Building and Environment 106 (2016) 167–174

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Associations between perceptions of odors and dryness and children's asthma and allergies: A cross-sectional study of home environment in Baotou

Zhongming Bu [a, b], Lifang Wang [c, d, e], Louise B. Weschler [f], Baizhan Li [a, b], Jan Sundell [c, d, *], Yinping Zhang [c, d, *]

[a] Key Laboratory of Three Gorges Reservoir Region's Eco-Environment, Ministry of Education, Chongqing University, Chongqing, 400045, PR China
[b] National Center for International Research of Low-Carbon and Green Buildings, Chongqing University, Chongqing, 400045, PR China
[c] Department of Building Science, Tsinghua University, Beijing, 100084, PR China
[d] Beijing Key Lab of Indoor Air Quality Evaluation and Control, Tsinghua University, Beijing, 100084, PR China
[e] School of Energy and Environment, Inner Mongolia University of Science and Technology, Baotou, 014010, PR China
[f] 161 Richdale Road, Colts Neck, NJ, 07722, USA

ARTICLE INFO

Article history:
Received 25 March 2016
Received in revised form
17 June 2016
Accepted 18 June 2016
Available online 20 June 2016

Keywords:
Odors
Dryness
Children
Indoor air quality (IAQ)
Risk

ABSTRACT

We analyzed perceptions of odors and dryness and their associations with asthma and allergic symptoms in 1–8 year-old children in Baotou, China. In this cross-sectional study, parents returned 4801 completed questionnaires. Odors reported frequently or sometimes were stuffy odor,45.2%; unpleasant odor,33.8%; pungent odor, 9.7%; moldy odor, 9.2%; tobacco smoke odor, 33.2%; dry air, 72.4% and humid air,22.5%.-Perceptions of all odors and of dry air (POD)were strongly associated with the risk of children's asthma and allergies but the perception of humid air was not. Dwelling owners reported significantly less odor perception than renters. Significant risk factors for POD were family history of asthma or allergies, living near a main road or highway, evidence of moisture related problems and never exposing bedding to sunshine. A higher proportion of women and allergic persons reported POD. The perception of dryness positively correlated with the use of humidifiers. We conclude that perception of odors and/or dryness can be proxies for indoor pollution, and as such, indicators of increased risk for children's asthma and allergic symptoms. Reducing moisture related signs and keeping good sanitary habits, both of which can be at least partially accomplished by ventilation, are likely effective strategies for addressing odors and dryness problems in residences.

1. Introduction

Perception of odors and sensory irritation are often the primary determinants of how people evaluate the acceptability of indoor air [1–3]. Daily life sources of odors include human bio-effluents, environmental tobacco smoke (ETS), bio-odorants released from fungus, perfume, cosmetics and building materials [4]. Sensory irritation may be caused by airborne compounds stimulating the mucosal tissues or skin [5,6], which is often expressed as "dryness" [7], and often simultaneously experienced with odor perception [1,8]. It is often assumed that physically dry indoor air causes the mucosa of the upper airways to "dry out" [9]. However, the sensation of dryness does not necessarily indicate low humidity; it can instead be associated with the presence of irritating indoor compounds [5,10–12], and associated with respiratory infections. A number of studies have reported that perception of odors and dryness (POD) are associated with sick building syndrome (SBS) symptoms [8,12,13]and accordingly could indicate risk for other adverse health effects.

While prevalences of asthma, allergies and airway symptoms among children in developed countries have plateaued and even declined during the last two decades [14–17], prevalences in developing countries continue to increase [18–21]. Although chemical and biological agents have been found to be linked to children's asthma and allergic disorders [22–24], the role of POD as

* Corresponding authors. Department of Building Science, Tsinghua University, Beijing, 100084, PR China.
E-mail addresses: zhangyp@tsinghua.edu.cn (Y. Zhang), sundellcc@gmail.com (J. Sundell).

http://dx.doi.org/10.1016/j.buildenv.2016.06.023
0360-1323/

direct determinants for evaluating the risk of children's asthma and allergies is not clear. Previous studies have been limited to demonstrating that moldy odor is strongly associated with asthma and allergic symptoms in preschool children [24–27].

The China, Children, Homes, Health (CCHH) project, consisting of a cross-sectional study followed by a case-control study, has aimed at characterizing associations between household exposures and children's asthma, allergies and other respiratory symptoms [20]. This ongoing study has reported that odors and air dryness perception are associated with the risk of SBS symptoms among adults [8,28]. Stuffy odor and air dryness were found to correlate with children's asthma and allergies in Urumqi, China [29]. However, perception of odors and dryness as related to children's asthma and allergies has not yet been systematically studied. Furthermore, although several factors related to indoor odors and air dryness were mentioned by Wang et al. in Chongqing [8], detailed information on potential influencing factors (e.g., respondents' demographic characteristics, building characteristics, lifestyle behaviors) is limited.

As an economic and industrial center of Inner Mongolia, North China, Baotou city has experienced rapid urbanization and modernization during the last few decades. Large numbers of synthetic building materials are used in modern houses. These materials emit pollutants, some of which have been present in indoor air only in the past 50 years [30]. A tight building envelopes, coupled with low ventilation rates aimed at energy efficiency, also allows concentrations of chemical and biological pollutants to increase. However, we have found no research on the effects of home environments on children's health effects in Baotou. The aims of this study were 1) to investigate the relationship between POD and children's asthma and allergic diseases, and 2) to explore associations between household factors and indoor POD in Baotou by using responses to the CCHH Phase I questionnaire.

2. Methods

2.1. Ethics statement

This study is part of Phase one of the CCHH study, which was approved by the ethical committee of the School of Public Health, Fudan University, Shanghai, China. The participants gave informed consent.

2.2. 2Subjects and questionnaire

Baotou has a permanent population of 2.77 million distributed over 360 km^2. Located in the west of Inner Mongolia, Baotou features a cold semi-arid climate, marked by long, cold and very dry winters. Temperatures often fall below −15 °C in winter and rise above 30 °C in summer. The study was carried out in Baotou from March 2014 to July 2014. The questionnaire asked about basic family demographic information, diseases or symptoms in children and family members, building characteristics, current home environmental exposures and lifestyle habits. Questions regarding asthma and allergic diseases and symptoms among children were from the ISAAC study [31]. Questions about indoor exposures were based on those from the ALLHOME study [32], the DBH study [33] and CCHH studies in other cities of China [8,27,28,34–40]. A modified version of a self-administered questionnaire, which was more appropriate to the culture, lifestyle, building structure and interior characteristics in Baotou, was distributed to 6950 children (aged 1–8 years-old)by teachers in 37 randomly selected kindergartens. The children delivered the questionnaires to their parents. For better cooperation, understanding and validation of our data, all participants were informed about the purpose and significance of the study before they answered the questions. The kindergartens were located in the 4 main urban districts of Baotou City, Kunlundu district, Qingshan district, Donghe district and Jiuyuan District. Children returned the completed questionnaires to their teachers one week later. Detailed information about the location of Baotou and the investigated areas of Baotou city are shown in Fig. 1.

Questions regarding POD are as follows:

"Stuffy odor": Have you ever been disturbed by any stuffy odor due to bad ventilation status in your house in the last 3 months? (frequently/sometime/no)

"Unpleasant odor": Have you ever been disturbed by any unpleasant odor in your house in the last 3 months? (frequently/sometimes/no)

"Pungent odor": Have you ever been disturbed by any pungent odor in your house in the last 3 months? (frequently/sometimes/no)

"Moldy odor": Have you ever been disturbed by any moldy odor in your house in the last 3 months? (frequently/sometimes/no)

"Smoke odor": Have you ever been disturbed by any tobacco smoke odor in your house in the last 3 months? (frequently/sometimes/no)

"Dry air": Have you ever been disturbed by sensations of air dryness in your house in the last 3 months? (frequently/sometimes/no)

"Humid air": Have you ever been disturbed by sensations of humid air in your house in the last 3 months? (frequently/sometimes/no)

POD questions were limited to "the last 3 months."Therefore, to improve reliability, we limited the time scale for asthma and allergic symptoms to the last 12 months:

"Wheezing last 12 months": In the last 12 months, has your child ever wheezed or whistled in the chest? (yes/no)

"Nocturnal cough last 12 months": In the last 12 months, has your child had a dry cough at night for over 2 weeks even without catching a cold or chest infection? (yes/no)

"Rhinitis last 12 months": In the last 12 months, has your child had a problem with sneezing, running or blocked nose even without catching a cold or flu? (yes/no)

"Eczema last 12 months": In the last 12 months, has your child had eczema problem at any time? (yes/no)

2.3. Statistical analysis

Analyses were performed using SPSS V.18.0 for Windows, with significance set at $p = 0.05$ (two-tailed tests). Pearson's Chi-square (χ^2) test was used to compare prevalence of POD and children's health status using cross-tab analysis. Adjusted odds ratios (aORs) with 95% confidence intervals (CI) were calculated by multiple logistic regressions after adjusting for children's gender, age, family history of asthma or allergies, and, for the dryness question, parent's gender. Multiple logistic regression models were constructed for each symptom, classified POD levels and all potential confounders. To explore household factors related to parent-reported POD, crude correlations between prevalences of investigated household indicators (e.g., respondents' demographic information, investigated buildings' characteristics and people's lifestyle behaviors) and POD were obtained from a Chi-square test. Stepwise logistic regression models were used to reveal the importance of different variables associated with POD. The forward regression (Wald) mode was used with an inclusion criteria of $p < 0.1$. Then all factors were forced in this model. The results were represented as OR with 95% CI.

3. Results

5511completed, valid questionnaires were obtained (response rate: 79.5%). We restricted our analyses to responses by children's parents only, which gave us 4801 questionnaires for analyses. Table 1 shows the prevalences of children's symptoms and their