ORIGINAL ARTICLE

Association Between Air Microbiological Exposure With Sick Building Syndrome (SBS) among College Dormitory Students in Public University

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ABSTRACT

Introduction: Microbiological pollutants in indoor air can lead to sick building syndrome (SBS). A conducive academic environment in university dormitories requires healthy indoor air quality to enhance student performance. This study aimed to determine the association between indoor air microbiological exposure and SBS among college dormitory students at a public university. **Methods:** A cross-sectional study was conducted among 112 male and female college dormitory students who stayed in the public university dormitory for more than three months. Respondents were given a self-administered questionnaire-based NIOSH Indoor Environmental Quality Survey. 14 houses were selected for the measurement of indoor air quality which included $PM_{2.5}$, PM_{10}, relative humidity (%), temperature (°C), air velocity (m/s), indoor bacterial concentration (cfu/m^3), and indoor mould concentration (cfu/m^3). **Results:** Higher percentages of SBS symptoms were reported among female (94.6%) college dormitory students compared to male (82.1%). A significant difference in itching symptom on the arms and forearms was found among individuals of different genders ($p<0.05$). Indoor air parameters such as temperature (OR = 2.56, 95% CI = 2.66-9.87), relative humidity (OR = 1.77, 95% CI = 1.54 – 5.79), indoor bacteria concentration (OR=2.28, 95% CI = 2.48 – 10.93), and indoor mould concentration (OR=2.59, 95% CI = 1.75 – 8.98) were significantly associated with the recent SBS symptoms. Multiple logistic regression showed that the most significant predictor of SBS was indoor mould concentration. **Conclusion:** Exposure to high concentrations of indoor bacteria and mould, high temperatures, and high relative humidity influenced the prevalence of SBS among college dormitory students. Further assessment and preventive action need to be taken to reduce the exposure of indoor air microbiological to the students.
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Keywords: Sick Building Syndrome Symptoms; Indoor Air Pollutants; Microbiological Pollutants; Indoor Air Quality; College Dormitory Students

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INTRODUCTION

University dormitories are functioned to provide a living place to students (1). These are the places where the students spend most of their time live, study and sleep besides giving them opportunity to build their own character and intelligence and developing their life skills. A healthy indoor air quality in the university dormitory is needed to provide a conducive environment to the students, increase their performance, and help the university reach their core mission in educating the students. The indoor environment has a substantial impact on human health (2). Exposure to indoor air pollutants significantly increases the risk of respiratory tract infection (3). There is a strong correlation between being exposed to indoor pollutants and experiencing higher rates of illness and death, especially among those who spend a significant amount of time in classrooms and other indoor facilities (4). According to World Health Organization, factors that are associated with indoor air problems are inadequate room temperature, air humidity, building dampness, ventilation flow and microbial exposure such as moulds and bacteria (5).

A study conducted among nursing students in Bangkok concluded that dormitory should have a good air quality, be convenient, clean, hygienic, and safe, all of which will improve not only the quality of life, but also academic performance achievement (6). According to United States Environmental Protection Agency (USEPA), humans spend 90 percent of their lifetime indoor compared to outdoor. They also stated that indoor air pollutants are two to five times and occasionally more than 100 times higher than outdoor air (7).

Microorganisms such as bacterial and fungi are always present in the air. In indoor environment, the most important source of airborne bacteria is the presence of human. Human activities such as talking, sneezing, coughing, walking, washing and toilet flushing can generate airborne biological particulate matter (8). Bioaerosol vary in their size distribution and composition, a large portion of bioaerosol are of respirable size ranging from 0.25 to 20μm for bacteria and 1 to 30μm for fungi. They can enter into human respiratory tract through two different routes of exposure namely by inhalation and by skin contact. Studies have shown consistent associations between indoor bioaerosol and sick building syndrome or allergic health effects in infants, children and adults (9-13).

The type of species, concentration and the level of exposure to bioaerosol in an indoor environment can be greatly influenced by indoor environmental conditions such as temperature, relative humidity and ventilation rate which may cause adverse health effects and comfort in the indoor environment (14). The growth of bioaerosol is enhanced with higher relative humidity and average temperature. The concentration of indoor bioaerosol is determined by the level of contamination in outdoor air, the air conditioning system used and the type of building materials used in indoor environment (15). Poor ventilation leads to the accumulation of pollutants from different sources and may increase the incidence of sick building syndrome among building occupants (16). Exposure to a high level of indoor air microbiological can lead individuals to experience several health effects, and usually, the building occupants experience the disease that can possibly trigger asthma, allergies, headaches, irritation of the eye, nose, and throat, and other respiratory diseases when allergens, irritants, and pollutants, are present in a building (17). Thus, this condition contributes to Sick Building Syndrome (SBS) symptoms (18).

According to USEPA, SBS is a term used to describe cases in which building occupants experience acute health and comfort effects that tend to be related to the amount of time spent in the building, but no underlying disease or cause has been found. The occupants stay in the building and the longer they need to stay in the building with this syndrome, the unhealthier they will be (7). The WHO also stated that the most common symptoms of SBS are irritation of the eyes, nose, and throat. Secondly, a person may experience a dry skin and dry mucosa. Thirdly, symptoms of fatigue, headache, nausea, and dizziness. Lastly, the occupants will feel hoarseness, wheezing, pruritus and non-hypersensitivity. One of sick building syndrome's important features is that the majority of the symptoms can be transient and remitted after one leaving the specific building environment (19).

Due to the increasing number of Coronavirus Disease (COVID – 19) cases in Malaysia, students who live in the college are likely to spend most of their time in dormitory and continue with the online learning and hybrid classes due to the strict movement control order by the government. According to a study in Thailand, dormitory rooms may be more polluted than the home environment, particularly when the dormitory are more crowded due to inadequate ventilation rates (6). The students living in their dormitory might be exposed to indoor air pollutants, which may lead to the development of sick building syndrome and resulting in reducing the student's productivity and learning process. Recently, there were concerns from the college students living in the dormitory regarding symptoms associated with poor indoor air quality and sign of mould on the wall and ceiling of the dormitory buildings. Besides, dormitory usually have high occupancy rates where the student shared rooms and other common facilities such as toilets, living room and pantry. A study conducted in hostels in Nigeria found that high occupancy rate had influenced the residents' well-being, comfort, and productivity, which eventually caused an unpleasant, disruptive, poor performance, absenteeism, and even disputes between students and administration (20). Therefore, this study aimed to determine the association between indoor air microbiological exposures with sick building syndrome among college dormitory students in a public university.

MATERIALS AND METHODS

Study location and subject selection

This study was a cross-sectional study conducted involving 112 college dormitory students aged between 19 to 30 years old who fulfilled the inclusion criteria; male and female who stayed in the public university dormitories for more than three months. Those with previous respiratory problems and smokers were excluded as the exclusion criteria. The study was conducted from August to December 2021 and due to the Movement Control Order, there were not more than 200 students who stayed more than three months in the college dormitory as they return to the university to continue the online class in the dormitory on June 2021.

A public university was selected as the location for this study and 14 college dormitories were selected for the measurement of indoor air quality. The design of the dormitory is using a housing system which consist of 4 rooms, 1 toilet, 1 living room and pantry in one house. Each room consist of two occupants and the whole house contributes to 8 occupants, thus the total number of students participated in this study was 112. The selection of the houses was based on the condition of the college building that had sign of leaking in pipeline that leads to water leakage at the ceiling and wall of the dormitory buildings. Besides, indoor mould could also be seen in many students houses. The college had male and female blocks that consist of five levels of floors. However, only dormitories on the first four levels were selected in this study since there is no occupant on the top floor. Each dormitory in the house had two panel window and the living room had three panel windows with 60 inches height and 48 inches width each. List of the selected houses was obtained from the college office and underwent purposive sampling.

Questionnaire

The questionnaire that was used in this study was self-administered questionnaire that contained three sections which included socio-demographic, current dormitory environment and information about health and well-being. This questionnaire was based on questionnaire from the National Institute Occupational Safety and Health (NIOSH) Indoor Environmental Quality Survey (1991) which had been validated by the previous study (21). To indicate whether the respondents were experiencing SBS symptoms, the respondents must at least have one of the sick building syndrome symptoms listed in the questionnaire.

Indoor Air Quality Sampling

Indoor air quality sampling was done at each floor of each block (male and female) by measuring $PM_{2.5}$, PM_{10}, relative humidity, temperature, air velocity, indoor bacteria concentration, and indoor mould concentration. Before conducted the air sampling, calibration for all of the instruments were conducted to ensure its sensitivity and to prevent errors during the data collection process. The sampling was conducted during the weekend for 4 hours between 08:00 am to 18:00 pm. Sampling was carried out in the middle of each students' rooms, living rooms and toilets as they spent most of their time at these locations. Therefore, a total of 56 rooms, 14 toilets and 14 living rooms were chosen as measuring points. The instruments were placed at the height of 1.2 – 1.8 m above the ground (adult's breathing zone). The sampling was carried out in triplicate at each of the measuring point. Besides, this study was conducted during the Movement Control Order (MCO), therefore most of the students spend 90% of their time in the dormitory as class were conducted through online session.

The indoor air quality was measured using the DUO SAS Super 360, TSI Optical Particle Sizer Model 3330 and TSI Model 9565-A Velocicalc Multi-Function Ventilation Meter. The TSI Optical Particle Sizer Model 3330 is utilized for air sampling, specifically for collecting fine and ultrafine particles such as $PM_{2.5}$ and PM_{10} designed to measure the size distribution and concentration of airborne particles, including those in the nano-size range (22). On the other hand, the TSI Model 9565-A Velocicalc Multi-Function Ventilation Meter is primarily used for measuring different parameters related to indoor air quality and ventilation, including air velocity, temperature, and humidity (23). Although it is not typically used for collecting or measuring pollutants, it can be used to evaluate ventilation system performance and indoor air quality.

Ethical committee approval

Ethical approval was obtained from the Medical Research Ethics Committee, Universiti Putra Malaysia Ref. No.: (JKEUPM) (JKEUPM-2021-359).

RESULTS

Socio-Demographic Characteristics

The total respondents involved in this study were 112 college dormitory students where 56 (50%) respondents were male students, and 56 (50%) respondents were female. Table I shows the summary of socio demographic characteristics of the study population. Majority of the respondents were Malay (72.3%) students, Chinese (16.1%) followed with Indian (8.0%) and other ethnicity (3.6%). Most of the students had normal BMI (48.2%). However only 32 (28.6%) and 14 (12.5%) of the students were overweight and obese respectively, which might be due to their sedentary lifestyle.

College Dormitories Environment Characteristics

Table I represents the current dormitories environment characteristics. 26 (23.2%) of the respondents reported that there was a water leakage or water damage at indoor walls, floor, or ceiling, 59 (52.7%) respondents reported that there was a visible mould growth on indoor walls, floor, or ceiling and 22 (19.6%) respondents reported on smell of mould in one or more rooms.

Comparison of Indoor Air Pollutants Concentrations

Table II represents the results of all the parameters for indoor air pollutants between male and female dormitories. Based on the analysis, on average, in 7 male dormitories and 7 female dormitories, the mass concentration of $PM_{2.5}$ in male dormitory was higher than female dormitory at mean (SD) 67.8 $\mu g/m^3$ (2.4$\mu g/m^3$) for male dormitory and 66.5 $\mu g/m^3$ (3.3$\mu g/m^3$) for female dormitory. However, for PM_{10}, there was only slightly different in reading between male dormitory at mean 70.3$\mu g/m^3$ (2.0$\mu g/m^3$) and female dormitory at mean 70.2 $\mu g/m^3$ (4.8 $\mu g/m^3$).

Meanwhile, for relative humidity, the mean reading

Table I : Socio-demographic of the respondents and Current dormitory environmental characteristics

Socio demographic	College Students (n=112), n (%)
Gender	
Male	56 (50)
Female	56 (50)
Ethnicity	
Malay	81 (72.3)
Chinese	18 (16.1)
Indian	9 (8.0)
Others	4 (3.6)
Body Mass Index	
Underweight (below 18.5)	12 (10.7)
Normal (19.5-24.9)	54 (48.2)
Overweight (25.0-29.9)	32 (28.6)
Obese (30.0 and above)	14 (12.5)
Water leakage or water damage at indoors walls, floor, or ceiling	
Yes	26 (23.2)
No	86 (76.8)
Visible mould growth on indoors walls, floor, or ceiling	
Yes	59 (52.7)
No	53 (47.3)
The smell of mould in one or more room	
Yes	22 (19.6)
No	90 (80.4)

N=112

Table II : Comparison of indoor air pollutant concentrations in male and female dormitories

Variables	Total		Male Dormitory		Female Dormitory	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
PM $_{10}$ (µg/m³)	69.6	4.2	70.3	2.0	70.2	4.8
PM $_{2.5}$ (µg/m³)	66.7 .6	3.8	67.8	2.4	66.5	3.3
Relative Humidity (%)	68.1	4.8	66.5	2.4	67.8	3.3
Temperature (°C)	29.5	1.1	28.9	0.9	29.5	1.0
Velocity (m/s)	0.42	0.1	0.43	0.1	0.41	0.1
Indoor bacteria concentration (cfu/m³)	103.7	52.3	81.3	47.1	104.1	55.3
Indoor fungi concentration (cfu/m³)	244.8	129.1	189.1	122.9	261.5	97.7

recorded in female dormitory was higher at 67.8% (3.3%) than male dormitory at mean 66.5% (2.4%). For temperature, female dormitory also recorded high mean at 29.5°C (1.0°C) as compared to male dormitory at mean 28.9°C (0.9°C). For air velocity, male dormitory recorded high air velocity at 0.43m/s (0.1m/s) compared to female dormitory at 0.41m/s (0.1m/s). As for the levels of indoor bioaerosol, mean reading of indoor bacteria concentration in female dormitory was higher at 104.1cfu/m^3 (55.3cfu/m^3) compared to male dormitory at mean 81.3cfu/m^3 (47.1cfu/m^3). For indoor mould concentration, female dormitory recorded higher mean reading at mean 261.5cfu/m^3 (97.7cfu/m^3) compared to male dormitory at 189.1cfu/m^3 (122.9cfu/m^3).

Prevalence and Comparison of Sick Building Syndrome among College Dormitory Students

Table III shows the prevalence of SBS symptoms and comparison of SBS symptoms among college dormitory students. The most general symptoms of sick building syndrome were itching on the hands and forearms, headache, flu and feeling tired and out of sort. 65 (58.0%) students had headache in the last three months, 57 (50.1%) students had itching on hands or forearm in the last three months, 60 (53.4%) students feeling tired and out of sort and 56 (50.0%) having symptom of flu. Overall, there was no significant difference for symptoms of sick building syndrome between male and female students except for symptom of itching on hands and forearms as reported by chi-square test analysis where 34 (30.7%) female students and and 23 (41.1%) male students reported to have this symptom at p-value 0.038 ($p<0.05$). Overall, it was observed that female students reportedly had slightly higher symptoms of sick building syndrome compared to male students with 94.6% and 82.1% respectively.

Association between Indoor Air Pollutants Exposure with Sick Building Syndrome

A chi-square test was performed to find out the relationship between the exposure to indoor air pollutants with sick building syndrome symptoms among college dormitory students and the results are show in Table IV. Based on the results obtained, college students who exposed to high relative humidity were 1.8 times more likely to get SBS symptoms (OR=1.77; 95% CI= 1.54-5.79). For temperature, college students who exposed to high temperature were 2.6 times more likely to experience SBS symptoms (OR=2.56; 95% CI = 2.66 – 9.87) compared to students who exposed low temperature. Meanwhile, for indoor bacteria and indoor mould, college students that exposed to high indoor bacteria and indoor mould were 2.3 and 2.6 times more likely to get SBS symptoms, respectively (OR=2.28; CI = 2.48 – 10.93; OR=2.59; CI = 1.75 – 8.98).

Predictor of Sick Building Syndrome among Study Respondents after Considering all the Confounders

Multiple logistic regression was performed to determine the main predictor of sick building syndrome after controlling all the confounders as shown in Table V. The confounders in this study were age, gender, ethnicity, and smoking status. The risk of getting symptoms of sick building syndrome increased among college students who exposed to high level of indoor mould (B = -1.279, p = 0.049, AOR= 0.28, 95% CI = 0.76-1.02, Nagelkerke R^2 = 0.105) as the results showed significant influence of sick building syndrome with indoor mould concentration.

DISCUSSION

Comparison of Indoor Air Pollutants Exposure in the College Dormitories

The findings on the levels of indoor air pollutants in this study are being compared with the Industry Code of Practice on Indoor Air Quality 2010 Standard (ICOP IAQ 2010) (24) established by the Department of Occupational Safety and Health (DOSH) Malaysia. However, there is no direct acceptable limit for the PM_{10} and $PM_{2.5}$ in indoor environment, thus these pollutants are compared with the respirable particulates at the limit of 150µg/m^3. Overall, the levels of $PM_{2.5}$ and PM_{10} in the present study showed high readings, both in the male and female dormitories, however still below the standard value. These readings were high as there might be due to lack of housekeeping, students' activities, and inadequate ventilation due to presence of ceiling fans and open windows only. The finding was consistent with a study that mentioned insufficient ventilation and inconsistent housekeeping have been linked to high concentrations of indoor particulate matters in school's dormitory (25). From observation, most of the students cooked in the dormitory, however in the questionnaire, we did not mention about cooking activities in the dormitory as it was prohibited by the management. A study mentioned that cooking activities can increase the concentration of particulate matters $PM_{2.5}$ up to 4.3 times (26). Besides, most of the students tend to close their window cause lack of ventilation in the dormitory and therefore there is no way out for the smoke during cooking activities.

For temperature, it is one of the most important factors for the growth and survival of biological contaminants in the indoor environment. The result also showed that the mean exposure value of temperature in both male and female dormitories were high compared to the recommended range provided by the Guidance Note on Ventilation and Indoor Air Quality (IAQ) For Residential Setting During COVID-19 Pandemic which should be in the range of 23-26°C (27). This recommended limit is in line

Table III : Comparison of Sick Building Syndrome between Male and Female College Students

Recent SBS symptoms	Total (%) (N=112)	Prevalence of SBS Symptoms N=112 (100%)		χ^2	p-value
		Yes	No		
Rashes on hands or forearms	43(38.4)				
Male		19(33.9)	37(66.1)	0.944	0.331
Female		24(42.9)	32(57.1)		
Rashes on the face or throat	29(25.9)				
Male		11(19.6)	45(80.4)	2.280	0.131
Female		18(32.1)	38(67.9)		
Eczema	19(20.0)		49(87.5)		
Male		7(12.5)	44(78.6)	1.586	0.208
Female		12(21.4)			
Itching on the face or on the throat	38(33.9)				
Male		17(30.4)	39(69.6)	0.637	0.425
Female		21(37.50	35(62.5)		
Itching on hands or forearms	57(50.1)				
Male		23(41.1)	33(58.9)	4.323	***0.038**
Female		34(30.7)	22(39.3)		
Eye irritation	44(39.3)				
Male		17(30.4)	39(69.6)	3.743	0.053
Female		27(48.2)	29(51.8)		
Swollen eyelids	16(14.3)				
Male		5(8.9)	51(91.1)	2.625	0.105
Female		11(19.6)	45(80.4)		
Headache	65(58.0)				
Male		28(50)	28(50)	2.970	0.085
Female		37(66.1)	19(33.9)		
Nausea	25(22.3)				
Male		9(16.1)	47(83.9)	2.523	0.112
Female		16(28.6)	40(71.4)		
Runny nose/nasal cataract	40(35.8)				
Male		17(30.4)	39(69.6)	1.400	0.237
Female		23(41.1)	33(58.9)		
Nasal congestion	46(41.1)				
Male		19(33.9)	37(66.1)	2.361	0.124
Female		27(48.2)	29(51.8)		
Throat dryness	52(46.4)				
Male		22(39.3)	30(53.6)	2.297	0.130
Female		34(60.7)	26(46.4)		
Feels like having a flu	56(50.0)				
Male		23(41.1)	33(58.9)	3.571	0.059
Female		33(58.9)	23(41.1)		
Sore throat	37(33.0)				
Male		14(25.0)	42(75.0)	3.269	0.071
Female		23(41.1)	33(58.9)		
Irritative cough	19(17.0)				
Male		8(14.3)	48(85.7)	0.570	0.450
Female		11(19.6)	45(80.4)		
Breathing difficulties	11(9.8)				
Male		3(5.4)	53(94.6)	2.520	0.112
Female		8(14.3)	48(85.7)		
Feeling tired and out of sort	60(53.4)				
Male		28(50)	28(50)	0.574	0.449
Female		32(57.1)	24(42.9)		

Chi-square analysis *Significant at p<0.05

Table IV : Association between Indoor Air Pollutants Exposures with Sick Building Syndrome

Indoor Air Pollutants	Recent SBS Symptoms	
	OR	95% CI
PM_{10} (µg/m^3)	1.77	0.54 - 5.79
$PM_{2.5}$ (µg/m^3)	0.93	0.23 - 3.25
Relative Humidity (%)	***1.77**	**1.54 - 5.79**
Temperature (°C)	***2.56**	**2.66 - 9.87**
Velocity (m/s)	0.93	0.27 - 3.27
Indoor bacteria concentration (CFU/m^3)	***2.28**	**2.48 - 10.93**
Indoor mold concentration (CFU/m^3)	***2.59**	**1.75 – 8.98**

*OR significant if 95% CI >1

Table V : Predictors of Sick Building Syndrome among Respondents after Controlling All Confounders

Variables	B	SE	P - value	AOR	95% CI
Indoor mould concentration	1.279	0.662	***0.049**	2.80	2.48 - 10.93
Temperature	1.294	0.718	0.072	2.65	2.66 - 9.87

Adjusted factors: Gender, Age, Ethnicity. Variables significant with *p < 0.05. B = regression coefficient, SE= Standard Error, AOR=Adjusted Odds Ratio; Nagelkerke R^2 = 10.5%, Overall percentage = 88. 4%.

with the ICOP Standard. Malaysia is characterized as warm and humid country which creates a favourable condition for the growth and multiplication of bioaerosol. The annual mean temperature in Malaysia is 26.4°C and the average of daily maximum temperature is 34°C and as a result, high temperatures have an impact on the comfort and health of the building's residents (28). A study also mentioned that the concentration of indoor mould and indoor bacteria increased if the temperature increased, however variation might be due to other environmental factors (29). As for the optimum temperature for the growth of biological pollutants indoors, Kumar et al. (2021) suggested at 37-40°C (30). Indoor temperatures in both male and female dormitories were slightly above the upper limit and this might be due to the measurement was taken during hot and dry weather. Even though the levels of temperature of present study did not achieve the optimum level of bacterial growth, this condition might influence the comfort and health of the college students as the rise of temperature may causes high respiration, thus increasing the carbon dioxide (CO_2) and water activity, which promoting the presence of biological contaminants (31).

Meanwhile, according to Guidance Note on Ventilation and Indoor Air Quality (IAQ) for Residential Setting during COVID-19 Pandemic 2021, relative humidity in this study was within the acceptable range of 40 – 70% as well as the mean of air velocity in both male and female dormitory were also within the acceptable range. This guidance also in line with the standard established by the ICOP Malaysia (24). However, based on the study conducted by Verdier et al. (2014), different types of fungus or bacteria require different amounts of water (in vapor form) to reproduce and grow. The majority require relative humidity of 60% or more in order to survive (32). As the result obtained from the present study, both male and female dormitories had an optimum RH reading for the indoor microbial to grow (>60%). Humidity more than 65% may cause the incidence of upper respiratory problems which might increase and can have adverse effects on people suffering from asthma and allergies (30). A study carried out in Singapore found that bioaerosol is made up of 50.5% of bacteria and 49.5% of fungi indoors due to the high humidity caused by the water damage on the building (33). This study was supported by Lignell (2008) where the concentration of microorganisms was relatively higher in moist damaged buildings than normal buildings (34).

Furthermore, indoor bacteria concentration and indoor mould concentration were higher in female students' dormitories compared to male dormitories. However, the mean levels for indoor bacteria and indoor mould does not exceed the recommended value by the World Health Organization (WHO) where indoor mould concentration should not exceed 500 cfu/m^3 and total microbial concentration should not exceed 1000 cfu/m^3. The reason why there were higher bacteria and mould presents in women dormitory were probably due to the water leaking of the ceiling and wall in the building, and ineffective ventilation system. The leak of water in the ceiling allows water to flow into the dormitory which increased the ideal conditions for fungi to flourish in terms of dampness (35).

Comparison of Sick Building Syndrome among College Students

In this study, the students were defined as having SBS if they have reported to have at least one symptom of SBS and it appears at least once a week (29). We found out that the most common SBS symptoms among the college dormitory students were headache, tiredness, being out of sorts, itching on hands, and flu. This study is supported by a previous study that the most common SBS symptoms were malaise and fatigue, headache, and runny nose (25). The higher prevalence of sick building syndrome among students were headache (10%), followed with confusion (9.5%) and fatigue (7.4%). In this study, there was one symptom that showing significant different between male and female students which was itching on arms and forearms ($p < 0.05$) (36).

According to a local study, gender appears to be a key factor in how different types of SBS symptoms are reported, with females more likely than males to experience SBS symptoms (37).Besides, a local study conducted among school students in Johor Bahru stated that out of 51.0% respondents that reported of having SBS symptoms, the prevalence of experiencing ocular, nasal, throat and dermal symptoms were 12.7%, 19.8%, 16.9% and 23.1% respectively. However, the prevalence of headache and tiredness were the highest with 19.5% and 23.1% respectively (38). Another study conducted among junior high schools students in Johor Bahru found that female students had allergy symptoms more than male students and reported more heachache and tiredness compare to male students (39). They also mentioned that headache, itching on the hands and tiredness were the most common symptoms among the students. Therefore, our findings were consistent with these two locals studies.

Associations between Indoor Air Pollutants Exposure with Sick Building Syndrome

The results of this study also indicated that there were associations between temperature, relative humidity, indoor bacteria concentration, and indoor mould with sick building syndrome. These findings were consistent with a local study which reported that there was a significant association between the levels of indoor air quality with the prevalence of sick building syndrome among the respondents after confounder have been adjusted (OR=1.12, 95% CI=1.05-9.15) (21). Our study was supported by a study in Johor Bharu which they also mentioned that there was an association between indoor microbiome exposure especially on relative humidity and indoor mould with the symptoms of sick building syndrome in their study (38).

In this study, relative humidity was associated with sick building syndrome. Humidity is one of the important risk factors for the development of sick building syndrome symptoms especially on mucosal and dermal symptoms (39). Besides, indoor bacteria concentration and indoor mould concentration also have associated with the development of sick building syndrome among college students in this present study. This was supported by a study in junior high school in Johor Bharu where they mentioned that there was an association between the microbial exposure with sick building syndrome especially with tiredness ($p < 0.05$) and mucosal symptoms among students in junior high school in Johor Bharu (38). They also stated that higher indoor relative humidity have an association with high concentration of bacteria.

Besides, sick building syndrome also was associated with exposure towards high indoor temperature. This study was consistent with a study that mentioned that temperature and relative humidity affected the SBS symptoms (36). Besides, a higher number of total fungi was related to higher indoor temperatures (25). Another study mentioned that environmental characteristics such as temperature was associated with sick building syndrome as well (38). Overall, the results conclude that the college students are more likely to develop sick building syndrome if they are exposed to high concentration of indoor bacteria and mould, high temperature and high relative humidity. Advances in profiling techniques for characterizing fungi is leading to new discoveries regarding the correlation between rare and unculturable fungi present indoors and biomarkers associated with airway inflammation (38).

According to Isa et al. (2020), monitoring airway inflammation through fractional exhaled nitric oxide (FeNO) measurement is a recommended and acceptable method for assessing the impact of indoor air pollutants. The results of the study showed that exposure to PM_{10} and $PM_{2.5}$ above the upper confidence limit (UCL) of 40.23μg/m^3 and 23.99μg/m^3, respectively, had the potential to elevate FeNO levels, particularly in asthmatic and atopic children (2). This highlights the impact of high levels of all measured pollutants in classrooms of urban schools on the FeNO levels of school children (40). Moreover, the study conducted by Onwusereaka et al. (2018) unveiled that the concentration of indoor mould was significantly greater in preschools located in urban areas as compared to those in suburban areas (17).

Factor Influenced the Sick Building Syndrome among College Students

Based on multivariate analysis after controlling all the confounders in this study, only indoor mould was found to be associated with the prevalence of sick building syndrome. This result indicated that it was 2.8 times more likely for college dormitory students to develop sick building syndrome symptoms if they were exposed to high concentration of indoor mould; 244.8 CFU/m^3 compared to those who were not exposed. However, previous study by Nor Faeiza et al. (2016) stated that it was 1.3 times more likely for the students to develop sick building syndrome if they were exposed to high concentration of indoor mould, although the association is not significant (p=0.987, OR=1.30) (28). Therefore, the result showed that the main predictor of sick building syndrome among college dormitory students after considering all the confounders was indoor mould.

CONCLUSION

In conclusion, this study will provide future reference for researcher to conduct a study regarding indoor air microbiology with the development of sick building syndrome as it can help in providing baseline data. This study also found a higher prevalence of sick building syndrome among female college students compared to male students. Moreover, headache, itchy on the hands or forearm, tiredness and out of sort and flu were higher reported among the college dormitory students. However, only symptom of itchy on the hands or forearms was associated with the prevalence of sick building syndrome. This study suggested that regular maintenance of building materials caused by moisture damage and regular housekeeping are important in maintaining a good indoor air quality in the dormitory. This study also found that exposure towards indoor air pollutants such as high concentration of indoor bacteria and indoor mould, temperature and relative humidity might increase the development of sick building syndrome among the college dormitory students. The main predictor of sick building syndrome among college dormitory students after controlling all the confounder was indoor mould concentration. Besides, this study also bounded with some limitations. As most of the data were self-reported, there is a risk of misreporting, affect bias (the tendency to consistently score positively or negatively on questionnaire items depending on the respondent's mood) and recall bias. Thus, future studies should try to recruit more representative population and consider a prospective study to minimize the bias. Besides, other limitation of this study was conducted and measured in a one-time measurement only due to the time constraint and therefore this might influence the results and the accuracy with the SBS outcomes. Therefore, future studies should consider a long-term study and use a specific biomarker to evaluate the variation of microbiology that contribute to sick building syndromes.

For recommendation, this study advised the management of the college to reduce or solve the indoor air quality problems in the college building. It is advised for the college management to do regular maintenance of building materials that was caused by moisture damage. Regular housekeeping and dormitory cleaning should be done by the college students to help eliminate the air pollutants. As well, it is advised to increase the ventilation system by opening the windows regularly or the college management can provide an exhaust fan to minimize the accumulation of moisture in the dormitory. By practicing these recommendations, it can improve indoor air quality in the dormitory to ensure the health status of the students and help them to achieve better performance in their studies. Hence, future study is recommended to focus more on ventilation system as the improvements can help to increase the amount of clean indoor air while diluting the harmful contaminants. Likewise, proper ventilation in the building with outside air may help reduce the spread of the COVID-19 as well as lower the exposure risk.

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