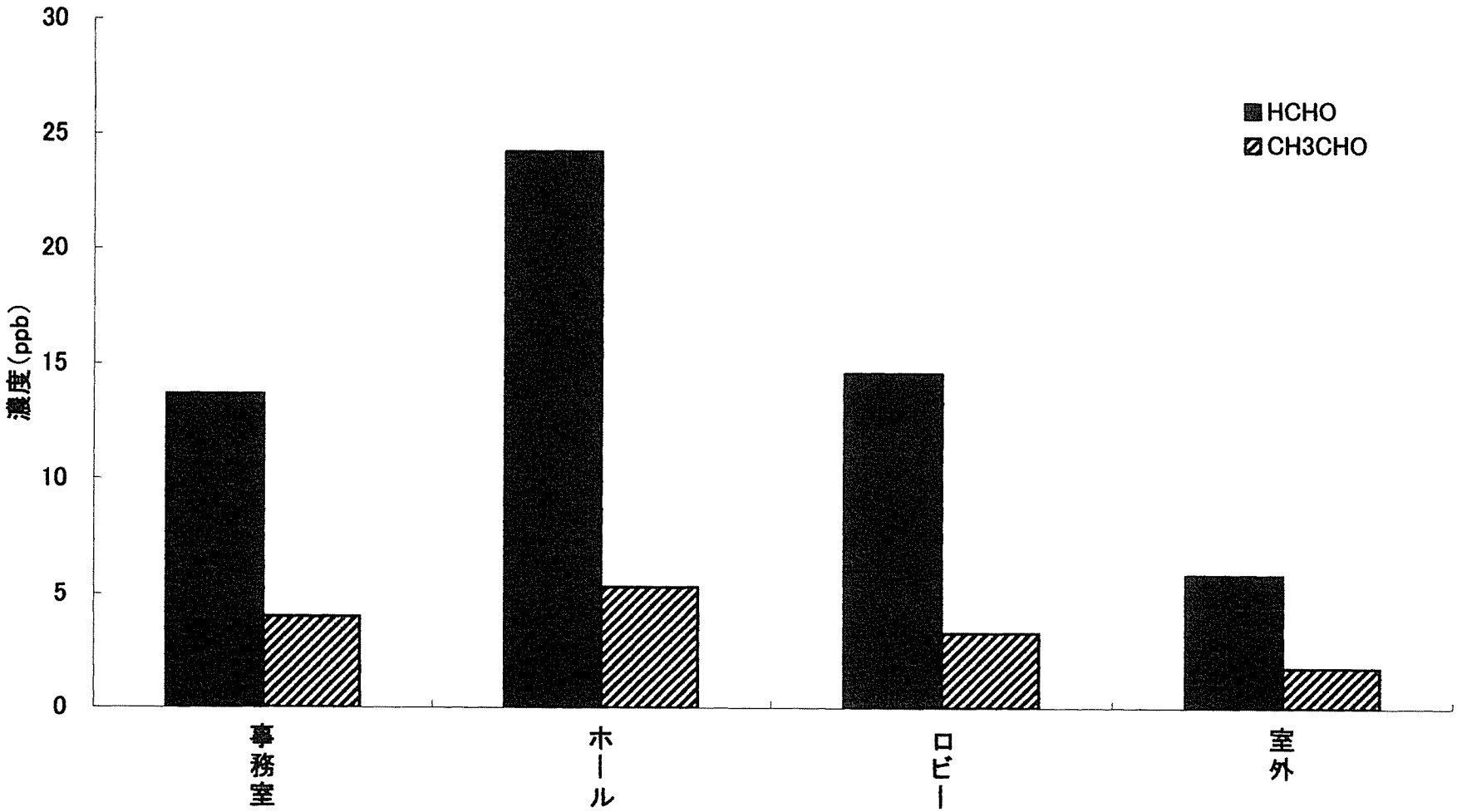

図26　音楽ホールにおけるアルデヒド類濃度比較

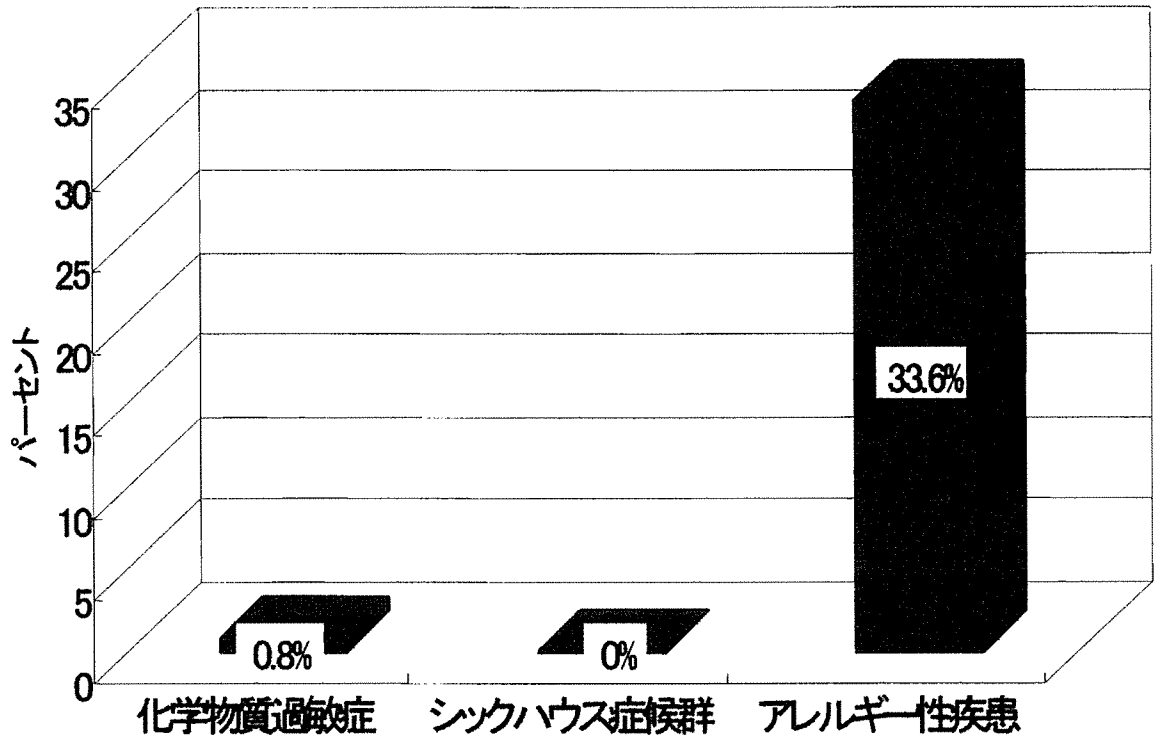

図27　診断されたことがある人の割合

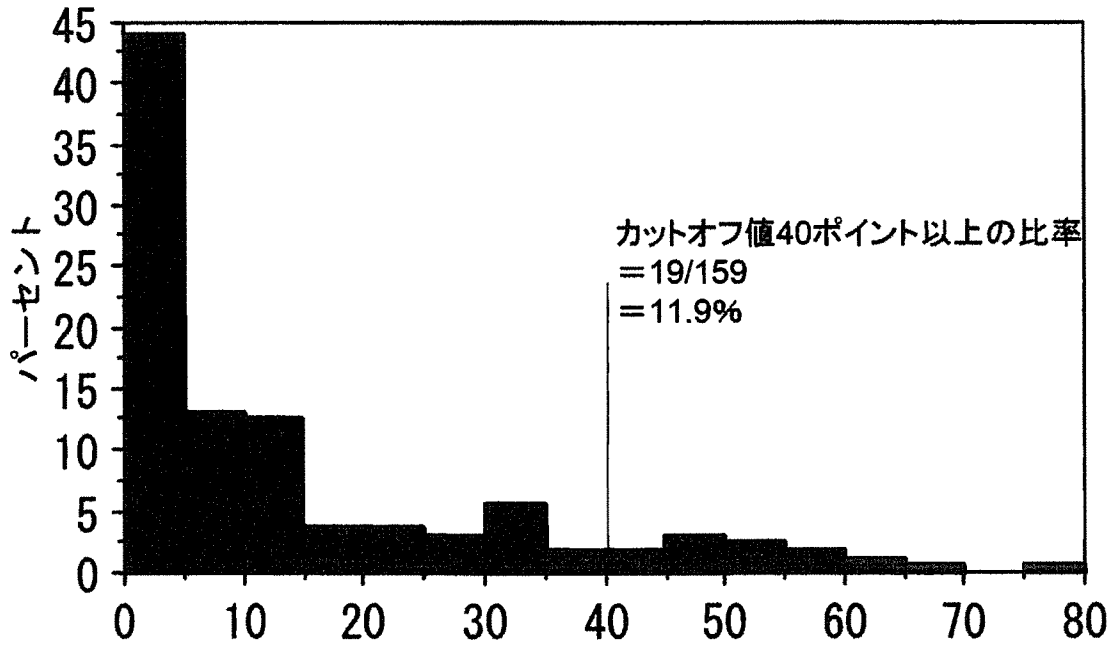

図28 「化学物質曝露による反応」についてのスコアの分布

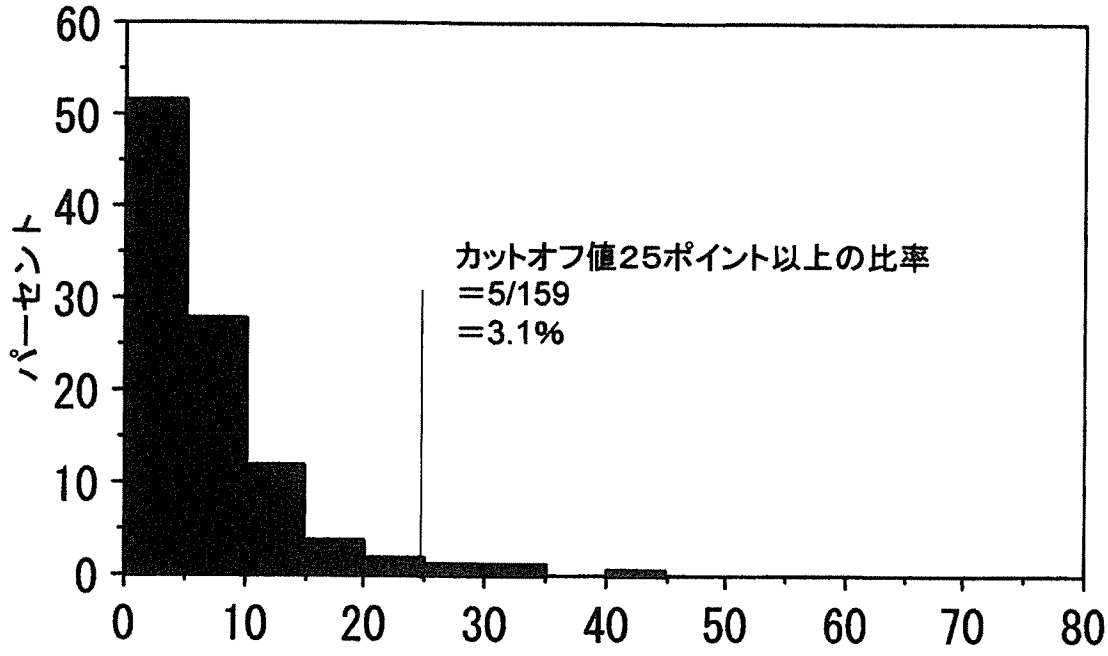

図29 「その他の化学物質曝露による反応」についてのスコアの分布

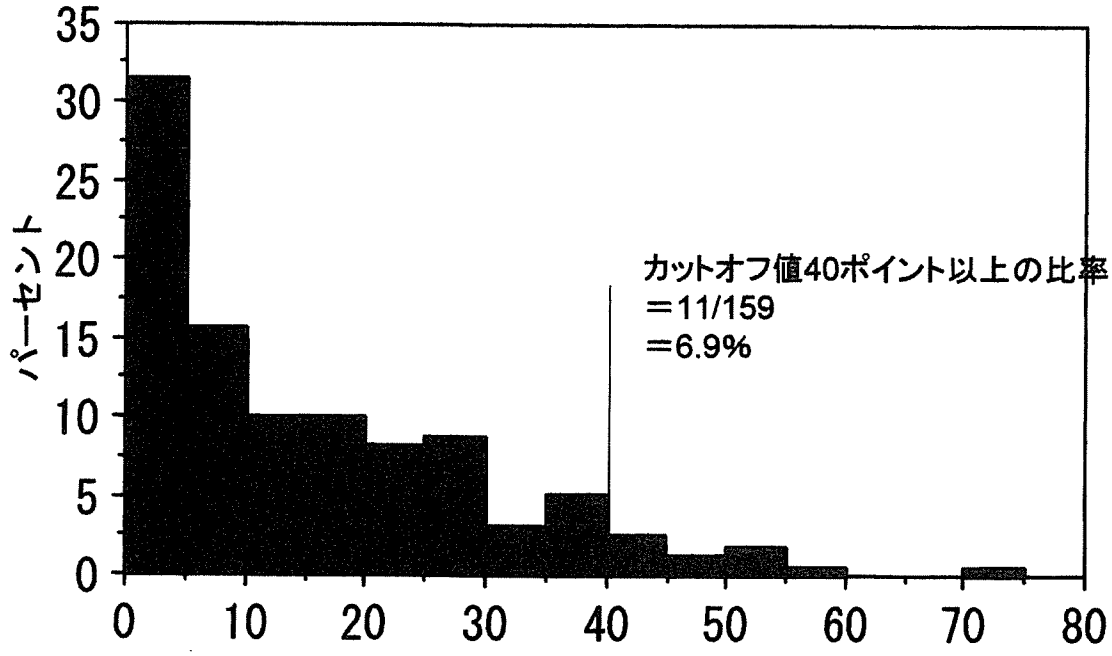

図30 「症状」についてのスコアの分布

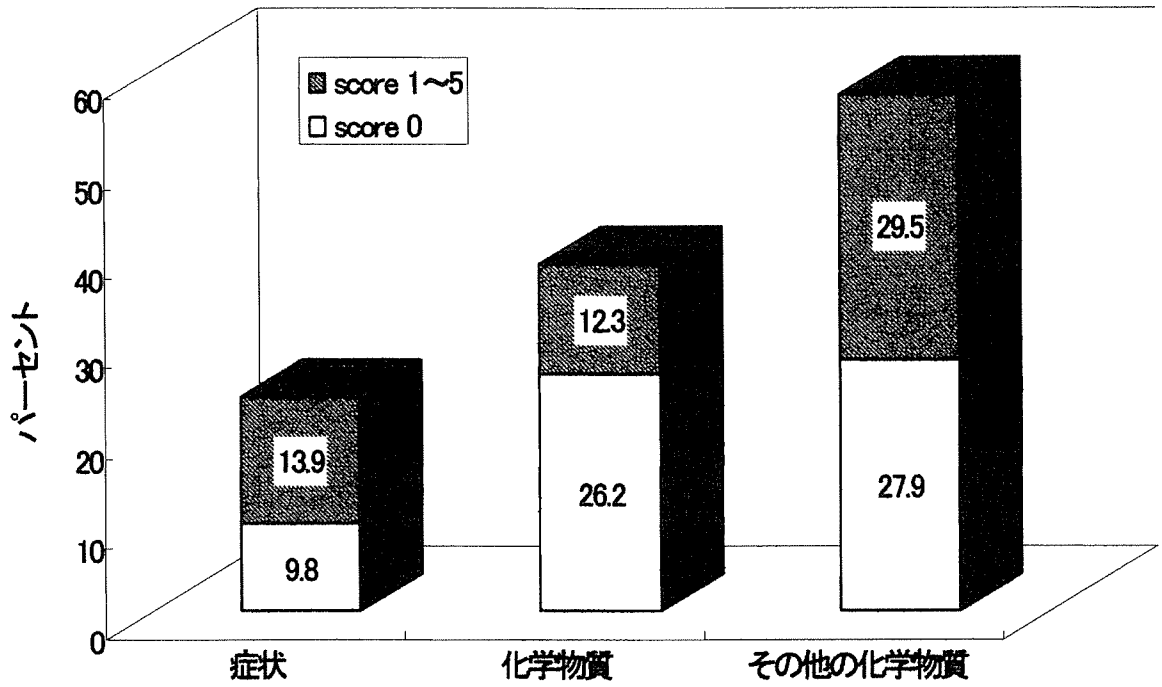

図31　3項目のスコアが0～5の人の割合

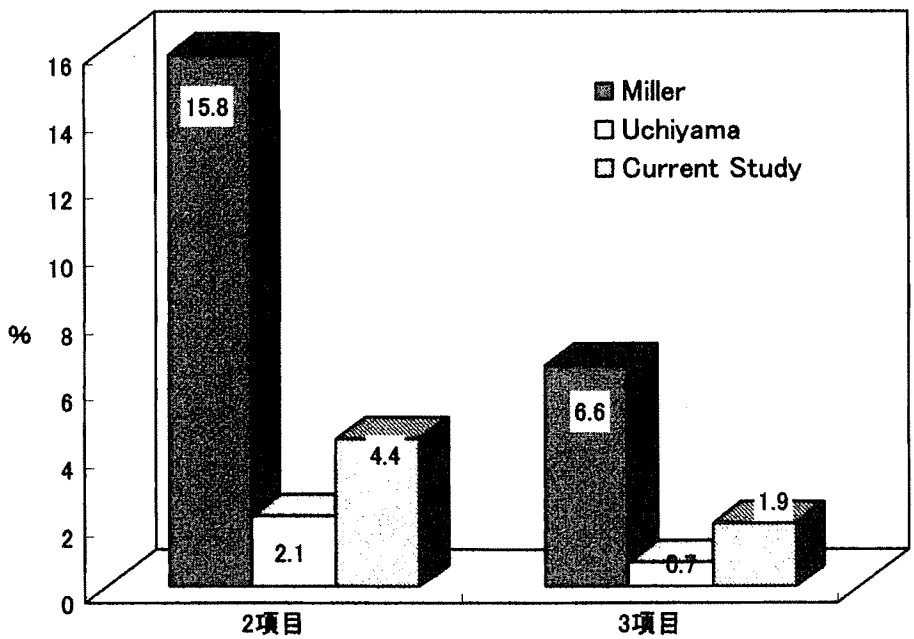

図32　カットオフ値を超えた人の割合の他の調査機関との比較

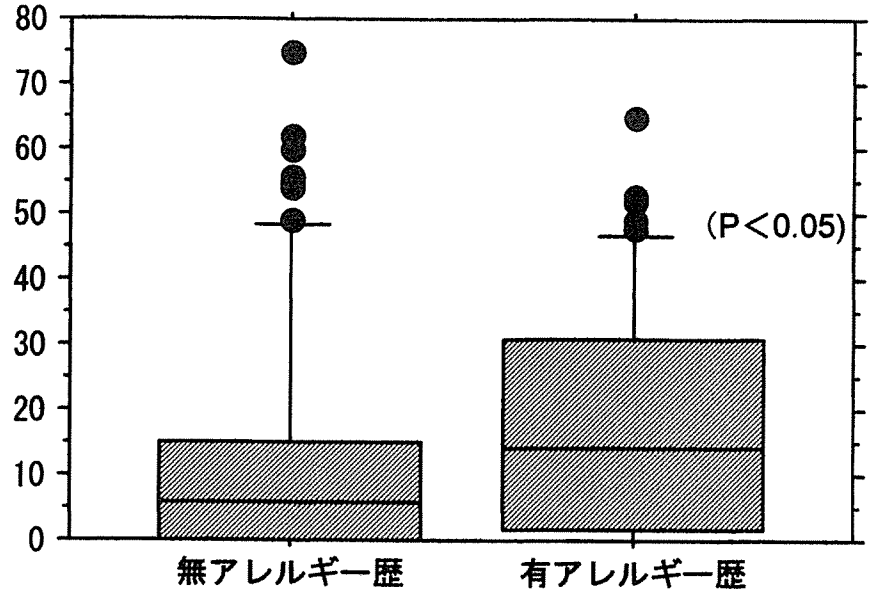

図33　アレルギー歴有無別の「化学物質曝露による反応についてのスコア」の分布

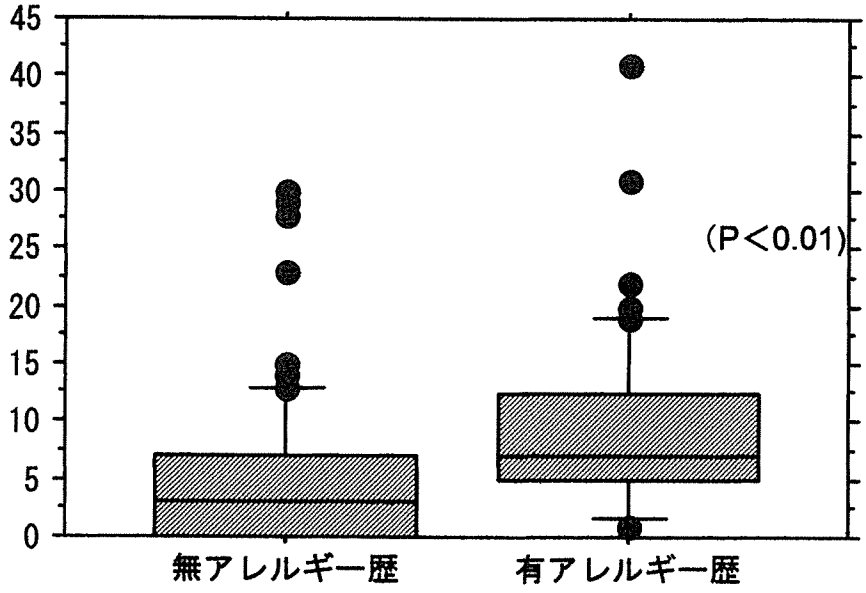

図34　アレルギー歴有無別の「その他の化学物質曝露による反応についてのスコア」の分布

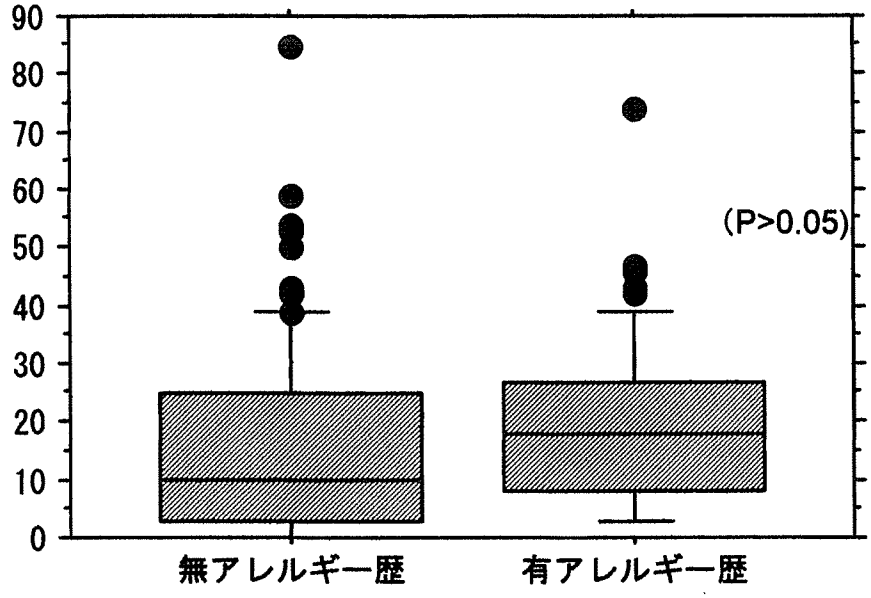

図35 アレルギー歴有無別の「症状についてのスコア」の分布

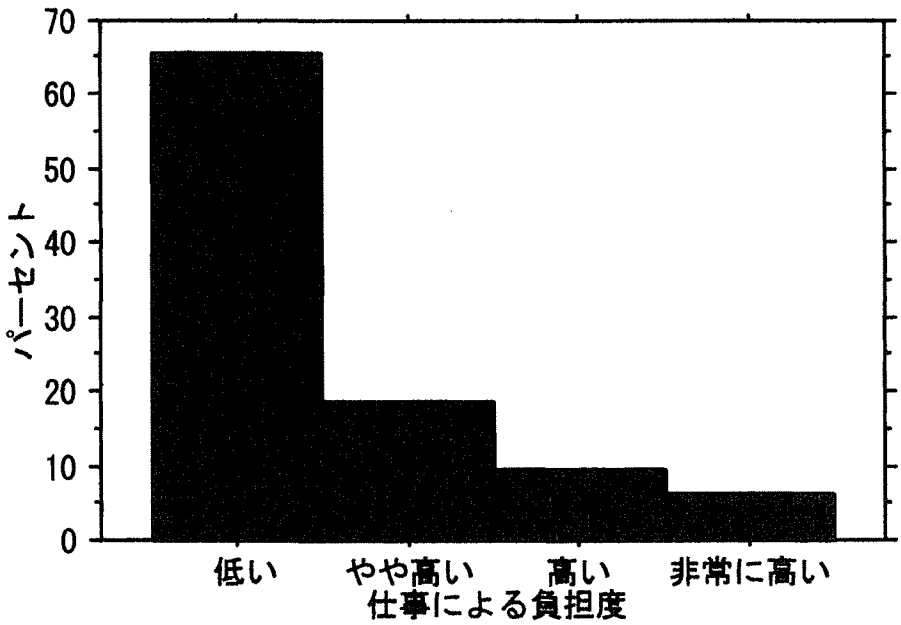

図36 仕事による負担度分布

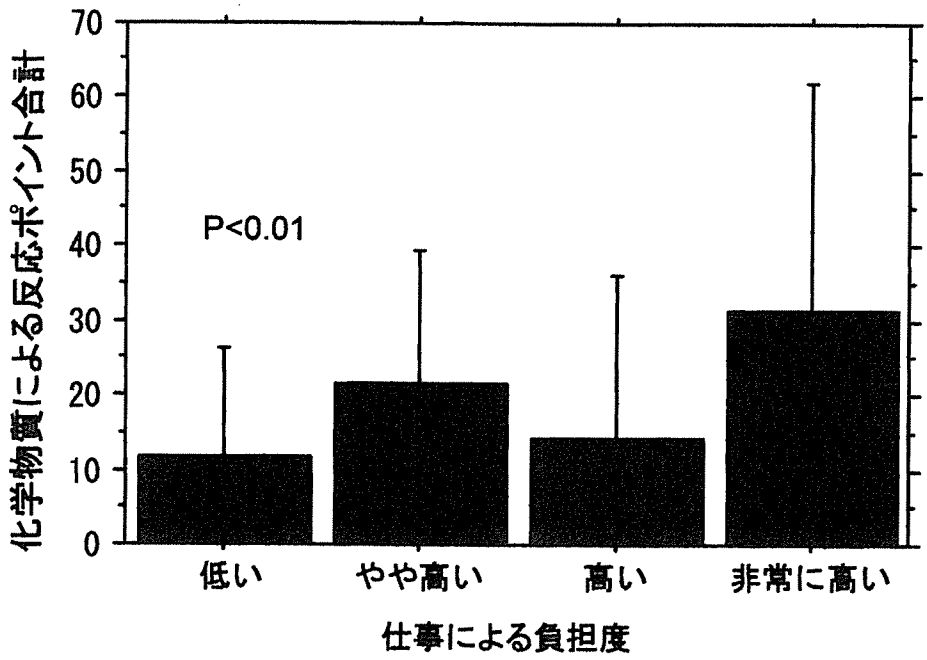

図37　仕事による負担度分類とMillerアンケートの「化学物質による反応」ポイントの分布

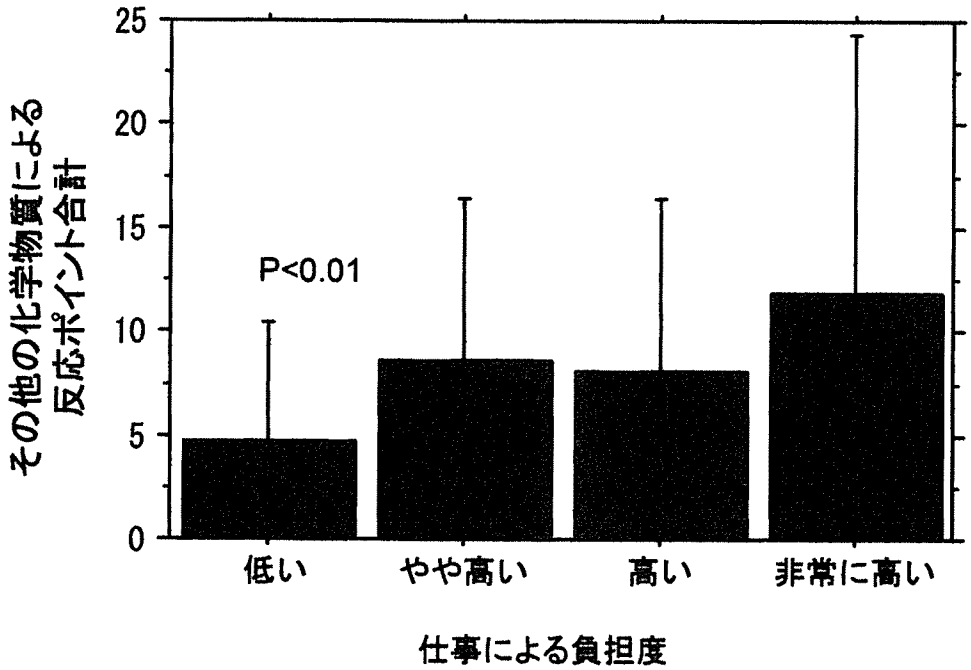

図38　仕事による負担度分類とMillerアンケートの「その他の化学物質による反応」ポイントの分布

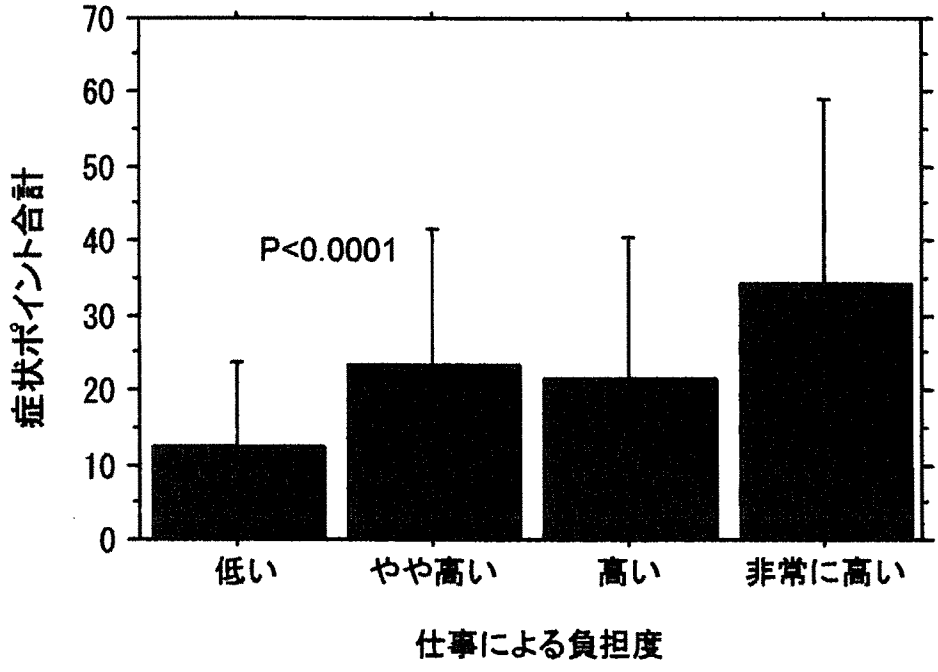

図39　仕事による負担度分類とMillerアンケートの「症状」ポイントの分布

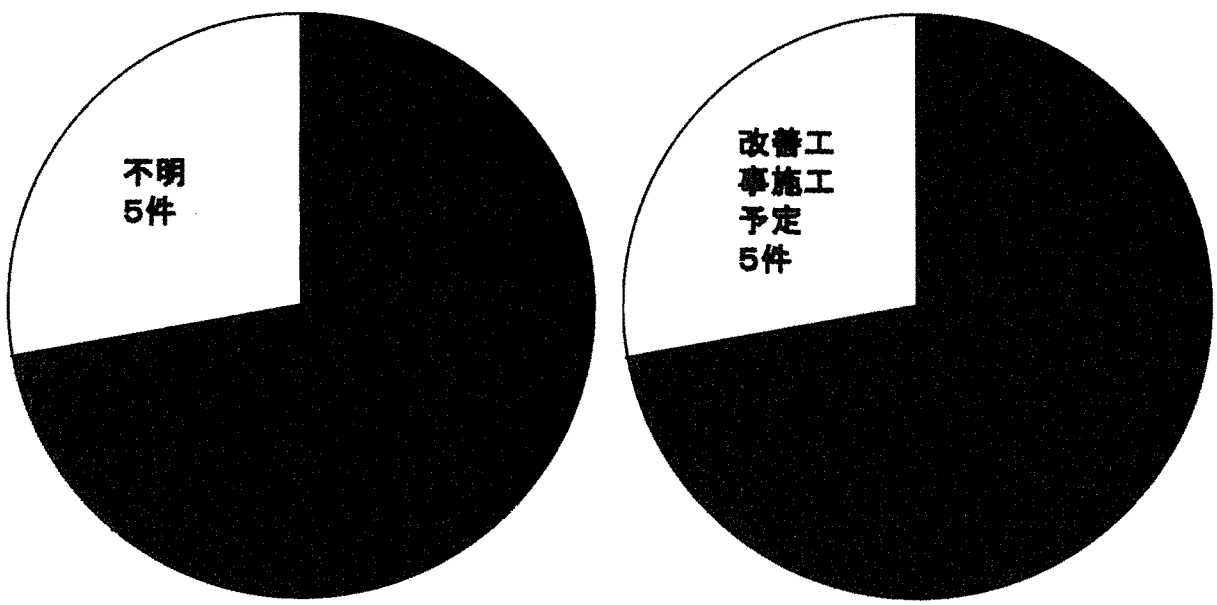

図40　アスベスト類使用18施設中の使用種別（左図）と対策（右図）

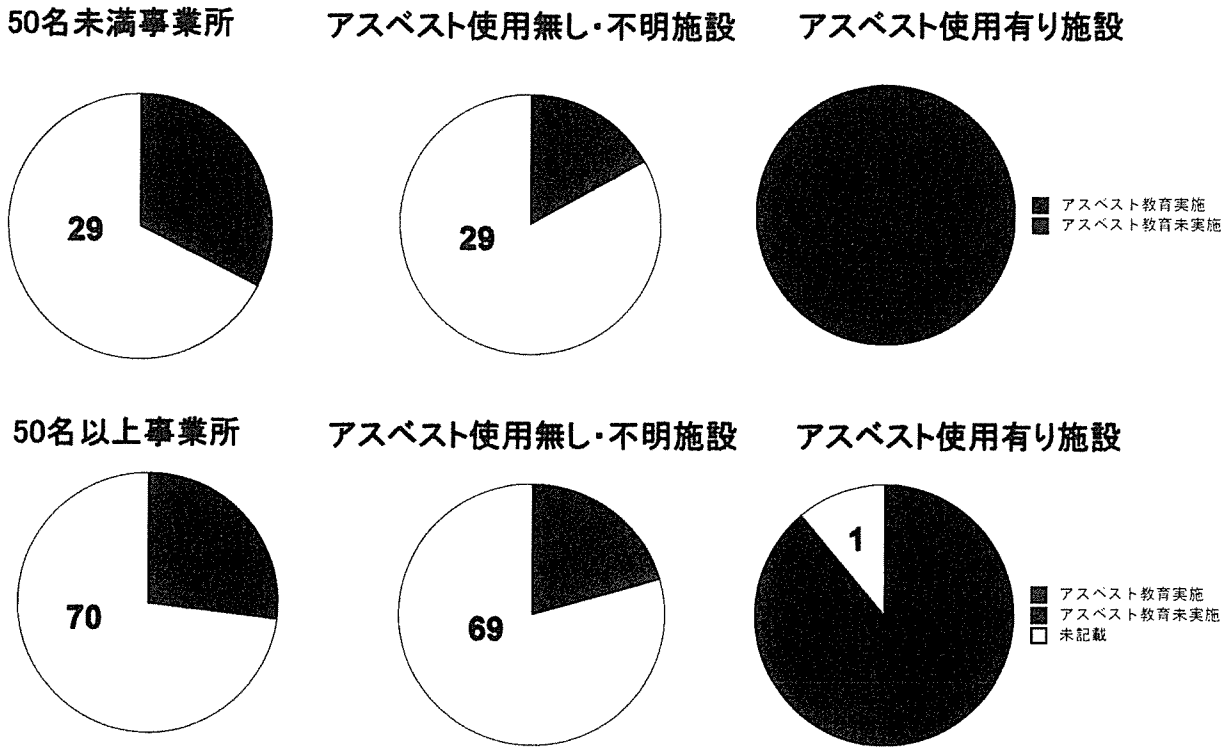

図41　アスベスト教育実施の有無
（企業規模別）

表1 アスベスト使用に関する質問票

A. 貴建築物の種類にあてはまるものを教えてください。

1.□興行場（映画館、演劇等の施設）　2.□百貨店
3.□集会場（各種会館、各種ホール）　4.□図書館
5.□博物館、美術館　6.□遊技場（パチンコ、ボーリング等の施設）
7.□店舗　8.□学校（小・中・高・大）
9.□事務所　10.□旅館、ホテル
11.□その他（　　）

B. 貴建築物の面積、建築年数、従業員数を教えてください。

_____m^2、　_____年、_____名

C. 屋内（屋根を含む）で、アスベストを使用していますか。

1.□はい
2.□いいえ
3.□不明

D. Cの質問で「はい」と答えた方についてのみお聞きします。

1. 使用しているアスベストの種類を教えてください。

1.□アモサイト（茶石綿）
2.□クリソタイル（白石綿）
3.□クロシドライト（青石綿）
4.□その他（　　）

2. アスベストを使用している部屋の使用形態（事務室など）をご記入ください。

（　　）

3. 使用箇所に改善工事等を施しましたか。

1.□はい
2.□いいえ
3.□施工予定である

施行している場合、施行部位（天井、露出など）及び、施行方法を教えてください。

・施行部位

1.□天井などに吹き付け
2.□その他（　　）

・施行方法

1.□吹き付け箇所を密閉
2.□完全除去
3.□その他（　　）

また、おおよその施行面積を教えてください。

_____m^2

4. 職員・従業員に対するアスベスト教育は行っていますか。

1.□はい
2.□いいえ

E. 回答担当者の職種を教えてください。

1.□衛生管理者
2.□人事
3.□労務
4.□その他（　　）

表2 大型スーパーマーケットにおける物理因子計測結果

測定点 (No.)	場所	測定時間	温度 (℃)	湿度 (%)	照度 (lx)	騒音 (dB)	風速 (m/s)	粉じん濃度 ($\mu g/m^3$)	粒径別の粉じん濃度 ($\mu g/m^3$)				CO (ppm)	CO_2 (ppm)
									PM1	PM2.5	PM7.5	PM10		
1F(オープン前)														
1	①エレベータ付近	9:20	24.5	50	432	62.8	0.10	0.014	0.4	2.1	2.4	7.5	0.4	468
2	②化粧品・雑貨等	9:40	23.8	60	294	62.6	0.16	0.009	0.7	3.2	3.6	11.3	0.4	427
3	③食品売り場	9:25	23.0	54	919	63.0	0.22	0.044	2.1	7.0	7.4	23.8	—	—
2F(オープン前)														
5	①エレベータ付近	9:20	26.2	58	453	65.4	0.07	0.005	0.3	3.9	4.4	6.5	0.4	468
6	②ゲームセンター	9:35	26.3	60	668	70.5	0.20	0.002	0.3	3.9	4.4	6.5	0.4	400
7	③衣料品	10:56	25.7	55	717	65.7	0.14	0.011	0.4	3.3	4.8	16.3	0.3	436
室外(オープン前)														
8	①駐車場正面	10:00	25.7	66	598	59.2	1.30	0.005	0.1	0.6	1.0	15.4	0.4	388
9	②駐車場側面	10:15	25.7	66	381	57.4	1.90	0.003	0.1	0.6	0.6	12.2	0.4	378
10	③搬入口(裏口)	10:20	26.1	68	206	69.8	1.40	0.004	0.2	2.0	4.0	9.9	0.5	370
1F(開店中)														
11	①エレベータ付近	11:00	25.5	43	1140	73.8	0.15	0.014	0.7	5.3	6.4	19.7	0.1	489
12	②化粧品・雑貨等	11:07	24.1	56	1503	67.9	0.19	0.004	0.2	2.2	2.6	13.0	0.3	423
13	③食品売り場	11:23	23.8	48	1860	67.5	0.11	0.021	1.0	4.6	6.7	21.9	0.1	485
2F(開店中)														
14	①エレベータ付近	11:35	23.1	54	1350	69.0	0.13	0.003	0.3	3.0	3.9	18.7	0	463
15	②ゲームセンター	11:40	24.5	50	1030	75.7	0.34	0.004	0.2	3.0	3.4	20.3	0.1	536
16	③衣料品	11:52	25.0	49	1347	65.5	0.17	0.005	0.3	3.4	3.6	26.9	0.03	496
室外(開店中)														
17	①駐車場正面	12:10	26.5	66	1190	59.1	0.35	0.018	0.5	4.6	5.3	55.2	0.1	410
18	②駐車場側面	12:15	27.6	65	5100	59.6	0.63	0.016	0.6	5.8	6.3	56.2	0.4	481
19	③搬入口(裏口)	12:24	26.4	70	5600	64.5	1.25	0.013	0.4	2.9	7.3	43.2	0.4	430

表3 中型スーパーマーケットにおける物理因子計測結果

測定点 (No.)	場所	測定時間	温度 (℃)	湿度 (%)	照度 (lx)	騒音 (dB)	風速 (m/s)	粉じん濃度 ($\mu g/m^3$)	粒径別の粉じん濃度 ($\mu g/m^3$)				CO (ppm)	CO_2 (ppm)
									PM1	PM2.5	PM7.5	PM10		
1	食品	8:45	23.2	58	1230	60.4	0.11	0.087	5.9	26.6	28.5	51.1	0.6	573
2	衣料品	9:10	25.5	65	334	51.1	0.03	0.053	2.5	10.1	11.2	43.5	0.45	552
3	室外	8:30	26.7	91	1250	76.5	1.20	0.165	11.7	57.0	68.0	174.8	1.0	438

表4 ホテルにおける物理因子計測結果

測定点 (No.)	場所	測定時間	温度 (℃)	湿度 (%)	照度 (lx)	騒音(dB)	風速 (m/s)	粉じん濃度 (mg/m^3)
1	室外	14:10	28.2	53	1260	—	2.50	0.013
2	2階ロビー	14:55	24.1	53	116	—	0.30	0.009
3	事務所	16:05	25.8	59	308	—	0.28	0.011
5	レストラン佳香	15:15	23.6	61	98	—	0.20	0.015
6	ブライダル	16:40	24.0	39	86	—	0.08	0.021
7	客室	15:45	24.6	56	117	—	0.25	0.021

表5 高等学校における物理因子計測結果

測定点 (No.)	場所	測定時間	温度 (℃)	湿度 (%)	照度 (lx)	騒音(dB)	風速 (m/s)	粉じん濃度 (mg/m^3)
1	教室	17:00	18.8	55	480	—	0.12	0.043
2	講堂	16:50	17.4	44	277	—	0.11	0.060
3	体育館	16:53	18.6	40	463	—	0.21	0.035

表6 芸術劇場における物理因子計測結果

測定点 (No.)	場所	測定時間	温度 (℃)	湿度 (%)	照度 (lx)	騒音(dB)	風速 (m/s)	粉じん濃度 (mg/m^3)
1	事務室	14:20	25.1	28	647	—	0.05	0.012
2	1階中央ホール	14:30	24.7	41	81.9	—	0.08	0.012
3	室外	15:00	—	—	783	—	2.20	0.014

表7 音楽ホールにおける物理因子計測結果

測定点 (No.)	場所	測定時間	温度 (℃)	湿度 (%)	照度 (lx)	騒音(dB)	風速 (m/s)	粉じん濃度 (mg/m^3)
1	事務室	10:02	23.9	45	631	—	0.10	0.082
2	大ホール	10:06	22.4	49	136	—	0.07	0.042
3	ロビー	10:09	20.7	54	115	—	0.07	0.083
4	室外	10:11	15.3	55	1050	—	0.33	0.138

表8　築後年数とアスベスト使用の有無

築後年数	アスベスト使用有	使用無し	不明	計
10年未満	0 (0)	50 (100)	0 (0)	50
10年以上20年未満	2 (5.7)	33 (94.3)	0 (0)	35
20年以上30年未満	4 (13.8)	23 (79.3)	2 (6.9)	29
30年以上	12 (30.8)	26 (66.7)	1 (2.6)	39

（　）内、パーセント

P<0.0001

研究成果の刊行に関する一覧表

発表者氏名	論文タイトル	発表誌名	出版年
Yukio Akiyama, Keiichi Arashidani, Naoki Kunugita, Takahiko Katoh and Iwao Uchiyama	Investigation of Air Pollution in Various Large-Scale Buildings and of Employees' Personal Exposure Level	Proceeding of the Indoor Environmental Quality: Problems, Research and Solutions	2006
Keiichi Arashidani, Naoki Kunugita, Yukio Akiyama, Takahiko Katoh and Iwao Uchiyama	Investigation of Air Pollution in Hotel and of Employees' Personal Exposure Level	Proceeding of the Indoor Environmental Quality: Problems, Research and Solutions	2006
嵐谷奎一、戸次加奈江、秋山幸雄、欅田尚樹(産業医科大学)、加藤貴彦(宮崎大学)、内山巌雄(京都大学大学院)	書店内の空気汚染調査	大気環境学会	2006
嵐谷奎一、伊藤小百合、欅田尚樹(産業医科大学)、加藤貴彦(宮崎大学)、内山巌雄(京都大学大学院)	大学施設内の空気汚染調査	大気環境学会	2006
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発表者氏名	論文タイトル	発表誌名	出版年
嵐谷奎一、戸次加奈江、秋山幸雄、欅田尚樹(産業医科大学)、加藤貴彦(宮崎大学)、内山巌雄(京都大学大学院)、	特定建築物内の揮発性有機化合物調査	産業医科大学学会	2006
嵐谷奎一、欅田尚樹、秋山幸雄、戸次加奈江(産業医科大学)、加藤貴彦(宮崎大学)、内山巌雄(京都大学)、山野優子(昭和大学)	特定建築物内の揮発性有機化合物濃度調査	室内環境学会	2006
欅田尚樹、嵐谷奎一、秋山幸雄、伊藤小百合(産業医科大学)、加藤貴彦(宮崎大学)、内山巌雄(京都大学)、山野優子(昭和大学)	特定建築物内のアルデヒド類濃度調査	室内環境学会	2006
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戸次加奈江、欅田尚樹、嵐谷奎一(産業医科大学)、加藤貴彦、真鍋龍治(宮崎大学)、山野優子(昭和大学)、内山巌雄(京都大学)	大型店舗内の揮発性有機溶剤濃度調査	大気環境学会九州支部総会	2007
欅田尚樹、嵐谷奎一(産業医科大学)、真鍋龍治、加藤貴彦(宮崎大学)、内山巌雄(京都大学大学院)	特定建築物における空気質および従業員の健康影響評価	日本衛生学会総会	2007

Investigation of Air Pollution in Various Large-Scale Buildings and of Employees' Personal Exposure Level

Yukio Akiyama, Keiichi Arashidani, Naoki Kunugita, Takahiko Katoh[1] and Iwano Uchiyama[2]

School of Health Sciences, University of Occupational and Environmental Health, Japan, 1-1 Iseigaoka, Yahatanishi-ku, Kitakyushu 807-8555 Japan

1 School of Medicine, University of Miyazaki, Miyazaki, Japan

2 Graduate School of Engineering, Kyoto University, Sakyo-ku, Kyoto, Japan

ABSTRACT

We investigated the condition of air pollution in various kinds of buildings such as university office, university library, barber shop and beauty parlor in university hospital, book store, department store, pachinko parlor, bowling alley and hotel. We also investigated the personal exposure level of employees at the above-mentioned buildings. The measured chemicals were 31 kinds of volatile organic compounds (VOCs), formaldehyde, acetaldehyde and nitrogen dioxide (NO_2). The chemicals were collected by a personal passive sampler. Generally speaking, ethyl acetate, toluene and decane showed high concentration (> 5 ppb). At bowling alley, 1,2,4-trimethylbenzene was found to be more than 150 ppb. At pachinko parlor and department store, methylethylketone was higher than other buildings. Bookstore showed highest concentration of toluene among all buildings investigated. As to aldehydes, the concentration of formaldehyde was between 10 and 55 ppb. Pachinko parlor showed the highest value. Acetaldehyde concentration was between 5 and 63 ppb. The highest was also given by pachinko parlor. NO_2 concentration was between 5 and 59 ppb. Among the buildings, department store and pachinko parlor gave higher values. The level of personal exposure generally had the same tendency with indoor air pollution level. The possible source of the characteristic chemicals at each building will be discussed.

INTRODUCTION

Recently, a big change in indoor air environment has been recognized. This new

problem is caused by high air tightness, high adiabatic and newly building material, and has been the cause of health problems. The resident in a newly-built home appealed for bodily bad condition and indisposition for this problem in around 1970. These symptoms are called Sick Building Syndrome and it has been paid attention. Afterwards, the symptom of the irregularity, and it is distinguished from a sick building syndrome and socially becomes a big problem. Approximately 80% of our life time is spent in an indoor air environment,[1] either in homes, work place etc. Especially, the indoor air quality is often worse than outdoor air and contains many pollutants. Jarke and co-workers[2] indicated that 118 chemicals were identified in the indoor air of new buildings, and the indoor pollutants arise probably from many parts, such as the carpeting, clothing furniture etc. Many researches on indoor air pollution[3] and the influence on health[4,5] have been performed. The investigations of air pollution in large-scale buildings to be open for public people such as university, department store and amusement facilities are not so many. However, it is necessary to investigate the indoor air quality of those buildings because many people may use them for the purpose of study, shopping and amusement etc. This study is aimed at grasping the realities of the conditions of the air environment of various large-scale buildings in Japan and of the chemical exposure of the employees.

METHOD

Studied Buildings

We investigated indoor and outdoor air quality at university office, university library, barber shop and beauty parlor in university hospital, book store, department store, pachinko parlor, bowling alley, hotel and museum in Japan. The sampling sites, the number of employees investigated and the characteristics of each building are listed in Table 1.

Collection and analysis of chemicals

The concentrations of the VOCs, aldehydes and NO_2 were measured. The collection of chemicals was carried out by a passive sampler. Passive samplers were used in all cases (Personal exposure, indoor air and outdoor air). To evaluate exposure level of workers to chemicals, the personal sampler was hooked on to a worker's breast. The samplers for collection of the chemicals were set up in each sampling site. After sampling, the VOCs and NO_2 samples were stored in a freezer and aldehyde samples were stored in a refrigerator. The analysis of VOCs is as

Table 1. Sampling site

Building	Site	Number of sampling places
University	Office	5
	Employees	10
	Library	5
	Employees	7
	Barber Shop	2
	Employees	2
	Beauty Parlor	2
	Employees	2
Book Store	1F	7
	Employees	5
Department Store	1F (Food Corner)	7
	Employees	5
	2F	6
	Employees	3
	6F	6
	Employees	3
	7F (Chinese Restaurant)	6
	Employees	5
Pachinko Parlor	1F	10
	Employees	12
Bowling Alley	1F	12
	Employees	5

For each buildings, outdoor air quality was also measured.

follows.[6] An activated charcoal (Pittsburgh PCB) in a sampling tube (Sibata, Japan) was moved to a test tube, 2 ml of carbon disulphide was added and then VOCs were extracted. The VOCs in extracted solution were analyzed by using a capillary gas chromatograph-mass spectrometer-apparatus (Hewlett Packard, USA) with auto sampler. The collection of aldehydes was carried out in a passive gas tube (Sibata, Japan) silica gel that is impregnated with 2,4-dinitrophenyl hydrazine. The aldehydes observed on the silica gel was extracted with the 3 ml acetonitril. The separation and determination were done by using HPLC apparatus (Shimadzu LC-10 AD, Japan).

The NO_2 that absorbs filter (Toyo Roshi, Japan) was extracted with a coloring solution. A coloring solution was prepared with a solution of sulfanilic acid, phosphoric acid and 0.1 wt% N-(1-naphthy) ethylenediamine dihydrochloride. NO_2 in the extracted solution was determined by using UV-VIS spectrophotometer (Shimadzu UV-2200A, Japan)

RESULTS

University office

As shown in Table 1, we performed the investigation at university office, university library, and barber shop and beauty parlor in university hospital. The 8-stories university was built 28 years ago. Table 2 shows the results of measurements of VOCs in university office (8 m x 38 m), and Table 3 shows those of aldehydes and NO_2.

Twenty-six kinds of VOCs were detected. Decane and 1,2,3-trimethylbenzene were in relatively high concentration (>10 ppb). Personal exposure level of university office workers to VOCs was less than 3 ppb during working time, whereas some VOCs such as toluene and p-dichlorobenzene gave higher value during non-working time suggesting that they may experience exposure at home.

The concentrations of NO_2 in indoor air during working time and of personal exposure were low (<20 ppb).

The concentrations of formaldehyde and acetaldehyde in indoor air during working time and of personal exposure were approximately 25 ppb and 6 ppb, respectively.

University library

Table 4 shows the three highest VOCs detected in university library and other settings. Aldehyde and NO_2 concentration in all sampling sites are shown in Table 4. Twenty-two kinds of VOCs were detected from university library. Except for decane, other VOCs during working time were in low concentration (<4 ppb) and were in similar concentrations as those of outdoor air. Exposure level of employees was in the same level as that of indoor air except for ethyl acetate. Toluene and p-dichlorobenzene showed high value during non-working time, suggesting that there were strong influence of living environment.

The concentration of NO_2 was less than 20 ppb in all situations.

Outdoor concentration of formaldehyde was approximately 10 ppb, whereas indoor concentration was 20-30 ppb. As to acetaldehyde, it was 2 ppb in outdoor air and ca. 10 ppb in indoor air and personal exposure.