A case-controll study of the effect of indoor environments on health problems of Japanese children, Part 2: Microorganisms and chemical compounds.

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SUMMARY

To clarify the association between indoor environmental factors and child health problems, epidemiological surveys of fourth- and fifth-grade children were conducted in Japan. A case-controlled field study involving 209 houses was conducted during the winter and the rainy season. Chemical compounds, fungal index, airborne fungi, and microorganisms in house dust were analysed. The association between each exposure and children's health was examined. Results indicate that the mean formaldehyde concentration in the case group was significantly lower than that of the control group in the winter ($p<0.01$). Fungal index, airborne fungi and microorganisms in house dust tended to be higher in case group than in the control group for both seasons.

IMPLICATIONS

This study added to our understanding of the microorganisms and chemicals found inside homes where Japanese children live. Results showed the necessary of the avoiding of high humidity in house to create healthier living conditions.

KEYWORDS

Children's Health, Allergic Symptom, Exposure Measurement, Case-controll Study

INTRODUCTION

The number of children affected by allergic diseases has increased in Japan (Ministry of Education, Culture, Sports, Science and Technology. 2007). To clarify the relation between indoor environmental factors and children's allergic diseases, epidemiological surveys for fourth- and fifth-grade primary school children was conducted throughout Japan beginning in July 2007. As part of the investigation, field surveys were conducted in houses containing children. The influence of each factor on child health conditions was examined by comparing the case group with the control group. This report also describes the fungal index, and concentration of certain chemical compounds, airborne fungi, settled fungi in house dust, and dust mite allergens.

METHODS

Measurements were conducted in houses where resident cooperation was obtained through a nationwide questionnaire (n = 2634) (Hasegawa *et al.*, 2011) on fourth- and fifth-grade children. Survey measurements were conducted during winter (November 2008 to March 2009) and in the rainy season (July to March in 2009) in a total of 209 houses.

The fungal index and concentrations of certain chemicals, airborne fungi, settled fungi in house dust, and dust mite allergens (Der p 1) were measurement; the number of subject houses in which measurements were conducted varied depending on the factors found. An outline of measurement methods and houses subjected to each measurement are shown in Table 1. Among houses measured in the rainy season, values shown in parentheses represent the number of houses measured twice during winter and the rainy season. For the survey, measurement kits, including samplers and detectors for measurements of chemical compound concentrations and fungal index, were sent to each house; residents set up the equipment and collected the data. Investigators visited some subject houses and collected airborne fungi and house dust on floor surfaces. All measurements were conducted in the living room and in a child's bedroom.

Table 1. Houses surveyed and an outline of measurement methods for each factor

Measurement Item	Number of Houses		Measurement Method
	Winter	Rainy season*[1]	
Chemical compound	95	46 (46)	The installation and the collection of the equipment are requested to each resident.
Fungal index	99	100 (64)	
Airborne fungus Settled fungi in house dust Dust mite allergen (Der 1)	24	24 (17)	Investigator visit each house and collect samples.

*1:Figure in parentheses are the number of houses coutinuously measured.

Measurement method for each item

Chemical compounds. Two chemical samplers (VOC-SD and DSD-DNPH, Supelco Inc.) were used to measure volatile organic compound (VOC) and carbonyl compounds, respectively. The samplers were suspended from the ceiling, and indoor air was absorbed passively over a period of 24 hours. After samplers were collected, chemical concentrations were analyzed by a private company using solvent extraction and gas chromatography.

Fungal index. The fungal index (*e.g.*, Abe *et al*., 1996) is a method for measuring fungal growth potential quantitatively. For this survey, fungal detectors were set on the floor in the northeast corner of the living room and in a child's bedroom at each house. The measurement period was two weeks in winter and four weeks in the rainy season.

Airborne fungi. Samples of fungi were collected from the living room, child's bedroom, and from outdoors. Airborne fungus was measured by blowing 100 L or 50 L of vacuumed air indoors and outdoors, respectively, with an air sampler (BioSamp MBS-1000, Midori Anzen Co.) into dichloran 18% glycerol agar (DG18). Microscopic analyses were conducted after cultivation at 25ºC for 5 to 7 days. After analyzing the fungal samples, the values were converted to the number of colony-forming units per cubic meter of air (cfu/m^3).

Settled fungi in house dust. House dust was collected for 2 minutes from 1 square meter of floor area using a special vacuum cleaner (PV-H22, Hitachi Ltd.). Microscopic analyses were conducted and the values converted to the number of colony forming units per milligram of dust (cfu/mg). DG18 was used as the medium.

Dust mite allergen. House dust for dust mite allergen measurement was collected by a method similar to that for settled fungi. Concentrations of Group 1 allergens (Der1, *i.e.*, Der f 1 and Der p 1) derived from mite excrement particles were determined using the ELISA method by a private company.

Definitions of case and control groups

The case group included the children with symptoms of allergic disease as determined by the ATS-DLD interview sheet (Japan Public Health Association, 1979) used for the preliminary questionnaire. The control group included children who didn't have symptoms at investigation time AND who may have had symptoms in the past. The case group accounted for 70% of the investigation in both seasons.

Date analysis

Factors that influenced allergic symptoms were clarified by the case-control study. The Mann-Whitney U test and t-test were used for statistical analysis. The software employed was SPSS 16.0J for Windows (SPSS Japan Inc.).

RESULTS

Chemical compound

Figure 1 compares formaldehyde, acetaldehyde, and total volatile organic compound (TVOC) concentrations between the case and control groups. Mean formaldehyde concentration of the case group was significantly lower than that of control group (living room and bed room, $p<0.001$ and $p<0.05$, respectively). However, mean acetaldehyde concentration in the living room of the case group was significantly greater than that of the control group ($p<0.001$). In addition, the magnitude of the mean TVOC concentrations of both groups had different trends depending on the room where measurements were obtained.

In the rainy season, no significant difference in formaldehyde, acetaldehyde, and TVOC concentrations between the case and control groups was found. However, mean formaldehyde concentration tended to be greater in the case group, although the difference was not statistically significant. Moreover, one house in the case group contained a very high concentration of TVOC.

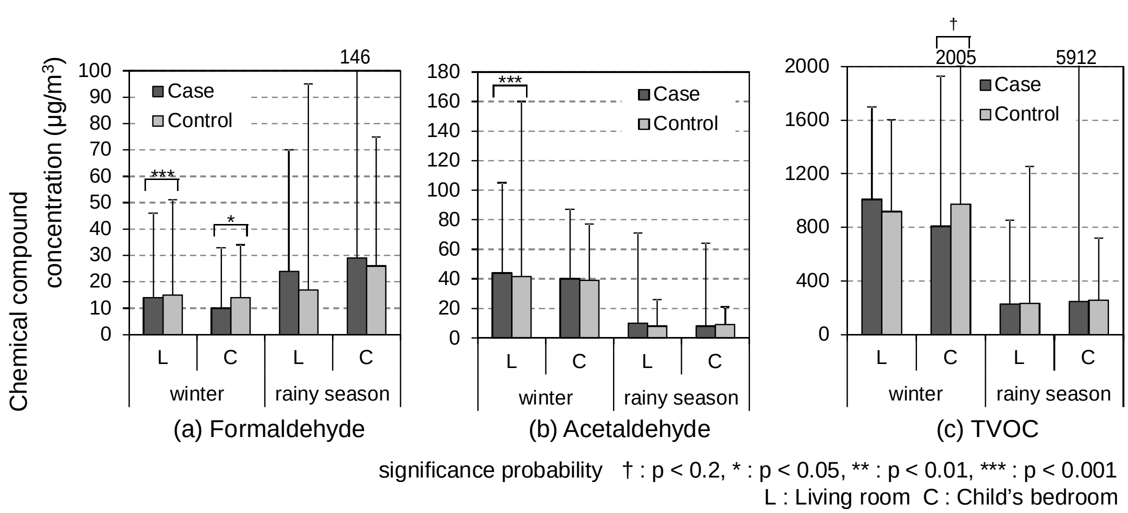

Figure 1. Comparative analysis of the chemical compound concentration

Fungal index

Figure 2 shows the percentile rank of the fungal index. Almost all of the houses were below the fungal index detection limit in the winter. However, fungal indices in the houses where it was measurable were high, and so the detection ratio of the case group tended to be slightly greater. In the rainy season, the fungal index of the case group tended to be greater than that of the control group in both rooms. This tendency was especially strong in the living room ($p<0.2$).

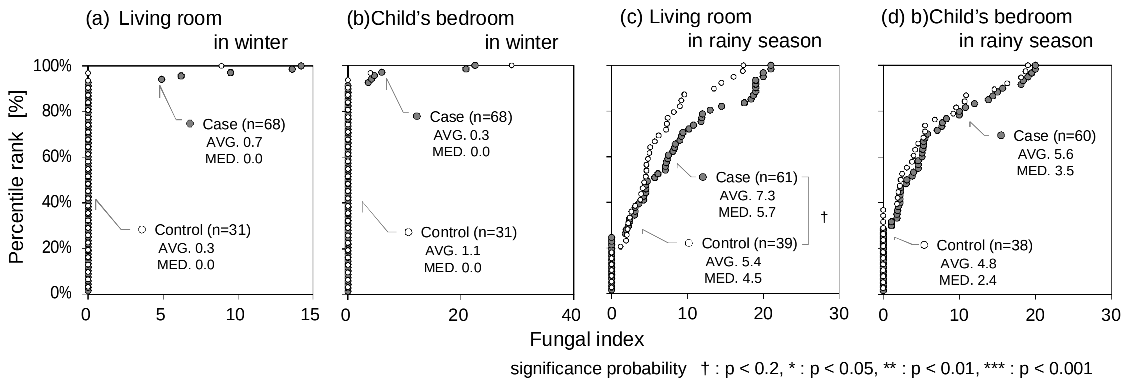

Figure 2. Percentile rank of fungal index

Indoor/outdoor ratio of airborne fungi

In this paper, the amounts of *Cladosporium*, *Aspergillus*, and *Penicillum sp*. were determined indoors and outdoors. Figures 3 to 5 show the percentile ranks of indoor/outdoor airborne fungal concentration ratio (I/O ratio) for each fungal species. No significant difference between the case and control groups was found for either season. However, the value for the case group tended to be greater. This tendency was especially remarkable at percentiles greater than 80%.

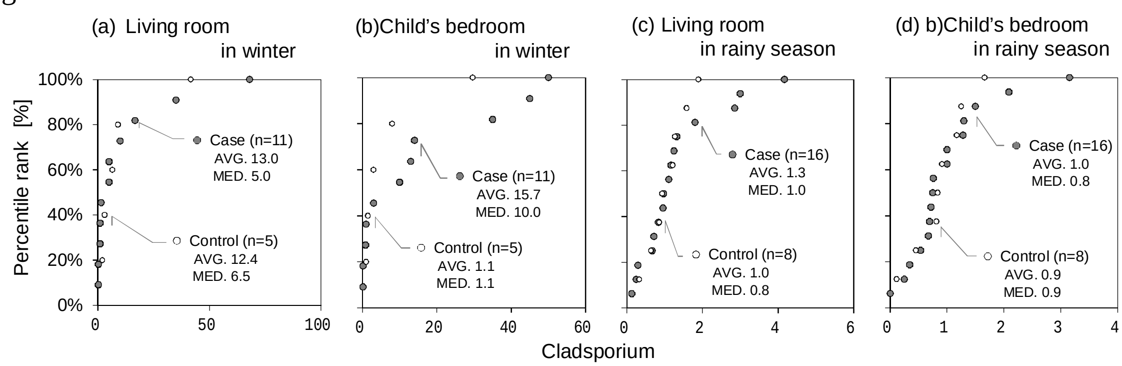

Figure 3. Percentile rank of I/O ratio of *Cladosporium sp*.

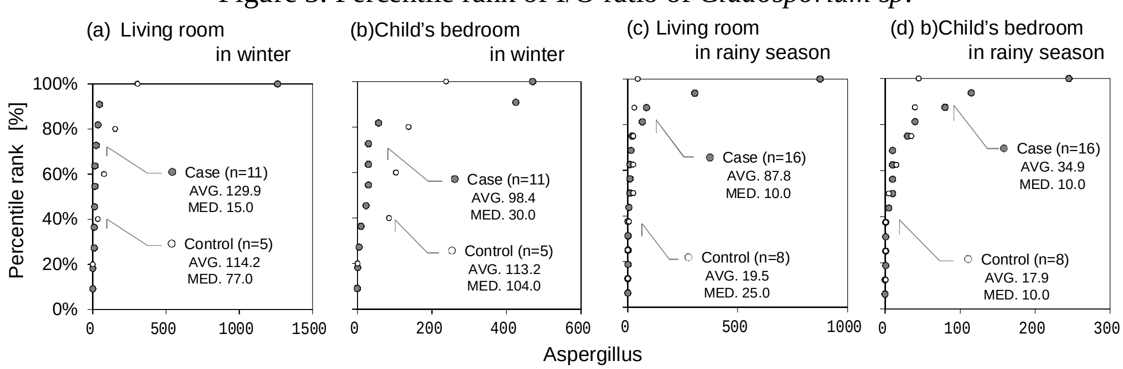

Figure 4. Percentile rank of I/O ratio of *Aspergillus sp*.

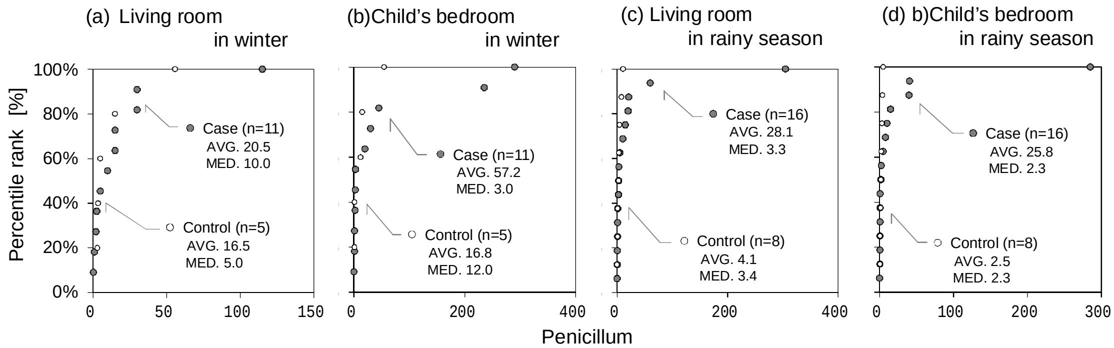

Figure 5. Percentile rank of I/O ratio of *Penicillum sp.*

Settled fungi in house dust

Figure 6 shows the percentile rank of measurement value of settled fungi in house dust. In both seasons, the value in the living room of the case group tended to be greater than that in the control group, although a significant difference could not be confirmed in the bedroom ($p<0.2$).

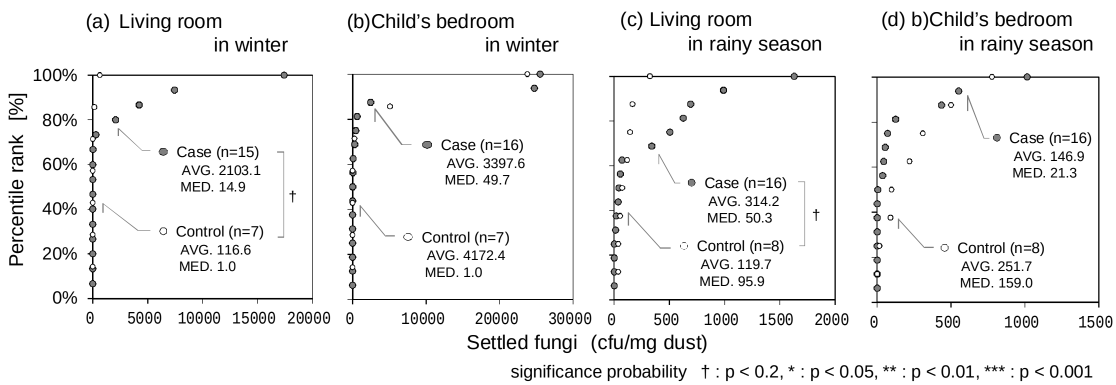

Figure 6. Percentile rank of settled fungi.

Dust mite allergen

Figure 6 shows the percentile rank of Der 1. The WHO standard indicates that the Der 1 sensitization level is 2 μg/g dust. There was no significant difference between the case and control groups and most houses exceeded the standard value in the rainy season. Although no significant difference was seen between the groups, high values were found for the case group in both seasons.

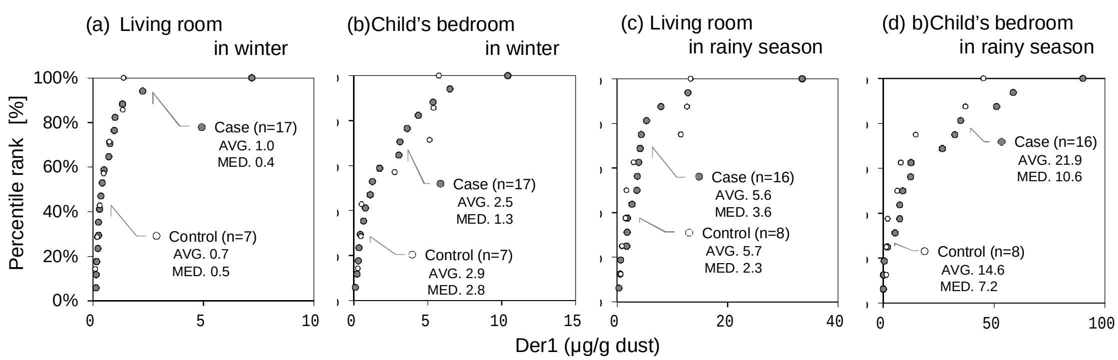

Figure 7. Percentile rank of dust mite allergen

DISCUSSION

In Japan, the Ministry of Health, Labor, and Welfare provides guideline values for chemicals in the home. Although the amount of acetaldehyde was somewhat high (30.0% greater than the guideline value), most chemicals didn't exceed the guidelines in the winter. The concentrations barely exceeded the guidelines in the rainy season. In contrast, many of the houses exceeded the WHO threshold level of dust mite allergen shown in both seasons (45.8% greater in winter, 87.5% greater in the rainy season). Microorganisms such as the dust mite had a greater effect than chemical concentrations on children's allergic diseases.

Results of the case-controlled study showed that fungal index, and the amounts of airborne fungi and microorganism in house dust for the case group tend to be higher than those of the control group in both seasons. A former study (Hasegawa *et al*., 2011) reported that relative humidity exceeded 70% near the floor surface area of the living room in the case group, which was significantly higher than that in the control group ($p<0.01$). These results suggest that the high humidity in houses of children with allergic symptom may promote the growth of microorganisms. WHO (2009) reports that dampness in buildings can affect health. Thus, in Japan, indoor environmental factors that promote dampness may influence allergy symptoms in children.

CONCLUSIONS

The relation between level of some microorganisms and chemicals inside houses and children's health problems was examined using a case-controlled study. The levels of microorganisms in houses of the case group tended to be higher than those of the control group. Detailed studies are planned to clarify and verify the association between indoor pollutants and allergy symptoms while considering house characteristics and occupant lifestyles.

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