ORIGINAL ARTICLE

Sick Building Syndrome among Office Workers in relation to Office Environment and Indoor Air Pollutant at an Academic Institution, Malaysia

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ABSTRACT

Introduction: Good indoor air quality (IAQ) is important for workers' well-being whilst simultaneously optimize work productivity and job performance of the workers in an office. This study aims to determine the association between the sick building syndrome (SBS) in relation to the personal factors, indoor office environment and indoor air pollutants at an academic institution in Malaysia. **Methods:** A total of 342 office workers; made up of 188 (55%) female and 154 male (45%), from 14 different office buildings; made up of administrative, faculties, centers, institutes and school, participated in this study. A self-administered questionnaire was used to determine symptoms related to SBS. Real time readings of IAQ parameters were conducted three times daily for 15 minutes /sampling point. **Results:** Results showed higher prevalence of the SBS symptoms generally among women; diagnosed asthma was positively associated with mucosal symptoms; current smoking was significantly associated with skin symptoms; and centralized air conditioning system, the use of photocopiers, printers or fax machines for more than 1 hour per day and installation of a new carpet in the office environment were significant risk factors of SBS. After adjusting for demographic characteristics, formaldehyde, ultrafine particle and total volatile organic compounds were significantly associated with mucosal symptoms. **Conclusion:** Demographic characteristics, indoor office environment and indoor air pollutants were significant risk factors of SBS among workers in this study. It is highly recommended to maintain good housekeeping and to isolate printers and photocopier machines from the main workplace since both were sources of particulates.

Keywords: Sick building syndrome, Indoor air pollutants, Office workers, Malaysia

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INTRODUCTION

In developing countries, poor indoor air quality (IAQ) is one of main public health issues; however, the number of studies conducted regarding IAQ and health is limited compared to those conducted in developed countries. According to the United States Environmental Protection Agency (US EPA) (1), IAQ refers to the quality of the air inside a building represented by the pollutants' concentrations and temperature, which, in turn, can affect the health, comfort and performance of the occupants. In the last decade, a growing body of scientific evidence has indicated that indoor air can be more polluted than the outdoor air. The concerns regarding indoor air quality is the time spent in the indoor environment. According to Ohura et al. (2), individuals spend up to 90% of their time indoors, especially in the home and office environment. The daily life of an office worker entails spending an average of 8.5 hour indoors, and previous studies have found that the level of indoor air pollutants in office buildings is greater than the level found outside (3,4).

With reference to the United States Department of Labour for Occupational Safety and Health Administration (OSHA) has estimated that in industrial buildings of different sectors, 30% of workers are working in substandard buildings and are exposed to poor indoor air quality (5). There are many reasons for poor IAQ in buildings, such as the presence of local sources of contaminants, poorly designed and maintained ventilation systems, and building construction or renovation (6). Usually, IAQ problems are closely related to mechanical ventilation and air conditioning (MVAC) systems with poor or improper maintenance, which, in turn, leads to inadequate ventilation and the inability to remove the contaminants from the room or building (7). This results in the accumulation of indoor air contaminants, such as carbon dioxide (CO2) and volatile organic compounds (VOC) in the building (8,9).

Poor IAQ potentially affect the health and well-being of the occupants, as well as the productivity and performance (8). About 1.6 million death each year due to the atmospheric pollution in building interiors and IAQ related health problem. Most employees' complaint included SBS and building related illness (BRI) (10,11). Sick building syndrome refers to non-specific complaints or symptoms related to the optical, dermal and respiratory systems. The symptoms are commonly associated with the time spent in a building, indoor activities, and furnishing which could affect a certain number of occupants in a building. The specific causes are usually not known, because sometimes the symptoms disappear or decreased when they leave the workplace or building (12). The risk factors associated with SBS have been identified with many studies conducted on the aetiology of SBS (13-15). In many instances, the lack of ventilation, and uncomfortable temperature and humidity were found to be associated with SBS. Carbon dioxide and VOC have been proven in other studies to be the major indoor air contaminants due to the lack of ventilation in workplaces (8,9).

MATERIALS AND METHODS

Subject recruitment and selection of office buildings

This was a cross-sectional study conducted in office buildings at an academic institution in Malaysia from May 2013 to October 2013. The study population was the office workers who work in offices with a mechanically ventilated air-conditioning system. The registrar office of the academic institution was contacted to obtain a list of all the offices and number of employees in each office. Only those who have been employed for 4 months were included in the study (3). There were a total of 61 offices in the academic institution. The selection of the office buildings was based on three characteristics: 1) age of the building, 2) type of mechanical, ventilating and air conditioning (MVAC) system used, and 3) type of carpeting. The buildings were categorized as new building (less than 10 years) or old building (more than 10 years), in accordance to the classification established by Nur Fadhilah & Juliana (3). The MVAC system used included both centralized and split unit systems. Among the 61 offices, 14 fulfilled the inclusion criteria as stated above. A letter was sent to the top management of the 14 offices for approval and written consent.

A complete assessment on indoor air pollutants was carried out in this study. A survey was conducted among 342 out of 701 workers to determine the SBS resulting 49% of the response rate. The 701 office workers selected randomly, fulfilled the study criteria of age range of 18 to 60 years and have worked for at least four months in the office building were included. Those who were pregnant or had been diagnosed with a chronic respiratory disease were excluded. The respondents consisted of 188 (55%) female and 154 (45%) male. Written consent was obtained prior to the questionnaire distribution to the respondents. The questionnaires were self-administered and collected within a week. After checking through each questionnaire, if uncertainties or missing data existed, respondents were called to clarify uncertainties in the missing data or the answer.

IAQ measurement

The IAQ measurement, real time monitoring was conducted for three days in which readings were taken three times daily – morning (9 – 11 am), noon (11 – 1 pm) and evening (3 - 5pm) for 15 minutes at each sampling point using direct readings instrument once the reading were stabilized. The sampling points depended on the room size in which minimum 1 per 500m2 as specified by the Malaysian Industry Code of Practice on Indoor Air Quality (MICOP) by the Department of Occupational Safety and Health, Malaysia 2010 (16). The small offices (< 500m2) had 3 sampling points while the big administrative offices (> 500m2) had 10-15 sampling points depending on the design. If the office was an open office, the sampling points were less than those with partitions such as booths or rooms with open doors. At least one sampling point was located in areas where the copying machines was placed. Question on frequency of printer or photocopier usage was included in questionnaire in this study. The assessment included the physical parameters and the chemical contaminants. All measurements were conducted according to the MICOP (16). The physical parameters measured comprised air temperature, relative humidity and air movement, while the chemical contaminants included carbon monoxide (CO), carbon dioxide (CO2), formaldehyde, respirable particulates (PM10) and total volatile organic compounds (TVOC). Ozone, which is one of the MICOP parameter was not measured in this study because of extremely low concentrations of ozone were detected in the pilot study before data collection, so instead, ultrafine particles [UFP (PM2.5)] was measured. Biological parameters such as total counts of bacteria and fungus were not measured in current study. The instruments used included a Q-TRAK™ Indoor Air Quality Monitor (Model 8554, TSI Incorporated, MN, USA), a VelociCalc® Plus Multi-Function Ventilation Meter (Model 8386, TSI Incorporated, MN, USA), a formaldehyde meter (htV-m, PPM Technology Ltd, UK), a DustTrak™ Aerosol Monitor (Model 8532, TSI Incorporated, MN, USA), a MiniRae Portable Gas Detector (Model 3000, RAE Systems by Honeywell, San Jose, USA), and, lastly, an ultrafine particle counter

(Model 8525, TSI Incorporated, MN, USA). Every reading at each point of sampling were recorded in a field data log sheet. All instrument used were calibrated according to the manufacturers' specifications.

The prevalence of sick building syndrome (SBS) related symptoms

A self-administered questionnaire in Bahasa Malaysia was given to the respondents to gather the demographic information, office characteristics and SBS symptoms within the same week of the office IAQ measurement. The questions were adapted from the Indoor Air Quality and Work Symptoms Survey, National Institute Occupational Safety and Health (NIOSH),Indoor Environmental Quality Survey (1991) and a previous SBS study (17). Office characteristics questions consisted of yes/no questions, on the new furniture in office and if the office walls were painted during the past three months. Questions on the number of airway infections during the last three months were included in the questionnaire. For the SBS symptoms, there were 16 questions which were grouped into three different groups namely (dermal, mucosal and general symptoms (3,4,17). Dermal symptoms included questions for rashes on hands or forearms, rashes on the face or throat, eczema, itching in the face or on the throat and itches on hands or forearms. Mucosal symptoms included questions on eye irritation, swollen eyelids, runny nose or nasal catarrh, nasal obstruction/ blocked nose, throat dryness, sore throat and irritating cough. At last, general symptoms included headache, nausea, the sense of catching a cold and feeling tired. Each of the SBS question had four alternative answers for their frequency of occurrence during the past three months. 'No, never' or 'Yes, sometimes 1–3 times per month' coded as 0 and 'Yes, often 1–4 times per week' or 'Yes, everyday' coded as 1. The respondents were classified as "having SBS" if they reported having at least one SBS symptom that occurred every day or one to four times per week. These symptoms were then categorised as weekly general symptoms, weekly mucosal symptoms and weekly skin symptoms (17).

The SBS questionnaire used in this study was tested for validity and reliability (18). Convergent validity showed there were significant positive correlations between mucosa symptoms with dermal symptoms ($r=0.638$, $p<0.001$) and general symptoms ($r=0.590$, $p<0.001$); and significant correlation between dermal symptoms with general symptoms ($r=0.347$, $p<0.001$).

Internal consistency reliability and test-retest reliability were used to determine the consistency and repeatability of the questionnaire. Internal consistency reliability of the SBS symptoms in this questionnaire was analysed using Kuder-Richardson (KR-20) and Cronbach's alpha test. Internal consistency reliability value of the questions was 0.887, which indicated acceptable internal consistency. The test-retest reliability of questionnaire among the participants in the pre-test indicated that the Cronbach's alpha values of the items ranged from 0.60-0.90, which showed that the reliability of the questions were good.

Data analysis

Data were analysed using Statistical Package for Social Sciences (SPSS) Version 21.0, for univariate, bivariate and multivariate analysis. Univariate analysis was used to analyse the descriptive data on demographic, office indoor environment and years of employment, and mean concentration of indoor air pollutants in the office. Bivariate analysis, Chi-square test was used to compare the SBS symptoms between male and female respondents. Logistic regression was used to analyse relationships between demographic information (gender, age, diagnosed asthma and currently smoking status) and SBS symptoms. Then, multivariate logistic regression, adjusted for gender, age, diagnosed asthma and current smoking status, was used to determine the relationships between office indoor environment and SBS symptoms, and between indoor air pollutants and SBS symptoms. The statistical tests carried out, used 2-tailed test at 5% significance level.

RESULTS

Table I shows the demographic information of the respondents. Men (22.1%) were more likely to be smokers and they (17.5%) had slightly higher prevalence of being diagnosed with asthma than the women (11.8%). Table II shows information on the office indoor environment and years of employment, while Table III shows the mean concentrations of indoor air pollutants in the 14 office buildings. The mean UFP concentrations exceeded the acceptable limit of 2000-4000 particles / m3 in all the office buildings except for Building 2, 6 and 10. Other pollutants were below the acceptable limit set up by the Malaysian Industry Code of Practice on Indoor Air Quality 2010.

The prevalence of SBS symptoms answered by "often (every week)" is shown in Table IV. The prevalence for the general symptoms was 18.7%; mucosal symptoms, 19.6%; and for skin symptoms, 10.2%. There was a significant difference in the prevalence of general and

Table I: Demographic information of office workers (N=342)

	Total, *n* (%)	Female, *n* (%)	Male, *n* (%)	Mean (SD) [a]	p-value
Number of subjects	342(100)	188(55)	154(45)		
Age [b]				34.10 (9.6)	0.206
Diagnosed asthma [c, d]	49(14.4)	22(11.8)	27(17.5)		0.175
Currently smoking [c, e]	35(10.2)	1(0.5)	34(22.1)		0.001**

**Significant at p value <0.01
[a] Mean ± Standard Deviation (SD)is reported for age as it is continuous variable
[b] p value analysed using t-test
[c] p value analysed using Chi-square test
[d] Subject with asthma that diagnosed by a doctor
[e] Subjects' smoking status

Table II: Information on the employment years of respondents and office indoor environment (N=342)

Variables		n (%)
Employment years in the office[a]	**<4 months**	207(60.5)
	>4 months	135(39.5)
Building age[b]	**<10 year**	77(22.5)
	>10 year	265(77.5)
MVAC system	**Centralized**	103(30.1)
	Split unit	239(69.9)
Carpeting [c]	**Yes**	163(47.7)
Use of photocopiers, printers or fax machines [d]	**<1 hour**	247(72.2)
	≥1 hour	95(27.8)
New furniture [e]	**Yes**	35(10.2)
New carpet [e]	**Yes**	16(4.7)
New wall paint [e]	**Yes**	19(5.6)
Water leak [e]	**Yes**	53(15.5)

MVAC system = mechanical ventilated air conditioning system
[a]Source (3): Nur Fadilah, R., & Juliana, J. (2012). Indoor air quality (IAQ) and sick buildings syndrome (SBS) among office workers in new and old building in Universiti Putra Malaysia, Serdang. *Health and the Environment Journal*, *3*(2), 98-109.
[b]Source (33): Runeson, R., NorbΔck, D., & Stattin, H. (2003). Symptoms and sense of coherence–a follow-up study of personnel from workplace buildings with indoor air problems. *International archives of occupational and environmental health*, *76*(1), 29-38.
[c]Office buildings that using carpet;
[d]Frequency of subjects using photocopiers, printers or fax machines;
[e]Office buildings that had installed new furniture, new carpet, new wall paint or had water leak in past 3 months

mucosal symptoms between genders in which the general symptoms were higher among women compared to men (p=0.020), while mucosal symptoms were higher in men than women (p=0.045).

The odd ratio (OR) for gender, age, diagnosed asthma and currently smoking with SBS symptoms obtained using the logistic regression models is shown in Table V. There was a significant association between gender and the mucosal symptoms. Age,diagnosed asthma and current smoking were significant risk factors for SBS symptoms. Workers who had diagnosed asthma had higher mucosal symptoms while those who were current smokers reported more skin symptoms.

Table IV: Prevalence of weekly SBS symptoms among office workers

Weekly SBS Symptoms	Total N=342 (%)	Female n=188 (%)	Male n=154 (%)	p-value[a]
Number of subjects,	100	55	45	
General symptoms ≥ 1[b]	18.7	23.4	13.0	**0.020***
Headache	9.4	13.8	3.9	**0.003***
Nausea	3.8	3.7	3.9	1.000
Feel like having flu	4.7	5.9	3.2	0.380
Tiredness	9.1	12.2	5.2	**0.039***
Mucosal symptoms ≥ 1[c]	19.6	15.4	24.7	**0.045***
Irritating eyes	4.7	5.9	3.2	0.380
Swollen eyes	2.9	2.1	3.9	0.520
Runny nose	3.2	3.7	2.6	0.780
Nose blocked	10.5	5.9	16.2	**0.003****
Dry throat	4.1	5.3	2.6	0.323
Sore throat	2.9	3.7	1.9	0.518
Irritating cough	2.3	2.7	1.9	0.941
Skin symptoms ≥ 1[d]	10.2	12.2	7.8	0.242
Rashes on hand	2.9	4.3	1.3	0.196
Rashes on face	3.2	1.6	5.2	0.117
Eczema	5.3	4.3	6.5	0.497
Itchy hand/arm	3.8	5.9	1.3	0.057
Itchy face	5.3	4.8	5.8	0.848

*Significant at p < 0.05; **significant at p < 0.01
[a] p-value in Chi-square test
[b] One or more than one general symptom was reported every week
[c] One or more than one mucosal symptom was reported every week
[d] One or more than one skin symptom was reported every week

Table III: Distributions of mean indoor air pollutants concentrations in office buildings

Building	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO_2 (ppm) AL:1000	342	414	459	313	463	611	501	414	426	303	455	476	411	369
CO (ppm) AL:10	0.53	0.23	0.30	0.50	0.74	0.63	0.36	1.16	0.16	0.83	0.26	0.80	0.62	0.57
T (°C) AL:23-26	24.3	22.8	23.1	25.5	23.8	23.6	24.1	23.5	22.8	27.6	23.10	25.9	25.1	24.6
RH (%) AL:40-70	53.47	56.63	54.05	46.27	70.10	64.22	60.80	45.72	56.73	38.12	55.17	38.80	45.64	52.55
F (ppm) AL:0.1	0.012	0.001	0.004	0.00	0.02	0.00	0.05	0.00	0.00	0.01	0.01	0.00	0.05	0.015
UFP (pt/m^3) AL:2000-4000	7338	3957	5064	6625	4921	3752	11646	6677	4138	3878	5113	7080	10275	5384
TVOC (ppm) AL:3	0.08	0.09	0.08	0.11	0.03	0.38	2.66	0.06	0.33	0.03	0.04	0.03	0.050	0.05
RD (mg/m^3) AL:0.15	0.075	0.089	0.088	0.11	0.04	0.10	0.13	0.09	0.09	0.11	0.09	0.11	0.090	0.07

CO_2-carbon dioxide; CO-carbon monoxide; T-temperature; AM-air movement; RH-relative humidity; F-formaldehyde; UFP-ultrafine particles; TVOC-total volatile organic compounds; RD-respirable dust; AL-action level

Table V: Association between gender, age, diagnosed asthma and currently smoking with SBS symptoms among respondents

		General symptoms	Mucosal symptoms	Skin symptoms
Gender	Female	1.00	1.00	1.00
	Male	0.57 (0.26-1.26)	**2.17 (1.02-4.62)***	**0.23 (0.06-0.85)***
Age[a]		**0.56 (0.38-0.81)***	**0.59 (0.41-0.86)****	0.88 (0.59-1.33)
Diagnosed asthma	Yes	1.17 (0.51-2.67)	**14.13 (6.54-30.53)*****	2.14(0.76-5.99)
Currently smoking	Yes	0.88 (0.26-2.90)	1.23 (0.43-3.49)	**11.47 (2.63-50.04)****

OR (95% CI) = Odd Ratio (95% Confidence Interval)
[a] OR calculated for 10 years increase in age
*Significant at p<0.05; ** significant at p<0.01; *** significant at p<0.001

Table VI shows associations between work and office indoor environment with SBS symptoms among the respondents. The use of a centralized MVAC system, photocopiers, printers or fax machines for more than one hour and office buildings with new carpet, were significant risk factors for skin symptoms. In addition, the office with new carpet was a significant risk factor for general symptoms.

Logistic regression was conducted after adjusting for the demographic information when determining for the indoor air pollutant risk factors in terms of SBS symptoms (Table VII). The results showed that only mucosal symptoms were significantly associated with indoor air pollutants, namely, formaldehyde, UFP and TVOC.

Table VI: Association between work and office indoor environment with SBS symptoms among respondents, OR (95% CI)[a]

Work and Office Indoor Environment		General symptoms	Mucosal symptoms	Skin symptoms
Years of employment	<4 year	1.00	1.00	1.00
	>4 year	2.13 (1.11-4.08)	0.86 (0.38-1.92)	0.55 (0.21-1.40)
Building age	<10 year	1.00	1.00	1.00
	>10 year	3.22 (0.67-12.65)	2.66 (0.73-6.21)	5.69 (0.88-36.56)
MVAC system	Split unit	1.00	1.00	1.00
	Centralized	0.24 (0.12-2.43)	0.43 (0.11-2.83)	**7.09 (1.08-46.63)***
Carpeting[b]	No	1.00	1.00	1.00
	Yes	0.63 (0.12-3.89)	1.36 (0.50-3.40)	1.64 (0.55-4.93)
Use of photocopiers, printers or fax machines[c]	<1 hour	1.00	1.00	1.00
	≥1 hour	0.99 (0.53-1.88)	0.87 (0.40-1.89)	**1.11 (1.14-1.97)***
New furniture[d]	No	1.00	1.00	1.00
	Yes	1.05 (0.37-2.93)	3.21 (0.81-12.71)	2.49 (0.63-9.95)
New carpet[d]	No	1.00	1.00	1.00
	Yes	**3.92 (1.19-12.86)***	2.26 (0.54-9.45)	**6.33 (1.40-28.63)***
New wall paint[d]	No	1.00	1.00	1.00
	Yes	0.90 (0.24-3.45)	0.45 (0.08-2.40)	0.27 (0.03-2.27)
Water damage[d]	No	1.00	1.00	1.00
	Yes	1.24 (0.57-2.71)	1.34 (0.54-3.30)	2.18 (0.79-5.99)

SBS = sick building syndrome
OR (95% CI) = Odd Ratio (95% Confidence Interval)
MVAC system = mechanical ventilated air conditioning system
[a]Odds ratios were adjusted for gender, age, diagnosed asthma and currently smoking
[b]Office buildings that using carpet;
[c]Frequency of subjects using photocopiers, printers or fax machines;
[d]Office buildings that had installed new furniture, new carpet, new wall painted or had water damage in past 3 month
*Significant at p<0.05

Table VII: Association between indoor air pollutants with SBS symptoms among workers[a]

Indoor Air Pollutants	General symptoms	Mucosal symptoms	Skin symptoms
CO_2 (ppm)	1.01 (0.99-1.02)	1.00 (1.00-1.02)	1.00 (0.99-1.01)
CO (ppm)	0.49 (0.11-2.34)	0.24 (0.03-1.95)	2.86 (0.39-21.22)
T (°C)	0.85 (0.61-1.19)	1.31 (0.92-1.88)	0.76 (0.50-1.15)
AM (m/s)	1.66 (0.23-12.20)	0.45 (0.03-6.56)	0.39 (0.02-6.19)
RH (%)	0.93 (0.81-1.05)	0.99 (0.86-1.14)	0.98 (0.84-1.15)
F (ppm)	7.84(0.03-19.83)	**3.36 (2.31-5.61)***	0.83 (0.00-2.46)
UFP (pt/ cm^3)	1.00(0.99-1.00)	**1.08 (1.01-1.21)***	1.00 (0.99-1.00)
TVOC (ppm)	0.53 (0.21-1.33)	**2.33 (1.63-4.33)***	0.70 (0.20-2.45)
RD(mg/ m^3)	0.58 (0.34-2.68)	0.01(0.01-1345.41)	0.32 (0.26-1.08)

SBS = sick building syndrome
OR (95% CI) = Odd Ratio (95% Confidence Interval)
CO_2-carbon dioxide; CO-carbon monoxide; T-temperature; AM-air movement; RH-relative humidity; F-formaldehyde ; UFP-ultrafine particles; TVOC-total volatile organic compounds; RD-respirable dust
[a]Odds ratios were adjusted for gender, age, diagnosed asthma and currently smoking
*Significant at p value < 0.05

DISCUSSION

In this study, mucosal symptoms (19.6%) and general symptoms (18.7%) were more frequently reported than skin symptoms (10.2%) as in other previous SBS studies (17, 19, 20, 21). Findings of a study among parents of preschool children in Chongqing, China, who showed that mucosal and general symptoms were higher than the skin symptoms. From this study, the prevalence was 1.5 to 2 times higher than a China study (17). Another office study from Japan reported general symptoms were the most commonly reported work-related symptoms (61%) among office workers and skin symptoms were the least reported symptoms (28.1%) (19). In addition, a few of the Swedish studies, carried out on the office environment (20) and home environment (21) reported similar trend of SBS symptoms as found in this study.

Numerous studies have shown that SBS symptoms are related to both personal and environmental risk factors (22,23,24). Personal factors, such as being female, and allergies are the risk factors of SBS symptoms (25,26). This study found that SBS symptoms were significantly different between genders, which was consistent with other studies. In most of the studies, the prevalence of women reporting SBS symptoms were two to three times higher than that reported by men (20, 27, 28, 29). Brasche et al. (30) hypothesized that different demographic factors, working conditions and job characteristics were possible factors influencing the gender difference in reporting SBS. In our study, workers who had asthma diagnosed by a doctor were associated with mucosal symptoms. A study by Zhang et al. (31) found that asthma and allergies (heredity) were the risk factors of SBS symptoms.

Younger respondents tend to report more SBS symptoms than older respondents, which was consistent with other studies (8,32,33,34). Psychological stress differs with various age groups (32). This study found significant relationship between smoking and skin symptoms among the office workers. Smoking increases the susceptibility and sensitivity of a person. Smokers experience higher exposure to environmental tobacco smoke (ETS), which contains more than one thousand chemical substances with more than 20 toxic chemicals are carcinogenic.

Multivariate logistic regression analysis showed that the prevalence of SBS symptoms were higher in buildings with a centralised MVAC system than with split unit air conditioning system. Air-conditioned buildings generally have a higher prevalence of symptomatic workers than the naturally ventilated buildings (35). A centralised system must be efficient in terms of ventilation and desorption of indoor air pollutants. If it is not well maintained, a poorly ventilated room may be worse as the pollutants are not removed and tend to accumulate in the whole building. The findings from an extensive office study by the USEPA showed that offices with no regularly scheduled inspections on heating, ventilation, and air-conditioning (HVAC) systems were significantly related with increased eye symptoms (OR=2.2), cough (OR=1.6) and upper respiratory symptoms (OR=1.5); and less frequent cleaning of drip pans and cooling coils was related with increased headache (OR=1.6) (36). In addition, skin symptoms were associated with air temperature in which the prevalence was lower among workers in buildings with a split unit system. In office with split unit air-conditioning system, workers were able to control the air temperature according to their comfort. During the data collection, majority of the workers in centralized MVAC system buildings complained that they cannot control the indoor air temperature which could be very cold at times.

Our findings showed that use of photocopiers, printers or fax machines were positively associated with skin symptoms. The literature showed that office equipment are potential sources of indoor pollutants namely ozone, particulate matter and volatile organic compounds which were emitted during copying and printing processes when heat is produced (37). In modern offices, printers and photocopiers are used widely by the workers. In this study the air quality of the areas with these machines were monitored daily. Ambient ultrafine particles in the office environment significantly increased during and after the printing processes, as found by Tang et al. (38). The ability of minute nano-particles, to penetrate the alveolar after being inhaled has a more deleterious effect on humans than the bigger particles, which results in the prevalence of mucosal symptoms (39). A study conducted by Jaakkola et al. (40) stated that the exposure to paper dust and fumes from photocopiers and printers was significantly associated with upper respiratory and skin symptoms, which were identified as SBS.

From the observation, photocopier and printers were used in open areas. In addition, most of the workers had their own printer located on their desk, while photocopiers were in designated areas and were normally shared by workers from several workstations. He et al. (41) stated that the emission of particles from printer machines that were not isolated from the work area constitute the main source of indoor air pollutants. Juliana et al. (42) found that the prevalence of respiratory health symptoms, such as cough, wheezing, and stuffy and runny nose, were significantly associated with a high concentration of UFP levels in the indoor office environment.

Studies have discovered that new carpeting and furnishing causes the emission of volatile organic compounds, such as formaldehyde. Bur and Alderfer (43) found that wall paint, carpet and cleaning detergent could release chemical irritants, which were the most frequent cause for the increase in the SBS symptoms in the office environment. In this study formaldehyde was monitored to determine its release from the wall paint and carpet in the offices

The results showed that general symptoms were associated with carbon dioxide, air temperature, formaldehyde, ultrafine particles and respirable dust, while mucosal symptoms were associated with carbon dioxide, air movement and respirable dust. A study among office workers in Egypt indicated that fatigue and headaches were the most prevalent symptoms, associated with poor ventilation, temperature and humidity (44). An excessively high air temperature in an office building might cause several SBS symptoms, such as fatigue and headaches, as well as reduce performance and alertness (35). Building materials, new furniture and new painting constitute possible sources of indoor air pollutants, such as volatile organic compounds, respirable particulates, ultrafine particles and formaldehyde (45, 46), measured in this study. A longitudinal study of SBS among pupils in China found that indoor PM10 was positively associated with the onset of skin, mucosal and general symptoms (31).

There were some limitations in this study. Cross-sectional study design of current study only able to determine significant risk factors and cannot draw cause and effect relationships between the variables. Inter-day variation might potentially affect the results of measurement and questionnaire. However, we tried to reduce the variation of these measurements by repeating the real time monitoring for three days and three times per day in each office. Indoor air quality is affected by outdoor air and climate. However, it is less likely that the outdoor air and climate severely influenced the strength of relationships between the IAQ and SBS symptoms. Another limitation of the study was small sample size limit the number of covariates examined in multivariate analysis of the current study. Occupational stress (19) and psychological factors (34), which are risk factors of SBS reported by other studies, were not investigated in this study. Thus, more large scale of office studies in tropical countries are recommended in the future.

CONCLUSION

The findings showed that the prevalence of SBS was higher among females than males. Diagnosed asthma was positively associated with mucosal symptoms of SBS, while currently smoking was associated with skin symptoms. A centralised air conditioning system, use of photocopiers, printers or fax machines for more than one hour per day and the use of new carpet in the office environment were the significant risk factors for SBS. After adjusting for demographic information, formaldehyde, UFP and TVOC were significantly associated with mucosal symptoms. Workers need to be aware of the potential risks posed by office equipment, such as printers and photocopier machines, as they emit UFP and paper dust during the work activities. Maintaining good housekeeping, and isolation of the printers and photocopiers from the main work areas would be highly recommended.

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REFERENCES

1. U.S. Environmental Protection Agency. Indoor air facts (revised): sick building syndrome (SBS). Cincinnati: U.S. Environmental Protection Agency; 2006.
2. Ohura T, Amagai T, Shen X, Li S, Zhang P, Zhu L. Comparative study on indoor air quality in Japan and China: Characteristics of residential indoor and outdoor VOCs. Atmos Environ. 2009;43(40):6352-9.
3. Nur Fadilah, R, Juliana, J. Indoor air quality (IAQ) and sick buildings syndrome (SBS) among office workers in new and old building in Universiti Putra Malaysia, Serdang. Health and the Environment Journal. 2012;3(2):98-109.
4. Syazwan Aizat I, Juliana J, Norhafizalina O, Azman ZA, Kamaruzaman, J. (2009). Indoor air quality and sick building syndrome in Malaysian buildings. Glob J Health Sci. 2009;1(2):126-136.
5. Occupational Safety and Health Administration. Indoor Air Quality [Internet]. Washington: United States Department of Labor, 1994 [cited 2018 December 12]; Available from: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=federal_register&p_id=13369
6. Tsai DH, Lin JS, Chan CC. Office workers' sick building syndrome and indoor carbon dioxide concentrations. J Occup Environ Hyg. 2012;9(5):345-351.
7. Apter A, Bracker A, Hodgson M, Sidman J, Leung WY. Epidemiology of the sick building syndrome. J Allergy Clin Immunol. 1994;94(2):277–288.
8. Burge S, Hedge A, Wilson S, Bass JH, Robertson A. Sick building syndrome: A study of 4373 office workers. Ann Occup Hyg. 1987;31(4A):493-504.
9. Fisk WJ. Health and productivity gains from better indoor environments and their implications for the U.S department of energy. In: Proceedings of E-Vision 2000 Conference; 2000 October 11-13; Washington, DC. Arlington (VA): RAND; 2001.
10. World Health Organization, WHO. Indoor air pollution [Internet]. World Health Organization, 2014 [Accessed: 2016 October 3]. Available from: http://www.who.int/indoorair/en/.
11. Occupational Safety and Health Administration. OSHA Technical Manual Indoor Air Quality Investigation, Indoor Air Quality Investigation [Internet]. Washington: United States Department of Labor, 1999. Section III, Chapter 2, Indoor air quality investigation; [cited 2015 May 13]; [about 3 screens]. Available from: https://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_2.html.
12. Kreiss K. The sick building syndrome: Where is the epidemiologic basis? Am J Public Health. 1990;80:1172-3.
13. Redlich CA, Sparer J, Cullen MR. Sick-building syndrome. Lancet. 1997;349 (9057):1013-6.
14. Mahmoudi M, Gershwin ME. Sick building syndrome. III. Stachybotrys chartarum. J. Asthma. 2000;37,191-8.
15. Lu CY, Ma YC, Lin JM, Chuang CY, Sung FC. Oxidative DNA damage estimated by urinary 8-hydroxydeoxyguanosine and indoor air pollution among non-smoking office employees. Environ Res. 2007;103:331–7.
16. Department of Occupational Safety and Health. Industry Code of Practice on Indoor Air Quality 2010. Putrajaya: Ministry of Human Resource; 2010. 45 p. JKKP DP(S)127/379/4-39.
17. Wang J, Li BZ, Yang Q, Wang H, Norback D, Sundell, J. Sick building syndrome among parents of preschool children in relation to home environment in Chongqing, China. Chin Sci Bull. 2013;58(34):4267-76.
18. Lim FL. Relationships between respiratory symptoms, airway inflammation, sick building syndrome and allergies with indoor office environment among workers in a Malaysian University [doctor of philosophy's thesis]. Serdang: Universiti Putra Malaysia; 2016. 131 p.
19. Azuma K, Ikeda K, Kagi N, Yanagi U, Osawa H. Prevalence and risk factors associated with nonspecific building-related symptoms in office

employees in Japan: relationships between work environment, Indoor Air Quality, and occupational stress. Indoor Air. 2015;25:499-511.
20. Sundell, J. On the association between building ventilation characteristics, some indoor environmental exposures, some allergic manifestations and subjective symptom reports. Indoor Air. 1994;4:7-49.
21. Bornehag C, Sundell, J, H∆gerhed, L. Dampness in dwellings and sick building symptoms among adults: A cross-sectional study on 8918 Swedish homes. In: Tham KW, Sekhar C, Cheong DKW, International Society of Indoor Air Quality and Climate, National University of Singapore, editors. Healthy Buildings 2003. Proceedings of 7th International Conference on Health Buildings; 2003 Dec 1-77; Singapore. Singapore: Conference Secretatiat. p. 582
22. Lu CY, Tsai MC, Muo CH, Kuo YH, Sung FC, Wu CC. Personal, psychosocial and environmental factors related to sick building syndrome in official employees of Taiwan. Int J Environ Res Public Health. 2018;15(7):1–9.
23. Lim FL, Hashim Z, Said S, Than LTL, Hisham J, Norb∆ck D. Sick building syndrome (SBS) among office workers in a Malaysian university — Associations with atopy, fractional exhaled nitric oxide (FeNO) and the office environment. Sci Total Environ. 2015;536:353–61.
24. Norb∆ck D, Edling C. Environmental, occupational, and personal factors related to the prevalence of sick building syndrome in the general population. Br J Ind Med. 1991;48:451–62.
25. Jafari MJ, Khajevandi AA, Najarkola SA, Yekaninejad MS, Pourhoseingholi MA, Omidi L, Kalantary S. Association of sick building syndrome with indoor air parameters. Tanaffos. 2015;14(1):55.
26. Wang SS, Chou CF, Chung FF, Hsiao HF, Huang CT, Wan GH. Prevalences of Sick Building Syndrome Symptoms in Respiratory Therapists and Hospital Office Workers in a Medical Center. Respiratory Treatment. 2015. 14(2):1-4.
27. Mendell M J. Non-specific symptoms in office workers: A review and summary of the epidemiological literature. Indoor Air. 1993, 3:227–36
28. Bjurnsson E, Janson C, Norb∆ck D, Boman G. Symptoms related to the sick building syndrome in a general population sample: Associations with atopy, bronchial hyper-responsiveness and anxiety. Int J Tuberc Lung Dis. 1998;2:1023–8
29. Hodgson M. The sick-building syndrome. Occup Med. 1995;10:167–75
30. Brasche S, Bullinger M, Morfeld M, Gebhardt HJ, Bischof W. Why do women suffer from sick building syndrome more often than men? Subjective higher sensitivity versus objective causes. Indoor Air. 2001;11(4):217–22
31. Zhang X, Li F, Zhang L, Zhou Z, Norback D. A longitudinal study of sick building syndrome (SBS) among pupils in relation to SO2, NO2, O3 and PM10 in schools in China. PLoS One. 2014;9(11):e112933.
32. Reijula K, Sundman-Digert C. Assessment of indoor air problems at work with a questionnaire. J Occup Environ Med. 2004;61:33-38.
33. Runeson R, Norb∆ck D, Stattin H. Symptoms and sense of coherence – a follow-up study of personnel from workplace buildings with indoor air problems. Int Arch Occp Environ Health. 2003;76,29-38.
34. Runeson R, Wahlstedt K, Wieslander G, Norb∆ck D. Personal and psychosocial factors and symptoms compatible with sick building syndrome in the Swedish workforce. Indoor Air. 2006;16:445-453.
35. Melikov AK, Kaczmarczyk J. Air movement and perceived air quality. Building and Environment. 2012. 47:400-9.
36. Mendell MJ, Lei-Gomez Q, Mirer A, Seppanen O, Brunner G. Risk factors in heating, ventilating, and air-conditioning systems for occupants symptoms in US office buildings: the EPA BASE study. Berkeley (US): Department of Energy's; 2006. 38p. Report No.: LBNL-61870
37. Wolkoff P, Wilkins CK, Clausen A, Larsen K. Comparison of volatile organic compounds from processed paper and toners from office copiers and printers: Methods, emission rates, and modelled concentrations. Indoor Air. 1993;3(2):113-23.
38. Tang T, Hurra J, Gminski R, Mersch-Sundermann V. Fine and ultrafine particles emitted from laser printers as indoor air contaminants in German offices. Environ Sci Pollut Res Int. 2012;19(9):3840-9.
39. Jiang H, Lu L. Measurement of the surface charge of ultra□ne particles from laser printers and analysis of their electrostatic force. Atmos Environ. 2010;44:3347-51.
40. Jaakkola MS, Yang L, Ieromnimon A, Jaakkola, JJK. Office work exposures and respiratory and sick building syndrome symptoms. J Occup Environ Med. 2007;64(3):178–84.
41. He C, Morawska L. Particle emission characteristics of office printers. Environ Sci Technol. 2007;41(17):6039-45.
42. Juliana J, Nordiyana MS, Suhaimi NF. Exposure to indoor air pollutants (formaldehyde, VOC, ultrafine particles) and respiratory health symptoms among office workers in old and new buildings in Universiti Putra Malaysia. IJANS. 2014;3(1):69-80.
43. Burr GA, Alderfer RJ. (1991). Health hazard evaluation report HETA-89-0065-2119 [Internet]. Toledo (OH): One Government Center; 1991 [cited 2015 Mei 18]. 78 p. HETA 89-065-2119. Available from: www.cdc.gov/niosh/hhe/reports/pdfs/1 989-0065-2119.pdf.
44. Abdel Hameed AA, Yasser IH, Khoder IM. Indoor air quality during renovation actions: A case study. J Environ Monit. 2004;6(9):740–4.

45. Sahlberg B, Wieslander G. Sick building syndrome in relation to domestic exposure in Sweden—A cohort study from 1991 to 2001. Scand J Public Health. 2010;38:232–8.
46. Gyntelberg F, Suadicani P. Dust and the sick building syndrome. Indoor Air. 1994;4:223-38.