"Dampness" and "Dryness": What is important for children's allergies? A cross-sectional study of 7366 children in northeast Chinese homes

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ABSTRACT

This study investigates associations of building dampness indicators, and perceptions of moldy odor, humidity and dryness (Dampness and Dryness, D&D) with children's asthma and allergies. Data were obtained from a cross-sectional study in Tianjin and Cangzhou, China from 2013 to 2014. Completed surveys were returned by 7366 families with children 0–8 years old. We studied D&D factors both in the current residence and the residence where the children lived immediately after birth. A total of 4.4% of the children had doctor-diagnosed asthma; 9.5% had doctor-diagnosed rhinitis; and 39.1% had doctor-diagnosed eczema. Most of the dampness indicators, perceptions of odors, and perceived dryness, were significantly associated with children's asthma and allergies. A reporting bias in parents (or guardians) who themselves had allergies was not found to be the reason for the associations between D&D and health effects. Compared with either previous or current exposure to D&D, continuous exposure to D&D was a greater risk for children's asthma and allergies. Perceived dryness was the most important studied risk factor for children's allergies in either current or previous homes.

1. Introduction

In developed countries, the prevalence of asthma and allergies increased dramatically from the 1970s to the early 2000s [1–3]. Since genetic factors [4,5] and outdoor environment pollution [6–8] could not wholly explain this rapid increase, there developed a search for home indoor environmental causes [9–12]. During this time, asthma and allergy prevalences in China remained low [2]. However, they began to increase in a similarly dramatic fashion in the early 2000s [13–16], and consequently, research into a possible environmental etiology has intensified in China.

Studies in several countries and areas have used the same questionnaire to investigate children's allergic diseases as related to the home environment: Sweden [17,18], Denmark [19], Bulgaria [20], South Korea [21], Singapore [22], USA [23,24], Mainland China [25–32] and Taiwan [33]. It has been demonstrated that various indoor environmental exposures – such as to dampness [17,19–22,25,27,34–38], pet-keeping [23,36], PVC floor covering [21,24,33] and new furniture [16,36] – are associated with increased risk of asthma and allergies in children. "Dampness" is one of the

earliest found [17] and most widely reported environmental risk factor, especially in cross-sectional studies [17,21,24–27,29]. However, causative agents and mechanisms for "dampness" as a risk have not been identified [11,39,40]. Meanwhile, perceived "dry air" as a health risk was reported many years ago [41]. However, a paradox emerged: in clean air, perception of "dryness" was not related to actual relative humidity (RH) at constant temperature, while "dryness" was perceived at relatively high RH in air with volatile organic pollutants [42]. Moreover, "dryness" has often been perceived in the presence of "dampness" indicators [18,28,37,43], especially when there is window condensation, a widely accepted dampness indicator [18,28,43].

Accordingly, the present study focuses on dwelling "dampness" and "dryness." In particular, this study aims to analyze (1) associations of children's asthma and allergies with individual visual "dampness" indicators, perceived moldy odor, humidity and "dryness" and (2) associations between "dampness" and "dryness" perception and (3) to explore what may have caused perceived dryness in the studied residences.

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2. Methods

This study is part of the China, Children, Homes, Health (CCHH) study [14,16,26–32]. It is a cross-sectional study carried out with a questionnaire survey conducted from 2013 to 2014. We studied 0 to 8 year-old children in Tianjin and Cangzhou [43]. The questionnaire consists of 99 questions addressing the child's demographic background, home environment, and family members' asthma and/or allergy history. We study the children's history and present status with respect to the diseases asthma, rhinitis and eczema.

2.1. Questionnaires

The questionnaires asked about various indicators of dampness and dryness in current dwellings and in earlier post-birth residences. We will refer to indicators of dampness, perceived odors and perceived dryness as D&D. Indicators for dampness are visible mold or damp spots, floor moisture, suspected dampness, and window condensation. For perceived odors, we used perceived moldy air, perceived humidity, and perceived dryness. These questions are as follows:

1) Mold or damp spots: visible mold or damp stains on the ceiling, walls or floor in the child's room (yes vs. no).
2) Suspected dampness: damp or mold problems on or inside the floor, walls or ceiling, suspected but not visible inside the residence (yes vs. no).
3) Floor moisture: floor covering that has detached or become discolored in the child's room (yes vs. no).
4) Condensation on windows: any condensation on the inner side of the window pane during winter in the child's room (yes vs. no).
5) Moldy odor: perceived moldy odor sometimes or every week during the last three months (yes vs. no).
6) Humid air: perceived humid air sometimes or every week during the last three months (yes vs. no).
7) Dry air: perceived dry air sometimes or every week during the last three months (yes vs. no).

Answers of "don't know" were treated as missing values.

We integrated each factor in either or both the early and current residences, so that there are four categories of exposure:

No exposure: neither the current residence nor the child's birth place were reported to have exposures;

Previous-only: only the previous residences were reported to have exposures;

Current-only: only the current residences were reported to have exposures;

Continuous: both current and previous residences were reported to have exposures.

Questions on children's asthma, and allergic symptoms were as follows:

1) Wheezing current: has your child had wheezing or whistling in the last 12 months (yes vs. no).
2) Dry cough current: has your child had a dry cough at night for more than two weeks, apart from a cough associated with a cold or chest infection (yes vs. no).
3) Doctor-diagnosed asthma (Diag. asthma): has your child been diagnosed with asthma by a doctor (yes vs. no).
4) Rhinitis current: has your child had a problem with sneezing, or a runny, or a blocked nose when he/she did not have a cold or the flu in the past 12 months (yes vs. no).
5) Doctor-diagnosed rhinitis (Diag. rhinitis): has your child ever been diagnosed with allergic rhinitis by a doctor (yes vs. no).
6) Eczema current: has your child had eczema symptoms at any time in the past 12 months (yes vs. no).
7) Doctor-diagnosed eczema (Diag. eczema): has the child ever been diagnosed with atopic eczema or atopic dermatitis by a doctor (yes vs. no).

2.2. Statistical methods

The associations of home D&D with health effects were calculated in multiple logistic regression models. Odds ratios were adjusted for the child's gender (boy vs. girl), age, family history of allergy, and house types (apartments, bungalows). All variables were tested for co-linearity before being used in the multiple logistic regression model. We used an "enter method" to find associations of children's allergies with dampness problems and calculated adjusted odds ratios (aOR) with 95% confidence intervals (CI).

Population attributable fraction (*PAF*) is the proportion of morbidity caused by exposure to a certain factor (e.g. dampness). Population attributable fractions (*PAF*) of dampness indictors and odors perceptions in this study were calculated using equation (1) [44,45]:

$$PAF = P_d \left(\frac{RR - 1}{RR} \right) \tag{1}$$

where *RR* is the relative risk, that is the ratio of exposure groups' incidence to the unexposed groups and P_d represents the proportion of cases exposed to risk factor [44,45]. We accepted a *P-value* of < 0.05 as significant. All analyses were performed with IBM SPSS v.19.0.

3. Results

3.1. Health outcomes

There were 7865 responses to the questionnaire yielding a response rate of 78.0%. Of all the children, 499 children were either older than 8 years, or did not have their age reported. Therefore, 7366 children were in the final analyses. Table 1 shows demographic information for these 7366 children.

The prevalence of children's asthma and allergic symptoms is shown in Table 2. The most frequently reported allergic symptom in the Tianjin and Cangzhou area was doctor-diagnosed eczema, followed by current rhinitis and current eczema. The prevalence of doctor-diagnosed asthma was highest in older children, whereas the prevalence of eczema symptom was highest in younger children. Boys, children with family allergy history, and children living in apartments reported significantly more allergies. When house locations were stratified, the prevalence of children's asthma and allergic symptoms were highest in the urban children (Table A1). When respondents were stratified, allergic parents reported significantly more children's allergic symptoms than non-allergic parents (Table A2).

3.2. Dampness, perceptions of moldy odor, humidity and dryness

The prevalences of dampness indicators, perceived moldy odor, and perceived humidity and dryness (D&D) in current and previous residences are shown in Table 3. Perceived dryness was the most frequently reported indicator both in current and previous homes.

Table 1
Demographic information for participating children (n = 7366).

		n(%)
Gender	Boy	3780(51.9)
	Girl	3499(48.1)
Age	< 3	225(3.0)
	3–5	3238(44.0)
	6–8	3903(53.0)
Families with a history of allergy	Yes	948(14.1)
House types	Apartment	4714(67.8)
	Bungalow	2239(32.2)