Dampness at dorm and its associations with allergy and airways infection among college students in China: a cross-sectional study

Abstract A cross-sectional study was carried out at Tianjin University campus, China, from February 21 to June 10, 2006, to survey the association between dampness in dorms and allergy and airways infection among college students. The health and dampness condition were self-reported by 3436 students living in 1511 dorm rooms located in 13 buildings on the campus. The buildings were selected according to their positions, construction periods and occupant densities. The allergy and airways infection symptoms involved wheezing, dry cough during night, rhinitis, eczema, cold/flu, ear inflammation, pneumonia and tuberculosis. The indoor moisture signs were mould/damp spots on walls, ceilings and floors; suspected or ever happened water damage; condensation on windowpane in winter and odours perceived by subjects themselves. This study showed there was significantly positive association between condensation and dry cough. Eczema was often reported in rooms with suspected moisture problem. Dampness was a significantly risk factor for common cold.

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Practical Implications

This paper indicated that dampness problem at dorms of Chinese students was a risk factor in irritating allergic symptoms, and hence there is a need for dorm environment improvement. The ventilation and microbiology problems in dorm environment corresponding to dampness should be further studied, especially when it is associated to occupants' health.

Introduction

During the recent 30 years the indoor environment has attracted more attentions because human spend more than 80% of their time indoors (Klepeis, 2001). Great changes have taken place in building construction and in the use of buildings, as well as life style and food habit. However, the prevalence of certain diseases like allergy and asthma has increased rapidly in the last decades especially in western countries. In many countries allergies and asthma are affecting a majority of children (Rado and Eriksson, 1999; Sundell and Kjellman, 1995). For example, the prevalence of asthma in school children in Britain has increased from 5.5% in 1973 to 12.0% in 1998 and up to 27.3% in 2003 (Burr et al., 2006). This rapid increasing rate must be due to environmental changes because the time period is too short for genetic changes.

Many international and multidisciplinary reviews have been carried out to identify associations between indoor environmental factors and allergies. A striking

result is that dampness in buildings has been associated to health problems like asthma and respiratory symptoms all over the world (Bornehag et al., 2001). A survey among 1 to 4-year-old children in Sweden found that windowpane condensation tended to be the most frequent in homes with children sensitized to cat and/or dog (Lindfors et al., 1995). Pirhonen et al. (1996) found that reports of bronchitis, common cold, rhinitis were strongly associated with living in a damp home. In a Canadian study, the odds ratios in homes with reported moulds or dampness ranged from 1.32 (1.06–1.39, 95% CI) for bronchitis to 1.89 (1.58–2.26, 95% CI) for cough (Dales et al., 1991). A survey carried out in Sweden showed an association between observed mouldy odours along the skirting board and allergic symptoms, mainly rhinitis, among children, which indicated that hidden moisture problem in building structure should not be ignored (Linda, H., unpublished data). However, the knowledge of the causal factors for allergic disease in damp buildings and the biological mechanisms involved are missing.

China is a developing country with traditional eastern life style. Nowadays, the prevalence rate of asthma in China is low when compared with western countries, even though the prevalence rate of asthma among children in Beijing has been up to 2%. A few studies have been carried out in China on indoor environmental factors and occupants' health. However almost all of them either focused on chemical pollutants, such as volatile organic compounds (VOC) in homes/offices and its association with sick building syndrome symptoms (Xu et al., 2005), or on airflow pattern in hospital/operation room (Tu and Chen, 2005). Dormitory is a kind of home environment for students and they are very crowded in China. Averagely, four people share one 20-m^2 dorm room. Such crowded spaces may supply a 'hotbed' for microbial growth and infectious agents. However, until now, no studies on associations between the dorm environment and allergies and airways infection have been carried out in China, or even in the world.

With the aim to study associations between the dorm environment and health effects such as allergies and airways infections, the study 'Dorm Environmental Factors and Its Assocsiation with Students' Health' was carried out in 2006 at Tianjin University campus, China. It was hypothesized that dorm dampness, substandard ventilation and microbiological exposures are risk indoor environmental factors in irritating allergies and airways infections. The study consisted of two phases, i.e., phase I cross-sectional study and phase II case–control study. In the case–control study, target rooms were selected to measure the physical, chemical, and biological parameters indoors, both in summer and winter. This paper only focused on the cross-sectional study.

Materials and methods

In this cross-sectional study, the dorm environment and occupants' health were surveyed by questionnaires. Thirteen (out of total of 25) dormitory buildings were selected to represent different ages of buildings, building locations and occupant densities. Totally 2117 rooms located inside these 13 buildings.

At Tianjin University a room of 20 m^2 is shared by six bachelor or four master or three Ph.D. students. A total of 2117 copies of dorm environment (Part I) questionnaire were sent to rooms located in 13 dorm buildings and 6500 copies of student health (Part II) questionnaire to corresponding room occupants. The whole process lasted for 3.5 months, from February 21 to June 10, 2006. The questionnaire survey was anonymous. Project members visited dorm rooms, sent questionnaires and informed dorm members how to complete. The questionnaires were collected 2 days later. One copy of dorm environment part was required for each room and completed by a 'volunteer' (one of the room members), while every member was required to answer health part. The information on building construction period was obtained from the dorm management centre of Tianjin University.

Questionnaire

The questionnaire used in the cross-sectional study comprised questions on the dorm environment and the students' health. The dorm environment questions included furnishing and furniture inside dorms, heating and ventilation systems, renovation and extension done to the dorm building, moisture problems, odours, pets indoors and passive smoking. The moisture problems of the dorm covered visible mould, damp stain, suspected moisture problem, water damage in the past or recent days, condensation on the inner windowpane in winter. The odour perceived by room members involved stuffy smell, pungent smell, mouldy smell, earthy, tobacco smoking, dry air, and other unpleasant smell. Regarding occupants' health there were questions concerning asthma, rhinitis, eczema, and airways infection. The questionnaire was mainly the same as earlier used in Sweden and Bulgaria for homes (Bornehag et al., 2005; Naydenov et al., 2005), with minor changes because of the dorm environment. The medical part of the questionnaire followed the ISAAC questionnaire (Asher et al., 2006). The questions on dorm technical characteristics and moisture problems are described in a previous paper (Sun et al., 2007), while these on occupants' health are summarized in an Appendix.

Statistical analysis method

Pearson Chi-square test was used to compare the frequencies of five dampness indicators (i.e., mould

spot, damp stain, suspected moisture problem, water damage, condensation) between different building construction periods, as well as between different groups of window type (Rosner, 2000). These two building characteristics were associated to damp indicators in the multiple logistic regression models by forward elimination technique. The criterion for significance in statistical analysis was $P < 0.05$. Wheezing, dry cough during night, rhinitis, and eczema in the last 12 months prior to this cross-sectional study were regressed to dampness indicators in general estimating equation (GEE). In the GEE model, the clusters were defined as students living in the same dorm room within the same building. The working correlation matrix structure was chosen as independent. The link function was logit (Jin, 2003). Odd ratios were calculated with 95% confidence intervals, as well as the odd ratios adjusted for such confounding factors as subject's gender, age, allergic disease of family member, whether the subject smoked in the last 3 month prior to the study, pet raising, passive smoking in dorms and building construction period. GEE model was also used to test the association between dampness and common cold, with adjustment for subjects' gender, age, whether subjects smoke in the last 3 months, passive smoking, building construction period and occupancy level of dorm rooms. The analysis was performed by using Statistical Package for the Social Sciences (SPSS) software 15.0 (SPSS Inc., Chicago, IL, USA).

Results

Subjects and response rate

Totally, 3712 students responded to the health questions, resulting in a response rate of 57%. Data for 1569 dorms were collected, meaning a response rate of 74.11%. After coupling dorm environment with occupants' health, 1511 rooms and 3436 students can be paired. These dorms and students were involved in the final analysis.

Subjects in this cross-sectional study aged from 17 to 45. The group comprised 48.1% female and 51.9% male, among whom 67.8% bachelor, 25.1% master and 7.2% Ph.D. students. The average age was 22 for bachelor, 25 for master and 29 for Ph.D. students. Subjects were born in places ranging the whole Chinese mainland, and were studying in 18 different schools of Tianjin University. More than 60% of the subjects had lived in the dorm for at least 2 years.

Building characteristics

Thirteen buildings were selected as survey targets, which had different building structures, construction periods, locations and occupancy levels. Four buildings

were constructed in year 1940–1960, with brick-stone structure and wooden frame windows; two buildings in year 1977–1983, and three in year 1993–1999 with brick structure and wooden/iron/PVC frame windows; while four buildings after 2000 with crawl-space foundation, concrete structure and PVC-frame windows. The ventilation systems of dorm rooms were all natural ventilation without any mechanical fans. Dorm rooms were simple bedrooms. Students on each floor shared two washing rooms and toilets.

Dampness problems indoors

12.2% of rooms had visible mould spots on walls, ceilings and floors, 18.9% had visible damp stains, 31.4% rooms had suspected moisture problems inside walls, floors and ceilings that were not visible from the surfaces, and 11.9% of rooms had flooding or any other water damages inside dorm rooms, either in the past or recently. More than half of the rooms had condensation on inner windowpane in winter. Less than 5 cm condensations at the bottom on the inner windowpane were observed in 22.4% rooms, while 16.7% rooms had 5–25 cm condensation, and 15.6% with more than 25 cm condensation. The frequencies of perceived odours are shown in Table 1. Dry air was the most common complaint.

The comparison of dry air perception in different condensation conditions is shown in Figure 1. In rooms with a condensation of more than 25 cm, 37.6% respondents assessed indoor air as often dry, while 29% perceived so in rooms with never condensation ($P < 0.012$).

Frequencies of dampness indicators among different groups and Pearson Chi-square test results are shown in Table 2. The construction period was significantly associated with all dampness indicators except for water damage. Mould spot, damp stain, and suspected water damage occurred more often in old buildings. Condensation on windowpanes was most commonly reported in buildings constructed after year 2000.

It was found that PVC frame windows were associated with more condensation, compared to other two window types ($P < 0.000$). In six-people sharing rooms, the frequency of more than 25 cm condensation

Table 1 Percentage of rooms with odours perceived by occupants

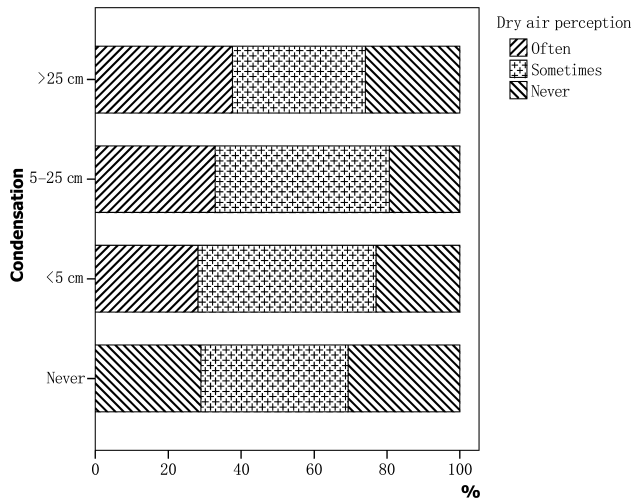| Odours	Often (Weekly), %	Sometimes, %
Stuffy	9.9	44.9
Pungent	6.4	25.6
Mouldy	8.0	25.1
Earthy	7.5	17.7
Tobacco smoke	9.3	16.4
Dry air	31.3	42.3
Other unpleasant smell	15.1	54.0

Fig. 1 Perception of 'dry air' as compared to condensation on windows during winter

on windowpanes was significantly higher compared with that of three-people sharing room ($P < 0.000$). In the multiple regression models by forward elimination technique, as shown in Table 3, PVC frame window seemed to reduce the occurrence of suspected moisture problem and water damage. However, in a stratified analysis for building construction period, the significant relationship between window type and suspected moisture problem, water damage disappeared.

Allergy

In the last 12 months prior to the study, 552 (16.7%) students had wheezing or whistle in chest, in which 522 reported under which circumstances such breathing difficulty problem occurred. 47.5% happened when students had a cold. A total of 300 (8.8%) students had dry cough during night in the last 12 months prior to the study. As for the diagnosed asthma and croup,

the percentages of students suffering from were quite low i.e., 1.8% for asthma and 2.1% for croup. 1675 (49.7%) students had sneezing or runny/blocked nose symptoms apart from having a cold/flu (rhinitis), while 631 (18.7%) and 378 (11.1%) had this symptom when contacting with animal and plant spore respectively. 220 (6.5%) students had ever been diagnosed hay fever by doctor. In the last 12 months 310 (9.0%) students developed eczema, while 53 (4.3%) students suffered from such skin itching problem at least one night per week. In this study, it was found that higher prevalence of wheezing was in the building constructed after year 2000.

The associations between allergic symptoms and dampness indicators were regressed in GEE models, as shown in Table 4. Dry cough during night had significantly positive association with condensation. The more often the suspected moisture problems were reported, the more students suffered from eczema.

Airways infection

In this cross-sectional study, common cold, ear inflammation, pneumonia and tuberculosis were involved in the airways infection section of the questionnaire. A total of 249 (7.3%) students were suffered from cold 6–10 times in the last 12 months prior to the study and 94 (2.8%) more than 10 times. Four hundred thirty-six (12.8%) students usually have a cold lasting for 2–4 weeks, 65 (1.9%) even lasting more than 4 weeks. 709 (20.8%) students ever suffered from ear inflammation more than one time. 232 (6.8%) students ever diagnosed by doctor pneumonia. Tuberculosis is a kind of chronic infectious disease, and characterized by fatigue, cough and night sweat, even chest pain and haemoptysis. Students were required to state whether they had symptoms mentioned above in the last 3 month prior to the survey. In 3401 valid responses, 30% in last 3 months

Table 2 Comparison of frequencies of dampness indicators among building age and window type groups

	Building construction period					Window type			
	1940–1960	1977–1983	1993–1999	After 2000	P value[a]	Wooden	PVC	Iron	P value[a]
Dampness indicators	n (%)	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Mould spot	43 (23.2)	35 (19.0)	27 (6.5)	78 (11.0)	**0.000**	49 (14.5)	131 (11.6)	1 (5.9)	0.142
Damp stain	54 (28.9)	51 (27.6)	43 (10.4)	136 (19.1)	**0.000**	71 (20.8)	209 (18.4)	1 (5.9)	0.234
Suspected[b]	85 (45.2)	74 (39.6)	102 (24.7)	209 (29.5)	**0.000**	127 (37.2)	338 (29.9)	3 (17.6)	**0.006**
Water damage									
Recently	11 (8.1)	33 (20.9)	16 (4.7)	63 (9.9)		33 (12.2)	89 (9.1)	0 (0.0)	
In the past	5 (3.7)	13 (8.2)	11 (3.2)	26 (4.1)	0.194	19 (7.0)	35 (3.6)	0 (0.0)	**0.001**
Condensation									
<5 cm	42 (28.4)	40 (26.1)	88 (27.8)	160 (28.9)		63 (24.9)	263 (29.3)	4 (30.8)	
5–25 cm	22 (14.9)	45 (29.4)	60 (19.0)	119 (21.5)		57 (22.5)	185 (20.6)	3 (23.1)	
>25 cm	19 (12.8)	24 (15.7)	54 (17.1)	133 (24.1)	**0.000**	25 (9.9)	203 (22.6)	1 (7.7)	**0.000**

[a]Pearson Chi-square test.
[b]Suspected moisture problems that are not visible on walls, ceilings and floors.
Bold values indicate statistically significant when $P < 0.05$.

Table 3 Multiple logistic regression analysis of association between building construction period, window type and dampness indicators in dorm rooms

| | Odd ratios (95% CI)[a] | | | | |
	Mould spot	Damp stain	Suspected moisture problem	Water damage	Condensation
Construction period					
1940–1960	1	1	1	1	1
1977–1983	1.05 (0.71, 1.56)	1.15 (0.82, 1.62)	0.69 (0.51, 0.94)	2.80 (1.74, 4.54)	1.93 (1.35, 2.78)
1993–1999	0.24 (0.16, 0.38)	0.24 (0.17, 0.35)	0.41 (0.31, 0.54)	0.53 (0.31, 0.92)	1.22 (0.89, 1.66)
After 2000	0.61 (0.44, 0.85)	0.70 (0.53, 0.93)	0.61 (0.47, 0.80)	1.84 (1.13, 3.00)	1.67 (1.23, 2.27)
Window type					
Wooden			1	1	1
Iron			0.27 (0.08, 0.90)	0.00	0.82 (0.35, 1.95)
PVC			0.80 (0.64, 0.99)	0.51 (0.36, 0.73)	1.80 (1.42, 2.28)

[a]Blank cell means that the factor was eliminated in the forward elimination process.

Table 4 General estimating equation analysis of association between dampness indicators and self-reported allergic symptoms

| | Wheezing | | Dry cough | | Rhinitis | | Eczema | |
Damp indicators	OR	AOR[a]	OR	AOR[a]	OR	AOR[a]	OR	AOR[a]
Mould spot	**1.39 (1.02, 1.90)***	1.29 (0.90, 1.85)	1.45 (0.99, 2.09)	1.00 (0.62, 1.61)	1.01 (0.80, 1.29)	1.06 (0.87, 1.38)	**1.61 (1.10, 2.35)***	1.29 (0.83, 2.00)
Damp stain	1.11 (0.84, 1.47)	1.08 (0.80, 1.47)	1.34 (0.96, 1.85)	1.09 (0.74, 1.63)	1.07 (0.88, 1.30)	1.07 (0.87, 1.32)	**1.43 (1.03, 1.99)***	1.27 (0.87, 1.84)
Suspected[b]	1.14 (0.91, 1.43)	1.20 (0.93, 1.54)	1.10 (0.84, 1.44)	1.04 (0.77, 1.43)	1.09 (0.93, 1.27)	1.05 (0.88, 1.25)	**1.35 (1.02, 1.80)***	**1.48 (1.07, 2.05)***
Water damage	1.34 (0.98, 1.85)	1.05 (0.72, 1.54)	**1.83 (1.28, 2.60)****	1.55 (0.98, 2.46)	1.20 (0.94, 1.52)	1.28 (0.97, 1.70)	1.46 (0.97, 2.18)	1.40 (0.87, 2.24)
Condensation								
<5 cm	0.88 (0.66, 1.18)	0.78 (0.56, 1.08)	0.92 (0.62, 1.36)	1.02 (0.66, 1.58)	0.94 (0.76, 1.17)	0.89 (0.70, 1.12)	1.05 (0.70, 1.57)	1.23 (0.79, 1.90)
5–25 cm	1.07 (0.77, 1.48)	1.10 (0.78, 1.57)	1.31 (0.88, 1.95)	**1.64 (1.06, 2.54)***	**1.35 (1.07, 1.71)***	1.25 (0.97, 1.61)	1.17 (0.75, 1.81)	1.23 (0.74, 2.05)
>25 cm	0.93 (0.67, 1.29)	0.83 (0.58, 1.21)	0.91 (0.60, 1.37)	1.01 (0.63, 1.62)	**1.30 (1.02, 1.65)***	1.18 (0.91, 1.52)	1.44 (0.96, 2.17)	1.38 (0.86, 2.23)

[a]Adjusted for gender, age, whether family members had allergy, whether the subject smoked in the last 3 month prior to the study, pet raising, passive smoking in dorms and building construction period.
[b]Suspected moisture problems that are not visible on walls, ceilings and floors.
**0.001 < P < 0.01, *0.01 < P < 0.05. Bold values indicate statistically significant when P < 0.05.

(sometimes/often) had early potential symptoms of tuberculosis such as fatigue, cough, fever, and even night sweat, while 5.4% (sometimes/often) had more serious disease symptoms e.g., chest pain or hemoptysis. Certainly not all these symptoms will develop into tuberculosis. They may be considered as indicators of existing of infectious agents, which could be influenced by indoor environmental factors such as crowded space, substandard ventilation. 58 (1.7%) students ever had a diagnosed tuberculosis.

In this study, students who shared rooms with six people had more possibilities of suffering from common cold for both 6–10 times and more than 10 times in the last 12 months prior to the survey, as shown in Figure 2. In the following case–control study, ventilation rate [liter per second per person, L/(s·per)] in some selected rooms were measured. A negative dose-response relationship between cold suffering rate and ventilation rate measured in winter when doors/windows were completely closed, was indicated. As seen in Table 5, the odds ratios of suffering from common cold were significantly higher than one in rooms with mould spot, damp stain, suspected moisture problem, and water damage.
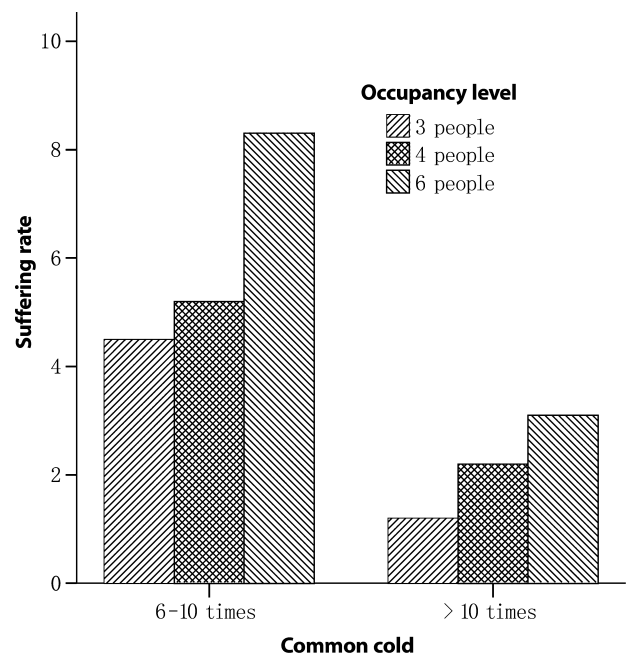

Fig. 2 Comparison of cold suffering rate in rooms with different occupancy levels

Table 5 General estimation equation analysis of association between dampness and self-reported common cold

Damp indicators	Cold (<6 times vs. ≥6 times)	
	OR	AOR[a]
Mould spot	**1.52 (1.06, 2.18)***	**1.72 (1.13, 2.62)* ***
Damp stain	1.22 (0.89, 1.68)	1.47 (1.03, 2.11)*
Suspected[b]	1.20 (0.92, 1.56)	1.36 (1.01, 1.83)*
Water damage	**1.60 (1.11, 2.32)***	**1.70 (1.11, 2.62)***
Condensation		
<5 cm	0.67 (0.46, 0.97)	0.79 (0.51, 1.21)
5–25 cm	1.17 (0.82, 1.68)	1.44 (0.95, 2.16)
>25 cm	1.13 (0.79, 1.62)	1.17 (0.76, 1.81)

[a]Adjusted for gender, age, whether the subject smoked in the last 3 month prior to the study, passive smoking in dorms, building construction period and occupancy level of dorm rooms.
[b]Suspected moisture problems that are not visible on walls, ceilings and floors.
**0.001 < P < 0.01, *0.01 < P < 0.05. Bold values indicate statistically significant when P < 0.05.

Dampness and health conditions among non-respondents

To find how representative of this cross-sectional study, 109 non-respondents were selected randomly to complete questionnaires involving eight questions on mould/damp spots, suspected moisture problems, recent/past water damage, condensation in winter, wheezing, rhinitis, and eczema in the last 12 months. The percentage of positive answer to each question among respondents and non-respondents respectively is shown in Table 6. It was found that more damp spots, suspected moisture problems and water damage occurred in rooms of non-respondent, while suffering rates of wheezing and rhinitis among non-respondents were higher than respondents However only the differences of damp stain and rhinitis between these two subgroups (non-respondent vs. respondent) reached significant levels (P < 0.05).

Table 6 Comparison of damp and health conditions between respondent and non-respondent

	Respondent, %	Non-respondent, %	P value[a]
Dampness			
Mould spot	12.2	11.9	0.921
Damp stain	18.9	29.4	**0.008**
Suspected moisture problem	31.4	38.9	0.108
Water damage			
Recent	8.2	5.5	
Past	3.7	9.2	0.071
Condensation			
<5 cm	28.2	27.5	
5–25 cm	21.0	19.0	
>25 cm	19.7	15.0	0.923
Health			
Wheezing	16.7	20.2	0.340
Rhinitis	49.7	66.1	**0.001**
Eczema	9.0	7.3	0.815

[a]Pearson Chi-square test.
Bold values indicate statistically significant when P < 0.05.

Discussion

In this cross-sectional study, the response rate on dorm environment was 74.11%, which was close to the rate of 79% in Sweden study (Bornehag et al., 2004), while the health response was a bit lower. The eight-question survey among non-respondents showed the damp stains were more often reported, compared to respondents. In China, the general publics are not educated about e.g., problems related to dampness. Moreover, the high environmental response rate supported that information bias cannot be a problem in the 'dampness' report. There were no significant differences of self-reported asthma and eczema prevalence between respondents and non-respondents. However, more non-respondents reported to suffer from rhinitis. This is probably because of misunderstanding of this question in the 'simple' eight-question questionnaire among some non-respondents. Without the description and background information of rhinitis in the context that was supplied in the cross-sectional study questionnaires, some subjects treated 'rhinitis' as common sneeze or runny/blocked nose problem. In this study, GEE model was used to eliminate the correlations within subjects of the same dorm. The significant association between self-reported dampness and health should not be due to self-selection bias, even though a 'volunteer' of the dorm members responded to dorm environment questions.

Even though the cross-sectional study was carried out for a period of only 3.5 months, subjects were required to state dampness indicators in the last 12 months prior to the study. The validity of the dorm dampness obtained in this self-administered questionnaire was discussed in another paper (Sun et al., 2007). The prevalence of dampness indicated by mould (12.2%) and water damage (11.9%) in buildings at Tianjin was a bit lower than the prevalence rate of 23–79% in tropical monsoon climate e.g., Taiwan (Li et al., 1997), while it was near to the typical rate of 4–25% in cold areas like Nordic countries (Forsberg et al., 1997).

Condensation on inner windowpane in winter had significant associations with occupancy level and window type. More condensation was perceived in buildings with PVC-frame windows and in six-people sharing room. This is probably due to that PVC window makes the building tighter and moisture indoors which cannot be removed by insufficient ventilation tends to condense on the colder windowpane, while cold and dry winter outdoor air can leak into room easily through wooden frame window which results in lower relative humidity (RH). In the next case–control study, it was also confirmed that rooms with PVC window had significant lower ventilation rate compared with wooden frame

window. The student dorms at Tianjin University were simple bedrooms, and the moisture load indoors was mainly from occupants' respiratory. Thus the condensation was more often observed in six-people sharing room than other less crowded rooms.

In this study, dry air was perceived more often in rooms with more than 25 cm condensations on windowpane. Condensation is often associated with lower ventilation rate, consequently more pollutants. This finding is in agreed with what have found in the previous Sweden study (Rado and Eriksson, 1999), i.e., dry air perception was rather due to pollutant environment than physical dry.

Among all subjects who were 23 years old averagely, the diagnosed asthma/croup was 3.9%, which was much lower than that in Swedish adults (8% asthma in 1999). Students living in buildings constructed after 2000 suffered from breathing difficulty/whistle quite often. In such buildings, no dampness problems (except for water damage and condensation) were significantly evident. On the other hand, in such 'new' buildings, six people shared one room and major rooms had more than 5 cm condensations. Condensation indicates lower ventilation rate, higher RH, consequently house dust-mite growth. It was also found that 13 rooms (totally, 29 rooms had pet raising) in buildings constructed after 2000 had pets indoors, while only one pet-raising room in buildings constructed in year 1940–1960. The GEE analysis indicated that the odds ratio of pet raising was 4.28 (2.35–7.80, 95% CI) for wheezing. Thus the wheezing problems in this study may be rather due to more allergens together with lower ventilation rate than to dampness in old buildings, which need to be confirmed in the case–control study. Not only in dorm room but also in other public premise, a lot of irritating, sensitising agents float in indoor air. Such agents together with substandard ventilation rate may entail a considerable risk of sensitization.

Dry cough had a significantly positive relationship with condensation, as well as an association between eczema and suspected water damage. It is undisputable that high moisture of indoor air or inside the building structure, e.g., in insulation material, stud construction, results in elevated concentrations of airborne microorganisms in the indoor environment, consequently gives rise to sensitization. However, little studies elucidated the significance of occurrence of microorganisms (apart from mould) and its associations with allergy, partly because of technical difficulties. Findings of mould sensitization indicated that microorganism must be at least an adjuvant factor in conjunction with allergic disease. Among asthmatic children in Sweden, one out of three was sensitized to mould spores (Sundell and Kjellman, 1995). In this study, microorganisms were not measured internal. Their occurrence was identified by microbial smell (pungent/moldy smell) inside or along building skirting. Dry cough more often occurred in old buildings where mouldy and pungent smell was significantly perceived often (data not shown).

In Sweden one to two infections per year occurred in adults and three to six infections per year in children (Rado and Eriksson, 1999), while in this study 10.1% young students suffered from common cold more than six times in the last 12 months prior to the survey. Students suffered from cold more often in rooms with dampness indicators after adjustment for confounders. Dampness problems indoors increased the outgassing of VOCs, which irritated the respiratory tract, and crowded space exacerbated the spreading of infectious disease.

In some previous researches, more allergic sensitization was found in individuals living in heavily polluted urban areas (Krämer et al., 2000; Nicolai et al., 2003). There is also an evidence of an association between allergy and increased atmospheric concentration of $PM_{2.5}$ (particles with aerodynamic diameter $\leq 2.5 \ \mu m$) (Annesi-Maesano et al., 2007). However such associations are lack of consistency at the population level studies. In the next case–control study, concentrations of respiratory particles were measured. Further analysis is needed to clarify the association between air particles (especially $PM_{2.5}$) and allergic symptoms.

The demographic information and living condition of these subjects involved in the present cross-sectional study were typical representatives for students in Chinese universities. This cross-sectional study thus has great interest in researching dorm environment and its association with allergic and infectious disease among university students in China, even internationally.

Conclusions

- Condensation on inner windowpane in winter had significant associations with PVC frame window and occupancy level. The PVC frame window made building tighter compared with wooden and iron frame window, and moisture content respired out by occupant cannot be removed efficiently in crowded spaces without mechanical ventilation.
- Dry air was more often perceived in rooms with more condensations. The condensation is an indicator of high RH inside room and poor ventilation. This finding justifies that subjective assessment of air dry is not only due to physically dry, but also due to insufficient ventilation in winter, subsequently more pollutions in dwellings.
- Higher wheezing suffering rate in the last 12 months prior to this survey were often found in buildings constructed after 2000 and/or in rooms with pets.

Dry cough during night had significantly positive relationship with condensation on inner windowpane in winter. Eczema was often reported in rooms with suspected moisture problem. The odds ratios of suffering from common cold were significantly increased in rooms with dampness indicators.

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Appendix: Questions on allergy and airways infection used in this cross-sectional study

Allergic diseases

1. Have you had wheezing or whistling in the chest in the last 12 months?
• Yes • No
If Yes, under which circumstances? (more than one alternative possible)
•When having a cold
•During exercise
•When laughing or weeping
•When playing or being outdoors
•In contact with furred animals
2. In the last 12 months, have you had a dry cough at night for more than 2 weeks, apart from a cough associated with a cold or chest infection?
• Yes • No
3. Have you been diagnosed with asthma by a doctor?
• Yes • No
4. Have you had croup (breathing difficulties with server (dry) cough)?
• Yes • No
5. In the last 12 months, have you had a problem with sneezing, or a runny, or a blocked nose when you did not have a cold or flu?
• Yes • No
6. In the last 12 months, have you had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after been in contact with furred animals?
• Yes • No
7. In the last 12 months, have you had a problem with sneezing, a runny or a blocked nose, or itchy-watery eyes after been in contact with pollen?
• No
• Yes, only at leafing (when the trees are leafing) (May)
• Yes, only with grass (July–August)
• Yes, both at leafing and with grass
8. Have you been diagnosed with hay fever or allergic rhinitis by doctor?
• Yes • No
9. Have you had itchy rash (eczema) at any time in the last 12 months?
• Yes • No

0. In the last 12 months, how often, on average, have you been kept awake at night by this itchy rash?
• Never
• Less than one night per week
• One or more nights per week

Airways infections

1. In the last 12 months, how many times have you had a cold?
•Less than 6 times
•6–10 times
•More than 10 times
2. How long does usually a cold last?
•Less than 2 weeks
•2–4 weeks
•More than 4 weeks
3. Have you been diagnosed with pneumonia by a doctor?
• Yes • No
4. Have you ever had inflammations of the ears?
•No
•Yes, 1–2 times
•Yes, 3–5 times
•Yes, more than 5 times
5. In the last 3 months, have you suffered from fatigue, cough, fever or night sweat?
•Yes, frequently (weekly)
•Yes, sometimes
•No, never
6. In the last 3 months, have you suffered from chest pain and haemoptysis?
•Yes, frequently (weekly)
•Yes, sometimes
•No, never
7. Have you been diagnosed with tuberculosis by a doctor?
• Yes • No

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