คุณภาพอากาศภายในอาคารและความสัมพันธ์กับกลุ่มอาการผิวหนังของนักศึกษาแพทย์ขณะเรียนมหกายวิภาคศาสตร์

Indoor air quality and its associations with skin related syndrome among medical students during gross anatomy dissection

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บทคัดย่อ

การศึกษานี้เป็นการศึกษาแบบภาคตัดขวางโดยมีวัตถุประสงค์เพื่อประเมินคุณภาพอากาศภายในอาคารปฏิบัติการกายวิภาคและหาความสัมพันธ์กับกลุ่มอาการผิวหนังของนักศึกษาแพทย์ขณะเรียนมหกายวิภาคศาสตร์ซึ่งดำเนินการเก็บข้อมูลระหว่างเดือนสิงหาคมถึงพฤศจิกายน พ.ศ. 2561 เป็นระยะเวลาทั้งสิ้น 4 เดือน เก็บรวบรวมข้อมูลโดยใช้แบบสอบถามซึ่งถูกพัฒนาขึ้นจากผู้วิจัยและใช้เครื่องมือทางวิทยาศาสตร์สำหรับตรวจวัดพารามิเตอร์อากาศภายในอาคาร แบบสอบถามประกอบด้วยลักษณะของประชากร ลักษณะของอาคาร และกลุ่มอาการผิวหนัง ใช้สถิติสัมประสิทธิ์สหสัมพันธ์ของเพียร์สันและสัมประสิทธิ์สหสัมพันธ์แบบสเปียร์แมนสำหรับการวิเคราะห์ข้อมูล ผลการศึกษาแสดงให้เห็นว่ามี 12 ปัจจัยที่มีความสัมพันธ์กับกลุ่มอาการผิวหนังของนักศึกษาแพทย์ขณะเรียนมหกายวิภาคศาสตร์ที่ระดับนัยสำคัญ 0.05 และเห็นได้ชัดเจนว่ามี 3 ปัจจัยจาก 12 ปัจจัย(ความชื้นสัมพัทธ์ จำนวนแบคทีเรียทั้งหมดในอากาศ และความเข้มของแสงสว่าง) ที่มีอิทธิพลกับกลุ่มอาการผิวหนังโดยใช้การวิเคราะห์การถดถอยพหุคูณ จากนั้นนำปัจจัยทั้ง 3 ปัจจัยพยากรณ์การเกิดกลุ่มอาการผิวหนังโดยพบว่าปัจจัยทั้ง 3 ปัจจัยสามารถทำนายการเกิดกลุ่มอาการผิวหนังได้อย่างแม่นยำร้อยละ 99.1 ดังนั้น ควรดำเนินการจัดการทั้ง 3 ปัจจัยโดยการประยุกต์หลักวิศวกรรมเพื่อควบคุมคุณภาพอากาศภายในอาคารปฏิบัติการทางกายวิภาคให้อยู่ในเกณฑ์ที่ยอมรับได้

คำสำคัญ: กลุ่มอาการผิวหนัง คุณภาพอากาศภายในอาคาร มหกายวิภาคศาสตร์ ห้องปฏิบัติการ นักศึกษาแพทย์

Abstract

The purpose of this cross-sectional study was to assess associations of skin related syndrome (SRS) related to indoor air concentration in a dose-dependent manner among medical students during gross anatomy dissection at a university in Thailand. The study was conducted between August and November 2018. Data collection involved using questionnaires which were developed by the researchers and used appropriate analytical instruments for the measurements of indoor air parameters. The questionnaires contained items related to population characteristics, building characteristics, and SRS. Pearson's correlation coefficient and Spearman's rank correlation were used to analyze data. The results showed that there were 12 factors significantly associated with SRS during gross anatomy dissection by medical students (P<0.05). Apparently, there were three influencing variables which included relative humidity, total bacteria in indoor air, and light intensity as tested using regression analysis. A regression model was run to predict the SRS of medical students from the 3 variables. These variables could significantly predict the SRS of medical students with a total success rate of 99.1% (R^2=0.991). Therefore, efforts should be made to manage those

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variables by applying an engineering approach to controlling the environmental parameters related to indoor air quality in the gross anatomy laboratory room.

Keywords: skin-related syndrome ; indoor air quality ; gross anatomy dissection ; laboratory room ; medical students

Introduction

In Thailand, indoor air pollution is a topic of interest. Due to economic growth and urban development, construction of high-rise buildings as well as department stores, schools and offices may cause indoor air pollution. The Environmental Protection Agency (EPA), a Federal agency of the United States of America, stated that workers spent up to 90% time in an indoor environment each day(US Environmental Protection Agency, 2020) . Notably, improper ventilation in the building leads to sick building syndrome (Zamani *et al*, 2013 ; Ponsoni & Raddi, 2010). According to a Public Health Statistics report, the morbidity rate of respiratory diseases has increased more over the past decade as has the mortality rate (Ministry of Public Health, 2018). Indoor air quality and sick building syndrome (SBS) are related to various illnesses (Zamani *et al*, 2013). SBS is a group of non-specific symptoms of general complaints such as skin related symptoms (SRS), general-ill related symptom (GRS) and mucosal related symptom (MRS)(Reuben *et al*, 2019). Previous literature indicated an association between environmental indoor air concentrations of gasses such as carbon dioxide (CO_2), carbon monoxide (CO), as well as total volatile organic compounds: VOCs (ppm), temperature ($^{\circ}$C), relative humidity (RH%), microorganisms and SBS(Sahlberg *et al*, 2013 ; Sun *et al.*, 2013 ; Lu *et al.*, 2016). The World Health Organization (WHO) defined SBS as an excess of building related irritations of the skin, mucosal membranes and others, including headache, fatigue, eye irritation, cough, tight chest, nasal stuffiness, wheeze and difficulty in breathing (Ponsoni & Raddi, 2010).

Indoor air quality concerns the air quality in and around gross anatomy laboratory buildings and facilities, which certainly affect the health and comfort of staff and medical students (Merrill, 2008). Poor air quality poses enormous health problems to workers, medical students and the environment as it may cause SRS (Reuben *et al*, 2019). The purpose of this cross-sectional study was to assess associations of SRS related to the concentration of contaminants in indoor air in a dose-dependent manner among medical students during gross anatomy dissection in a university in Thailand.

Materials and methods

Study area

The study area was a gross anatomy dissection study room located on the 1st floor of a building a, Thammasat University, Thailand. This gross anatomy dissection room wis ventilated naturally as shown in Figure 1. Indoor air quality monitoring areas were set as 4 areas as shown in Figure 2 ;

Area A: contain 1 group of students (Group 1)

Area B: contain 3 groups of students (Group 2, 5, and 8)

Area C: contain 4 groups of students (Group 3, 4, 6, and 7)

Area D: No students

Figure 1. Gross anatomy dissection study room.

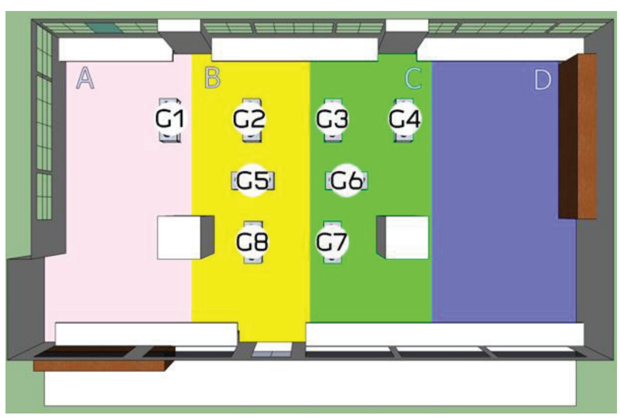

Figure 2 Indoor air quality monitoring area.

Study design and participants

A cross-sectional study was conducted between August and November 2018. The study was carried out among students who studied gross anatomy dissection.

All participantsewere overl18 years old students and were chosen through random sampling. The recruitment process was based on the inclusion and exclusion criteria. As a result, 53 students were recruited as participants and were separated to work on 6 anatomical parts as follows ;

1) Anatomy of back and suboccipital region: designated 'Back'

2) Pectoral region, axilla and upper extremities: designated 'Upper limb'

3) Muscle of facial expression and mastication: designated 'Superficial face'

4) Dissection of temporal region and TMJ: designated 'Deep face'

5) Dissection of triangle of neck: designated 'Anterior Neck'

6) Anterior abdominal wall and abdominal organs: designated 'Abdominal'.

Data collection and Instruments

Questionnaires were completed by face-to-face interviews with all participants after clasashad finished. General information and SRS during gross anatomy dissection were assessed via questionnaires. The questionnaires were developed and adopted from previous studies by researchers based on the severity level which was approved by 3 experts before data collection with IOC ; 0.70-1.00.

The environmental parameters related to indoor air quality, total fungi and bacteria in ambient air were measured using IAQ meter and impactors. The Indoor air quality meter (Q-TRAK Indoor Air Quality Monitor Model 7575) was calibrated to measuof carbon dioxide (CO_2), carbon monoxide (CO), total volatile organic compounds (TVOCs), temperature and relative humidity (RH%). An impactor (Bio Sampler: SAS SUPER ISO 100) was calibrated and set up at flow 100 liters/minute with a dish containing trypticase soy agar for bacteria and malt extract agar for fungi. ApPersonal pump with sorbent tube (10% ; 2- hydroxyethyl) piperidine on XAD-2, 120 mg/60 mg) was used for all area and personal formaldehyde concentration in the air sampling. Personal pumps were calibrated and set up at for 0.01 to 0.10 liters/minute ; NIOSH Method 254ueemployinf gas chromatography wih, FID detector was used for analyzing the formaldehyde concentration in the air.

After environmental samples were completed, questionnaires were collected and analyzed.

Data analysis

The data were analyzed with the statistical program Statistical Package for Social Sciences (SPSS version 23). Descriptive statistics such as frequency and percentage were used for analyzing the socio-demographic of the respondents as well as gender, age, and underlying diseases. The analysis also included the number of hours the students spent studying daily and weekly. Pearson's correlation coefficient and spearman's rank correlation were used to determine the association between those variables, and SRS. Furthermore, regression analysis was used to identify the factors significantly associated with SRS and predict its possible occurrence. regression analysis wan also performed to predict SRS.

Before using regression analysis, several key assumptionenwere considere.: The linear correlation was confirmed between SRS and the independent variables. The use of scatter plots showed whether there was a linear correlation. There was no multivariate normality and multicollinearity. Variance Inflation Factor (VIF) values and homoscedasticits were used to teed an assumptions. A plot of standardized residuals versus predicted valuen was used to show whether pointe were equally distributed across all values of the independent variables. All key assumptions were passed for testing.

Ethical consideration

Ethical approval to conduct this study was received from the Human Research Ethics Committee of Thammasat University, No.3. Ethical approval number is 061/2561 and the date of approval was September 5, 2018.

Results and Discussion

General information

Table 1 demonstrates the general profile and SRS of the sample population. There were 53 respondents including 37 females and 16 mally. The results showed that 69.8% of the female participants were between 19-26 years old and 88.7% were non-contact lens wearers. About 81.1% of the respondents had no underlying diseases and more than 88.0% took 3 hours for gross anatomy dissection class each time (day/week), 28.3%, 20.8%, 18.9%, 17.0%, 17.0%, and 11.3% of the respondents reported that they had SRS symptoms in part of back, anterior neck, upper limp, superficial face, abdominal, and deep face dissection, respectively.

Table 1 General characteristics and SRS of the respondents (n=53)

Characteristics		Part of Gross Anatomy Dissection, n (%)					
		Back	Upper limp	Superficial face	Deep face	Anterior neck	Abdominal
Gender	Male	16 (30.2)	16 (30.2)	16 (30.2)	16 (30.2)	16 (30.2)	16 (30.2)
	Female	37 (69.8)	37 (69.8)	37 (69.8)	37 (69.8)	37 (69.8)	37 (69.8)
Age (Years old) (Mean $\pm$ SD: 20.45 $\pm$ 2.074)	19	24 (45.3)	24 (45.3)	24 (45.3)	24 (45.3)	24 (45.3)	24 (45.3)
	20	16 (30.2)	16 (30.2)	16 (30.2)	16 (30.2)	16 (30.2)	16 (30.2)
	21	3 (5.7)	3 (5.7)	3 (5.7)	3 (5.7)	3 (5.7)	3 (5.7)
	23	2 (3.8)	2 (3.8)	2 (3.8)	2 (3.8)	2 (3.8)	2 (3.8)
	24	2 (3.8)	2 (3.8)	2 (3.8)	2 (3.8)	2 (3.8)	2 (3.8)
	25	5 (9.4)	5 (9.4)	5 (9.4)	5 (9.4)	5 (9.4)	5 (9.4)
	26	1 (1.9)	1 (1.9)	1 (1.9)	1 (1.9)	1 (1.9)	1 (1.9)
Contact lens wearing	No	48 (90.6)	47 (88.7)	45 (84.9)	47 (88.7)	48 (90.6)	48 (90.6)
	Yes	5 (9.4)	6 (11.3)	8 (15.1)	6 (11.3)	5 (9.4)	5 (9.4)
Underlying Diseases	No	43 (81.1)	43 (81.1)	43 (81.1)	43 (81.1)	43 (81.1)	43 (81.1)
	Yes	10 (18.9)	10 (18.9)	10 (18.9)	10 (18.9)	10 (18.9)	10 (18.9)
Time of Gross Anatomy Dissection class (Hours/ time) (Mean $\pm$ SD: 3.12 $\pm$ 0.334)	3	50 (94.3)	37 (69.8)	45 (84.9)	52 (98.1)	51 (96.2)	44 (83.0)
	4	3 (5.7)	15 (28.3)	8 (15.1)	1 (1.9)	2 (3.8)	9 (17.0)
	5	0 (0)	1 (1.9)	0 (0)	0 (0)	0 (0)	0 (0)
Skin-related syndrome (SRS)	No	38 (71.7)	43 (81.1)	44 (83.0)	47 (88.7)	42 (79.2)	44 (83.0)
	Yes	15 (28.3)	10 (18.9)	9 (17.0)	6 (11.3)	11 (20.8)	9 (17.0)

Environmental and indoor air concentrations

The indoor air concentrations for biological parameters in Table 2 ranged in a dose-dependent manner from 122.5 to 535.0 CFU/m^3, 137.5 to 775.0 CFU/m^3 for total fungi and total bacteria in indoor air, respectively. Most of the high number of colony counts per 1 m^3 of air were in anatomy of back and suboccipital region dissections. The results showed that two areas for fungal content in indoor air and three areas for bacteria in indoor air were found to be higher than WHO Guideline 2010(World Health Organization, 2010) Table 3 describes the environmental parameters related to the indoor air quality result. For TVOC, the mean indoor air concentration was 1.60 ppm (range 1-2 ppm). All of the sampling areas were below the recommended limits of the Department of Health (Thailand) (less than 2 ppm).

Based on formaldehyde concentration measurement in both the laboratory environment and in personal sampling, the mean formaldehyde concentration in laboratory area was 0.5312 ppm (range 0.0421-1.0801 ppm). More than 75% of the area points were below the recommended limits of Occupational Safety and Health Administration (OSHA) Standard (≤0.75 ppm). However, half of them were found to be higher than OSHA Standard with the mean formaldehyde concentration 0.6655 ppm (range 0.0437– 1.3841 ppm). The highest concentration was in group 7 (area B) in anatomy of back and suboccipital region dissection.

The results demonstrated that the temperature and relative humidity in sampling areas were higher than the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) Standard 55-2010 (range 22.0-26.1 °C and range 30.0-65.0%, respectively). The mean temperature of sampling areas was 31.06 °C, in muscle of facial expression and mastication dissection were found highest temperature in area A and C. Relative humidity measured ranged from 64.0 to 82.6 % (mean 72.8 %). The highest located in area D with Anatomy of back and suboccipital region dissection.

This study found that carbon dioxide (CO_2) and carbon monoxide (CO) concentration were below the recommended limits of ASHRAE 62 (less than 700 ppm and less than 9 ppm, respectively). The mean CO_2 concentration was 459.5 ppm with range from 423.0-511.0 ppm while CO concentration range from 0.60-3.80 ppm (mean 1.72 ppm).

In addition, more than 60.0% of light intensity sampleg areas were found below the Department of Thai Labour Standard (>400 lux) with range from 311.6-532.8 Lux. The lowest level located in area B while learning anatomy of back and suboccipital region dissection.

Table 2 Biological parameters

Part of Gross Anatomy Dissection	n=20	Area	Colony counts per 1 m^3 of air (CFU/m^3)	
			Fungal in indoor air	Bacteria in indoor air
Back and suboccipital region	1	A	357.5	737.5*
	1	B	507.5*	775.0*
	1	C	387.5	732.5*
	1	D	255.0	480.0
Upper limp	1	A	262.5	225.0
	1	B	440.0	150.0
	1	C	535.0*	197.5
	1	D	442.5	137.5
Superficial face	1	A	315.0	232.5
	1	B	382.5	302.5
	1	C	337.5	172.5
	1	D	322.5	197.5
Deep face	1	A	267.5	262.5
	1	B	337.5	202.5
	1	C	295.0	207.5
	1	D	270.0	200.0
Anterior neck	1	A	390.0	240.0
	1	B	147.5	295.0
	1	C	220.0	182.5
	1	D	122.5	180.0

Noted: * means higher than WHO Standard 2010 (≤500 CFU/m^3)

Table 3 The environmental parameters related to indoor air quality

Part of Gross Anatomy Dissection	Area	Total VOCs concentration (ppm) n=20	Formaldehyde concentration (ppm) Area sampling n=12	Formaldehyde concentration (ppm) Personal sampling n=12		Temp (°C) n=20	Relative Humidity (%) n=20	CO_2 (ppm) n=20	CO (ppm) n=20	Light (lux) n=20
Back and suboccipital region	A	1.0	0.7324 to 0.9667 [a]	G1	0.7656 [a]	28.1 [b]	81.8 [c]	451	2.4	339.8 [d]
	B	2.0		G5	1.0707 [a]	28.4 [b]	82.4 [c]	511	1.3	311.6 [d]
	C	2.0		G3 G7	0.8900 [a] 1.3841 [a]	28.3 [b]	82.5 [c]	436	1.5	314.8 [d]
	D	2.0		There are no study groups in this area.	Not applicable	28.3 [b]	82.6 [c]	451	1.8	342.1 [d]
Upper limp	A	1.0	0.5330 to 1.0801 [a]	Not applicable	Not applicable	31.8 [b]	69.9 [c]	435	1.9	420.2
	B	2.0		G2 G8	1.3581 [a] 0.9209 [a]	31.8 [b]	70.1 [c]	465	1.5	345.8 [d]
	C	2.0		Not applicable	Not applicable	31.8 [b]	70.2 [c]	473	0.6	336.5 [d]
	D	2.0		There are no study groups in this area.	Not applicable	31.7 [b]	69.9 [c]	453	1.1	259.7 [d]
Superficial face	A	1.0	0.0421 to 0.1177	Not applicable	Not applicable	32.4 [b]	71.4 [c]	466	1.2	532.8
	B	1.0		Not applicable	Not applicable	32.3 [b]	70.2 [c]	460	1.2	514.5
	C	2.0		G4 G6	0.0437 0.0858	32.4 [b]	70.1 [c]	462	1.2	502.5
	D	1.0		There are no study groups in this area.	Not applicable	32.3 [b]	69.3 [c]	464	1.1	362.4 [d]
Deep face	A	1.0	0.4809 to 0.5511	Not applicable	Not applicable	31.7 [b]	64.6 [c]	423	3.7	444.6
	B	1.0		Not applicable	Not applicable	31.9 [b]	64.1 [c]	438	3.7	403.0
	C	2.0		G4 G7	0.6982 0.5608	31.9 [b]	64.4 [c]	449	3.8	392.7 [d]
	D	1.0		There are no study groups in this area.	Not applicable	31.9 [b]	64.0 [c]	436	3.7	263.0 [d]
Anterior neck	A	2.0	0.2372 to 0.5338	G1	0.0865	31.1 [b]	76.4 [c]	451	0.7	368.0 [d]
	B	2.0		G5	0.1218	31.1 [b]	77.2 [c]	481	0.6	328.4 [d]
	C	2.0		Not applicable	Not applicable	31.0 [b]	77.2 [c]	485	0.6	392.1 [d]
	D	2.0		There are no study groups in this area.	Not applicable	31.0 [b]	77.6 [c]	500	0.7	307.7 [d]

Notes: a means higher than OSHA Standard (≤0.75 ppm), b means higher than ASHRAE Standard 55-2010 (range 22.0-26.1 °C), c means higher than ASHRAE Standard 55-2010 (range 30.0-65.0%), d means lower than Department of Thai Labour Standard (≥400 lux)

Association between independent variables and SRS Independent variables included anatomical part subject to gross anatomy dissection, study duration of gross anatomy dissection class, number of microbial colonies, formaldehyde concentration both of personal and area sampling, light intensity, carbon dioxide (CO_2), carbon monoxide (CO), total volatile organic compounds (TVOCs), temperature and relative humidity (RH%). The association between independent variables and SRS were analyzed using Spearman's rank correlation coefficients and Pearson's correlation coefficient as shown in Table 4-5.

The results showed that the correlations between anatomical part of gross anatomy dissection, temperature, light intensity and SRS were highly negative. In addition, the correlation between carbon monoxide (CO) and SRS was low negative.

In contrast there was a highly positive correlation between relative humidity and SRS. In terms of bacteria in indoor air, formaldehyde concentration in area samples and SRS, there was a positive correlation (Spearman's rank correlation coefficient 0.481 and 0.498 respectively at *p-value<0.01*) while the correlation between fungi in indoor air, formaldehyde concentration in personal samples, total VOCs, CO_2 and SRS was low positive.

Table 4 Association between part of gross anatomy dissection and skin-related syndrome (SRS)

Independent variables	Pearson's Correlation Coefficient	*p-value*
Part of gross anatomy dissection	-0.996	<0.001*

* *p-value*<0.05

Table 5 Association between independent variables (Internal scale) and skin-related syndrome (SRS)

Independent variables	Spearman's Correlation Coefficient	*p-value*
Time of gross anatomy dissection class	0.047	0.443
Fungi in indoor air	0.212	0.001*
Bacteria in indoor air	0.481	<0.001*
Formaldehyde concentration (personal sampling)	0.359	<0.001*
Formaldehyde concentration (area sampling)	0.498	<0.001*
Total VOCs	0.146	0.018*
Temperature	-0.906	<0.001*
Relative Humidity (%RH)	0.894	<0.001*
CO_2	0.341	<0.001*
CO	-0.281	<0.001*
Light intensity	-0.872	<0.001*

* *p-value*<0.05

Socio-demographic, environmental and indoor air monitoring was included into the model to test their correlation with SRS. Regression analysis covered twelve affected variables from those analyses. Only three influencing variables were tested by using regression analysis as shown in Table 6. The regression analysis model formula is shown in Equation (1).

$$Y = 0.055 + 0.093X_1 + 0.013X_2 + 0.006X_3 \quad (1)$$

Where

Y= SRS prevalence rate

X_1 = Total bacteria in indoor air evaluation (1 = Pass, 2 = Not pass)

X_2 = Light intensity evaluation (1 = Pass, 2 = Not pass)

X_3 = Relative humidity evaluation (1 = Pass, 2 = Not pass)

Table 6 Regression analysis model for predicting SRS prevalence rate

Independent variables	Unstandardized Coefficients		t	*p-value**
	B	Std. Error		
Constant	0.055	0.001	50.559	<0.001*
Total bacteria in indoor air evaluation: X_1	0.093	0.001	131.813	<0.001*
Light intensity evaluation: X_2	0.013	0.001	24.729	<0.001*
Relative humidity evaluation: X_3	0.006	0.001	10.498	<0.001*
R=0.996 R^2=0.991 Std.Error=0.00390 F=10011.290 Sig=0				

* *p-value*<0.05

This study found that 28.3%, 20.8%, 18.9%, 17.0%, 17.0%, and 11.3% of the respondents reported that they had SRS symptoms in part of back, anterior neck, upper limp, superficial face, abdominal, and deep face dissection respectively which supported the results of one previous study (Takaoka *et al.*, 2016) . Two areas with fungi in indoor air and three areas with bacteria in indoor air were found to be higher than WHO Standard. Similarly, research in 2010 in the USA found that the mean concentration in indoor airborne culturable bacteria and fungi was similar while other studies found values more than 10 times higher (Mainelis & Yao , 2004 ; Madureira *et al.*, 2015) According to formaldehyde concentration measured in both laboratory environment and personal sampling, about 25% of the area points had higher concentration than the recommended limits of the OSHA Standard. The highest concentration was in anatomy of back and suboccipital region dissection sections. This affirms a similar study in formaldehyde exposure among medical students during anatomy laboratory which reported that sections of anatomy regions related to higher formaldehyde concentrations (Promtes *et al.*, 2014). Moreover, half of the personal samples had formaldehyde concentration higher than OSHA standards. The highest concentration was in group 7 (area B) in anatomy of back and suboccipital region dissection.

The results demonstrated that temperature and relative humidity sampling areas were higher than ASHRAE Standard 55-2010. This may be according to the natural ventilation in the laboratory. In addition, more than 60.0% of light intensity measurements in sampling areas were below the Department of Labour Protection and Welfare standard.

The results further showed that between environmental factors including temperature, light intensity and SRS, there was a high negative correlation while between carbon monoxide (CO) and SRS. However, the correlation between relative humidity and SRS was found to have a high positive correlation. The association between bacteria in indoor air, formaldehyde concentration in area samples and SRS had a positive correlation while the association between fungi in indoor air, formaldehyde concentration in personal samples, total VOCs, CO_2 and SRS had low positive correlation. This is found to be similar to other studies on indoor air quality and SRS (Sahlberg *et al.*, 2013 ; Lu *et al.*, 2016 ; Yeo *et al.*, 2009 ; Crook & Burton, 2010) A regression analysis model was ran to predict SRS prevalence rate of medical students from three influencing factors successfully predicted 99.1% (R^2=0.991) which was a good fit for the data. Based on previous literature, there were risk factors for symptom groups and indoor air quality associated with SBS which can be used for predicting SBS by multiple logistic regression analysis (Bak *et al.*, 1997 ; Arikan *et al.*, 2018)

Conclusions

This study found that in some areas of gross anatomy dissection study rooms, the levels of fungi and bacteria in indoor air were higher than WHO Guideline 2010 and more than 50.0 % of formaldehyde concentration of personal samples were found to be higher than OSHA Standard. In addition, temperature and relative humidity sampling areas were higher than ASHRAE Standard 55-2010 and most of light intensity sampling areas were found to be below the Department of Labour Protection and Welfare standard. The 12 factors significantly associated with SRS during gross anatomy dissection of medical students. Only 3 variables ; relative humidity, total bacteria in indoor air, and light intensity could significantly predict SRS of medical students.

A cross-sectional study can only show a snapshot in time, with an underestimation of the actual situation because data are collected from a small population and small numbers of study sites. This study concentrated on medical students, and can serve as a baseline for relevant agencies. Thus, university policy implementation and risk communication will be introduced to the students and staff to develop safety programs and sustain improvement of behavior. Future directions of this research include applying the engineering approach to controlling the environmental parameters related to indoor air quality in the gross anatomy laboratory room.

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