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REGULAR ARTICLE

Dampness, food habits, and sick building syndrome symptoms in elementary school pupils

Yasuaki Saijo · Yoshihiko Nakagi · Toshihiro Ito · Yoshihiko Sugioka · Hitoshi Endo · Takahiko Yoshida

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Abstract
Objectives We investigated dampness/mold in schools and dwellings, and food habits and subjective symptoms in elementary school pupils, in order to clarify the effect of dampness and food habits on subjective symptoms in elementary school pupils.
Methods Questionnaires were used to investigate dampness in classrooms and dwellings in Hokkaido, Japan, and its effect on subjective symptoms in 1,077 pupils in 8 elementary schools. We used a dampness index for both the home and classroom; the index was the sum of the presence of four dampness indicators: (1) visible mold, (2) moldy odor, (3) water leakage, and (4) condensation on windowpanes. The questionnaire also contained queries about food habits, as follows: the frequency of eating breakfast, whether the energy provided by the school lunch was sufficient, and whether eating too many snacks and/or sweets were consumed. Adjusted logistic regression was used to determine whether dampness and food habits were related to the subjective symptoms.
Results In fully adjusted models, the home dampness index was significantly related to cough, general symptoms, and having at least one symptom; the classroom dampness index was significantly related to nasal symptoms. In addition, usually not eating breakfast was significantly related to eye symptoms, and too many snacks and/or sweets was significantly related to eye, nasal, and general symptoms.
Conclusions Both home and classroom dampness can affect pupils' health. Home dampness, in particular, was significantly related to cough and general symptoms, and classroom dampness was significantly related to nasal symptoms. Furthermore, favorable food habits have a positive effect on pupils' subjective symptoms.

Keywords Dampness · Mold · Sick building syndrome · School pupils · Food habits

Introduction

There has been much concern about the effect of indoor environments on residents' health. Many studies have demonstrated that building dampness and mold have adverse health effects on residents [1–3].

The school environment affects children's health. Adverse health effects of dampness and mold in school buildings on school children have been reported [4–7]. Moreover, an interventional study, in which a moisture-damaged school was repaired, showed a positive effect on schoolchildren's health [8]. Home dampness and mold also have adverse health effects on children [9–11] and home remediation against moisture sources has a protective effect in asthmatic children [12].

A dampness index that was the sum of the presence of several dampness indicators [13] was initially reported to be related to sick building syndrome (SBS) symptoms and asthmatic symptoms in Swedish multifamily building studies [13, 14]. We also have reported the significant relation of this dampness index to SBS symptoms in newly built dwellings [15–17] and public apartment houses [18]. However, to our knowledge, there has been no report on the simultaneous evaluation of home and school dampness and their association with children's health.

Y. Saijo (✉) · Y. Nakagi · T. Ito · Y. Sugioka · H. Endo · T. Yoshida
Department of Health Science, Asahikawa Medical College, Midorigaoka, E2-1-1-1 Asahikawa, Hokkaido 078-8510, Japan
e-mail: y-saijo@asahikawa-med.ac.jp

It has been reported that psychosocial factors are associated with SBS [19]. Lifestyle factors—such as work time, sleep time, and alcohol consumption—are also related to SBS [20]. In children, the relationship of unhealthy eating patterns to unfavorable overall school performance has been reported [21], though the relationship of such eating patterns to SBS has not been reported. Thus, lifestyle factors, including food habits, may affect children's subjective symptoms.

From the point of view of improving children's health and their overall school performance, it is important to clarify environmental and lifestyle risk factors for SBS development that can be improved to reduce children's subjective symptoms. In this study, we explored dampness in schools and dwellings, food habits, and subjective symptoms in elementary school pupils in eight elementary schools in Hokkaido Prefecture (the north island of Japan) to clarify the relationship between home dampness, classroom dampness, food habits, and subjective symptoms.

Methods

Study population

Nayoro city and Asahikawa city are located in Hokkaido, the north island of Japan. The eight elementary schools under study included all seven municipal elementary schools in the Nayoro district of Nayoro city (the other district, Furen, had five) and one elementary school affiliated with the university in Asahikawa city. Nayoro is located near Asahikawa (60 km apart), and the two cities have a similar inland climate.

We distributed anonymous parent-administered questionnaires to 1,753 pupils through classroom teachers between November and December 2007. The questionnaires included questions about subjective symptoms, food habits, and dwelling characteristics. Each classroom teacher retrieved the questionnaires from his or her pupils. The classroom teachers were also asked to answer a questionnaire about classroom dampness. School characteristics were gathered from the vice principal of each school. Of the 1,753 pupils, 1,141 (65.1%) answered the questionnaires. We finally analyzed 1,077 (61.4%) questionnaires, after excluding questionnaires that had any missing information. All classroom characteristics questionnaires were answered by the classroom teachers ($n = 61$). This study was conducted after obtaining informed consent from all subjects and approval from the institutional ethics board for epidemiological studies at Asahikawa Medical College.

Subjective symptoms, food habits, and dwelling characteristics

We used a modified parent-administered questionnaire, MM080 for schools, designed for epidemiological assessment of SBS involving elementary school pupils [22]. We translated the English version of the MM080 into Japanese for schools, based on the Japanese version of the MM040EA, which is a validated self-administered questionnaire designed for epidemiological assessment of SBS involving adults [23]. The questionnaire contained information on grade, sex, food habits, dwelling characteristics, and subjective symptoms.

Symptoms surveyed during the preceding 3 months were as follows: fatigue; headache; sleep problems; itching, burning, or irritation of the eyes; irritated, stuffy, or runny nose; cough; dry or flushed facial skin; scaling/itching of the scalp or ears; and dry, itching, or red-skinned hands. Each question had three alternative answers: Yes, often (every week); Yes, sometimes; and No, never. An additional query concerning the attribution of a symptom to the child's school environment, present in the original questionnaire [22], was not used in this study.

Symptoms that occurred often (weekly) were defined as positive. For the analysis, symptoms were categorized as follows: general symptoms (fatigue, headache, and sleep problems) and symptoms involving the eyes, nose, cough, and skin. The questionnaires also contained queries about the history of asthma, hay fever, eczema, and food allergies in the previous year.

Queries about food habits were concerned with the frequency of eating breakfast (always, almost always, 1–3 times per week, never:the latter two categories were defined as "usually not eating breakfast"), whether the energy provided by the school lunch was sufficient or not (yes/no), and whether too many snacks and/or sweets were consumed (yes/no).

The self-administered questionnaire contained queries about the housing type (solitary or other), year of construction (before 1980, later, or unknown), heating (electric stove or other; gas, kerosene, or wood stove), ventilation (natural, mechanical, or unknown), wall-to-wall carpeting in a child's room (yes/no), furry animals or birds in the home (yes/no), a smoker in the home (yes/no), anyone smoking indoors at home (yes/no), signs of moisture/mold damage (yes/no), and condensation on windowpanes (yes/no). In the original MM080 for schools, the year of construction of the dwelling was categorized as before 1960 or later, but we revised it to before 1980 or later because the lifespan of Japanese buildings is relatively short. We considered that one of the original queries: "Are there signs of moisture/mold damage", was difficult for Japanese

participants to understand. Therefore, we used queries about visible mold (yes/no), perception of moldy odor (yes/no), and episodes of water leakage during the past 5 years (yes/no).

We constructed a home dampness index. The index considered four dampness indicators: (1) visible mold, (2) perception of moldy odor, (3) episodes of water leakage during the past 5 years, and (4) condensation on windowpanes. The home dampness index was calculated by the sum of the presence of these indicators.

Classroom characteristics

We distributed the questionnaire about classroom characteristics to classroom teachers. It contained queries about the number of pupils in the class, perception of visible mold (yes/no), moldy odor (yes/no), episodes of water leakage during the past 5 years (yes/no), and condensation on windowpanes (yes/no). By using these results, we calculated a class dampness index. It was calculated by the sum of the presence of four dampness indicators in the classroom: (1) visible mold, (2) perception of moldy odor, (3) episodes of water leakage during the past 5 years, and (4) condensation on windowpanes.

Statistical analysis

The prevalence of subjective symptoms in boys and girls was compared by the χ^2 test. Odds ratios (ORs) for each subjective symptom were analyzed using logistic regression. To obtain multivariate adjusted ORs for each subjective symptom in relation to home and classroom dampness indicators, their dampness indexes, and food habits, we controlled the possible confounders, including age, sex, 1-year history of allergic diseases, housing type (solitary or other), construction year of dwelling (1980 or before, after 1980, or unknown), type of heating of dwelling (electric or other), ventilation of dwelling (mechanical, natural, or unknown), construction year of school, ventilation of school, and number of pupils in the class (<20, 21–30, or ≥31), and each dampness indicator and food habit was introduced separately in the model. Dampness indicators, dampness indexes, and food habits were introduced separately in the model. Moreover, to estimate statistical dose–response relationships, *P* values for trends of home and classroom dampness indexes were analyzed.

Finally, fully adjusted model analyses were performed to obtain the ORs of home and classroom dampness indexes and food habits after adjustment for age, sex, 1-year history of allergic diseases, housing type (solitary or other), construction year of dwelling (1980 or before, after1980, or unknown), type of heating of dwelling (electric or other), ventilation of dwelling (mechanical, natural, or unknown), construction year of school, ventilation of school, and number of pupils in the class (category).

For all statistical analyses, a 5% level of significance was applied. All statistical analyses were conducted using SPSS for Windows version 17.0 (SPSS., Chicago, IL, USA).

Results

Table 1 lists the characteristics of pupils and their homes. The status of home dampness was as follows: 29.0% had

Table 1 Characteristics of pupils and their homes ($n = 1,077$)

	n (%)
Grade	
1st	190 (17.6)
2nd	165 (15.3)
3rd	198 (18.4)
4th	156 (14.5)
5th	179 (16.6)
6th	189 (17.5)
Sex	
Boys	516 (47.9)
Girls	561 (52.1)
Allergy within 1 year	379 (35.2)
Type of housing	
Solitary house	791 (73.4)
Year of construction	
1980 or before	250 (23.2)
After 1980	730 (67.8)
Unknown	97 (9.0)
Heating	
Electric	129 (12.0)
Ventilation	
Natural	553 (51.3)
Mechanical	456 (42.3)
Unknown	68 (6.3)
Wall-to-wall carpeting in a child's room	523 (48.6)
Furry animals or birds in the home	263 (24.4)
Smoker indoors at home	557 (51.7)
Visible mold	312 (29.0)
Moldy odor	89 (8.3)
Water leakage	179 (16.6)
Condensation on windowpanes	595 (55.2)
Usually not eating breakfast (1–3 times per week, never)	28 (2.6)
Insufficient energy at school lunch	97 (9.0)
Too many snacks and/or sweets	245 (22.7)

visible mold, 8.3% had a moldy odor, 16.6% had water leakage, and 55.2% had condensation on windowpanes. Food habits were as follows: 2.6% usually did not eat breakfast (1–3 times per week or never), 9.0% had insufficient energy after a school lunch, and 22.7% had too many snacks and/or sweets.

Table 2 lists the characteristics of schools and classrooms. The status of classroom dampness was as follows: 14.8% had visible mold, 14.8% had a moldy odor, 11.5% had water leakage, and 36.1% had condensation on windowpanes.

Table 3 lists the prevalence of subjective symptoms in this survey. Eye symptoms, nasal symptoms, cough, skin symptoms, and general symptoms were found in 4.4%, 14.0%, 4.8%, 11.3%, and 4.8% of children, respectively. Any symptoms (at least one of skin, eye, nasal, throat, or general symptoms) were found in 25.2% of children. Boys had a significantly higher prevalence of nasal symptoms and any symptoms compared to girls.

Table 2 Characteristics of schools ($n = 8$) and classrooms ($n = 61$)

	School *n* (%)	Classroom *n* (%)
Year of construction		
After1995	3 (37.5)	24 (39.3)
Before 1987	5 (62.5)	37 (60.7)
Ventilation system		
Natural	4 (50)	29 (47.5)
Mechanical	4 (50)	32 (52.5)
Moldy odor	3 (37.5)	9 (14.8)
Visible mold	2 (25)	9 (14.8)
Water leakage	3 (37.5)	7 (11.5)
Condensation on windowpanes	3 (37.5)	22 (36.1)
Number of pupils per class		
≤20		8 (14.8)
21–30		23 (37.7)
≥31		29 (47.5)

Table 4 shows the multivariate ORs of the dampness indicators and food habits for subjective symptoms adjusted by age, sex, allergy, construction year of dwelling, housing type (solitary or other), ventilation of dwelling, type of heating of dwelling, construction year of school, ventilation of school, and number of pupils per class. Usually not eating breakfast had significantly higher ORs for eye symptoms. Too many snacks and/or sweets had significantly high ORs for eye, nasal, general symptoms, and any symptoms. Water leakage in the dwelling had significantly high ORs for cough, general symptoms, and any symptoms. The home dampness index had significantly high ORs for cough, general symptoms, and any symptoms. The classroom dampness index had significantly lower ORs for general symptoms and marginally significantly high ORs for cough.

Table 5 shows the fully adjusted ORs of home and classroom dampness indexes and food habits for subjective symptoms. Usually not eating breakfast had a significantly high OR for eye symptoms. Too many snacks and sweets had significantly high ORs for eye, nasal, and general symptoms. The home dampness index had significantly high ORs for cough (P for trend = 0.007; dampness index 4 vs. 0: OR 5.43, 95% confidence interval [CI]: 1.41–20.9); general symptoms (dampness index 4 vs. 0: OR 3.57, 95% CI: 1.51–12.5); and any symptoms (P for trend = 0.016, dampness index 4 vs. 0: OR 2.92, 95% CI: 1.22–6.99). The classroom dampness index had a significantly higher OR for nasal symptoms (P for trend = 0.040).

Discussion

In this study, we found significant relationships between both home and classroom dampness and subjective symptoms. In the fully adjusted models, the home dampness index was significantly related to cough, general symptoms, and any symptoms, and the classroom dampness

Table 3 Prevalence of subjective symptoms in boys and girls

	Boys ($n = 516$) *n* (%)	Girls ($n = 561$) *n* (%)	All pupils ($n = 1077$) *n* (%)	*P* (Boys vs. girls)
Eye	22 (4.3)	25 (4.5)	47 (4.4)	0.877
Nose	87 (16.9)	64 (11.4)	151 (14.0)	0.010
Cough	29 (5.6)	23 (4.1)	52 (4.8)	0.245
Skin	57 (11.0)	65 (11.6)	122 (11.3)	0.780
General	22 (4.3)	28 (5.0)	52 (4.8)	0.795
Any[a]	144 (27.9)	127 (22.6)	271 (25.2)	0.047

Symptoms that occurred often (weekly)

[a] Having at least one of the above symptoms

Table 4 Multivariate adjusted odds ratios (ORs) of dampness and food habits for subjective symptoms

	Eye		Nose		Cough		Skin		General		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*
Usually not eating breakfast	3.84 (1.22–12.5)	0.022	1.72 (0.68–1.34)	0.246	0.66 (0.08–5.00)	0.687	0.75 (0.21–2.70)	0.653	2.70 (0.85–8.33)	0.093	1.69 (0.75–3.85)	0.208
Insufficient energy at school lunch	1.17 (0.44–3.10)	0.755	1.69 (0.97–2.95)	0.065	1.86 (0.83–4.17)	0.134	1.59 (0.86–2.91)	0.137	0.75 (0.26–2.14)	0.586	1.28 (0.79–2.07)	0.310
Too many snacks and/or sweets	2.56 (1.38–4.75)	0.003	1.64 (1.09–2.45)	0.017	1.31 (0.69–2.48)	0.405	0.99 (0.62–1.58)	0.973	2.63 (1.46–4.76)	0.001	1.49 (1.07–2.08)	0.018
Home												
Visible mold	1.28 (0.66–2.48)	0.465	1.18 (0.79–1.77)	0.427	1.60 (0.87–2.95)	0.129	0.94 (0.60–1.47)	0.771	1.65 (0.90–3.03)	0.106	1.20 (0.87–1.66)	0.270
Moldy odor	1.06 (0.35–3.28)	0.915	1.00 (0.52–1.94)	0.998	1.78 (0.75–4.22)	0.192	0.97 (0.47–2.04)	0.943	2.05 (0.90–4.64)	0.086	1.37 (0.82–2.30)	0.229
Water leakage	0.79 (0.32–1.94)	0.604	1.28 (0.79–2.06)	0.315	2.54 (1.34–4.83)	0.004	1.19 (0.71–1.99)	0.506	2.42 (1.27–4.64)	0.008	1.42 (0.97–2.07)	0.073
Condensation on windowpanes	1.02 (0.52–2.00)	0.967	1.18 (0.78–1.78)	0.428	1.53 (0.77–3.03)	0.226	1.16 (0.74–1.81)	0.526	1.15 (0.59–2.23)	0.675	1.30 (0.94–1.81)	0.117
Dampness index												
0	Reference		Reference		Reference		Reference		Reference		Reference	
1	0.63 (0.27–1.47)	0.283	0.96 (0.59–1.58)	0.881	0.92 (0.39–2.15)	0.847	1.13 (0.67–1.90)	0.653	0.63 (0.26–153)	0.309	1.12 (0.76–1.65)	0.577
2	1.11 (0.49–2.50)	0.807	1.33 (0.80–2.20)	0.279	1.08 (0.44–2.64)	0.871	1.08 (0.61–1.93)	0.787	1.18 (0.51–2.73)	0.697	1.32 (0.87–2.01)	0.189
3	0.92 (0.30–2.81)	0.807	1.22 (0.62–2.39)	0.567	2.74 (109–6.86)	0.032	0.90 (0.42–1.93)	0.782	1.73 (0.70–4.48)	0.258	1.27 (0.74–2.19)	0.390
4	1.03 (0.12–8.70)	0.982	1.35 (0.42–4.42)	0.615	4.94 (1.32–18.5)	0.018	1.98 (0.64–6.14)	0.238	4.82 (1.40–16.6)	0.012	3.20 (1.36–7.54)	0.008
P for trend	0.853		0.281		0.008		0.702		0.017		0.030	
Classroom												
Visible mold	0.82 (0.30–2.26)	0.705	1.53 (0.87–2.68)	0.140	1.20 (0.48–2.98)	0.698	1.17 (0.62–2.21)	0.628	0.63 (0.25–1.64)	0.357	1.39 (0.88–2.20)	0.155
Moldy odor	1.35 (0.55–3.32)	0.520	1.46 (0.87–2.45)	0.148	1.63 (0.68–3.91)	0.275	1.82 (1.00–3.32)	0.052	0.58 (0.22–1.53)	0.272	1.32 (0.86–2.02)	0.211
Water leakage	0.55 (0.18–1.73)	0.309	1.24 (0.71–2.16)	0.442	1.42 (0.61–3.28)	0.414	1.02 (0.55–1.90)	0.940	0.24 (0.06–1.03)	0.055	0.94 (0.60–1.48)	0.790
Condensation on windowpanes	0.77 (0.28–2.13)	0.618	1.72 (0.90–3.29)	0.102	1.79 (0.61–5.30)	0.292	0.93 (0.48–1.82)	0.839	0.47 (0.19–1.17)	0.104	0.92 (0.57–1.48)	0.727
Dampness index												
0	Reference		Reference		Reference		Reference		Reference		Reference	
1	0.58 (0.17–1.98)	0.381	1.71 (0.90–3.25)	0.101	1.39 (0.48–4.05)	0.544	0.72 (0.34–1.51)	0.379	0.42 (0.13–1.33)	0.139	0.74 (0.44–1.26)	0.272
2	0.85 (0.25–2.89)	0.799	1.34 (0.65–2.77)	0.424	1.40 (0.44–4.46)	0.573	0.83 (0.37–1.86)	0.641	0.64 (0.23–1.74)	0.378	0.92 (0.53–1.61)	0.768
3	1.31 (0.32–5.30)	0.704	2.03 (0.86–4.80)	0.107	1.15 (0.25–5.28)	0.859	1.42 (0.56–3.61)	0.463	0.27 (0.05–1.49)	0.133	0.99 (0.49–2.00)	0.969
4	0.51 (0.09–2.81)	0.437	2.30 (0.99–5.38)	0.054	2.33 (0.67–8.14)	0.184	1.51 (0.61–3.74)	0.376	0.16 (0.02–1.41)	0.099	1.42 (0.72–2.77)	0.312
P for trend	0.675		0.050		0.244		0.401		0.042		0.443	

Each dampness indicator and food habit was introduced separately in the model

CI confidence interval

[a] Adjusted for age, sex, allergy, construction year of dwelling, housing type (solitary or other), ventilation of dwelling, type of heating of dwelling, construction year of school, ventilation of school, and number of pupils per class

Table 5 Fully adjusted odds ratios of dampness and food habits for subjective symptoms

	Eye		Nose		Cough		Skin		General		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*
Usually not eating breakfast	3.7 (1.11–12.5)	0.033	1.89 (0.72– 4.76)	0.200	0.61 (0.07–5.00)	0.642	0.71 (0.19–2.63)	0.593	2.12 (0.63–7.14)	0.223	1.59 (0.68–3.70)	0.286
Insufficient energy at school lunch	1.25 (0.47–3.38)	0.656	1.6 (0.91–2.81)	0.102	1.78 (0.78–4.06)	0.171	1.59 (0.86–2.94)	0.141	0.71 (0.24–2.11)	0.534	1.26 (0.77–2.05)	0.357
Too many snacks and/or sweets	2.43 (1.29–4.57)	0.006	1.57 (1.04–2.37)	0.034	1.28 (0.67–2.47)	0.454	0.96 (0.60–1.54)	0.865	2.45 (1.33–4.53)	0.004	1.4 (1.00–1.97)	0.051
Home												
Dampness index												
0	Reference		Reference		Reference		Reference		Reference		Reference	
1	0.6 (0.25–1.43)	0.249	0.96 (0.59–1.59)	0.874	0.93 (0.40–2.19)	0.867	1.15 (0.68–1.95)	0.593	0.62 (0.26–1.52)	0.298	1.12 (0.76–1.66)	0.578
2	1.01 (0.44–2.33)	0.988	1.31 (0.78–2.20)	0.316	1.04 (0.42–2.55)	0.934	1.09 (0.61–1.96)	0.778	0.93 (0.40–2.19)	0.871	1.27 (0.83–1.94)	0.278
3	0.95 (0.31–2.94)	0.927	1.27 (0.64–2.51)	0.498	2.8 (1.11–7.07)	0.029	0.92 (0.43–1.99)	0.833	1.65 (0.63–4.30)	0.309	1.29 (0.75–2.23)	0.365
4	0.67 (0.07–3.02)	0.72	1.3 (0.39–4.31)	0.67	5.43 (1.41–20.9)	0.014	2.08 (0.65–6.60)	0.215	3.57 (1.01–12.5)	0.047	2.92 (1.22–6.99)	0.016
P for trend	0.645		0.184		0.007		0.566		0.056		0.047	
Classroom												
Dampness index												
0	Reference		Reference		Reference		Reference		Reference		Reference	
1	0.6 (0.17–2.11)	0.419	1.82 (0.95–3.49)	0.074	1.5 (0.50–4.48)	0.472	0.71 (0.34–1.50)	0.368	0.49 (0.15–1.62)	0.243	0.79 (0.46–1.34)	0.379
2	0.93 (0.27–3.21)	0.903	1.41 (0.68–2.92)	0.354	1.46 (0.45–4.77)	0.53	0.81 (0.36–1.83)	0.61	0.74 (0.26–2.08)	0.565	0.96 (0.55–1.70)	0.898
3	1.65 (0.39–6.92)	0.496	2.28 (0.95–5.44)	0.063	1.26 (0.27–5.94)	0.771	1.39 (0.54–3.55)	0.497	0.33 (0.06–1.85)	0.207	1.07 (0.53–2.19)	0.848
4	0.51 (0.09–2.98)	0.451	2.38 (1.00–5.66)	0.051	2.43 (0.67–8.85)	0.179	1.41 (0.56–3.54)	0.463	0.19 (0.02–1.70)	0.139	1.48 (0.75–2.94)	0.258
P for trend	0.763		0.04		0.232		0.469		0.09		0.348	

All the above variables were included in the model

[a] Adjusted for age, sex, allergy, construction year of dwelling, housing type (solitary or other), ventilation of dwelling, type of heating of dwelling, construction year of school, ventilation of school, and number of pupils per class

index was significantly related to nasal symptoms. In addition, usually not eating breakfast was significantly related to eye symptoms, and too many snacks and/or sweets was significantly related to eye, nasal, and general symptoms. To our knowledge, this is the first report on the relationship between both home and classroom dampness and subjective symptoms in pupils, with the simultaneous evaluation of home and classroom dampness.

In regard to differences between the sexes, boys had more symptoms than girls in this study. In a previous study, no significant difference in the prevalence of atopic dermatitis between boys and girls in Japan was reported [24]. However, the prevalence of asthma and rhinitis in boys was greater than that in girls [25–27]. Similar to previous studies, our study showed a higher symptom prevalence among boys than girls.

In the present study, we used the MM080 questionnaire [22]. There has been no previous report on the prevalence of symptoms in pupils using the MM080 for schools in Japan. The MM080 developers reported that the prevalence rate of each symptom was 2%–7% (http://www.orebroll.se/uso/page____17918.aspx). The prevalence of nasal symptoms found in the present study was rather high. The reason for this was probably because allergic rhinitis has been the most prevalent allergic disease and its prevalence has been increasing in Japan [25].

In a previous study of newly built dwellings in Hokkaido, Japan, visible mold and condensation on windowpanes and/or walls were found at rates of 15.6% and 41.7%, respectively. [16] Another study of newly built dwellings in Japan (including six prefectures), found visible mold, moldy odor, water leakage, and condensation on windowpanes and/or walls in 39.8%, 7.8%, 4.7%, and 51.8% of dwellings, respectively [15]. A study of old apartment houses in Hokkaido, Japan, found visible mold, moldy odor, water leakage, and condensation on windowpanes in 59.5%, 62.1%, 20.8%, and 81.8% of dwellings, respectively [18]. In a Swedish multifamily dwellings study, moldy odor, water leakage, and condensation on windowpanes, were found in 12.4%, 12.7%, and 9.0% of dwellings, respectively [13]. Moreover, in another Swedish dwellings study, water leakage (during the previous year), visible dampness (mold or damp spot), and condensation on windowpanes were seen in 17.8%, 1.5%, and 14.3% [9] of dwellings, respectively. Thus, Japanese dwellings have higher dampness rates. Of note, the annual average outdoor temperature and relative humidity in Asahikawa and Stockholm were 6.7°C and 76% and 6.7°C and 76%, respectively (World Meteorological Organization; Japan Meteorological Agency). However, inadequate waterproofing of the buildings, water leakage, and moisture from human indoor activities are important contributors to building dampness [2] and differences in these factors between Japan and Nordic countries are little investigated. One possible explanation for these differences is that many Japanese people regard low humidity as a risk factor for respiratory infections, such as influenza virus infection in winter [28] and adenovirus infection in summer [29] and may prefer high humidity, especially in winter. However, further studies will be needed to clarify the cause of these differences in dampness and preferable constructions and indoor activities.

In the present study, we found that the home dampness index was significantly associated with cough (3 and 4 vs. 0; *P* for trend), general symptoms (4 vs. 0), and any symptoms (4 vs. 0; *P* for trend), and the classroom dampness index was significantly associated with increased nasal symptoms (*P* for trend) in the fully adjusted models. Because the significances of *P* for trend possibly indicated the dose–response for dampness exposure, these significances may reflect the effect of dampness on the symptoms.

A metaanalysis showed that home dampness was significantly associated with children's asthma and cough [3]. Home dampness is reflected in evening and night exposure, and nocturnal cough is common in asthmatic patients [30]. The adverse effect of school dampness on respiratory symptoms has also been reported [31]. However, in the present study, we saw no significant relationships between classroom dampness and cough. This may be attributed to the shorter time in the school and/or the inadequate statistical power of the study.

Dampness is related to general symptoms in adults [1, 13] and children [31, 32]. In the present study, only the home dampness index was significantly related to general symptoms; this finding may be due to the longer time in the home and/or the inadequate statistical power of the study. Classroom dampness, not home dampness, was significantly related to nasal symptoms. Because nasal symptoms are strongest just after waking up in the morning [33], exposure to home dampness seems to be important. These nasal symptoms remain strong until noon [33]; therefore, the classroom dampness could possibly affect the late circadian peak of nasal symptoms.

As for the dampness index, the index, consisting of condensation on windows, high air humidity in the bathroom, moldy odor, and water leakage had significantly increased ORs for SBS symptoms in Swedish multiresident houses [13]. In Taipei office buildings, the dampness index had significantly increased ORs for eye irritation, cough, and lethargy/fatigue [34]. Moreover, several studies of Japanese dwellings reported that the dampness index had significantly increased ORs for SBS symptoms [15–18].

As previously mentioned, it has been reported that lifestyle can affect SBS symptoms [20]. In the present study, usually not eating breakfast had significantly higher ORs for eye symptoms, and too many snacks and/or sweets

had higher ORs for eye, nasal, general symptoms, and any symptoms. Thus, favorable food habits probably have a positive effect on subjective symptoms. However, there is a possibility that favorable food habits are related to lower ORs for subjective symptoms via other favorable lifestyle factors.

The present study had several limitations. First, if participants knew that dampness was a risk factor for the subjective symptoms, people whose houses had dampness problems might tend to report subjective symptoms, which could have caused a bias. However, exposure to chemicals has been highlighted in Japan, and many Japanese may prefer higher humidity in winter. Besides, classroom dampness was assessed by classroom teachers who did not know the pupils' symptoms. Therefore, such a bias would seem to have occurred rarely in this study. If nonrespondents had tended to have no subjective symptoms, the symptom prevalence rate may have been overestimated. Secondly, a lower response rate may also have affected the significant relationship between dampness and subjective symptoms, because the statistical power would have been reduced. Thus, in each dampness indicator, only water leakage in dwellings had significantly higher ORs for cough and general symptoms in the multivariate adjustment analyses. Thirdly, in the fully adjusted analyses, the *P* for trends of the dampness index was not necessarily consistent with the *P* of each dampness index number (OR of home dampness index for general symptoms; OR of class dampness index for nasal symptoms). This may also have been caused by reduced statistical power. A seasonal variation in SBS symptoms—an increase in mucosal and skin symptoms during winter and spring—has been reported [35]. Fourthly, the season of this study may have affected the prevalence of subjective symptoms. Regarding the symptom part of the MM040 questionnaire, several studies have defined positive symptoms as those occurring often, but "whether the symptoms were attributed to the work environment or not" was not included in the definition of SBS symptoms [13, 23]. Fifthly, the MM080 includes queries about "whether the symptoms were attributed to the school environment or not." Because our study focused on both the home and school environments, "whether the symptoms were attributed to the school environment or not" was not used in our subjective symptom definition. The Japanese version of the MM080 has not been validated by another Japanese study. However, the queries on subjective symptoms contain common SBS symptoms that are included in the MM040. Therefore, we believe that we were able to estimate the SBS symptoms properly. Finally, this study was conducted in two cities in Hokkaido, Japan. Therefore, generalization of the results of this study to other districts in Japan and to other countries is difficult. But many studies have reported the effect of dampness on pupils' health.

In conclusion, both home and classroom dampness can affect pupils' health. Home dampness, in particular, was significantly related to cough and general symptoms, and classroom dampness was significantly related to nasal symptoms. Furthermore, favorable food habits have a positive effect on pupils' subjective symptoms. Thus, to improve the deleterious effects of both home and school dampness, improving pupils' food habits is one of the measures that can be used to protect pupils' health, especially in the case of SBS. However, further studies are required to investigate the dampness of the environment and lifestyle factors for improving pupils' health.

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