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Home Dampness, Childhood Asthma, Hay Fever and Airway Symptoms in Shanghai, China: Associations, Dose-response Relationships and Lifestyle's Influences

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Abstract

Numerous studies of associations between dampness and respiratory diseases have been conducted, but their implications remain inconclusive. In this study of 13,335 parent-reported questionnaires (response rate: 85.3%), we analyzed associations between home dampness and asthma and related symptoms in 4-6-year-old children in a cross-sectional study of Shanghai. Indicators of home dampness were strongly and significantly associated with dry cough, wheeze and rhinitis symptoms. In the current residence, children with visible mold spots (VMS) exposure had 32% higher risk for asthma (Adjusted OR, 95%CI: 1.32, 1.07~1.64); damp clothing and/or bedding (frequently) was strongly associated with dry cough (1.78, 1.37~2.30); condensation on windows was strongly associated with hay fever (1.60, 1.27~2.01). In the early-life residence, visible mold spots or damp stains (frequently) were strongly associated with dry cough (2.20, 1.55~3.11) and rhinitis ever (1.57, 1.11~2.21). Associations between dampness and diseases among children with or without family history of atopy were similar. The total number of dampness-indicators had strong dose-response rela-

tionships with investigated health outcomes. Actions, including opening windows of the child's room at night and cleaning the child's room frequently, could potentially mitigate 25% of home VMS, thereby preventing more than 1.5 % of attributable risk of the studied symptoms.

Keywords

Asthma, Rhinitis, Dampness, Home, Preschool Children, Attributable risk

Practical Implications

Home dampness is a strong risk factor for childhood asthma, hay fever and related airway symptoms. Improving ventilation of the child's bedroom during night, cleaning the child's room more frequently and exposing clothing/beddings to sunshine frequently are practical methods to reduce home dampness-related exposures.

Introduction

The prevalences of childhood asthma and allergies in developed countries are high whereas the prevalences in developing countries are low (Asher et al. 2006; Anandan et al. 2010). However, prevalences in developed countries are stable or decreasing (Zöllner et al., 2005; Poulos et al., 2005; Grize et al., 2006; Duggan et al., 2012), whereas the prevalences among children in developing countries have been reported to be increasing (Asher et al. 2006). Specifically, studies over the past 10 years indicate that the prevalences of asthma and allergies in China are rapidly increasing (Wong et al., 2004a; Zhao et al. 2010; Yangzong et al., 2012; Qu et al., 2013; Zhang et al., 2013b). In Shanghai, a cross-sectional questionnaire study found that the prevalence of asthma among children had increased from 1.90% in 1990 to 10.3% in 2011 (Huang et al., 2013; Liu et al., 2013), most likely due to changed environmental exposures (Zhang et al., 2013b), and perhaps especially exposures in the homes (Relace and

Lowrey, 1980; von Mutius, 2002; Diette et al., 2007; Turner, 2012). The China, Children, Homes, Health (CCHH) project is currently studying associations between home environment and asthma and allergies in 10 cities in China (Huang et al., 2013; Liu et al., 2013, 2014; Qu et al., 2013; Wang et al., 2013a, 2013b; Zhang et al., 2013a, 2013b; Zhao et al. 2013). Recently, the Shanghai group of CCHH reported that early furred pet-keeping (Huang et al., 2013) and parental smoking (Liu et al., 2013) were risk factors for asthma and allergies among preschool children. Many studies have shown that dampness-related problems (as evidenced by such signs as visible mold, visible damp stains, condensation on windows, and perceived mold odor) in the residence are significant risk factors for asthma and asthma-related symptoms among children (Peat et al., 1998; Bornehag et al., 2001;Bornehag et al., 2004b; Jaakkola et al., 2005; Fisk et al., 2007; Tischer et al., 2011; Mendell et al., 2011; Quansah et al., 2012; Weinmayr et al., 2013; Sun and Sundell, 2013) and adults (Brunekreef et al., 1992; Gunnbjörnsdottir et al., 2003; Blanc et al.,2013; Norbäck et al., 2013). Bornehag et al. have concluded that dampness in buildings appears to increase the risk of health effects (dry cough, wheeze and asthma), especially in children (Bornehag et al., 2001). However, a causal relationship between dampness, and mechanisms for dampness related respiratory symptoms have not been shown (Bornehag et al., 2001; Bornehag et al., 2004b;Mendell et al., 2011). The ALLHOME study in Bulgaria (Naydenov et al., 2008) and the Dampness in Buildings and Health (DBH) study in Sweden (Larsson et al., 2011) have found that the significant associations between home dampness and asthma and/or allergy among preschool children were partly confounded by parents' reporting bias in cross-sectional questionnaire studies. In the DBH study, parents with allergic symptoms, or with allergic children, tended to report more moisture-related problems than other parents.

In China, home dampness has also been found to be positively associated with childhood asthma and allergy (Yang et al., 1997; Wong et al., 2004b; Hsu et al., 2010; Wang et al., 2012; Wang et al., 2013a; 2013b; Zhao et al.; 2013; Zhang et al. 2013a). However, further studies are still needed to elucidate the association between dampness and childhood health (Sun et al., 2009; Wu et al., 2010; Wang et al., 2013a). Moreover, most studies on dampness and health have been taken place in relatively "dry' areas of the world, such as North America and Northern Europe. There are few studies from more severely humid areas. An area where "dampness' is much more common provides a more stringent test than the more dry areas previously studied. Shanghai, located in the Yangtze River estuary near to the Chinese East Sea, has a typical subtropical monsoon climate. The indoor environment in Shanghai is hot-moist in summer and cold-moist in winter, and the outdoor air temperature differs significantly from season to season. Residents here probably experience more moisture-related problems than residents in most other regions of China and the world. However, because the outdoor weather in Shanghai is always wet, the residents here probably have little awareness about associations between home dampness and childhood airway diseases. In Sweden, awareness is high due to a nationwide campaign addressing allergy and risk factors (Larsson et al., 2011), and in USA, awareness is also likely high due to media interest in "mold" as well as many lawsuits (Sun and Sundell, 2013). Nothing like this has happened in China. Meanwhile, many home environments have greatly changed in Shanghai during the recent and ongoing modernization, and currently, there are great differences among different types of residences (Liu et al., 2014).

Using the questionnaire designed for phase one of the CCHH study, this paper aims to: 1) analyze associations between both early (at birth) and current (at the time of the questionnaire study) home dampness with asthma and related respiratory symptoms among preschool children in a very humid area of China; 2) investigate associations between some lifestyle practices and home dampness; 3) investigate how much of asthma and related symptoms might be prevented by reducing home dampness.

Methods

This paper is part of Phase one of the CCHH study, and is a cross-sectional investigation of associations between both current and early (at birth) residential environments and asthma/allergy among preschool children. The study was carried out in Shanghai from April 2011 to April 2012. The study was approved by the ethical committee in the School of Public Health, Fudan University in Shanghai, China.

Subjects and Survey

The subjects were preschool children in kindergartens. A multistage sampling method was used to obtain a representative sample of Shanghai children. Three urban districts (Jing'an, Hongkou, and Zhabei) and two suburban districts (Fengxian and Baoshan) were selected from 18 districts of Shanghai (8 urban districts and 10 suburban districts). About 15 kindergartens were randomly chosen in each selected district, and questionnaires were distributed to parents of the children in these kindergartens. A total of 17,898 children in 72 kindergartens were surveyed. The questionnaires were filled out in two ways: 1) parents completed the questionnaires when attending a parent-teacher meeting or other programs in the kindergartens; 2) questionnaires and questionnaire-guidance were posted to the kindergartens where teachers distributed them to parents and posted completed questionnaires back to us.

Questionnaire

The questionnaire included questions on the children's basic demographic information, early and current home environmental exposures, diseases or symptoms in children and their family members (asthma/allergy history), lifestyle habits, and food habits. Symptoms among children were obtained from responses to the ISAAC study questions (Asher et al., 1995). Asthma and airways symptoms are defined as follows: 1) Wheeze: children have had wheezing or whistling in the chest; 2) Asthma: children have been diagnosed with asthma by a doctor; 3)

Dry cough: In the past year, children have had a dry cough at night for more than two weeks, apart from a cough associated with a cold or chest infection; 4) Rhinitis: children have had sneezing, or a runny nose or a blocked nose without a cold or flu; 5) Hay fever (allergic rhinitis): children have been diagnosed with hay fever (allergic rhinitis) by a doctor. In this paper, asthma and hay fever ever (during lifetime since birth) were studied, and wheeze and rhinitis within the past year (before the questionnaire) and ever were studied. Family history of atopy was defined as asthma or allergic problems in the father, mother, grandparents, or siblings. Six home dampness-related indicators, namely visible mold, damp stains, water damage, damp clothing/bedding, mold odor and condensation on the inner windowpane in winter, were analyzed. The questions about dampness are similar to those of the ALLHOME study (Naydenov et al., 2008), the DBH study (Bornehag et al., 2004a), Texas in America (Sun and Sundell, 2013) and CCHH studies in other China cities (Qu et al., 2013; Wang et al., 2013a, 2013b; Zhang et al., 2013a, 2013b; Zhao et al. 2013). The questionnaire used for CCHH Phase one is shown in the Supporting Information (Table S5) of the CCHH summary article (Zhang et al., 2013b). Some questions have been slightly altered to better address particular aspects of Shanghai culture and lifestyles. The questions for this study are shown in the Supplemental Materials (Tables S1~S4).

Statistical methods

Statistical analyses were performed with SPSS 17.0 (SPSS Ltd., Chicago, Illinois, USA). Pearson's chi-squared test was used to compare the prevalence of asthma and airway symptoms for different dampness-related indicators, and to test the differences in home dampness between families with and without selected lifestyles. Gamma's test for correlation (Schraw et al., 2012) was used to calculate the correlation coefficient (G) between different dampness-related problems for which the variables are dichotomous (Yes vs. No). Bivariate (crude odds ratio, OR) and multiple logistic regression models (adjusted odds ratio, AOR) were used to reveal associations and dose-response relationships between home moisture-related exposures and diseases. Confidence intervals of 95% are also shown, with the criterion for significance in statistical analysis set at $P<0.05$. Potential confounders, which have been found to have significant associations with childhood asthma or other airway symptoms in the previous analyses, were adjusted for in multiple logistic regression models. These include age, sex, location of surveyed kindergartens, ownership of current residence, early pet-keeping, early parental smoking, current parental smoking, duration of breastfeeding, and family history of atopy. Linear trends between the combined numbers of reported home dampness-related indicators and prevalences of diseases were tested by Mantel-Haenszel linear-by-linear association chi-squared test (Agresti 2013). In multiple logistic regression analyses of associations between home dampness and lifestyle practices, all selected lifestyle practices were included as independent variables in one model and adjusted for in each of the other practices. Attributable risk (AR) and attributable fraction (AF) (Webb and Bain, 2011) of the prevalences of diseases due to dampness-related exposures were calculated as were attributable risk reduction (ARR) and attributable fraction reduction (AFR) of the prevalences for the reduction in dampness indicators. Detailed methods for the calculation of these indices are shown in the Supplemental Materials (Supplemental Methods).

Results

Demographic data and home dampness-related indicators

A total of 15,266 questionnaires for 1-8 year-old children were returned. This paper focuses on children aged 4-6 years old (n=13,335), as they were the large majority (87.4%) of the sample. Four year old (n=5561), five year old (n=4399), and six year old (n=3375) children account for 41.7%, 33.0% and 25.3% of the 4-6 year olds respectively. Boys are 50.8% of the total. Because we did not restrict the age of children before our questionnaire, but distributed the questionnaire to all parents of children in the kindergartens, we are not able to know how many questionnaires were sent to 4-6-year-old children's parents. Thus, we cannot calculate the response rates for these children and therefore use the overall response rate (85.3%) for 1-8 year-old children as the response rate in this paper. More information about sample sizes for different dampness-related indicators and potential confounders is shown in Tables 1 and S5 (Supplemental Materials). Six questions about dampness in the current residence and three about dampness in the early residence (at the time of the child's birth) were asked. The responses are also shown in Table 1.

Correlations among different dampness-related exposures are shown in Table 2. Some indicators had strongly positive and statistically significant correlations with each other, while most of correlations were moderate or low. The strongest correlations were between visible mold spots and visible damp stains in the current residence, and between condensation on windows in the current residence and in the early residence.

Associations between home dampness and diseases

Prevalences and numbers of children with asthma and related symptoms for different home dampness-indicators in the survey are shown in Tables 1 and S5, respectively. The prevalences of asthma, wheeze, dry cough, rhinitis and hay fever among children who have or did had exposure to dampness-related exposures are significantly higher than for those children who have not (or did not have) such exposures. Larger numbers of dampness indicators in both the current and early residences were associated with higher prevalences of these diseases or symptoms. The influence of potential confounders also is shown in Table 1.

Tables S6 and 3 respectively show associations between diseases and nine home dampness-related exposures from the bivariate and multiple logistic regression analyses. Dry cough in the past year (IPY), wheeze and rhinitis had statistically significant and strongly positive associations with all dampness indicators, whereas doctor-diagnosed asthma and hay fever had less consistent associations with dampness indicators. For associations between one studied dampness indicator and different health outcomes: 1) for the current residence, both visible mold spots and damp stains had the strongest positive associations with wheeze (ever) and dry cough (IPY); damp clothing and/or bedding (frequently or sometimes), water damage (before the past year or in the past year), and condensation on windows (> 25 cm or 5~25 cm) had the strongest associations with dry cough (IPY); and moldy odor had the strongest associations with wheeze (IPY). 2) For the early residence, frequently finding visible mold spots or damp stains had the strongest associations with dry cough (IPY); condensation on windows in winter (frequently or sometimes) and moldy odor had the strongest associations with wheeze (IPY).

By stratifying for family history of atopy (FHA, Yes vs. No), we also further investigated associations between home dampness and asthma (Table 4 and S7), dry cough (Table S8), wheeze in the past year (Table S9), wheeze ever (Table S10), rhinitis in the past year (Table S11), rhinitis ever (S12), and hay fever (Tables 4 and S13). Whether exposed to dampness or not, children with FHA had much higher prevalence of the studied diseases than those without FHA (Tables 1 and S5; Tables S7~S13). Meanwhile, whether children had FHA or not, most of the dampness exposures were strongly and significantly associated with the studied diseases (Tables S7~S13), and most of the associations between dampness and the diseases among children with or without FHA were similar both before and after adjusted by potential confounders.

Dose-response relationships between home dampness and diseases

Tables S15 and 5 show dose-response relationships between diseases and the number (n) of reported dampness-related indicators, in bivariate and multiple logistic regression analyses respectively. The dose-response relationships were very strong, although the uptrend of odds ratios in these tables fluctuated with the number of reported dampness indicators in the current residence. ORs for higher numbers of dampness indicators are less robust perhaps because the number of reported indicators decreased with increasing numbers of indicators. Tables 1 and 3 also show associations between the frequency or number of exposure indicators and health outcomes. The more home dampness-related indicators reported in the current residence, or in the early residence, or both in current and/or early residence, the stronger the associations. The test for a linear trend between the number of home dampness-related indicators and prevalences of diseases by a chi-squared test (Table 6) also further indicated there is a strong dose-response relationship.

Figures S1, S2 and S3 also show best-fit linear trends between prevalences and the number (n) of dampness-related indicators for different illnesses and symptoms. As the reported number of dampness-related indicators increased, prevalences of studied diseases increased linearly. Although the prevalence for hay fever (ever) and rhinitis (IPY) decrease from n = 5 to n = 6, the best-fit line still has a positive slope.

Lifestyle habits, home dampness-related exposures and diseases

Associations between the resident's lifestyle habits and home dampness-indicators are shown in Tables 7 and S16. More frequent opening of windows in the child's room at night was associated with reductions in all studied dampness-indicators except moldy odor. More frequent cleaning of the child's room was associated with reductions of all dampness-indicators. Exposing clothing/beddings to sunshine more frequently was associated with fewer reports of mold odor, but more damp clothing and/or bedding (Table S16). In the logistic regression analyses (Tables S17 and S18), the crude ORs for the selected lifestyle practices were significantly associated with reduced home dampness-related indicators. Many were still significant after adjustment for the other lifestyle practices. All studied lifestyle practices were associated with a reduction of visible mold spots (VMS). Associations between lifestyle practices and prevalences of asthma and related symptoms were also calculated (Tables 8 and S19). Most of the prevalences among children with the studied lifestyle practices were lower than among children without these parental practices. Furthermore, frequently exposing the bedding to sunshine is protective for children both with and without damp bedding exposure (Table 8).

Attributable risk (AR) and attributable fraction (AF) for health problems among children exposed to dampness-related indicators were calculated (Table S20). Most of the ARs were larger than 5.0%, with all of the corresponding AFs higher than 10%. Table 9 shows the potential attributable risk reduction and attributable fraction reduction that could be achieved by reducing VMS. Based on the Table 5 findings, the studied lifestyle practices can each reduce VMS by about 25%. Such a reduction in VMS would in turn reduce by more than 0.5% and 6.0% respectively the AR and AF for asthma, 0.5% and 3.0% respectively the AR and AF for hay fever, and more than 1.5% of AR the related airway symptoms due to home VMS exposure.

Discussion

This study of 13,335 children from 72 randomly selected kindergartens is the largest cross-sectional study on the home environment and childhood asthma, allergy and airway symptoms conducted to date in China (Zhang et al., 2013b). A response rate of 85.3% makes it likely that the study gives a valid and reliable picture of the home environment as it relates to asthma and allergies among children in Shanghai. The questionnaire we used has been validated previously with regard to health questions in the ISAAC study (Asher et al., 1995), and with regard to the home environment in studies in Sweden (Bornehag et al., 2004a;

Hägerhed-Engman et al., 2009), Bulgaria (Naydenov et al., 2008), and in Tianjin in China (Sun et al., 2009).

As in all cross-sectional studies, there can be no inference made about causality between exposure and health problems. There is also a potential error resulting from over-reporting those risk factors that respondents are aware of. Thus, if parents “think” that “dampness” is a risk factor for asthma and allergies, they may tend to report more “dampness” if they have a sick child in the family. This error was found in a study in Sweden (Larsson et al., 2011). However, the knowledge of risk factors for asthma and allergies is likely not as great in China. In Sweden, there had been a large information campaign for the general public about risk factors for asthma and allergies a few years before the study (Larsson et al., 2011). Nothing similar has happened in China. Consequently, findings in China for associations between dampness and asthma and allergies should be free of such bias. This, however, must be tested in a follow up study on incident cases in China.

The home dampness-related problems in Shanghai are more serious than those found for Chongqing (Wang et al., 2013a) and Sweden (Hägerhed-Engman et al., 2009). In Chongqing, Wang et al. surveyed 5,299 parents of 3~6 years old children and found that in the current residence, the prevalence of visible mold spots was 5.3%, visible damp stains 8.3%, damp clothing and/or bedding 35.1%, moldy odor 11.6%, and condensation on windows (≥ 5 cm) 14.3%, while the corresponding prevalences in Shanghai were all larger, at 7.8%, 15.3%, 42.2%, 11.9%, and 26.5% respectively. In Sweden, Hägerhed-Engman et al. surveyed 8,918 dwellings of 1-6 years old children and found the prevalence of visible dampness (mold and/or damp stains) to be 1.3%, condensation on windows (≥ 5 cm) 15.8% and moldy odor 4.1%.

In agreement with many other studies (Peat et al., 1998; Bornehag et al., 2001; Bornehag et al., 2004b; Jaakkola et al., 2005; Fisk et al., 2007; Mendell et al., 2011; Tischer et al., 2011; Quansah et al., 2012; Wang et al., 2013a, 2013b), we found that home dampness signs were strongly and positively associated with childhood asthma and asthma-related symptoms. Peat et al. reviewed studies conducted before 1997 and found that the range of odds ratios (ORs) for the association of childhood symptoms with home dampness or mold was generally from 1.5 to 3.5. Later reviews (Bornehag et al. 2001; 2004b) found that the relative risks of home dampness indicators for childhood asthma, dry cough, and wheeze had ORs in the range of 1.4 to 2.2, while Fisk et al. found that the central estimates of ORs for health outcomes ranged from 1.34 to 1.75, and that dampness and mold were associated with an increase in respiratory and asthma-related symptoms of approximately 30~50% (Fisk et al., 2007), that is, somewhat higher than found in the present study. In 2011, Tischer et al. conducted a meta-analysis of home mold and dampness exposures and childhood asthma and allergy, and found that early mold exposures were associated with asthma in young children and allergic rhinitis symptoms in school-age children (Tischer et al., 2011). Mendell et al. concluded from their review that evidence of dampness or mold environmental exposures were consistently and positively associated with the initiation of asthma, and allergic and respiratory symptoms (Mendell et al., 2011). In a parallel CCHH study in Chongqing, Wang et al. found that both early and current home dampness were strongly and positively associated with childhood wheeze (ever), dry cough in recent months, and rhinitis (ever), but were not consistently associated with doctor-diagnosed asthma and hay fever (allergic rhinitis) (Wang et al., 2013a). Their findings suggested that early home dampness exposures might increase the risk of asthmatic symptoms (dry cough and wheeze) and rhinitis in later childhood, and that current home dampness exposure is also a risk for asthma-related symptoms.

In addition to findings consistent with those of other studies, we found that some dampness indicators reported by parents have significant and strong correlations with each other (Table 2). Shanghai residences reported to have one dampness indicator tended to have other dampness indicators. Thus, associations between specific dampness indicators and childhood symptoms may by confounded by each other. Also, because some dampness indicators (such as the specific height of condensation on the windows and moldy odor) may be more subjectively reported than others, and parents' individual definitions of dampness-related problems may perhaps be different, thus weakening the validity of the reports. The definitions of wheeze (ever) and rhinitis (ever) may also be confounded by parents' recall error and lack of awareness of the symptoms.

Because the DBH study in Sweden (Larsson et al., 2011) found that family history of atopy (FHA) may confound the associations between home dampness indicators and childhood airway diseases, we have further analyzed such associations by stratifying the children into two subgroups, with or without FHA (Table 4 and Table S7~S13). Most of such associations among children with FHA were similar to those without FHA. These findings indicate that dampness can increase the risk of asthma, hay fever and related symptoms with or without parental atopy. Mitigation of dampness perhaps could reduce asthma/symptoms in children with or without FHA. The prevalences among children with FHA, however, were notably higher than among children without parental atopy. These findings indicated that children with FHA may have asthma/symptoms regardless of whether they have much dampness exposure, and FHA must be considered in the analysis of associations between home environmental exposures and childhood allergies.

As in many previous studies (Peat et al., 1998; Fisk et al., 2007; Mendell et al., 2011; Quansah et al., 2012; Norbäck et al. 2013; Weinmayr et al., 2013), we found that the combined numbers of home dampness-related indicators had a strong dose-response positive relationship with childhood asthma-related symptoms (Figures S1, S2, and S3; Tables 6, 7, S14, and S15) by different analytical models. A study in Taiwan (Hsu et al., 2010) also found a dose-dependent relationship between home visible mold growth and IgE levels, an indicator of allergic response in humans. We also found that various lifestyle practices could reduce dampness exposure. Parents reporting practices such as opening the window of child's room, putting clothing/bedding to sunshine, and cleaning the child's room, reported fewer home dampness indicators. These results are consistent with those of a parallel CCHH study in Chongqing (Wang et al., 2013a). Since Shanghai has hot summers and cold winters, parents would likely have different frequencies in opening the windows in the child's room in different seasons for home natural ventilation. In order to save electricity, Shanghai residents would perhaps also close the windows in the child's room during nights when they used the split heating/air-conditioning unit for cooling or heating in hot-summers or cold-winters. Thus the home ventilation rate and indoor environmental exposures in different seasons would be different. Thereby associations between home dampness indicators (as well as childhood asthma and related symptoms) and parents' opening the windows in different seasons were different (Tables 7, S17, and S19). On the other hand, parents who have increased the frequency of cleaning their child's room due to allergy reported significantly higher prevalences of all diseases than those parents who have not changed (Figure S4). This behavior strongly suggests reverse causality: parents clean the child's room more frequently because their child is sick. Other lifestyle practices may also be attributed to reverse causality, as shown in the study about the duration of breastfeeding and childhood asthma and allergy (Qu et al. 2013). Tables 5 and S17 show that parents possibly open windows more frequently due to their perception of moldy odor, and also put clothing/bedding to sunshine because the clothing/bedding is damp (Tables S16 and S18). Nonetheless, it is possible that these lifestyle practices can ameliorate home dampness-related problems and can at least reduce the frequency of asthmatic attacks and symptoms (dry cough and wheeze). The findings in Tables 7 and S17 also suggest the possibility that those parents who have higher socioeconomic status are perhaps more willing to take their sick child to a doctor, and also are more aware of associations between home environments and health outcomes. If so, because they have more resources to improve their home environments, they may have higher desire to buy related devices such as air humidifiers or purifiers than others (Liu et al., 2014).

We also calculated attributable risks and attributable fractions of asthma, hay fever, and related symptoms prevalences (Table S20) for home dampness-related exposures. The results show by how much prevalence is increased by the presence of home dampness indicators. We found that for children with home dampness exposures, about 10% of their asthma, hay fever, and related airway symptoms were due to home dampness exposures independently of other factors. We then calculated attributable risk reductions (ARR) and attributable fraction reductions (AFR) of asthma, hay fever and related symptoms for a reduction in the VMS (a home dampness indicator) that would result from each studied lifestyle practice (Table 9). We estimated that more than 0.5% of asthma and hay fever, and 1.5% of related airway symptoms due to dampness exposure as indicated by VMS could be prevented by opening the child's room window in spring, summer, autumn, and winter (frequently or sometimes), or by cleaning child's room more than once every two weeks.

Although the literature for associations between home dampness-related exposures and childhood asthma and related symptoms is large, to the authors' knowledge, this study is the first cross-sectional study that focuses on associations between home dampness-related exposures and childhood asthma, hay fever and related symptoms in such sufficiently large samples, with deep analysis by different methods ever in the China mainland. This study has added several novel contributions to the existed large body of literature about dampness and respiratory diseases: 1) the burden of home dampness-related indictors among preschool children in Shanghai are worse than in Chongqing (Wang et al, 2013a) or Sweden (Hägerhed-Engman et al., 2009). 2) Home dampness has significant associations with childhood respiratory diseases in a hot-humid and cold-humid city, Shanghai. Such associations have previously been found for a warm-humid area of the United States (Sun and Sundell, 2013) and a relatively dry, cold areas in Scandinavia (Bornehag et al., 2001; Mendell et al., 2011; Norbäck et al., 2013). 3) A new home dampness indicator, namely damp bedding and/or clothing, has been proposed in parallel with the CCHH study in Chongqing (Wang et al, 2013a). 4) By stratifying family history of atopy in China, we have shown that home dampness increases the risk of asthma, hay fever and related symptoms among children regardless of whether there is a family history of atopy. 4) By combining indicators of dampness, we made a scoring system to investigate associations between different environmental exposures and health outcomes; this system provided a methodological reference for similar studies. 5) We calculated ARR and AFR of health outcomes for a reduction in VMS, a home dampness indicator, that could be expected from some simple, low-cost lifestyle practices. Such information could guide public health policy in developing mitigation measures for childhood asthma, hay fever and related symptoms. Our findings, analyzed in different regression models, suggest that there is perhaps a causal relationship between dampness exposures and childhood respiratory diseases, although more longitudinal and interventional studies must be conducted to further elucidate and explain this speculation (Bornehag et al., 2004b);

Conclusion

Home dampness-related exposure is a strong risk factor for childhood asthma and asthma-related symptoms. Improving home ventilation, increasing the cleaning frequency of the child's room and exposing clothing/beddings to sunshine probably can reduce home dampness-related exposures.

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Table 1 Prevalence of asthma and airway symptoms for different dampness-related indicators and potential confounders

Items		Sample size n (%)	Prevalence, %						
			Asthma [a] ever	Dry cough IPY [b]	Wheeze IPY [b]	Wheeze ever	Rhinitis IPY [b]	Rhinitis ever	Hay fever [a] ever
Dampness indicator: In Current residence									
1) Visible mold spots	Yes	987 (7.8)	13.6	26.3	29.2	37.0	49.9	61.2	14.5
	No	11603 (92.2)	10.0***	18.8***	20.9***	27.3***	41.9***	53.3***	12.4
2) Visible damp stains	Yes	1939 (15.3)	12.4	25.4	28.3	36.4	48.1	60.3	14.9
	No	10728 (84.7)	9.9**	18.5***	20.5***	26.8***	41.6***	52.7***	12.2**
3) Damp clothing and/or bedding									
Yes, frequently		357 (2.8)	14.3	28.2	29.0	36.0	52.8	62.5	15.9
Yes, sometimes		5071 (39.3)	10.9	21.9	24.8	31.7	45.1	57.4	12.4
No, never		7453 (57.9)	9.8**	17.7***	19.2***	25.6***	40.7***	51.4***	12.5
4) Water damage									
Yes, BPY [c]		1142 (9.5)	11.7	24.8	27.0	34.1	48.4	59.9	16.4
Yes, IPY [b]		1043 (8.7)	11.0	26.7	26.0	34.4	49.7	59.3	14.8
No, never		9820 (81.8)	10.0	17.9***	20.1***	26.5***	41.2***	52.5***	11.9**
5) Condensation on windows in winter									
Yes, > 25 cm		802 (7.9)	15.6	32.0	30.2	37.1	53.8	61.1	18.9
Yes, 5～25 cm		1882 (18.6)	10.8	23.4	23.7	30.4	49.3	57.5	15.3
Yes, < 5 cm		2947 (29.2)	11.8	20.7	24.8	31.9	45.5	56.3	13.7
No, never		4474 (44.3)	8.5***	15.2***	17.5***	23.6***	37.4***	51.0***	9.9**
6) Moldy odor									
Yes, frequently		93 (0.8)	15.2	30.8	38.2	46.7	53.9	69.6	13.5

Items	Sample size n (%)	Prevalence, % Asthma [a] ever	Dry cough IPY [b]	Wheeze IPY [b]	Wheeze ever	Rhinitis IPY [b]	Rhinitis ever	Hay fever [a] ever
Yes, sometime	1328 (11.1)	12.3	22.1	28.6	34.6	48.3	61.8	13.8
No, never	10565(88.1)	9.7**	18.7***	20.1***	26.7***	41.4***	52.3***	12.0
Dampness indicator: In early residence (at time of the child's birth)								
1) Visible mold spotsor damp stains								
Yes, frequently	175 (1.3)	16.8	33.1	31.2	38.0	51.2	65.1	14.1
Yes, sometime	1598 (12.3)	11.6	24.9	29.2	36.6	48.1	61.2	15.1
No, never	11222 (86.4)	9.9**	18.6***	20.5***	27.0***	41.9***	52.9***	12.2**
2) Condensation on windows in winter								
Yes, frequently	1306 (10.1)	15.5	29.9	30.5	38.1	55.5	62.2	17.5
Yes, sometime	5586 (43.2)	10.9	20.5	23.8	30.7	45.1	56.3	13.6
No, never	6043 (46.7)	8.5***	16.5***	17.8***	23.7***	37.8***	50.4***	10.4***
3) Moldy odor								
Yes, frequently	46 (0.4)	14.0	43.2	43.2	46.5	69.0	77.3	15.9
Yes, sometime	929 (7.6)	11.7	22.5	31.6	38.5	47.2	61.4	15.3
No, never	11201 (92.0)	9.8	18.9***	20.3***	26.7***	41.6***	52.7***	12.2*
Potential confounders								
1) Sex Male	6753 (50.8)	11.9	18.9	23.6	31.2	44.5	56.0	14.4
Female	6536 (49.2)	8.7***	20.0	19.9***	25.4***	40.8***	52.1***	10.6***
2) Age > 4	5561 (41.7)	11.1	18.1	21.7	29.1	42.5	54.7	13.3
(years) ≤ 4	7774 (58.3)	9.2***	21.3***	21.8	27.3*	42.9	53.3	11.6**

Table 1 continued.

Items	Sample size n (%)	Prevalence, % Asthma [a] ever	Dry cough IPY [b]	Wheeze IPY [b]	Wheeze ever	Rhinitis IPY [b]	Rhinitis ever	Hay fever [a] ever
3) Location of kindergarten								
Urban	7576 (56.8)	11.9	20.0	21.2	28.2	47.3	58.9	15.3
Suburban	5759 (43.2)	8.2***	18.8	22.5	28.5	36.5***	47.8***	9.0***
4) Ownership of current residence								
Owned	8224 (63.2)	10.9	20.8	21.6	28.3	45.3	55.4	14.2
Rented	4795 (36.8)	9.4**	17.3***	22.1	28.5	38.6***	52.0***	9.7***
5) Early pet-keeping, at the child's birth [d]								
Yes	1628 (12.4)	11.8	22.0	25.6	32.0	45.2	56.7	14.2
No	11515 (87.6)	10.1*	19.1**	21.1***	27.7***	42.2*	53.6*	12.3*
6) Early parental smoking, at the child's birth [e]								
Yes	5524 (42.0)	10.7	19.5	22.3	29.2	42.2	53.8	12.6
No	7631 (58.0)	10.0	19.5	21.2	27.6*	43.0	54.2	12.5
7) Current parental smoking [e]								
Yes	7319 (56.5)	10.5	19.6	22.5	29.1	42.6	53.9	12.6
No	5637 (43.5)	10.1	19.5	20.7*	27.3*	42.8	54.0	12.6
8) Duration of breastfeeding (months)								
≤ 6	7605 (58.2)	11.4	20.6	22.1	28.9	44.8	56.0	14.6
> 6	5456 (41.8)	8.9***	17.8***	21.2	27.5	39.5***	51.2***	9.9***
9) Family history of atopy (FHA)								
Yes	3097 (23.9)	20.8	29.6	33.7	43.7	62.2	70.5	29.7
No	9837 (76.1)	7.0***	16.4***	17.8***	23.3***	36.3***	48.7***	7.3***

[a] doctor-diagnosed; [b] IPY: in the past year; [c] BPY: before the past year; [d] the associations between pet-keeping and childhood asthma and other symptoms have been analyzed and published by Huang et al. (Huang et al. 2013); [e] the associations between home smoke and childhood asthma and other symptoms have been analyzed and published by Liu et al. (Liu et al. 2013). * $0.01 \le p < 0.05$; ** $0.001 \le p < 0.01$; *** $p < 0.001$ in Pearson's Chi-square (χ^2) Test.

Table 2 Correlations between the number of dampness-related indicators in current and early residence

Damp idex		Correlation coefficient (G) [a]							
		In current residence					In early residence		
		Visible damp stains	Damp clothing and/or bedding	Water damage	Condensation on window	Moldy odor	Visible mold spots or damp stains	Condensation on window	Moldy odor
In current residence	1) Visible mold spots	**0.952**	0.521	**0.665**	0.361	0.202	**0.758**	0.310	**0.676**
	2) Visible damp stains	-	0.466	**0.733**	0.346	0.257	**0.675**	0.262	0.585
	3) Damp clothing and/or bedding [b]		-	0.436	0.287	0.242	0.459	0.216	**0.646**
	4) Water damage [c]			-	0.304	0.258	0.584	0.240	0.500
	5) Condensation on window [d]				-	0.074*	0.226	**0.891**	0.164
	6) Moldy odor					-	0.254	0.136	0.509
In early residence	1) Visible mold spots or damp stains [b]						-	0.460	**0.794**
	2) Condensation on window [d]							-	0.354
	3) Moldy odor								-

[a] the *p*-values for correlation coefficients are equal ("*" in the table for 0.074 of item 5)) or less than 0.001. Those correlation coefficients, which are higher than 0.600, are bold; [b] includes frequently and sometimes; [c] includes before the past year and in the past year; [d] includes all condensation reports, that is>25 cm, 5～25 cm and < 5 cm.

Table 3 Associations between asthma and airway symptoms and home dampness-related exposures in the multiple logistic regression analyses

Items (Yes vs. No, No=1.00)	AOR,95%CI[a]						
	Asthma [b], ever	Dry cough, IPY [c]	Wheeze, IPY [c]	Wheeze, ever	Rhinitis, IPY [c]	Rhinitis, ever	Hay fever [b], ever
In Current residence							
1) Visible mold spots	1.32,1.07-1.64**	1.43,1.21-1.68***	1.42,1.21-1.66***	1.45,1.25-1.68***	1.35,1.16-1.56***	1.36,1.18-1.58***	1.13,0.92-1.40
2) Visible damp stains	1.16,0.98-1.36	1.40,1.24-1.58***	1.42,1.26-1.60***	1.47,1.32-1.65***	1.23,1.10-1.37***	1.26,1.13-1.41***	1.13,0.96-1.32
3) Damp clothing and/or bedding							
Yes, frequently	1.32,0.93-1.87	1.78,1.37-2.30***	1.46,1.12-1.90**	1.40,1.09-1.79*	1.70,1.33-2.16***	1.62,1.27-2.06***	1.29,0.94-1.79
Yes, sometimes	1.10,0.97-1.25	1.32,1.20-1.45***	1.30,1.18-1.43***	1.29,1.18-1.40***	1.20,1.11-1.30***	1.29,1.20-1.40***	0.97,0.86-1.10
4) Water damage							
Yes, before the past year	1.08,0.88-1.34	1.48,1.27-1.72***	1.34,1.15-1.56***	1.32,1.14-1.52***	1.25,1.09-1.44**	1.30,1.13-1.49***	1.39,1.15-1.67**
Yes, in the past year	0.96,0.77-1.19	1.58,1.35-1.85***	1.23,1.05-1.44*	1.31,1.13-1.52***	1.28,1.11-1.47**	1.21,1.05-1.39**	1.14,0.93-1.39
5) Condensation on windows in winter							
Yes, >25 cm	1.65,1.30-2.11***	2.19,1.82-2.64***	1.83,1.51-2.20***	1.70,1.42-2.03***	1.61,1.36-1.90***	1.27,1.08-1.51**	1.60,1.27-2.01***
Yes, 5～25 cm	1.10,0.90-1.34	1.46,1.26-1.69***	1.38,1.20-1.60***	1.31,1.15-1.49***	1.44,1.28-1.62***	1.19,1.06-1.34**	1.25,1.04-1.50*
Yes, <5 cm	1.25,1.06-1.49*	1.32,1.16-1.50***	1.53,1.35-1.73***	1.47,1.31-1.65***	1.25,1.13-1.39***	1.15,1.04-1.27**	1.17,0.99-1.38
6) Moldy odor [d]	1.25,1.07-1.45**	1.30,1.16-1.45***	1.35,1.21-1.51***	1.32,1.19-1.46***	1.24,1.13-1.37***	1.20,1.09-1.31***	1.09,0.95-1.26

In early residence (at time of the child's birth)							
1) Visible mold spotsor damp stains							
Yes, frequently	1.75,1.10-2.77*	2.20,1.55-3.11***	1.52,1.05-2.18*	1.47,1.04-2.08*	1.31,0.93-1.83	1.57,1.11-2.21*	1.23,0.76-1.99
Yes, sometimes	1.12,0.93-1.34	1.46,1.28-1.67***	1.55,1.37-1.76***	1.53,1.36-1.73***	1.25,1.11-1.40***	1.37,1.22-1.54***	1.32,1.12-1.56**
2) Condensation on windows in winter							
Yes, frequently	1.58,1.30-1.92***	1.80,1.55-2.09***	1.83,1.58-2.13***	1.74,1.52-2.00***	1.71,1.50-1.96***	1.40,1.22-1.60***	1.28,1.06-1.54*
Yes, sometimes	1.17,1.02-1.33*	1.18,1.07-1.31**	1.39,1.26-1.54***	1.37,1.25-1.50***	1.23,1.13-1.33***	1.19,1.10-1.29***	1.15,1.02-1.31*
3) Moldy odor [d]	1.16,0.89-1.50	1.36,1.13-1.64**	1.73,1.48-2.02***	1.60,1.35-1.88***	1.33,1.15-1.54***	1.50,1.28-1.76***	1.39,1.10-1.76**

[a] adjusted by age (≤ 4 vs. > 4 year old), sex (male vs. female), location of studied kindergartens (urban vs. suburban district), ownership of the current residence (owned vs. rented), early pet-keeping (yes vs. no), early parental smoking (yes vs. no), current parental smoking (yes vs. no), duration of breast-feeding (≤ 6 vs. > 6 months), and family history of atopy; [b] doctor-diagnosed; [c] IPY: in the past year; [d] includes frequently and sometimes; *$0.01 \leq p < 0.05$; **$0.001 \leq p < 0.01$; ***$p < 0.001$.

Table 4 Adjusted odds ratios between dampness and asthma and hay fever, stratified according to family history of atopy

Damp index	AOR [a], 95% CI (Yes vs. No, No=1.00)			
	Asthma, ever		Hay fever, ever	
	FHA [b] (*N*=3097)	N-FHA [c] (*N*=9837)	FHA [b] (*N*=3097)	N-FHA [c] (*N*=9837)
In current residence				
1) Visible mold spots	1.34,0.99-1.82	1.28,0.95-1.72	1.22,0.91-1.62	1.03,0.75-1.41
2) Visible damp stains	1.04,0.83-1.32	1.30,1.04-1.63*	1.01,0.82-1.25	1.25,1.00-1.57*
3) Damp clothing and/or bedding				

Yes, frequently	1.14,0.70-1.86	1.55,0.97-2.47	1.04,0.66-1.62	1.51,0.96-2.37
Yes, sometimes	1.07,0.88-1.29	1.12,0.95-1.34	0.99,0.83-1.17	0.94,0.80-1.12
4) Water damage				
Yes, BPY [d]	1.04,0.77-1.40	1.15,0.86-1.54	1.33,1.02-1.72*	1.39,1.06-1.83*
Yes, IPY [e]	0.86,0.63-1.17	1.08,0.79-1.48	1.13,0.87-1.48	1.12,0.83-1.53
5) Condensation on windows in winter				
Yes, > 25 cm	1.41*,1.00-2.00	1.93,1.39-2.68***	1.21,0.88-1.66	2.30,1.66-3.17***
Yes, 5～25 cm	0.93,0.70-1.25	1.26,0.97-1.63	0.97,0.75-1.25	1.65,1.28-2.12***
Yes, < 5 cm	1.20,0.93-1.56	1.27,1.01-1.58*	0.95,0.75-1.20	1.40,1.12-1.76***
6) Moldy odor	1.15,0.92-1.44	1.33,1.09-1.62**	1.11,0.91-1.36	1.08,0.88-1.31
In early residence (at time of the child's birth)				
1) Visible mold spotsor damp stains				
Yes, frequently	1.66,0.85-3.25	1.76,0.93-3.32	1.29,0.67-2.48	1.17,0.56-2.42
Yes, sometime	0.90,0.68-1.18	1.34,1.05-1.70*	1.38,1.10-1.73**	1.25,0.98-1.58
2) Condensation on windows in winter				
Yes, frequently	1.37,1.04-1.80*	1.84,1.42-2.40***	1.00,0.78-1.29	1.72,1.32-2.26***
Yes, sometime	1.16,0.95-1.43	1.18,0.99-1.41	0.99,0.83-1.19	1.31,1.10-1.56**
3) Moldy odor	0.93,0.66-1.30	1.41,1.04-2.00*	1.44,1.08-1.92*	1.31,0.96-1.77

[a] adjusted by age (≤ 4vs. > 4 year old), sex (male vs. female), location of the studied kindergartens (urban vs. suburban district), ownership of the current residence (owned vs. rented), early pet-keeping (yes vs. no), early parental smoking (yes vs. no), current parental smoking (yes vs. no), and duration of breast-feeding (≤ 6 vs. > 6 months); [b] FHA: family history of atopy; [c] N-FHA: no family history of atopy; [d] BPY: Before the past year; [e] IPY: In the past year. $^{*}0.01 \leq p < 0.05$; $^{**}0.001 \leq p < 0.01$; $^{***}p < 0.001$.

Table 5 Dose-response relationships between dampness-related exposures and childhood asthma and airway symptoms in multiple logistic regression analyses [a]

Items	Sample size, *N* (%)	AOR,95%CI [a]						
		Asthma [b], ever	Dry cough, IPY [c]	Wheeze, IPY [c]	Wheeze, ever	Rhinitis, IPY [c]	Rhinitis, ever	Hay fever [b], ever
Reported number(n) of dampness indicators in the current residence								
n=0	1638 (20.1)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
n=1	2653 (32.6)	1.26,0.99-1.61	1.31,1.09-1.58***	1.47,1.22-1.78***	1.48,1.25-1.75***	1.35,1.17-1.56***	1.29,1.13-1.47***	1.17,0.93-1.48
n=2	2034 (25.0)	1.31,1.02-1.69*	1.63,1.34-1.98***	1.95,1.61-2.37***	1.82,1.53-2.16***	1.57,1.35-1.82***	1.42,1.23-1.64***	1.39,1.10-1.77**
n=3	1064 (13.1)	1.60,1.20-2.12**	2.13,1.72-2.65***	2.41,1.94-2.99***	2.24,1.84-2.73***	1.81,1.52-2.16***	1.71,1.44-2.03***	1.36,1.03-1.79*
n=4	454 (5.6)	1.38,0.95-2.02	2.59,1.97-3.41***	2.13,1.60-2.82***	2.14,1.65-2.78***	1.66,1.31-2.10***	1.60,1.27-2.01***	1.80,1.27-2.55**
n=5	222 (2.7)	1.78,1.12-2.84*	2.14,1.48-3.08***	2.70,1.90-3.84***	2.58,1.86-3.59***	1.96,1.43-2.70***	1.61,1.17-2.20**	1.69,1.07-2.65*
n=6	67 (0.8)	2.07,0.96-4.44	3.46,1.96-6.10***	3.25,1.82-5.83***	3.29,1.89-5.71***	2.03,1.18-3.51*	3.43,1.89-6.24***	0.67,0.25-1.84
Reported number (n) of dampness indicators in the early residence during the child's birth								
n=0	5006 (42.0)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
n=1	5364 (45.0)	1.30,1.13-1.51***	1.28,1.15-1.43***	1.46,1.31-1.62***	1.41,1.28-1.55***	1.29,1.18-1.40***	1.20,1.10-1.30***	1.20,1.05-1.37**
n=2	1187 (10.0)	1.24,0.98-1.56	1.69,1.44-1.99***	1.90,1.62-2.22***	1.79,1.54-2.07***	1.50,1.30-1.72***	1.56,1.35-1.79***	1.70,1.39-2.07***
n=3	354 (3.0)	1.40,0.97-2.02	1.99,1.53-2.58***	2.73,2.13-3.49***	2.58,2.04-3.28***	1.61,1.26-2.05***	1.80,1.40-2.30***	1.21,0.85-1.73
Whether current residence and/or early residence during child's birth has/had dampness-related problems [d]								

CN & EN	1284 (16.4)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CY & EN	1881 (24.0)	1.31,0.97-1.76	1.35,1.09-1.68**	1.65,1.32-2.06***	1.64,1.35-2.00***	1.30,1.11-1.54**	1.27,1.08-1.48**	1.19,0.90-1.57
CN & EY	300 (3.8)	1.39,0.85-2.28	1.06,0.71-1.59	1.62,1.11-2.35*	1.56,1.11-2.18*	1.13,0.85-1.52	1.15,0.88-1.52	1.31,0.82-2.10
CY & EY	4363 (55.7)	1.90,1.13-3.21*	2.51,1.72-3.65***	2.26,1.86-2.76***	3.54,2.51-5.00***	1.66,1.44-1.92***	1.77,1.28-2.46**	1.10,0.63-1.92

[a] adjusted by age (≤ 4 vs. > 4 year old), sex (male vs. female), the location of studied kindergartens (urban vs. suburban district), ownership of current residence (owned vs. rented), early pet-keeping (yes vs. no), early parental smoking (yes vs. no), current parental smoking (yes vs. no), duration of breast-feeding (≤ 6 vs. > 6 months),and family history of atopy; [b] doctor-diagnosed; [c] IPY: in the past year; [d] CN and CY stands for current residence "No" and "Yes" dampness-related problems respectively; EN and EY stands for early residence during child's birth "No" and "Yes" dampness-related problems respectively; "Has/had" was defined as parents reporting at least one damp index in the current/early residence. *$0.01 \le p < 0.05$; **$0.001 \le p < 0.01$; ***$p < 0.001$.

Table 6 Chi-squared test for linear trend between numbers of reported home dampness-related indicators and prevalences

	Chi-square (χ^2) [a]						
	Asthma [b], ever	Dry cough, IPY [c]	Wheeze, IPY [c]	Wheeze, ever	Rhinitis, IPY [c]	Rhinitis, ever	Hay fever [b], ever
Reported number(n) of dampness indicators in the current residence							
(n=0) vs. (n=1) vs. (n=2) vs. (n=3) vs. (n=4) vs. (n=5) vs. (n=6)	34.0	133.9	146.9	148.2	91.5	75.8	29.8
Reported number (n) of dampness indicators in the early residence during the child's birth							
(n=0) vs. (n=1) vs. (n=2) vs. (n=3)	25.8	94.0	175.1	172.0	102.9	97.6	48.2
Whether current residence and/or early residence during child's birth has/had dampness-related problems							
(CN & EN) vs. (CY & EN or	33.8	89.9	113.2	120.5	107.0	78.4	41.7

CN & EY) vs. (CY & EY) [d]

[a] All of the p-values in chi-squared test are smaller than 0.001; [b] doctor-diagnosed; [c] IPY: in the past year; [d] CN and CY stands for current residence "No" and "Yes" dampness-related problems respectively; EN and EY stands for early residence during child's birth "No" and "Yes" dampness-related problems respectively; "Has/had" was defined as parents reporting at least one damp index in the current/early residence.

Table 7 Associations between lifestyle practices and residential dampness-related exposures in the current residence

Lifestyle practices	Sample size N (%)	Frequency, N (%)				
		Visible mold spots	Visible damp stains	Damp clothing and/or bedding [a]	Condensation on windows [b]	Moldy odor
1) Open window [c] in Spring						
Frequently	5796 (44.1)	412 (7.5)	858 (15.6)	2190 (39.0)	2373 (53.7)	1595 (30.2)
Sometimes	5860 (44.6)	422 (7.6)	828 (14.8)	2525 (44.6)	2504 (56.9)	1733 (32.6)
Never	1486 (11.3)	144 (10.2)**	239 (16.8)	638 (44.0)***	716 (60.9)***	350 (25.5)***
2) Open window [c] in Summer						
Frequently	8090 (61.9)	576 (7.5)	1195 (15.5)	3279 (41.9)	3377 (54.9)	2294 (31.1)
Sometimes	3879 (29.7)	295 (8.0)	562 (15.2)	1622 (43.2)	1652 (56.6)	1100 (31.3)
Never	1092 (8.4)	107 (10.3)**	166 (16.0)	430 (40.1)	547 (63.0)***	267 (26.2)**
3) Open window [c] in Autumn						
Frequently	5730 (45.5)	401 (7.3)	820 (15.0)	2195 (39.3)	2388 (54.5)	1628 (30.9)
Sometimes	5594 (44.4)	412 (7.8)	831 (15.5)	2419 (44.6)	2466 (57.8)	1637 (31.9)
Never	1282 (10.2)	123 (10.1)**	207 (17.0)	530 (42.5)***	596 (60.0)***	308 (25.6)***
4) Open window [c] in Winter						
Frequently	2187 (17.4)	151 (7.3)	322 (15.5)	759 (35.7)	778 (47.1)	596 (29.7)

Sometimes	5828 (46.5)	386 (7.0)	781 (14.0)	2460 (43.5)	2416 (54.3)	1740 (32.5)
Never	4528 (36.1)	390 (9.0)**	740 (17.0)***	1910 (43.2)***	2334 (64.1)***	1222 (29.1)**
5) The frequency of cleaning child's room						
Everyday	7897 (60.2)	569 (7.6)	1108 (14.7)	2978 (38.8)	3304 (54.0)	2149 (30.0)
Twice per week	3354 (25.6)	246 (7.7)	508 (15.8)	1483 (45.6)	1467 (57.4)	975 (31.8)
Once per week	1561 (11.9)	129 (8.8)	255 (17.2)	755 (49.9)	701 (61.3)	458 (31.5)
< Once per week [d]	301 (2.3)	32 (11.9)*	47 (17.5)*	158 (53.2)***	124 (61.1)***	87 (31.9)

[a] includes frequently and sometimes; [b] includes>25 cm, 5～25 cm and < 5 cm; [c] opening the window of the child's bedroom during the night; [d] Once per 2 weeks or less; *0.01≤ p <0.05; **0.001≤ p <0.01; *** p <0.001 in Pearson's chi-squared test.

Table 8 Associations between exposing clothing and/or bedding to sunshine and childhood asthma, hay fever and related symptoms, stratified according to presence of damp clothing and/or bedding in current residence

	Damp clothing and/or bedding							
	Yes (N=5428)				No (N=7453)			
	Pre. (%) [a]		OR	AOR, 95%CI [c]	Pre. (%) [a]		OR	AOR, 95%CI [c]
	Fre. [b]	No-Fre. [b]			Fre. [b]	No-Fre. [b]		
Asthma [d], ever	10.8	12.0	0.89	0.99,0.77-1.24	9.8	9.9	0.99	1.07,0.85-1.34
Dry cough, IPY [e]	21.5	24.5*	0.85*	0.90,0.76-1.06	17.3	20.2*	0.83*	0.84,0.71-0.99*
Wheeze, IPY [e]	24.8	26.0	0.94	0.97,0.82-1.14	18.9	21.0	0.88	0.90,0.76-1.07
Wheeze, ever	31.4	34.3	0.88	0.91,0.78-1.06	25.2	28.1*	0.86*	0.87,0.95-1.02
Rhinitis, IPY [e]	44.9	48.8	0.86*	0.96,0.83-1.12	40.1	44.2*	0.84*	0.88,0.76-1.01
Rhinitis, ever	56.7	61.6**	0.82**	0.90,0.78-1.05	50.7	56.1**	0.81**	0.84,0.73-0.96*
Hay fever [d], ever	12.0	15.4**	0.75**	0.85,0.69-1.06	12.4	13.3	0.92	1.00,0.81-1.23

[a] Pre.: Prevalence; [b] Whether exposing clothing and/or bedding to sunshine; Fre.: Frequently (N=10786); No-Fre.: Sometimes (N=2173) and/or Never (N=131); [c] adjusted by age (≤ 4 vs. > 4 year old), sex (male vs. female), location of studied kindergartens (urban vs. suburban district), ownership of the current residence (owned vs. rented), early pet-keeping (yes vs. no),

early parental smoking (yes vs. no), current parental smoking (yes vs. no), duration of breast-feeding (≤ 6 vs. > 6 months), and family history of atopy; [d] doctor-diagnosed; [e] in the past year; $^{*}0.01 \leq p < 0.05$; $^{**}0.001 \leq p < 0.01$.

Table 9 Reduction in AR and AF of prevalences with reduction visible mold spots (VMS) by different lifestyle practices [a]

Lifestyles	Reduction of VMS (%)	Attributable risk reduction (ARR, %); Attributable fraction reduction (AFR, %)						
		Asthma [b] ever	Dry cough IPY [c]	Wheeze IPY [c]	Wheeze ever	Rhinitis IPY [c]	Rhinitis ever	Hay fever [b] ever
1) Open window [d] in spring								
Frequently	26.5	1.0; 7.0	2.0; 7.5	2.2; 7.5	2.6; 6.9	2.1; 4.2	2.1; 3.4	0.6; 3.8
Sometimes	25.5	0.9; 6.7	1.9; 7.3	2.1; 7.2	2.6; 6.7	2.0; 4.2	2.0; 3.3	0.5; 2.7
2) Open window [d] in summer								
Frequently	27.2	1.0; 7.2	2.0; 7.8	2.3; 7.7	2.6; 7.1	2.2; 4.4	2.1; 3.5	0.6; 3.9
Sometimes	22.3	0.8; 5.9	1.7; 6.4	1.9; 6.3	2.2; 5.9	1.8; 3.6	1.8; 2.9	0.5; 3.2
3) Open window [d] in autumn								
Frequently	27.7	1.0; 7.3	2.1; 7.9	2.3; 7.9	2.7; 7.3	2.2; 4.4	2.2; 3.6	0.6; 4.0
Sometimes	22.8	0.8; 6.0	1.7; 6.5	1.9; 6.5	2.2; 6.0	1.8; 3.7	1.8; 2.9	0.5: 3.3
4) Open window [d] in winter								
Frequently	18.9	0.7; 5.0	1.4; 5.4	1.6; 5.4	1.8; 5.0	1.5; 3.0	1.5; 2.4	0.4; 2.7
Sometimes	22.2	0.8; 5.9	1.7; 6.3	1.8; 6.3	2.2; 5.8	1.8; 3.6	1.8; 2.9	0.5; 3.2
5) The frequency of cleaning child's room								
Everyday	36.1	1.3; 9.6	2.7; 10.3	3.0; 10.3	3.5; 9.5	2.9; 5.8	2.9; 4.7	0.8; 5.2
Twice per week	35.3	1.3; 9.3	2.6; 10.1	2.9; 10.0	3.4; 9.3	2.8; 5.7	2.8; 4.6	0.7; 5.1
Once per week	26.1	0.9; 6.9	2.0; 7.4	2.2; 7.4	2.5; 6.8	2.1; 4.2	2.1; 3.4	0.5; 3.8

[a] because visible mold spots (VMS) could be reduced by all of the studied lifestyle practices (Table 7), we only calculate how much Attributable risk (AR) and Attributable fraction (AF) could be reduced when VMS was reduced by different lifestyle practices; [b] doctor-diagnosed; [c] in the past year; [d] open windows of child's room during night.