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Abstract

The effect of dampness on sick building syndrome (SBS) symptoms has not been fully investigated in Japan. The purpose of this study is to elucidate the possible effects of dampness on SBS symptoms among residents in Japanese public apartment houses.

A questionnaire was used to investigate the degree of dampness in public apartment houses in Asahikawa, Japan and its effect on SBS symptoms, involving 480 residents in 64 buildings. Dampness indicators were as follow: condensation on the windowpanes, condensation on the walls and/or closets, visible mold in the bathrooms, visible mold on the walls, window frames, and/or closet, moldy odor, slow drying of the wet towels in bathrooms, water leakage, and bad drainage in bathrooms. All dampness indicators except for visible mold in bathrooms had significantly higher odds ratios (ORs) for all or any SBS symptoms after adjustment. The dampness index, the number of positive dampness indicators was significantly related to all SBS symptoms after adjustment.

In conclusion, there are serious problems relating to dampness in Japanese public housing, which affects the health of residents. There is a need to educate the residents about the relationship between dampness and SBS, and building problems should be rectified.

Introduction

Sick building syndrome (SBS), which occurs in newly built dwellings due to exposure to chemicals such as formaldehyde or volatile organic compounds, has been spotlighted in Japan. According to previous reports, exposure to chemicals in the indoor air along with the dampness are related to SBS symptoms in people living in Japanese newly built dwellings [1,2]. The relationship between dampness and SBS symptoms, in relatively old dwellings has been previously reported in Europe [3-7]. Two scientific reviews have shown that dampness in buildings appears to increase the risk of health effects such as coughing, wheezing, and asthma [8,9]. However, in Japan, there has been no report about the relationship between dampness and SBS symptoms in old multi-residential buildings.

According to the Housing and Land Survey of 2003 by the Statistic Bureau of Japanese Ministry of Internal Affairs and Communications (http://www.stat.go.jp/english/data/jyutaku/index.htm), the peak construction period for public dwellings was the 1970s, and that for privately owned rental dwellings was the late 1980s. Zock et al. has reported that older houses are more prone to water-retention problems resulting from a combination of insufficient heating and ventilation, leading to dampness [10,11]. Almost all these Japanese public apartments were reinforced concrete or concrete block buildings. In a study of Finnish schools, any damage from moisture to wooden school buildings did not affect fungal concentrations, but the effect of moisture damage in concrete schools was clearly demonstrated by higher fungal concentrations compared with the reference schools [12]. As the majority of Japanese public apartment houses are old and constructed of concrete, it follows that there will be more dampness, which may result in adverse effects on the residents' health. Therefore, a study of dampness in Japanese public apartment houses in relation to SBS would be helpful.

In this study, we explore dampness and SBS symptoms among the residents of public apartment houses in Asahikawa city, Hokkaido prefecture (north island of Japan) to elucidate the effect of dampness on SBS symptoms in relatively old, concrete multi-resident buildings.

Methods

Study populations

Asahikawa city is located in Hokkaido, the north island of Japan. Average outdoor temperature and relative humidity (2003-2007) in winter were −5.9°C (range: -13.9 to - 1.1) and 69%, in spring were 4.9 °C (-6.6 to 20.1) and 80%, in summer were 19.7°C (11.8 to 28.8) and 74%, and in autumn 9.5°C (-2.2 to 22.2) and 79%.

We distributed postal self-administered questionnaires to 1582 dwellings of 40 municipal and 24 prefectural apartment buildings at Midorigaoka town, Asahikawa city, Hokkaido in September 2006. Income limitations for residents of municipal and prefuctural housing were almost same. We requested a resident in the family whose birthday was the nearest to the day of receipt of the questionnaire to answer the questionnaire. In October 2006, we re-distributed the questionnaires to the residents who had not responded to the first survey. The questionnaires included questions about the building characteristics, dampness indicator, and subjective symptoms. Out of the 1582 residents, 493 (31.1%) answered the questionnaires. After excluding those subjects who had not answered the queries about gender, age and/or SBS symptoms, we finally analyzed 480 questionnaires (30.3%). This study was conducted with all the subjects' informed consents and was approved by the institutional ethical board for epidemiological studies at Asahikawa Medical College.

SBS symptoms and personal factors

The questionnaire contained information on age, gender, and job status including full-time job, part-time job, student, or unemployed. We used the symptoms query part of the Japanese version of MM040EA, a validated self-administered questionnaire designed for epidemiologic assessment of SBS symptoms [13]. Symptoms surveyed, for the preceding 3-month period, were as follows: fatigue; feeling heavy-headed; headache; nausea/dizziness; difficulty concentrating; itching, burning, or irritation of the eyes; irritated, stuffy, or runny nose; hoarse, dry throat; cough; dry or flushed facial skin; scaling/itching of the scalp or ears; and dry, itching, or red-skinned hands. For each symptom, the following answers were possible: “Yes, often (every week);” “Yes, sometimes;” and “No, never.” An additional query concerning the attribution of a symptom to the home environment was included in the questionnaire.

Symptoms that occurred often (weekly) and thought to be attributed to the home environment were defined as positive. For the analysis, symptoms were categorized by anatomical sites: general symptoms (fatigue, feeling heavy-headed, headache, nausea/dizziness, having difficulty concentrating), symptoms involving the eyes, nose, throat (including cough), and skin. The questionnaires also contained queries about history of any previous treatment by a physician for allergies or asthma.

Assessment of building dampness and other building factors

The self-administered questionnaire contained queries about condensation on windowpanes, condensation on the walls and/or closet, visible mold in the bathrooms, visible mold on the walls, window frames, and/or closet, perception of moldy odor in the dwelling, slow drying of wet towels in the bathroom, episodes of water leakage during past five years, and bad drainage in the bathroom.

The questionnaire also contained information on the age of the building, the number of residents living together in the dwelling, and the number of rooms; subsequently, the population density (number of residents/room) was calculated.

Statistical analysis

Statistical analysis was performed by multiple logistic regression, and crude and adjusted odds ratios with 95% confidence intervals (OR, 95% CI) were calculated. For all statistical analyses, a 5% level of significance was applied. To obtain adjusted OR for each SBS symptom, we controlled for age (≤30, 30–39, 40–49, 50–59, ≥60), gender, history of allergic diseases, type of tenure (municipal or prefectural), and population density (number of residents/room), and each of the eight dampness indicators were introduced separately in the model. Since population density had several missing values, its mean was assigned to the missing values. As the age of buildings and occupational status were not significantly related to the SBS symptoms in the crude analyses, these two factors were not included in the model.

Next, to address the dose-response relationships between symptoms and exposure to dampness, a building dampness index was constructed. The index considered eight dampness indicators, and we defined the variable values as the sum of positive dampness indicators. Then, adjusted ORs for dampness index were analyzed. The group of 0–1 or 0-3 dampness index was applied to reference, and the odds ratios of the groups of 2 or 3 to 8 dampness indexes were analyzed. And, to estimate statistical dose-response relations, p values for trend were analyzed.

All statistical analyses were conducted using SPSS software for Windows version 15.0 (SPSS Inc., Chicago, U.S.A.).

Results

Table 1 shows that 67.5% participants were female, and 45.0% were 60 years old or older. Table 2 shows the number of subjects according to the building characteristics and dampness. The number of subjects living in municipal apartment houses was larger than in prefectural apartment houses (60.2% as against 38.2%). Almost all subjects had lived in the building for 20 years or more since its construction (94%). The Status eight indicators for building dampness were as follow: 81.8% had condensation on the windowpanes; 40.6% on the walls and/or closet; 79.2% had visible mold in the bathrooms; 59.5% had visible mold on the window frames, walls, and/or closet; 61.2% had moldy odor; 63.4% had slow drying of wet towels in the bathrooms; 20.8% had water leakage during past five years; and 60.7% had bad drainage in the bathroom. Calculated from the data of the number of residents and rooms, average population density (number of residents/room) was 0.49.

Table 3 shows SBS symptoms observed in the survey. Eye symptoms, nose symptoms, skin symptoms, throat symptoms, and general symptoms were found in 5.6%, 12.5%, 5.6%, 10.0%, and 6.3%, respectively. Some symptoms (at least one of skin, eye, nose, throat, or general symptoms) were found in 19.4%. All symptoms were more prevalent among females than males.

Table 4 shows univariate ORs of subjects' characteristics for SBS symptoms. Female subjects had significantly higher ORs for nose, throat, and all or any symptoms compared to male subjects. Thirty to 39-year-old subjects had significantly higher ORs for nose and all or any symptoms, and less than 30-year-old subjects had significantly higher OR for skin symptoms compared to 60-year-old or older subjects, respectively. Those subjects with a history of allergy or asthma had significantly higher ORs. Meanwhile, occupation was not significantly related to SBS symptoms.

Table 5 shows univariate ORs of building characteristics for SBS symptoms. Subjects living in municipal apartment houses had a significantly higher OR for all or any symptoms than those living in prefectural ones. Age of the building was not significantly related to their SBS symptoms. Population density (number of residents/room) had significantly lower ORs for nose and all or any symptoms. All dampness indicators had significantly higher ORs for nose, throat and all or any symptoms. Five dampness indicators (visible mold on the window frames, walls, and/or closet, moldy odor, slow drying of the wet towels in bathrooms, water leakage during past five years, and bad drainage in bathroom) for eye symptom, five indicators for skin symptom, six indicators for throat symptom, and three indicators for general symptom also had significantly higher ORs.

Table 6 shows adjusted ORs for dampness indicators for SBS symptoms of subjects. All dampness indicators except for visible mold in the bathrooms had significantly higher ORs for all or any symptoms, although all dampness indicators had significantly higher ORs in crude analyses. Four indicators for eye symptom, four indicators for nose symptom, one indicator for skin symptom, three indicators for throat symptom, and four indicators for general symptom also had significantly higher ORs.

To address the dose-response relationships between symptoms and exposure to dampness, a building dampness index was used. The index considered eight dampness indicators, and the dampness index was significantly related to all SBS symptoms (Table 7). Also eight dampness indicators positive had significant high odds ratio (16.6 to 57.5) for all SBS symptoms.

Discussion

In this study, we found significant relationships between dampness indicators and SBS symptoms, as the number of the dampness indices increased the ORs for each SBS symptom increased. As previously mentioned, the relationship between dampness and SBS symptoms among the residents living in relatively old dwellings has been reported in Europe. However, to our knowledge, this is the first report about the relationship between dampness and SBS symptoms in old multi-residential buildings in Japan. We believe this study is valuable because the SBS symptoms were evaluated using by validated MM040 questionnaire and the significant relationships between dampness and the SBS symptoms in old Japanese buildings were elucidated.

Females had more symptoms than males. This may be because non-occupational females such as homemakers spent longer periods in the dwellings than the males in this study. It has also been generally stated that the frequency of complaints about sick building symptom was higher in females than in males [14,15]. The history of allergy or asthma had significantly higher ORs, which is in agreement with previous studies [15-17].

All or any symptoms were found in 19.4% of subjects, and nose symptom was the most prevalent. A lower response rate may overestimate the SBS prevalence rate, since the residents who had no symptoms would be uninterested in the research and might therefore be non-responders. If all non-respondents were assumed to have no SBS symptoms, the prevalence rate of SBS would be 5.9%. Thus, real prevalence rate might range from 5.9 to 19.4%. The prevalence rate of this study cannot be compared to that of the author's previous study of Japanese newly built dwellings (prevalence rate: 33.1%) because the symptom questionnaire was different and the characteristics of the residents were different. Residents living in public apartment houses have limited income and therefore do not own their houses. The fact that they are socioeconomically disadvantaged has to be considered as a confounding factor because this would also trigger health problems.

MM040 is a validated self-administered questionnaire designed for epidemiologic assessment of indoor air problems [18], and we used its symptoms part. Compared with other studies using the MM040 symptoms query for research on dwellings, Engvall et al. defined positive symptoms as those occurring often, but whether the symptoms were attributed to the home environment or not was not included in their SBS symptom definition [6]. In the study performed at the Japanese workplace using the MM040 query, the positive symptoms were also defined as in the study of Engvall et al. [13]. We, on the other hand, have defined the positive symptoms as those occurring often and also attributed them to the home environment, so positive symptoms were previously prone to be underestimated. In another workplace study, with the positive symptoms defined in a similar way [19], the prevalence of nose symptoms (20%) and fatigue (16%, one of the general symptoms) etc. were higher than those of our study. Since our study focused on the general population, the subjects involved elderly people compared to those in studies performed in the workplaces. Several study reported lower prevalence of SBS symptoms at high age [15,20,21]. It has been reported that 21- to 40-year-old individuals had more symptoms than either younger or older individuals [22]. However, the oldest elderly subject had more symptoms in the study performed on multi-family residential houses in Stockholm, including subjects older than 65 years old [23], and it has been reported that age was a significant risk factor for SBS symptoms only in males [14]. Furthermore, no relationship between SBS symptoms and age has been reported [24,25]. Thus, the difference in prevalence of SBS symptoms between each age group was controversial, and that of the Japanese has not yet been fully examined. In our study, among the registered subjects, older people were dominant, and while the younger subjects had a significantly higher OR for SBS symptoms, this situation resulted in a relatively lower prevalence of SBS symptoms.

The positive rates of dampness index were relatively high in this study. In the previous study on new dwellings in Japan, condensation on the windowpanes and/or walls and mold growth were 41.7% and 15.6%, respectively [2]. In the Swedish multi-family dwellings study, condensation on the windowpanes, high air humidity in the bathroom, mold odor, and water leakage (during past five years) were 9.0, 12.4, 7.6, and 12.7%, respectively [6]. Also in the

Swedish dwellings study, water leakage (during a previous year), visible dampness (mold or damp spot), and condensation on the windowpanes (more than 5 cm) were 17.8%, 1.5%, and 14.3% [7]. The reasons for the higher dampness rates are as follows: (1) No building has a mechanical ventilation system; the residents can use the ventilation openings and exhaust fan in the kitchen. Unfortunately, we did not collect information on the rate of ventilation opening or the frequency of use of the exhaust fan. However, the residents, especially socioeconomically disadvantaged people such as the elderly, may be prone to the reduced ventilation in winter to enhance heating efficiency. This behavior would tend to increase air humidity. (2) Because many Japanese people regard low humidity as a risk factor for respiratory infections such as influenza virus infection in winter [26], adenovirus infection in summer [27], they prefer high humidity.

The associations between dampness and health related problems are well in accordance with many previous studies [7-9,28], and, in our study, all dampness indexes except visible mold in the bathrooms had significantly increased ORs for all or any symptoms. Due to less prevalence of condensation on the walls and/or closet, and visible mold on the window frames, walls, and/or closet, we had initially speculated that these indicators represented a more severe status of dampness. Condensation on the walls and/or closet had a significantly higher OR for all or any symptoms, but the OR was smaller than that of condensation on the windowpanes. Thus, condensation on the windowpanes is an adequate dampness indicator for practical use.

Furthermore, more than 5 cm of condensation on windowpane was used in the Swedish study [7]. Thus, we should decide whether a more detailed definition of condensation on windowpane is required or not. Point estimates of ORs of visible mold in the bathrooms and visible mold on the window frames, walls, and/or closet were similar for all or any symptoms, but only visible mold on the window frames, walls, and/or closet had statistical significance. Other studies used visible dampness including visible mold and damp spots in the rooms [7], and visible mold in dwelling [29,30] as dampness indicators. Whether mold in the bathrooms or mold in the rooms was the preferred visible mold indicator has not been adequately elucidated. However, judging from our study, visible mold in the rooms may be a better exposure indicator for estimating the possibility of prevalence SBS.

We investigated the relationship of bad drainage in the bathrooms on SBS symptoms, and the indicator had significant higher OR for all symptoms. Another bathroom indicator, slow drying of the wet towels in bathrooms had higher statistically significant OR for all symptoms except for nose symptoms. The query about bad drainage in the bathroom was added since the authors had heard about the problem, but there had been no reference to the problem of water drainage in Japanese public housing bathrooms. Therefore, for general use, slow drying of wet towels in the bathrooms [6] is better because it includes the ventilation status in the bathrooms. However, measures to improve the water drainage should be taken in Japanese public housing.

“Dampness”, especially as regards “condensation on window panes”, suggests that inadequate ventilation in homes constitutes a major risk factor for health effects [31]. Another possible reasons why dampness causes SBS symptoms are as follows: (1) Higher air humidity facilitates the growth of microorganisms, which can produce microbial volatile organic compounds (MVOC) [32] and (1→3)-β-D-gulucan [33]. (2) High air humidity facilitates an increase in the number of house-dust mites [34]. (3) Structural dampness causes chemical degradation of building materials, such as formation and emission of 2-ethyl-1-hexanol, 1-butanol, etc. from polyvinyl chloride (PVC) floor coverings [35].

As previously mentioned, allergic diseases are risk factors for SBS development [15-17]. Therefore, we considered the history of allergic diseases as a confounder for SBS symptom analysis. Thus, we include the history of allergic diseases in multivariate models (Table 6 and 7).

If participants knew that dampness was a risk factor for the SBS symptoms, people whose houses had dampness problems might tend to report SBS symptoms and its could cause bias. However, as previously mentioned, exposure to chemicals has been spotlighted in Japan, and many Japanese prefer higher humidity. Therefore, such bias seemed to occurred rarely in this study. If non-respondents were prone to have no SBS symptoms, the prevalence rate may be overestimated as previously mentioned. Furthermore, if non-respondents were prone to have no or little dampness problems the odds ratio of dampness may be overestimated. Lower response rate may also affect the significant relationships between dampness indicators and the SBS symptoms since the sample size was reduced. Asahikawa city is second largest city in Hokkaido, and we selected one residential town where public apartments were relatively concentrated. However, the selection was not randomized, so further studies in which response rate is higher and participants are randomly selected will be needed.

In conclusion, there are many problems related to dampness in Japanese public houses, and the dampness affects the residents' health. Therefore, residents need to be made aware of the relationship between dampness and SBS symptoms to avoid the growing rate of health problems, and the building problems should be rectified. Since many socioeconomically disadvantaged elderly people live in public apartment houses, a balance between ventilation and heating efficiency in winter is important. Further studies are needed to clarify the problems of old public housing in other Japanese regions and other countries, and to developed inexpensive and ecological measures to rectify the problems related to dampness, especially in winter.

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Table 1. Characteristics of the residents

	Number	%
Gender		
Male	156	32.5
Female	324	67.5
Age (range: 18–93)		
≤30	26	5.4
30 to 39	72	15.0
40 to 49	56	11.7
50 to 59	110	22.9
≥60	216	45.0
Occupation		
Full-time	115	24.0
Part-time	90	28.8
Student	4	0.8
Retired or unemployed	265	55.2
Unknown	6	1.3
Allergy or asthma	216	45.0

Table 2. Number of subjects according to the building characteristics and dampness

	Number of subjects	%
Type of tenure		
Municipal	289	60.2
Prefectural	191	38.3
Building age		
≤9	17	3.5
10–19	12	2.5
20–29	152	31.7
≥30	299	62.3
Number of rooms		
2	17	3.5
3	255	53.1
4	208	43.3
Number of subjects		
1	166	34.6
2	177	36.9
3	63	13.1
4–5	68	14.2
Unknown	6	1.3
Dampness indicator		
Condensation on the windowpanes (n = 477)	390	81.8
Condensation on the walls and/or closet (n = 470)	191	40.6
Visible mold in the bathrooms (n = 477)	378	79.2
Visible mold on the window frames, walls, and/or closet (n = 474)	282	59.5
Moldy odor (n = 477)	296	62.1
Slow drying of the wet towels in bathrooms (n = 475)	301	63.4
Water leakage during past five years (n = 466)	97	20.8
Bad water drainage in bathroom (n = 468)	284	60.7

Table 3. Prevalence of sick building syndrome symptoms* in female and male participants

	Male (%) (n = 156)	Female (%) (n = 324)	Total (%) (n = 480)
Eye symptoms	4.5	6.2	5.6
Nose symptoms	7.1	15.1	12.5
Skin symptoms	5.1	5.9	5.6
Throat and/or cough	5.1	12.3	10.0
General symptoms	3.8	7.4	6.3
All or any symptoms	12.8	22.5	19.4

* occurred often (weekly) and thought to be attributed to the home environment

Table 4. Univariate odds ratios of subjects' characteristic for SBS symptoms

	Eye		Nose		Skin		Throat and/or cough		General		All or any	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95%CI)	P	OR (95%CI)	P
Gender Female (vs. male)	1.50 (0.58–3.39)	0.455	2.35 (1.19–4.46)	0.014	1.15 (0.19–2.69)	0.743	2.61 (1.19–5.71)	0.017	2.00 (0.80-5.00)	0.138	1.98 (1.16-3.38)	0.013
Age												
≤30	3.39 (0.99–11.5)	0.051	1.44 (0.39–5.25)	0.585	4.44 (1.41–14.0)	0.011	2.62 (0.88–7.78)	0.083	0.54 (0.07-4.23)	0.554	2.04 (0.80-5.24)	0.137
30 to 39	1.10 (0.34–3.56)	0.878	3.40 (1.64–7.04)	0.001	1.69 (0.60–4.76)	0.317	1.77 (0.78–4.04)	0.173	1.22 (0.45-3.27)	0.695	2.44 (1.31-4.55)	0.005
40 to 49	0.69 (0.15–3.21)	0.636	1.83 (0.75–4.47)	0.182	0.34 (0.04–2.68)	0.305	1.57 (0.62–3.97)	0.339	1.03 (3.28-3.24)	0.959	1.68 (0.81-3.45)	0.161
50 to 59	1.08 (0.39–2.99)	0.889	1.60 (0.77–3.36)	0.211	0.70 (0.22–2.26)	0.555	0.86 (0.36–2.05)	0.738	0.51 (0.16-1.56)	0.236	1.09 (0.58-2.03)	0.799
≥60	Reference		Reference		Reference		Reference		Reference		Reference	
Occupation												
Full-time	Reference		Reference		Reference		Reference		Reference		Reference	
Part-time	0.53 (0.13–2.12)	0.371	0.90 (0.38–2.14)	0.814	0.46 (0.12–0.18)	0.264	1.15 (0.43–3.11)	0.784	1.30 (0.40-4.17)	0.662	1.54 (0.76-3.12)	0.232
Retired or unemployed	0.99 (0.40–2.48)	0.985	1.10 (0.57–2.13)	0.782	0.86 (0.36–2.07)	0.735	1.50 (0.69–3.28)	0.305	1.32 (0.51-3.43)	0.563	1.38 (0.77-2.48)	0.282
Student, unknown	1.71 (1.89-15.5)	0.632	0.80 (0.09–6.82)	0.840	0.00*	0.999	1.31 (0.15–11.5)	0.808	0.00 *	0.999	0.60 (0.07-5.02)	0.636
Allergy or asthma	4.63 (1.83–11.7)	0.001	11.9 (5.30–26.9)	<0.0001	3.75 (1.55–9.04)	0.003	4.75 (2.36–9.57)	<0.0001	2.59 (1.19-5.66)	0.017	5.39 (3.20-9.07)	<0.0001

*confidence interval: incalculable

Table 5. Univariate odds ratios of building characteristics for SBS symptoms

	Eye		Nose		Skin		Throat and/or cough		General		Any	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Municipal (vs. Prefuctural)	1.61 (0.69–3.76)	0.271	1.38 (0.78–2.43)	0.276	1.95 (0.81–4.72)	0.136	1.51 (0.80–2.87)	0.205	2.28 (0.96–5.41)	0.063	1.69 (1.04–2.75)	0.035
Building age												
≤9	0.00 *	0.998	0.98 (0.12–7.78)	0.981	0.46 (0.06–3.54)	0.454	0.00*	0.998	0.00 *	0.998	0.54 (0.12–2.44)	0.425
10–19	3.12 (0.64–15.3)	0.161	3.12 (0.64–45.3)	0.161	1.46 (0.31–6.94)	0.633	1.86 (0.39–8.91)	0.436	2.52 (0.52–12.2)	0.252	2.03 (0.59–6.98)	0.259
20–29	0.75 (0.31–1.85)	0.536	0.64 (0.25–1.65)	0.357	1.17 (0.66–2.09)	0.592	1.17 (0.62–2.21)	0.623	0.52 (0.21–1.30)	0.163	0.92 (0.56–1.51)	0.739
≥30	Reference		Reference		Reference		Reference		Reference		Reference	
Density (n = 474)**	1.36 (0.39–4.82)	0.63	2.73 (1.17–6.39)	0.019	2.86 (0.88–9.33)	0.082	2.59 (1.02–6.56)	0.044	0.51 (0.13–1.97)	0.328	1.85 (0.89–3.86)	0.099
Dampness indicator												<0.001
Condensation on the windowpanes (n = 477)	>10^8*	0.997	7.43 (1.18–31.0)	0.006	6.14 (0.82–45.9)	0.077	>10^8*	0.996	6.65 (0.89–49.6)	0.064	6.05 (2.16–17.0)	0.011
Condensation on the walls and/or closet (n = 470)	1.92 (0.86–4.34)	0.113	2.30 (1.32–4.03)	0.003	2.56 (1.10–5.97)	0.030	2.25 (1.21–4.18)	0.010	1.50 (6.97–3.22)	0.301	2.31 (1.47–3.69)	0.001
Visible mold in the bathrooms (n = 477)	7.24 (0.97–54.0)	0.054	3.20 (1.25–8.23)	0.016	3.44 (0.80–14.8)	0.097	3.13 (1.10–8.93)	0.033	1.28 (0.47–3.43)	0.631	2.47 (1.23–4.96)	<0.0001
Visible mold on the window frames, walls, and/or closet (n = 474)	3.17 (1.18–8.51)	0.022	2.48 (1.32–4.65)	0.005	3.01 (1.12–8.13)	0.030	2.83 (1.38–5.84)	0.005	1.55 (0.69–3.49)	0.287	2.50 (1.49–4.21)	<0.001
Moldy odor (n = 477)	17.3 (2.33–128.9)	0.005	4.61 (2.14–9.95)	<0.0001	3.73 (1.27–11.0)	0.017	4.00 (1.75–9.11)	0.001	3.25 (1.22–8.64)	0.018	3.96 (2.20–7.13)	0.001
Slow drying of the wet towels in bathrooms (n =	7.45 (1.74–31.9)	0.007	2.50 (1.29–4.85)	0.007	4.72 (1.40–15.9)	0.013	3.66 (1.60–8.35)	0.002	4.02 (1.38–11.7)	0.011	3.07 (1.74–5.39)	<0.0001

475)												
Water leakage during past five years (n = 466)	1.99 (0.87–4.60)	0.105	2.97 (1.66–5.32)	<0.0001	1.15 (0.15–2.95)	0.770	2.97 (1.58–5.58)	0.001	3.20 (1.50–6.85)	0.003	2.31 (1.38–3.85)	0.001
Bad drainage in bathroom (n = 468)	5.99 (2.66–13.5)	<0.0001	4.14 (2.22–7.70)	<0.0001	5.03 (2.22–11.4)	<0.001	5.46 (2.83–10.5)	<0.0001	7.26 (3.31–15.9)	<0.0001	4.13 (2.36–7.24)	<0.001

*confidence interval incalculable

**number of residents/room: continuous variable (n = 474)

Table 6. Adjusted odds ratios of building characteristics for SBS symptoms

	Eye		Nose		Skin		Throat and/or cough		General		All or any	
	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P
Condensation on the window panes (n = 477)	>10^8*	0.996	5.27 (1.20–23.1)	0.027	5.53 (0.71–43.0)	0.103	>10^8*	0.996	6.83 (0.89–52.4)	0.064	5.12 (1.75–15.0)	0.003
Condensation on the walls and/or closet (n = 470)	1.67 (0.67–4.13)	0.264	1.49 (0.77–2.86)	0.233	2.15 (0.84–5.52)	0.111	1.66 (0.82–3.34)	0.156	1.64 (0.70–3.91)	0.255	1.85 (1.07–3.18)	0.026
Visible mold in the bathrooms (n = 477)	7.09 (0.92–54.8)	0.06	2.03 (0.72–5.67)	0.177	3.10 (0.68–14.2)	0.143	2.53 (0.84–7.67)	0.100	1.26 (0.44–3.65)	0.667	1.87 (0.87–4.02)	0.109
Visible mold on the window frames, walls, and/or closet (n = 474)	2.93 (1.02–8.44)	0.046	1.43 (0.69–2.95)	0.332	2.59 (0.89–7.56)	0.081	2.13 (0.97–4.69)	0.061	1.50 (0.62–3.66)	0.369	1.83 (1.02–3.30)	0.043
Moldy odor (n = 477)	13.7 (1.80–104.5)	0.012	2.45 (1.08–5.59)	0.033	2.80 (0.90–8.72)	0.075	2.66 (1.12–6.34)	0.027	3.00 (1.07–8.40)	0.036	2.69 (1.43–5.07)	0.002
Slow drying of the wet towels in bathrooms (n = 475)	6.43 (1.46–-28.3)	0.014	1.37 (0.66–2.84)	0.394	4.03 (1.14–14.3)	0.031	2.60 (1.10–6.17)	0.030	3.41 (1.13–10.3)	0.030	2.12 (1.16–3.89)	0.014
Water leakage during past five years (n = 466)	1.57 (0.65–3.80)	0.315	2.00 (1.04–3.82)	0.037	0.95 (0.35–2.56)	0.920	2.41 (1.22–4.76)	0.011	3.26 (1.44–7.36)	0.004	1.81 (1.03-3.18)	0.039
Bad drainage in bathroom (n = 468)	6.61 (2.67–16.3)	<0.0001	4.54 (2.16–9.55)	<0.0001	5.28 (2.11–13.2)	<0.0001	5.91 (2.81–12.4)	<0.0001	10.86 (4.34–26.7)	<0.0001	4.37 (2.29–8.22)	<0.0001

[a] Adjusted for age (≤30, 30–39, 40–49, 50–59, ≥60), gender, history of allergy disease, type of tenure (municipal or prefuctural), population density (number of residents/room; its mean (0.49) was applied to missing values); each of the eight building dampness indicators were introduced separately in the model

*confidence interval incalculable

Table 7. Adjusted odds ratios of dampness index for SBS symptoms (n=441)

	Eye		Nose		Skin		Throat and/or cough		General		All or any	
	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P	OR[a] (95% CI)	P
Dampness index												
0-1(n = 63)	Reference[b] (0-1 and 2)		Reference		Reference		Reference		Reference[b] (0-1 and 2)		Reference	
2 (n = 47)			2.60 (0.37–18.1)	0.335	1.37 (0.08–23.4)	0.826	1.50 (0.09–25.5)	0.777			3.60 (0.60–21.5)	0.161
3 (n = 49)	0.00 *	0.998	0.56 (0.05–6.75)	0.649	1.31 (0.08–22.1)	0.853	1.24 (0.07–20.8)	0.883	3.24 (0.50–20.7)	0.214	3.44 (0.61–19.3)	0.161
4 (n = 63)	1.62 (0.10–27.2)	0.734	2.93 (0.52–15.8)	0.211	2.16 (0.19–25.4)	0.538	4.83 (0.53–43.9)	0.162	2.60 (0.41–16.6)	0.312	6.91 (1.42–33.7)	0.017
5 (n = 55)	5.16 (0.50–53.6)	0.169	2.80 (0.52–15.0)	0.229	2.86 (0.27–30.3)	0.383	8.30 (0.96–71.6)	0.054	2.86 (0.43–18.9)	0.276	7.07 (1.44–34.7)	0.016
6 (n = 109)	17.2 (2.06–143.1)	0.008	3.04 (0.61–15.1)	0.174	4.53 (0.50–41.1)	0.179	9.11 (1.11–74.8)	0.040	5.48 (1.04–28.92)	0.045	9.64 (2.07–44.8)	0.004
7 (n = 39)	11.4 (1.11–118.9)	0.041	5.55 (1.00–30.7)	0.050	6.17 (0.59–64.9)	0.130	8.10 (0.87–75.8)	0.067	8.87 (1.35–58.3)	0.023	10.7 (2.06–55.5)	0.005
8 (n = 16)	35.8 (2.93–437.5)	0.005	16.6 (2.46–112.6)	0.004	28.8 (2.37–350.3)	0.008	57.5 (5.50–600.2)	<0.001	47.7 (6.27–361.1)	<0.001	38.0 (5.92–244.1)	<0.001
P for trend	<0.0001		0.003		0.005		<0.0001		<0.001		<0.0001	

[a] Adjusted for age (≤30, 30–39, 40–49, 50–59, ≥60), gender, history of allergic diseases, type of tenure (municipal or prefuctural), population density (number of residents/room; its mean (0.49) was applied to missing values)

[b] As the group of 0–1 dampness index contained no subjects with nose and general symptoms, odds ratios were incalculable when only the group of 0–1 was applied to reference.

*confidence interval incalculable