INDOOR AIR POLLUTION AND CHEMICAL SENSITIVITY
- Measurement of indoor pesticide levels in the northern island of Japan -

S Nakai[1], Y Yanagisawa[2], Y Ichibe[3], T Namba[3], S Ishikawa[3], Y Nishioka[4], J Vallarino[4] and J Spengler[4]

[1] Yokohama National University & CREST, JST, Japan
[2] University of Tokyo, Japan
[3] School of Medicine, Kitasato University, Japan
[4] Harvard School of Public Health, U.S.A.

ABSTRACT

As the first step in an epidemiological study on chemical sensitivity, the indoor pesticide and other contaminant levels related to chemical sensitivity (HCHO, VOCs) were measured at approximately thirty houses in Hokkaido. The houses were divided into two groups. Group 1 houses were constructed with commercially available materials. For group 2 houses, if a low-emitting (VOC) material could be identified that performs as well as the standard material, the lower-emitting material was selected. Measurements were conducted for one week during the winter and early spring of 1998. Several eye examinations expected to be objective measurements of chemical sensitivity were also conducted in July 1998. For the two chemicals, tri-butyl phosphate and di-2-etylhexyl phthalate, group 1 levels are generally higher than group 2. On the other hand, the mean di-butyl phthalate concentrations are much higher in group 2 than group 1. Some indexes of pupillray light reflex were different between groups. The results show that some differences in indoor environment and health conditions between group 1 and 2 are observed, but the causes are unknown. It is necessary to conduct a follow-up study and to establish a good epidemiological design to investigate the relationship between indoor environment and chemical sensitivity.

INTRODUCTION

Recently, chemical sensitivity due to the exposure to chemical pollutants emitted from several indoor sources such as building materials and furniture has been becoming the focus of public concern [1]. Chemical sensitivity, frequently called “multiple chemical sensitivity” or “MCS”, is a clinical phenomenon in which individuals, after acute or intermittent exposures to one or more chemicals, commonly organophosphate pesticides, report that they become overly sensitive to a wide variety of chemically-unrelated compounds, which can include ethanol, caffeine and other psychotropic drugs [2-4]. Although many clinical observations of patients with chemical sensitivity have been reported, epidemiological knowledge about chemical sensitivity, i.e. how many patients exist and which factors contribute to the incidence of chemical sensitivity, is still unclear [5]. As the first step in an epidemiological study on the relationship between indoor environment and chemical sensitivity, we measured several air pollutant levels related to chemical sensitivity inside several residences and investigated the relationship between house construction type and other house characteristics, and pollutant levels. Several eye examinations expected to be objective measurements of chemical sensitivity were also conducted to check the feasibility of objective tests of chemical sensitivity in the field study.

MATERIALS AND METHODS

Approximately thirty houses in Hokkaido, a northern island of Japan, were selected as the study subjects. In Hokkaido, houses are required to be better sealed and insulated than in other regions of Japan. The sealing and insulation of houses is strongly related to indoor air pollution as well as comfortable housing in especially cold climates. The houses are divided into two groups. Group 1 houses are constructed using commercially available materials, which are selected without regard to their pollutants emission characteristics, such as HCHO and VOCs. For group 2 houses, if a low-emitting material can be identified that performs as well as the standard material, the lower-emitting material is selected. All houses are constructed within one year. Indoor pesticides (organophosphates) and phthalic ester considered as plausible causal pollutants for chemical sensitivity are measured. Measurements were conducted for one week during the winter and early spring of 1998. One sorbent sample tube (SKC, Catalog no.226-01) connected to a Pocket Pump (SKC, 210-1002) was placed inside each house. Approximately 1 m^3 indoor air was collected by the pump (100 ml/min). Concentrations of organophosphates and phthalic ester were analyzed by GC/MS. Duplicate samplers were set in several houses to investigate the reliability of the measurements. House characteristics which might be related to indoor levels of air pollutants were investigated using a questionnaire. HCHO and VOCs were also measured in both groups during the same measurement period [6]. Concentrations of organophosphates and phthalic ester by house construction type are described as well as measurement reliability and the relationship among pollutants.

Several eye examinations such as pupillary light reflex, smooth pursuit movement (SPM) and modulation transfer function (MTF) [7] were also conducted in July 1998. The subjects in the health study were part of the residents who participated in the measurement study. Each participant was requested to come to a public hall close to his/her house. Each examination was conducted by a eye doctor. Pupillary light reflex was measured by open-loop pupillography (binocular Iriscorder C2514 Hamamatsu Photonics). The details of the examinations and their applicability in the clinical and field survey are written in another paper [8]. Respiratory and other symptoms related to chemical sensitivity were checked using a questionnaire which was newly developed. In this paper, summary statistics of initial pupil area (A1) and time to recover to 63 % of pupil area change after light stimulus (T5) of pupillary light reflex are briefly reported.

RESULTS

Measurement study

The number of houses was fifteen for group 1 and twelve for group 2. Tri-butyl phosphate (TBP), tris(2-chloroethyl) phosphate (TCEP), chlorpyrifos, di-ethyl phthalate (DEP), di-butyl phthalate (DBP), and di-2-etylhexyl phthalate (DEHP) were the pollutants measured in the study.

Reliability of the samples is shown in Table 1. We used intraclass correlation coefficient as a measure of the reliability. The values of intraclass correlation coefficients were very high. This table shows that the measurements were reliable, and might be valid. For DEHP, the coefficient is lower than the others. The reason may be that one sample of several pairs are under the detection limit and the number of samples under the detection limit was more than the others. Mean values of duplicate samples are used as the indoor levels for the representative house in the following analyses. The values less than the detection limit were considered as zero.

Table 1. Intraclass correlation coefficients (n=15)

TBP	0.985
TCEP	0.965
Chlorpyrifos	1.000
DEP	0.966
DBP	0.997
DEHP	0.835

Summary statistics of pollutant levels are described in Table 2. Most of the values were under the detection limit for TCEP, chlorpyrifos and DEP. It is not a good idea to consider statistically the distributions and related factors for these chemicals, however it will be necessary to investigate the emission sources related to the concentration of these chemicals specifically. Mean TBP concentrations are 61.1 ng/m^3 for group 1 and 13.2 ng/m^3 for group 2, and mean DEHP levels are 337.7 ng/m^3 for group 1 and 59.3 ng/m^3 for group 2. For these two chemicals, group 1 levels are generally higher than group 2. On the other hand, mean DBP concentrations are 15,503 ng/m^3 for group 2 and 625 ng/m^3 for group 1. The maximum value in group 1 houses is almost the same as the minimum value in group 2 houses.

Table 2. Indoor pesticide and other contaminant levels stratified by house type (ng/m^3)

	Group 1 Houses (n=15)					Group 2 Houses (n=12)				
	Mean	s.d.	25%	50%	75%	Mean	s.d.	25%	50%	75%
TBP	61.1	135.8	8	13	52	13.2	11.8	4.8	10.8	15
TCEP	0.7	1.9	0	0	0	0.7	2.5	0	0	0
Chrolpyrifos	1.6	6.2	0	0	0	0	0	0	0	0
DEP	0	0	0	0	0	118	283	0	0	116.3
DBP	625	3985	197	553	825.5	15503	15151	6984	9856.3	19723
DHP	337.7	255.2	159.5	239	469.5	59.3	66.5	4.5	100.5	208.5

Because the distributions of these chemicals are skewed, Spearman's rank correlation coefficients between chemicals are calculated and shown in Table 3. The upper values of the table are for group 1 houses and the lower values are for group 2. Correlation coefficients are relatively low for both groups. However, the correlation pattern in each group seems to be different. The relationship between DBP and DEHP is moderately high in group 1 (r=0.621), but less related in group 2 (r=-0197). DBP may be used for some materials selectively in group 2 houses.

Table 3. The relationship between the chemicals (Spearman's rank correlation coefficient)

Coefficient (p value)	TBP	TCEP	Chlorpyrifos	DEP	DBP	DEHP
TBP		-0.018 (0.950)	-0.062 (0.827)	-	0.079 (0.781)	0.393 (0.148)
TCEP	-0.306 (0.334)		-0.133 (0.637)	-	-0.090 (0.751)	-0.453 (0.090)
Chlorpyrifos	-	-		-	-0.371 (0.173)	-0.247 (0.374)
DEP	-0.158 (0.624)	-0.208 (0.517)	-		-	-
DBP	0.266 (0.404)	-0.480 (0.114)	-	0.591 (0.043)		0.621 (0.013)
DEHP	-0.035 (0.914)	0.044 (0.892)	-	0.084 (0.796)	-0.197 (0.539)	

Upper values: Group 1 houses Lower values: Group 2 houses
-: all of the values (chlorpyrifos or DEP) are zero

Health study

Thirty eight persons participated in the health study. Mean age of group 1 is 29.2 years old and 44.2 for group2. Figure 1 shows group means of initial pupil area (A1). Means of initial pupil area for both eyes in group 1 are greater than in group 2. In group 1 houses, mean values were 46.7 mm^2 (s.d. 11.1 mm^2) for right eye and 44.5 mm^2 (s.d. 9.6 mm^2) for left eye. In group2, 35.7 mm^2 (s.d. 9.2 mm^2) for right eyes and 36.7 mm^2 (s.d. 11.1 mm^2) were reported.

Mean T5s for group 1 (1629.8 msec (s.d. 782.4 msec) for right eye and 1651.7 msec (s.d. 852.4 msec) for left eye) were also higher than group 2 (999.0 msec (s.d. 782.4 msec) for right eye and 1247.8 msec (s.d. 673.6 msec) for left eye).

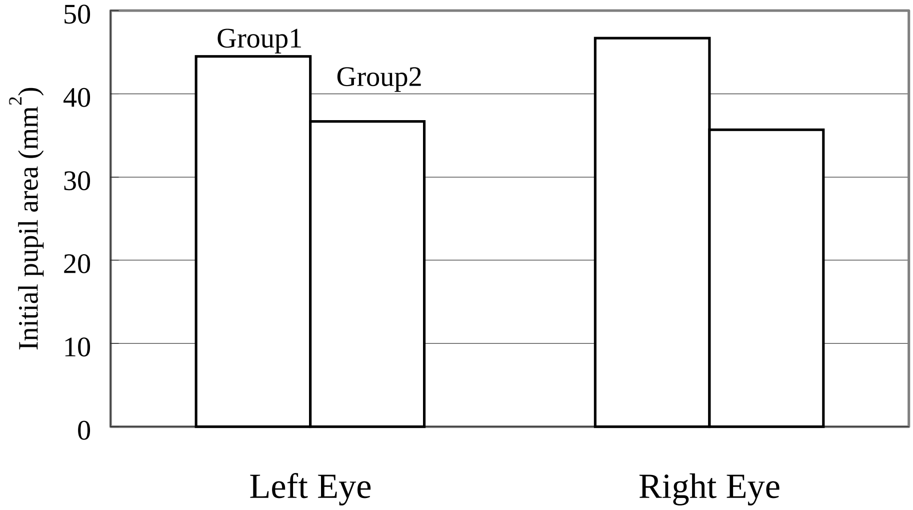

Figure 1. Means of initial pupil area (A1) for both eyes by group

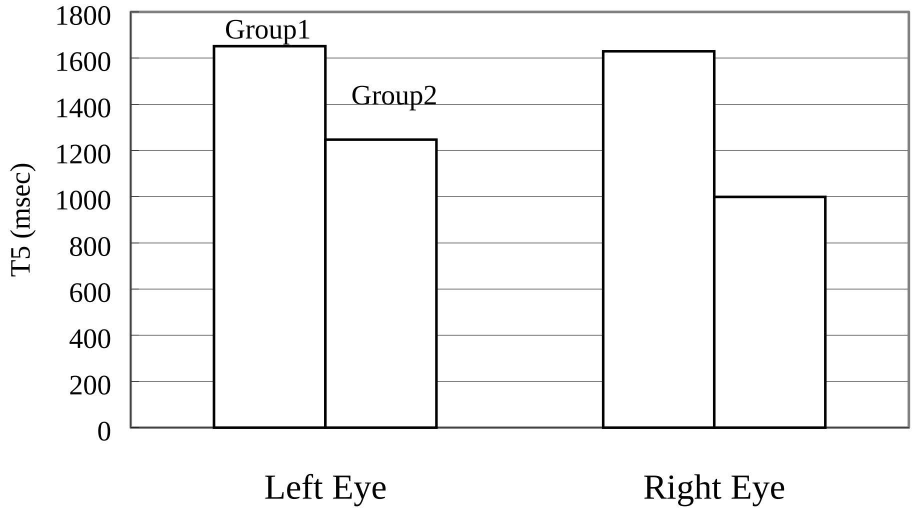

Figure 2. Time to recover to 63 % of A3* after dilation from minimum state (T5) by group
* Pupil area change after light stimulus

DISCUSSION

The results show some differences in indoor environment between group 1 and group 2, but the causes are unknown. Collation of concentration measurement, house characteristics, and health assessment data are still ongoing. When the whole data is compiled, it will be necessary to consider the distribution of chemicals among groups and the factors contributing to the indoor environment in detail. The measurements were conducted only one time in winter. It is necessary to conduct a follow-up study and to investigate the difference in indoor environment according to construction type. Measurements of other chemical levels may be also needed.

The results of pupillary light reflex may be different among groups, although no adjustments for the comparison of the means were conducted. However, it is impossible to say any conclusion about the relationship between house construction type and chemical sensitivity, because the study was not well designed epidemiologically. It will be necessary to establish a good design of the epidemiological study on chemical sensitivity related to indoor environment based on the study of this study. Houses as total systems that affect for human health, as well as indoor pollution, should be also considered in the neighboring community.

ACKNOWLEDGEMENTS

This study was supported by Winter Research Institute, Co. and CREST (Core Research for Evolutional Science and Technology), JST (Japan Science and Technology Corporation). The cooperation of the participating families is greatly appreciated.

REFERENCES

1. Ishikawa, S. 1998. Unidentified complaints by chemical substances: Diagnostic criteria of the multiple chemical sensitivity (in Japanese). *Jpn. J. Psychosom. med.* Vol. 38, pp 95-102.
2. Cullen, MR. 1987. Workers with multiple chemical sensitivities. *Occup. Med. State Art Rev.* Vol 2., pp 655-806.
3. Ashford, N A and Miller, C S. 1989. Chemical sensitivity. *A report to the New Jersey State Department of Health.*
4. Overstreet, D H, Miller, C S, Janowsky, D S and Russell, RW. 1996. Potential animal model of multiple chemical sensitivity with chlinergic supersensitivity. *Toxicology.* Vol. 111, pp 119-134.
5. Miller, C S. 1996. Chemical sensitivity: symptom, syndrome or mechanism for disease? *Toxicology*. Vol. 111, pp 69-86
6. Vallarino, J, Spengler, J, Nishioka, Y and Yanagisawa, Y. 1999. Evaluation of material selection as a strategy for improving indoor air quality in new residential construction. *Proceedings of the 8th International Conference on Indoor Air Quality and Climate – Indoor Air '99.*
7. Shirakawa, S, Rea, W J, Ishikawa, S and Johnson, AR. 1991. Evaluation of the autonomic nervous system response by pupillographical study in the chemically sensitive patient. *Environ. Med.* Vol. 8, pp 121-127.
8. Ishikawa, S, Miyata, M, Namba, T, et al. An Application of neuro-ophthalmological examinations to establish the diagnosis of human hazards caused by sick building/house syndrome. *Proceedings of the 8th International Conference on Indoor Air Quality and Climate – Indoor Air '99.*