Case-Control study for the Association Between Indoor Environmental Factors and Children's Health Problems in Japan – Part 2 Results of Measurements during Rainy Season and Winter

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Abstract

In order to clarify the association between indoor environmental factors and children's health problems, indoor air quality was investigated during the winter and rainy seasons in Japan. The total of 209 houses was classified into case and control groups whether the child have allergy symptom or not. The number of the houses in case and control groups is 133 and 76, respectively. This survey included measurement of indoor temperature, humidity, the pollution of chemical compound and mite allergen (Der 1). These measurements were conducted in the living room and children's room. It was found that the excess rate of relative humidity 70% in the case group was higher than that of the control group. During rainy season, in most houses (87.5%) Der 1 concentrations exceeded the proposed thresholds of allergic sensitization. The Der 1 concentration of the case group was higher than the control group. It was concluded that the chemical concentration including HCHO was less than the recommended value in many houses. On the other hand, Der 1 exceeded the proposed thresholds of allergic sensitization in the winter and rainy seasons.

Keywords: Children's Health, Allergic Symptoms, Exposure Measurement, Aldehyde, VOC, Mite Allergen

Introduction

Recently, the total number of children affected by allergic diseases has increased in Japan. In order to clarify the relationship between indoor environmental factors and children's allergic diseases, epidemiological surveys for 4th and 5th grade primary school children have been carried out all over Japan since July 2007. In the Phase 2 survey, which surveys the building characteristics, the indoor environment, and factors related to the children's health were investigated using a questionnaire. From houses in the Phase 2 survey, some houses were selected for the houses investigated in the Phase 3 survey, in which the relationship between the indoor environment and children's health was investigated in detail by measuring the indoor environment of houses. This paper reports the results of the Phase 3 survey, which reveals the actual situations of indoor temperature, humidity, the concentration of the chemical compounds including formaldehyde, and the mite allergens. Moreover, the influence of the pollution concentration of these factors on the children's health were examined by the case-control study.

Objectives

(1) Surveyed houses

The measurements were conducted during the winter (November 2008 ~ March 2009) and rainy seasons (July ~ August 2009) in houses where occupants agreed to participate in the Phase 3 survey. These houses were selected from the prior questionnaire survey (Phase 2).

The number of surveyed houses varied depending on the prefecture and measurement items (Table 1). Temperature and humidity were measured in 104 houses during the winter and in 105 houses during the rainy season. Out of them, 68 houses were measured twice in both seasons. Concentrations of the chemical compounds were measured in 95 and 46 houses during the winter and rainy seasons, respectively. All houses measured in the rainy season had already been measured once in the winter. Concentration of the mite allergen was measured in 24 houses in both seasons. Out of them, 17 houses were measured twice in the winter and rainy seasons.

(2) Definitions of case and control groups

The case group includes the children who have the symptom of some allergic diseases evaluated by the ATS-DLD interview sheet (former Environment Agency)[1)] that is used for the preliminary questionnaire survey (Phase2). The control group includes children who have no symptoms at the time of investigation or used to have symptoms in the past. The case group accounted for 70% of the total houses investigated in both seasons.

(3) Measurement items

This survey included the measurements of indoor temperature, humidity, concentration of various chemical compounds in the air and concentration of mite allergens in the house dust. The measurement kits including measuring devices, such as temperature and humidity sensors with recorders (TR 72 U, T&D Corporation), two chemical samplers (VOC-SD and

DSD-DNPH, SUPELCO, Inc.) were sent to each house. Residents were requested to set up the equipment in particular places. In some houses, investigators visited the house and collected the house dust from the floor surfaces using a vacuum cleaner. All measurements were conducted in the living room and the children's rooms.

(a) Indoor temperature and humidity

In winter, temperature and humidity were placed near the center (approximately 1.0 m above the floor surface) and northeast corner of both the living room and children's rooms. The total of measurement points per house is four. In rainy seasons, the sensors were placed only near the center of the living rooms and the children's room. The temperature and humidity were monitored for two weeks in the winter and four weeks in the rainy season. The data was recorded every 10 minutes during the measurement period.

(b) Chemical compound concentration

In order to measure the concentration of chemical compound in rooms, two chemical samplers were suspended from the ceiling and indoor air was absorbed passively in a period of 24 hours. These samplers were used for the measurement of volatile organic compound (VOC) and carbonyl compound respectively. After samplers were collected, the chemical concentrations were analyzed using solvent extraction and gas chromatography by the private company.

(c) Concentration of dust mite allergen

The house dust was collected for two minutes using a special vacuum cleaner from $1m^2$ floor area. Concentration of Group1 allergens (i.e. Der f 1 and Der p 1) derived from mite excrement particles were analyzed using the ELIZA method by the private company.

(4) Statistical analysis

The factors which influence on allergic symptoms are clarified by the case-control study. Mann-Whitney U test was used for a statistical analysis method. The software SPSS 16.0J for Windows was used to run the analysis.

Results and Discussion

(1) Indoor temperature and humidity

Figures 1(a) and (b) show the statistical values of the temperature and the humidity of the living rooms and the children's rooms for both cases in winter. For the temperature shown in Figure 1(a), the mean value of the control group was higher than that of the case group in the living rooms and the children's rooms in both November and February. However, the average temperature of the case group was higher than the control group in December. Figure 1(b) shows the result of the relative humidity. Relative humidity for both groups in the children's room are higher than the living rooms through in these months. The average relative humidity of the case group exceeds the control group in December. Even though the mean value of relative humidity in the living rooms have similar values between both groups for the months of November and February, the difference between the maximum value and the minimum

value was greater in the case group. Such tendency isn't limited to the relative humidity. It is also seen in the result of the temperature in February.

The ratio for the relative humidity exceeded 70%rh for the measurement period is divided into the case group and the control group. It is shown in Figure 2 with the percentile rank. The 70%rh excess rate in each house was calculated because it was reported that the high level of relative humidity that exceeded 70%rh will influence the growth rate of mold [2)]. As a result, relative humidity 70%rh excess rates of the vicinity of the center of the room and the northeast corner in the case group tend to be higher than those in the control group for both living rooms and children's rooms in the winter. Figure 2(a) illustrates the results for the northeast corners of the living room. The difference between the case and the control groups was big. It was confirmed that the relative humidity 70%rh excess rate of the case group is higher than that of the control group in 50% of the houses. This value of case group is statistically (t-test) significantly higher than the control group ($p<0.05$). It was found in Figure 2(b) that the overall values of the case group in the vicinity of the center of the living rooms during rainy seasons tend to be higher ($p<0.2$) than those of the control group..

(2) Chemical compound concentration

Table 2 shows the measurement results of the chemical compound concentrations in 95 houses (190 rooms) during the winter. The TVOC concentration was assumed to be a total value of the chemical compound identified in both the winter and rainy seasons. The

concentration was expressed as 0 μg/m^3 in the case that the measurement value was below the lowest values that were able to be detected. The Ministry of Health, Labour and Welfare in Japan indicated the guideline values of the chemical compounds concentrations shown in Table 2. There were some houses with values of acetaldehyde and p-dichlorobenzene exceeded the guidelines during the winter. The excess rate of acetaldehyde and p-dichlorobenzene was 30.0% and 3.7%, respectively. Other chemicals didn't exceed the guideline. The excess rate of TVOC was 17.4%.

Table 3 shows the measurement results of the chemical compound concentration in 46 houses (92 rooms) during the rainy season. There were few houses where formaldehyde, acetaldehyde and p-dichlorobenzene exceeded the guideline values. However the number of locations where the value exceeded was less than five points for each chemical compound. These excess rates were not high. On the other hand, for p-dichlorobenzene concentration, there was a house where the values were more than 5000μg/m^3. In this house, the high value of p-dichlorobenzene concentration was also measured in the winter. This house used mothballs in the living room and the closet. The child living in this house has atopic dermatitis, and it is possible that the existence of these sources of p-dichlorobenzene affect the symptom. The excess rate of the tentative target value of TVOC was 7.6%, and this value was lower than that of the rainy season.

Figure 3 shows the comparison of the measured concentrations between the case group and

the control group during the winter. It was found that the mean TVOC concentration of the case group was higher than that of the control group. However, this result was not significant. For other chemical compounds, a significant difference between the case and the control groups was not also found. It was only seen that the mean formaldehyde concentration of the case group was significantly lower than that of the control group ($p<0.01$). The best explanation was that parents with children affected by allergic diseases likely tried to create better indoor environments for the children in order to reduce the symptoms. However, both values were lower than the guideline value. In the rainy season, there wasn't a significant difference between the case and control groups.

(3) Concentration of mite allergen (Der 1)

1) Winter season

Figure 4 shows the result of measuring the concentration of house dust mite allergen (Der 1) during winter. The WHO standard shows 2μg of the allergic subject Der 1 is a sensitization level. There were 11 houses where this value was exceeded (the excess rate: 45.8%). Among these houses, a high concentration value more than 10μg/g was detected in a house (aki-4) in Akita Prefecture. The child living in this house had serious rhinitis problem. It seems that high concentration value of Der 1 contributes to the symptom severity. In the houses where the standard value had been exceeded, the concentration value in the children's room was higher than that of the living room. The situation of an indoor environment in a bedroom with

a carpet, bedding and closet provide the appropriate environment for growth of the mites.

2) Rainy season

Figure 5 shows the measurment results of the concentration of dust mite allergen (Der 1) during the rainy season. There were 21 houses (87.5%) where the sensitization level was exceeded. It was found that the concentration of mite allergen in the rainy season is higher than that in winter. In many houses where the standard value had been exceeded, high concentration was measured in the children's room as the same as the situation of the winter investigation. A case house (aki-5) located in Akita Prefecture showed the highest concentration of mite allergen. There were carpet, stuffed toys and a garnish of bed used. In this house, the existence of these things was the cause for the growing of mites. These findings corresponded with the fact that the child living in this house also had severe allergy symptoms.

It is reported that the frequency of room cleaning is related to the concentration of mite allergens on the floor[3)]. However, there is no relation between the cleaning frequency reported by residents and the concentration of mite allergens in both seasons.

Figure 6 shows the accumulation frequency of the Der1 concentration for the case and the control groups. It was found that the houses with high ranks of Der1 concentrations in both seasons belong to the case group. And measured values in the case group are generally higher than those concentrations of the control group in both seasons. However, a significant

difference was not seen for the case group and the control groups in both seasons.

Conclusions

The epidemiological survey conducted to 4th and 5th grade primary school children gave the following findings. (1) The excess rate of the relative humidity (70%) in the case group was higher than that of the control group. (2) The value of the chemical concentrations didn't exceed the guideline values in many houses surveyed. (3)The concentration of the formaldehyde in the case group was significantly lower than that of the control group in the winter. However, both values were low compared with the guideline value. (4)The excess rate of the allergic sensitization threshold of the Der1 concentration was 45.8% and 87.5% in the winter and rainy season, respectively. (5)When comparing the Der1 concentrations, the case group tends to be higher than that of the control group. From these results, it is found that the concentration of the mite allergen often exceeds the standard values in many houses but the situation was not found in case of the chemical compounds. So, it is expected that the high concentration of the exposure the mite allergen was the causes of allergic deceases. From the result that the Der1 concentration of the case group tends to be higher than that of the control group, children's health might be influenced by the exposure to more mite allergens. Moreover, from the results that the excess rate of the relative humidity (70%) in the case group was higher than that of the control group, there is a possibility that a high humidity environment suitable for the growth of mold and mite was developed in the houses of the

children who had an allergic symptom. The indoor environmental factors that relates to such dampness may have influences on the symptom.

Acknowledgments

The authors like to thank the occupants of the investigated dwellings for their helpful cooperation. This project is conducted as a part of Research Project for Creation of Housing that Promotes Health and Well-being (Chair: Prof. Shuzo Murakami, Chief Executive, Building Research Institute). This study was supported partially by Japan Society for the Promotion of Science, Housing Research Foundation, TOSTEM Foundation for Construction Materials Industry Promotion and the Kajima Foundation's Research Grant.

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Table 1 Number of surveyed houses in prefectures

Prefectural and city governments	Temperature,humidity		Chemical compound		Dust mite allergen (Der 1)	
	Winter	Rainy season	Winter	Rainy season	Winter	Rainy season
Hokkaido	3	4	3	3		
Aomori		7				2
Iwate	3	4	3	1	3	3
Miyagi	4	7	4	4	3	5
Fukushima		2				
Akita	13	11	13	11	10	7
Yamagata		6				
Tochigi		3				1
Gunma		3				1
Saitama	15	11	15	9	8	5
Chiba	49	29	46	18		
Kanagawa	3	1	2			
Niigata	3	6	3			
Shizuoka	4	1	3			
Wakayama	7	4	3			
Hyogo		6				
total	104	105	95	46	24	24

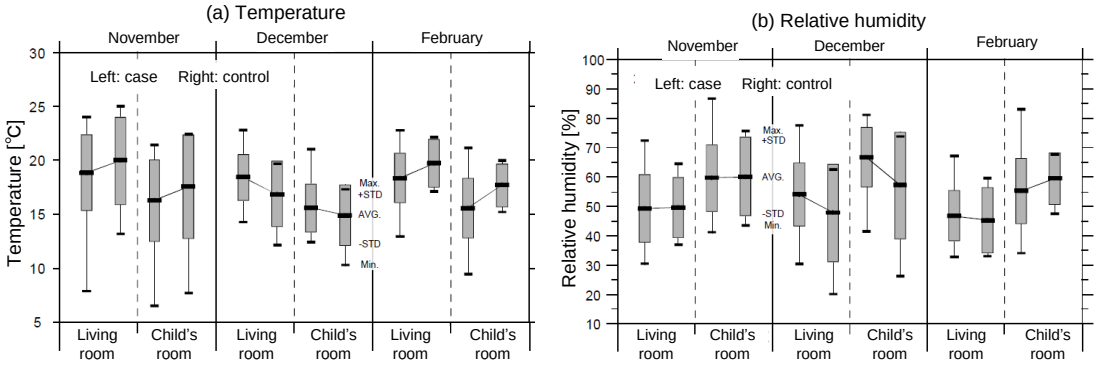

Fig. 1 Statistical values of the temperature and the humidity

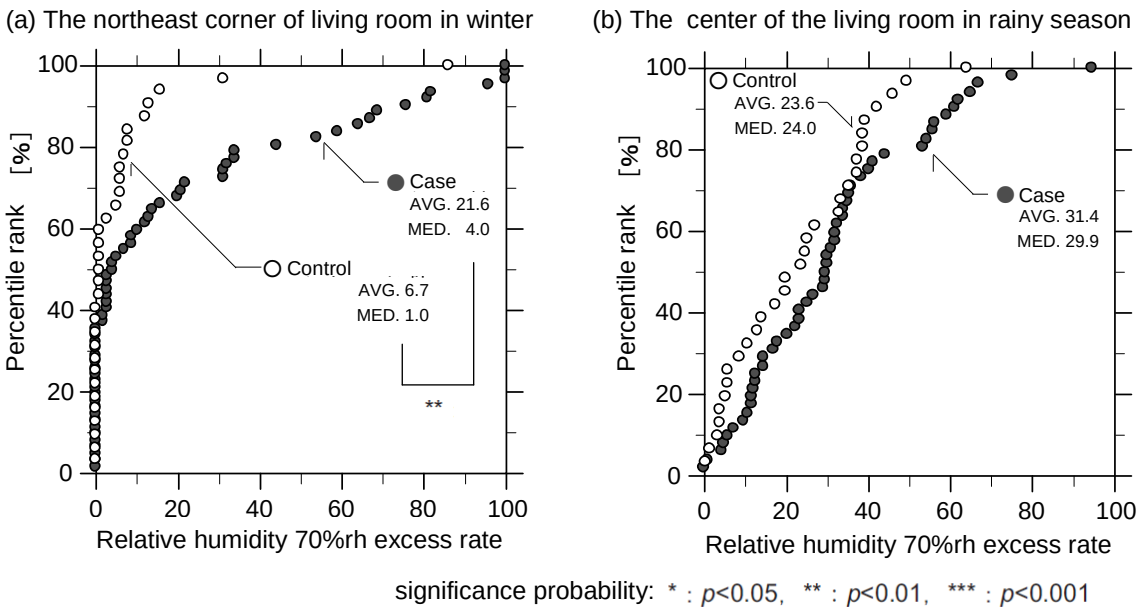

Fig. 2 Percentile rank of relative humidity 70%rh excess rate

Table 2 Measurement results of chemical compound concentration in the winter

	N=190		Indoor concentration (μg/m³)						guideline value in Japan
	Number of detection	Rate of detection	Max	Minimum	Average	Median	Number of excess	Rate of excess	
Formaldehyde	187	98.4%	51.0	0.0	14.4	12.0	0	0.0%	100
Acetaldehyde	190	100.0%	160.0	11.0	44.2	41.0	57	30.0%	48
Toluene	186	97.9%	88.0	0.0	13.1	10.0	0	0.0%	260
Xylene	170	89.5%	171.0	0.0	10.7	5.0	0	0.0%	870
Ethylbenzene	174	91.6%	50.0	0.0	4.0	3.0	0	0.0%	3800
Styrene	28	14.7%	5.0	0.0	0.3	0.0	0	0.0%	220
P-dichlorobenzene	141	74.2%	490.0	0.0	26.1	3.0	7	3.7%	240
TVOC	190	100.0%	1550.0	45.0	291.5	225.0	33	17.4%	400

Table 3 Measurement results of chemical compound concentration in the rainy season

	N=190		Indoor concentration (μg/m³)						guideline value in Japan
	Number of detection	Rate of detection	Max	Minimum	Average	Median	Number of excess	Rate of excess	
Formaldehyde	92	100.0%	146.0	6.1	31.8	25.7	1	1.1%	100
Acetaldehyde	68	73.9%	71.4	0.0	11.5	8.7	2	2.2%	48
Toluene	88	95.7%	125.3	0.0	21.9	17.7	0	0.0%	260
Xylene	17	18.5%	169.3	0.0	8.0	0.0	0	0.0%	870
Ethylbenzene	22	23.9%	42.0	0.0	2.8	0.0	0	0.0%	3800
Styrene	0	0.0%	0.0	0.0	0.0	0.0	0	0.0%	220
P-dichlorobenzene	8	8.7%	5510.0	0.0	84.6	0.0	4	4.3%	240
TVOC	92	100.0%	5757.8	21.1	220.7	90.4	7	7.6%	400

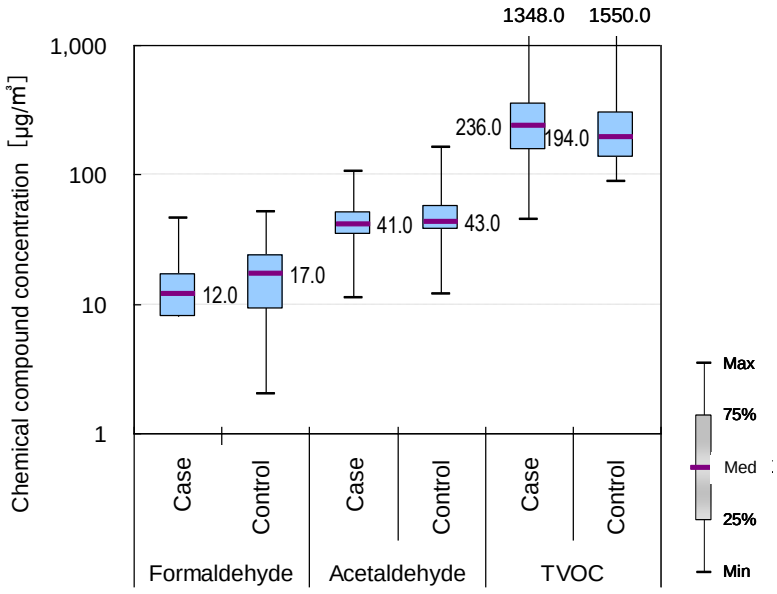

Fig. 3 Statistical value of the chemical compound concentration in winter

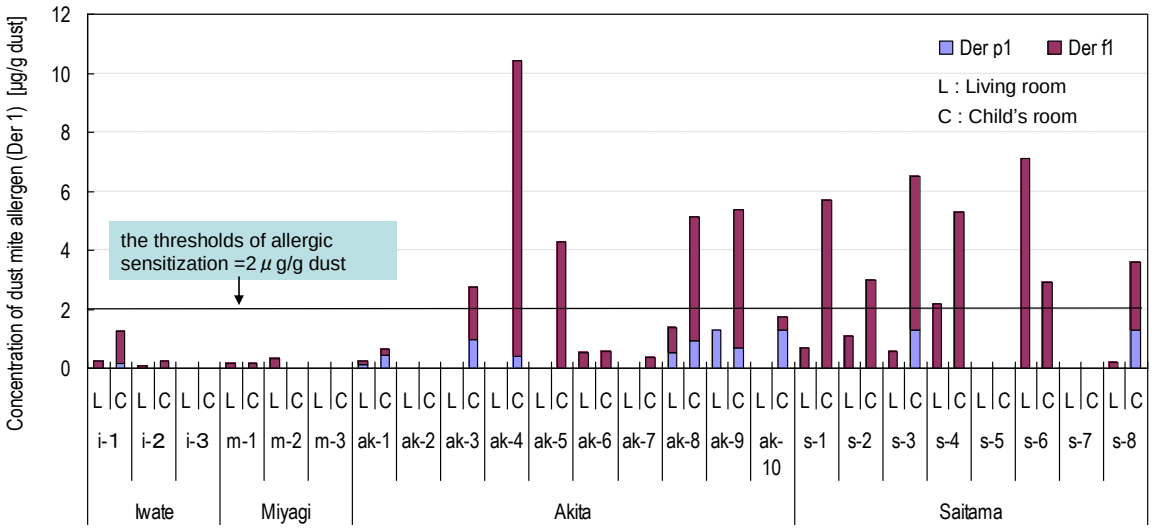

Fig. 4 Concentration of dust mite allergen (Der 1) in the winter

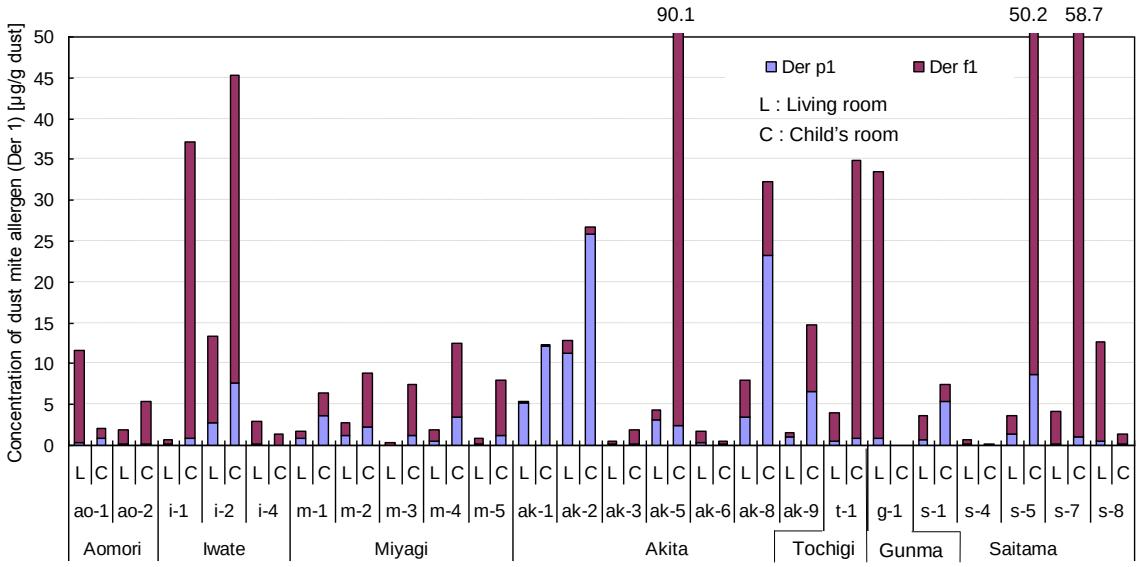

Fig. 5 Concentration of dust mite allergen (Der 1) in the rainy season

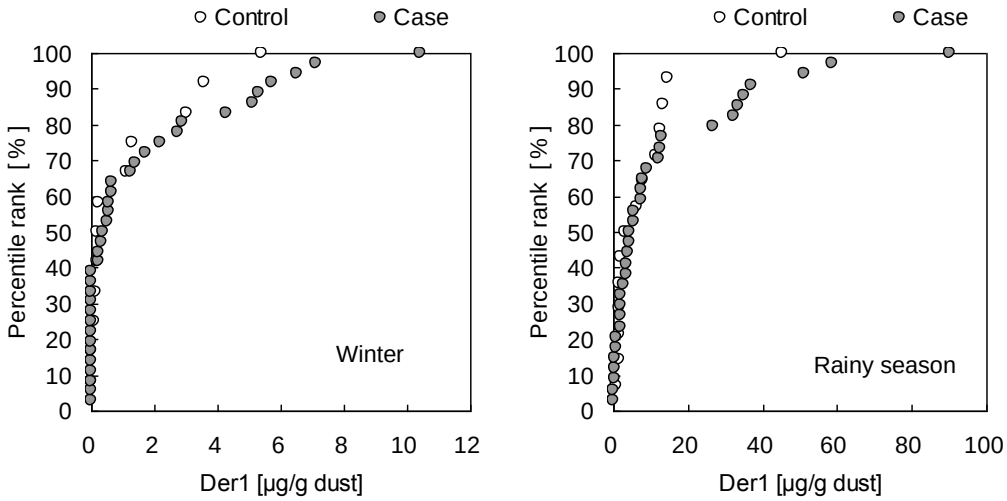

Fig.6 Percentile rank of concentration of dust mite allergen (Der 1)