthier neighborhood conditions.

Children’s exposure to the poor quality of indoor air has been the most important concern (World Health Organization, 2015, 2017a). Our study found that children living in areas of cigarette and incense smoke were significantly associated with the symptoms of dry cough at night and shortness of breath, which was consistent with many previous studies. Salo et al. (2004) found the strongest associations (OR > 1, 95% CI) between smoking (cigarette smoke) at home and respiratory symptoms (i.e., cough and phlegm without colds among children). In addition, Chen et al. (2011) and Pirastu et al. (2009) found similar results, which showed that children exposed to tobacco smoke since infancy had an increased prevalence of current wheeze and asthma. More than 7,000 chemicals have been found in tobacco and cigarette smoke, which are chemically active and trigger profound and potentially fatal changes in the body (State of Victoria, 2018). The effects of these dangerous chemicals in cigarette smoke, such as tar, carbon monoxide, hydrogen cyanide, oxidizing chemicals, metals, and radioactive

compounds, on human health are well known. They are ingested in the body by inhaling. Moreover, this study found that smoking by family members was a possible risk factor (AOR > 1) for the symptoms of dry cough at night, phlegm, and running nose without cold.

Incense smoke is usually found in the houses of Buddhist families who burn incense while they pray to Buddha. Although incense sticks are made from natural materials such as bamboo and wood, some chemical materials are added as oxidizers and binders. When an incense stick is burned, it becomes smoke and ash, which contain many particles and gas products, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2), as well as many organic compounds, such as benzene, toluene, xylenes, aldehydes, and polycyclic aromatic hydrocarbons (PAH), which can affect the human respiratory system (Torben Eggert & Ole Christian Hansen, 2004; Wang, Lee, Ho, & Kang, 2004). Wang et al. (2011) found an association between the frequency of burning incense at home and the increased risk of current asthma and wheezing during exercise, especially in genetically susceptible children.

The results of our study found that vectors (i.e., cockroach and rat) in the house increased the odds of the symptoms of a dry cough at night ($p < 0.05$) and phlegm ($p < 0.05$) among the children who participated in the study. Home renovations and flowers with pollen were positively associated with respiratory symptoms, but statistical significance was not achieved. Our findings regarding vectors were inconsistent with the findings of Chen et al. (2011), which showed an association between children who were exposed to cockroaches since infancy and asthma (OR = 2.16; 95% CI, 1.15–4.07), which supported the findings of Kim Le et al. (2005). However, vectors have been recognized as risk factors for allergy symptoms and respiratory symptoms, including asthma, particularly the presence of cockroaches in indoor dirt and decay in the residence, which produce the key allergens in inner-city homes (Partners Asthma Center, 2010). Furthermore, some of the worst asthma cases were found to have exposure to high concentrations of cockroach allergens in the residence, as well as the tendency to allergic reactions to cockroach allergens, which increased the severity of asthma (Do, Zhao, & Gao, 2016). In addition, a review study by Do et al. (2016) showed a significant association with asthma induced by cockroach allergens.

Many substances are produced during home construction, such as chemicals in paint, dust in roofing materials, and cement. Such substances can cause allergic reactions and respiratory symptoms (Claire Gagné 2010). Dong et al. (2014) also showed that home renovations in the previous two years were significantly associated with respiratory symptoms and asthma among children and could increase the prevalence of those symptoms. Although our findings were inconsistent with Dong et al., we found that home renovation was a potential risk factor for almost all respiratory and asthma symptoms in this study.

Wall dampness in the residence, flowers with pollen, and charcoal smoke were found to be possible risk factors for the symptoms in our study. These findings were inconsistent with other studies that found associations. For example, Chen et al. (2011), Nguyen et al. (2010), and Wang et al. (2014) found that wall dampness was associated with asthma. Dampness is known as a cause of mold growth, which is an allergen (Centers for Disease Control and Prevention (CDC), 2017) that causes respiratory and asthma symptoms. Furthermore, Erbas et al. (2013) found that asthma in children could be increased by persistent exposure to pollen during infancy. In addition, Bautista et al. (2009) found an increasing trend toward the risk of respiratory infection in young children when they were exposed to charcoal smoke (Bautista, Correa, Baumgartner, Breysse, & Matanoski, 2009). Salo et al. (2004) found the strongest associations (OR > 1, 95% CI) between coal burned for cooking in the home and wheezing among children. Charcoal smoke was produced by the incomplete burning of carbon-containing materials, which formed a mixture of particles and chemicals. Exposure to the mixture of these particles in smoke,

such as CO, CO_2, and particulate matter (PM), is dangerous for humans (New York State Department of Health, 2016).

The present study has several limitations. First, a self-reported questionnaire was used as the measurement tool, which may have led to information bias. Moreover, parents who live in worse residential environments may be more likely to overreport respiratory symptoms (Visness et al., 2019). In a future study, hospital-based records of respiratory and asthma disease should be considered. Asthma status and symptoms should be validated by physician diagnosis, medications, or emergency department visits to minimize self-reporting biases. Second, only two primary schools in the Din Daneng district, which is controlled by the Bangkok Metropolitan Administration, were selected. Therefore, the findings of this study cannot be generalized to other primary school children in urban areas. However, to the best of our knowledge, this is the first study to investigate the relationship between home environments and respiratory symptoms among a large sample size of primary school children in a highly polluted area in Bangkok, Thailand. Third, the respiratory and asthma symptoms in this study were considered over a long term (12 months), which may have led to recall bias. Fourth, our study did not collect samples of indoor air quality to confirm an association between air quality and health outcomes. However, our study included all significant predictors in residential environments of respiratory health in children. Finally, our study did not consider the sizes or processes of businesses near the children's residences, including furniture shops, garment/clothing factories, and garage/car care facilities. Differences in factory processes may lead to different emissions. A future study should investigate the emissions from each type of factory and business.

The findings of our study showed that residential environments, including tenant status, garment/clothing shops near residence, cigarette smoke, and incense smoke, were positively and significantly associated with respiratory and asthma symptoms. Further interventions to improve residential environments and control housing quality should be considered to reduce respiratory and asthma symptoms among children in urban areas.

Methods

Study participants and study area

A cross-sectional study was conducted during the summer of 2018. The Din Daeng district was selected as the study setting because it is the highest polluted area in inner Bangkok, according to the Pollution Control Department (PCD) of Thailand. As discussed in "Excessive PM2.5 in 69 areas of Bangkok" (2020), the PCD reported that a 24-hour mean of particulate matter of less than 2.5 micrometers (PM2.5) in Din Daeng exceeded the Thailand air quality standard in 27% of all measurements, while in the Thonburi district it exceeded 11% of all measurements.

Two of three primary public schools in the district took part in this study. All children in two primary public schools were invited to participate. Of the total 814 students, 658 primary school children who met the inclusion criteria were willing to be included in the study. The inclusion criteria were children aged between 6 and 10 years who had lived in the Din Daeng district for at least one year. Students who were absent on the day of recruitment were asked to participate in the study on the day that they were present. This study was approved by the Ethics Review Committee of Chulalongkorn University (COA No. 085/2561). This research was performed in accordance with relevant guidelines and regulations. Informed consent was obtained for all parents of the participants.

Questionnaire

The self-reported questionnaire was a modified form of the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire. The parents of the children provided information about residential environments and respiratory and asthma symptoms in their child during the previous 12 months, such as wheezing or whistling in the chest (i.e., asthma), dry cough at night, phlegm, shortness of breath, and running nose without cold symptoms. Based on the World Allergy Organization's criteria for diagnosing asthma symptoms in children, a positive answer to the question, "Have your child had those symptoms in the past 12 months?" was considered to indicate respiratory and asthma symptoms. A positive response to questions about having experienced wheezing or whistling in the chest during the past 12 months was also considered to indicate asthma (Matsui, et al., 2008).

The children's characteristics and residential environmental conditions were reported by their parents. The characteristics were the age of the child (years), gender (male/female), height (cm), weight at present (kg), weight at birth (kg), family history of asthma (yes/no), and exercise (yes/no). The residential conditions included type of residence (single-family house, townhouse, flat, apartment, condominium, or slum), age of residence (years), and ownership status of residents (owner/tenant). Places near the residence (less than 100 meters) were the following: furniture shop (yes/no), garment and/or clothing shop (yes/no), garage (yes/no), car care (yes/no), petrol station (yes/no), and fresh market and/or restaurant (cooking smoke) (yes/no). Other possible residential risk factors included family member smoker (yes/ no), stove used for cooking (yes/ no), presence of wall dampness during the last 12 months (yes/ no), home renovation during the last 12 months (yes/no), insecticide used during the last 12 month (yes/ no), presence of flowers with pollen (yes/no), presence of vectors during the last 12 month (yes/no), pets (yes/no), child living in incense smoke area (yes/ no), and child living in cigarette smoke area (yes/no).

Statistical analysis

SPSS version 22 was used to conduct all statistical analyses in this study. Regarding descriptive statistics, categorical data were reported by frequency and percentage. Continuous data were presented as mean and standard deviation (SD). Cases of skewed, median, and interquartile ranking (IQR) were reported. The chi-square and Fisher's exact tests were applied to assess the association among categorical data in the bivariate analysis. Continuous variables were evaluated using the Mann–Whitney U test to observe differences between having and not having respiratory and asthma symptoms. A multivariate analysis was performed using a binary logistic regression. In each respiratory symptom, the final model included variables that showed significant values of less than 0.2 in the bivariate analysis ($p < 0.20$). The potential confounders of age, gender (male/female), family history of asthma (yes/no), ownership status of residents (owner/tenant), and smokers among family members (yes/no) were included in the models in an a priori approach. Adjusted odd ratios (AOR) with 95% confidence intervals were presented. All reported p-values were two-sided and defined at a 5% level of significance. The final models were evaluated for sensitivity analysis by excluding 2.3% of the children who had a family history of asthma (Supplement Table S3). Effect modification was explored by age group (younger group, 6–7 years; older, 8–10 years) (Supplement Table S4) and sex (Supplement Table S5).

Declarations

AUTHORS' CONTRIBUTIONS

N.P., S.N., and N.T. conceptualized the study. N.P. and N.T. conducted the study and analyzed the results. N.P. and N.T. wrote original draft. N.P. and N.T. reviewed and edited the draft. All authors reviewed the manuscript.

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Tables

Due to technical limitations, Tables 1, 2, and 3 are only available as a download in the Supplemental Files section.

Supplementary Files

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- TableS2respiraotrychldrenBKK.docx
- TableS3Sensitivityanalysis.docx
- TableS4Sensitivityanalysis.docx
- TableS5Sensitivityanalysis.docx