

EXPOSURE ASSESSMENT OF CHEMICAL SENSITIVITY PATIENTS

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ABSTRACT

We measured the personal exposure levels of chemical sensitivity (CS) patients. The objective of the study is to understand the variations in the patients' personal exposure levels and to investigate the relationship between exposure levels and the recuperation of CS symptoms.

Subjects were all female CS patients. This study examined aldehydes and volatile organic compounds (VOCs). Personal exposure levels and indoor and outdoor concentrations were measured over one-week periods nearly every month since autumn 2000. Measurements continued for at least six months.

Personal exposure levels were nearly identical to the indoor concentrations, and the levels were less than Japan's indoor air guideline. Personal exposure levels did not decrease over the measurement periods while formaldehyde levels increased from winter to summer. Severity scores decreased and no positive relationship was observed between the exposure levels and the recuperation of CS symptoms.

INDEX TERMS

Chemical sensitivity (CS), Exposure assessment, Aldehydes, VOCs, Longitudinal measurement

INTRODUCTION

It is defined that chemical sensitivity (CS), an increasingly common clinical phenomenon in which individuals report hypersensitivity to a wide variety of chemically-unrelated compounds, is caused by low-level and long-term exposure or very high exposure to some chemical(s) (Cullen 1987). Many researchers have studied the mechanism of CS and methods for its diagnosis, cure, and care (Meggs et al 1996, Gibson et al 2003). However, the relationship between chemical exposures and CS remains unknown. We measured the personal exposure levels of CS patients. The objective of the study is to understand the variations in the patients' exposure levels and to investigate the relationship between exposure levels and recuperation of CS symptoms.

RESEARCH METHODS

We selected female CS patients as study subjects. Selection criteria included diagnosis at Kitasato Institute Hospital just before entry into the study; age under 60 years; and no occupational exposure to chemicals. Accordingly, chemical emissions at home—from housing materials and/or furniture—may be associated with the patients' onset of CS. During a hospital consultation, staff explained the purpose of the study and invited patients to participate. Patients voluntarily decided whether or not to become study subjects. Written consent for study participation was obtained from each subject.

This study examined VOCs and aldehydes. Indoor and outdoor concentrations were measured over one-week periods nearly every month since autumn 2000. Personal exposure levels to aldehydes were also measured during each measurement period. A passive gas tube for organic solvents (Sibata Scientific Technology Ltd., No.8015-066) was used to analyze VOCs and a Sep-Pak XPoSure aldehyde sampler (Waters Corporation, No.047205) was used for aldehyde sampling. VOCs, extracted from activated charcoal using CS₂, were analyzed by gas chromatography-mass spectrometry (GC-MS). Aldehydes were eluted with acetonitrile and analyzed by high performance liquid chromatography (HPLC). Measurements continued for at least six months. For indoor measurements, samplers were placed in a living room and a bedroom.

Subjects were asked to keep a daily symptom diary during each measurement period. The diary includes ten

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symptom-related questions adopted from the Quick Environmental Exposure and Sensitivity Inventory (QEESI) (Miller and Prihoda 1999). The QEESI rates the severity of symptoms on a 0-10 scale, but our diary only asked subjects to indicate (yes/no) whether they were experiencing symptoms. Each patient was asked to fill in the diary every night during VOC and aldehyde measurement periods. The total number of positive (“yes”) answers for each measurement period, referred to as the “diary score,” relates to the severity of symptoms.

Active and passive sampling of VOCs and aldehydes was conducted to find chemicals responsible for the onset of symptoms related to CS. The measurements were taken during one week in autumn 2001. Subjects were asked to carry a pump with two cartridges for VOCs and aldehydes for active sampling method and two passive samplers for the passive sampling method for one week. Subjects were asked to turn on the pump at the moment any symptoms appeared and to switch it off when the symptoms disappeared. If the concentrations of some particular compounds were higher in the active sampling method than passive sampling, those compounds are suspected as responsible chemicals for CS (Shinohara et al. 2004). This sampling method focuses on the short-term relationship between chemical exposures and CS.

We describe the longitudinal change of VOC and aldehyde concentrations and also discuss the relationship between the concentrations and the diary score.

RESULTS AND DISCUSSION

We followed six CS patients, the characteristics of whom are shown in Table 1. All subjects are house wives with an age range of 34-51 years. Four patients live in detached houses and three patients live in reinforced concreted houses. House ages range from 1 month to 1.3 years. The ages of each patient and house were recorded during the first measurement. The QEESI was administered during the first and second consultations at the Kitasato Institute Hospital. Questions about the patient’s condition before the onset of CS are included in the QEESI, allowing a comparison of QEESI scores over time. While QEESI scores varied among patients, each patient’s highest score was recorded during the first consultation. This suggests that patients’ CS-related symptoms may be most pronounced at the time of onset followed by a decrease in the severity of symptoms over time.

Table 1. Characteristics of the six patients

Patient ID	Age (yrs)	Occup.	House structure	Age of house	QEESI Score		
					Before onset	First consultation	Second consultation
A	51	HW	RC detached	1.3 years	3	33	24
B	36	HW	RC apartment	4 months	12	62	---*
C	41	HW	RC apartment	6 months	6	25	10
D	34	HW	Wooden detached	1.5 years	13	20	13
E	43	HW	Wooden detached	7 months	10	13	---*
F	34	HW	Wooden detached	1 month	2	53	11

HW: House wife, RC: Reinforced concrete

* No second consultation

Figure 1 shows the formaldehyde concentrations in the living room, bedroom, and outdoor air at patient-A’s home. We can only describe the results about patient-A, because of the page limitation. However, the results of longitudinal measurements for other five patients were similar as patient-A. Measurements for this patient were taken between November 2000 and November 2001. Formaldehyde concentrations in the living room and the bedroom were similar; the concentrations are less than the indoor air guideline in Japan (80 ppb). Outdoor concentrations were lower than indoor concentrations throughout the measurement periods. Indoor and outdoor concentrations increased from winter to summer.

Acetaldehyde was also analyzed (results not shown). Acetaldehyde concentrations in the living room and bedroom were almost the same; the levels were less than 20 ppb. No seasonal trend was observed for acetaldehyde.

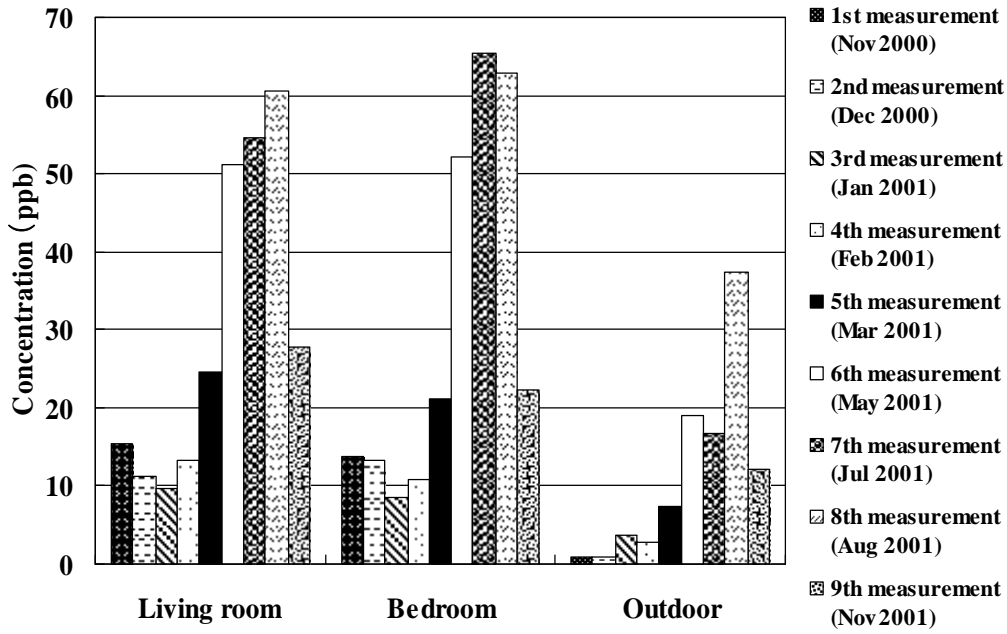


Figure 1. Formaldehyde concentrations at patient A's home

Figure 2 shows personal exposure levels for patient A. The personal exposure levels and the corresponding time trend were nearly identical to the indoor concentrations. Figure 2 also shows the diary scores, indicated as a solid line. Each diary score represents the total for the week during that measurement period. The highest score, obtained during the first measurement period, was 15. The diary scores decreased over the measurement periods, even though formaldehyde exposure levels increased. Thus, no positive relationship between formaldehyde levels and the recuperation of CS symptoms was observed. Several reasons for this may be considered: (1) The patient may have developed a tolerance to the chemicals during the study; (2) Other chemicals may be responsible for the severity of CS symptoms; or (3) It may be difficult to evaluate the relationship between exposure levels and the severity of symptoms based on weekly observations.

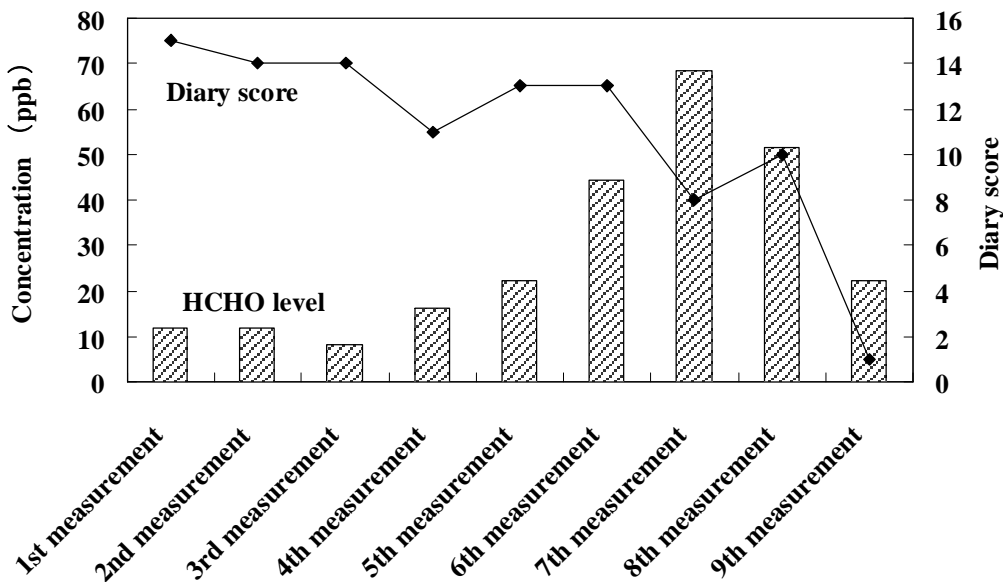


Figure 2. Personal exposure levels to formaldehyde and QEESI scores for patient A

Figure 3 shows the VOC levels for patient A's home. Due to laboratory trouble there are no data for the second measurement. At a concentration of 110 $\mu\text{g}/\text{m}^3$ (result not shown), the level of limonene during the 5th



measurement period (March 2001) was higher than the other periods. Concentrations of other VOCs, however, were relatively low throughout each period, considering the age of the house (1.3 years). No relationship between VOCs and the diary score was observed. The results for aldehyde and VOC measurements as well as diary scores for the other patients were similar to those of patient A.

Figure 4 shows the results of active and passive sampling of exposure levels for patient A. The measurement was taken during the 9th measurement period. The weekly average of formaldehyde (passive sampling) was 22.2 ppb while the actively sampled exposure level while she was experiencing symptoms was 38.6 ppb. This may show that formaldehyde is a chemical responsible for the onset of her symptoms and that the critical level for her health is approximately 40 ppb. The acetaldehyde level from the passive sampling was also slightly lower than the level from the active sampling; hence, acetaldehyde may also be a chemical responsible for CS-related symptoms. However, the 38.6 ppb formaldehyde level was less than the weekly averages during the summer (see Figure 1). As mentioned above, other chemicals may be responsible for the symptoms rather than formaldehyde, or the temporal change in formaldehyde levels may be more critical than the seasonal/monthly change. The possibility of “masking” (Rea 1992) should be also considered.

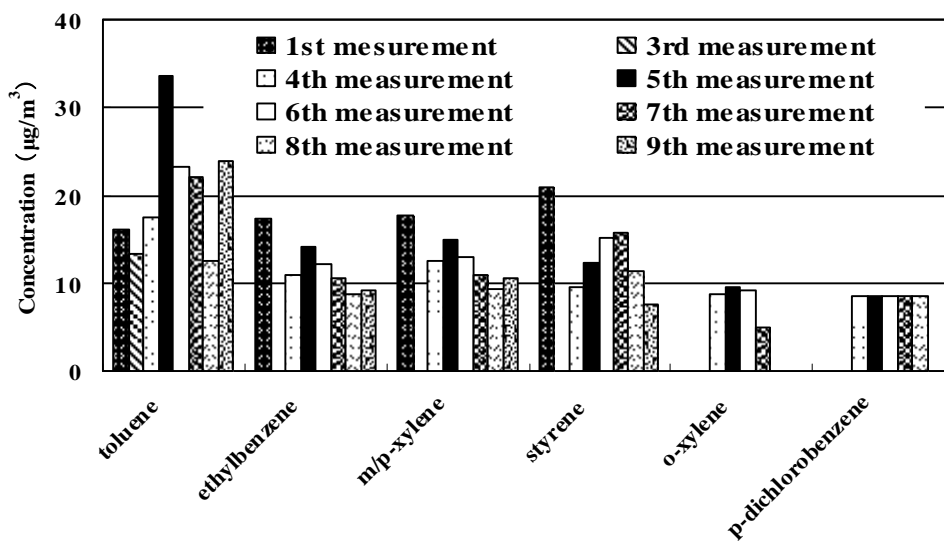


Figure 3. Living room VOC concentrations at patient A's home

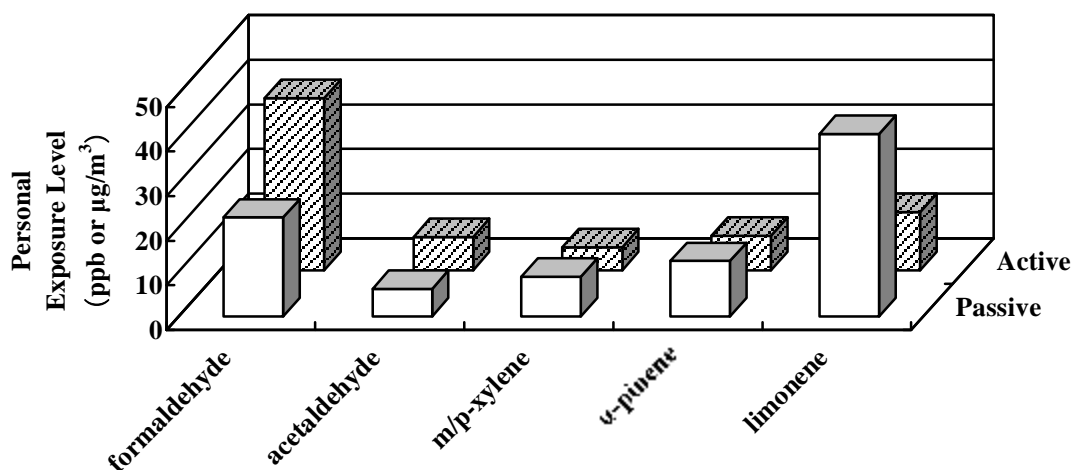


Figure 4. Results of active and passive sampling

Note: Formaldehyde and acetaldehyde are in ppb and m/p-xylene, α-pinene, and limonene are in µg/m³.



Furthermore, α -pinene and limonene levels from the passive sampling were higher than those from the active sampling. This may indicate that these two VOCs have preventive effects on CS, but this is an unrealistic interpretation. The results need more careful consideration.

Active and passive sampling for the other five patients (B-F) produced varied results and did not reveal any general rules that held across each patient.

CONCLUSION AND IMPLICATIONS

We investigated the longitudinal change of personal exposure levels for CS patients, and observed the seasonal/monthly trends in their personal exposure levels. No relationship between the recuperation of CS-related symptoms and the concentrations of aldehyde and VOCs was recognized; although, based on the results from active and passive sampling, some of the chemicals may be responsible for the symptoms. Further exposure assessment studies of CS patients are needed. CS patients present with various characteristics and exposure backgrounds. The selection criteria for study subjects and the measurement methods will be important factors in future studies.

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