



UNIVERSITI PUTRA MALAYSIA

***ASSOCIATION BETWEEN INDOOR AIR QUALITY (IAQ) AND SICK
BUILDING SYNDROME (SBS) SYMPTOMS AMONG LIBRARY
STAFFS IN UNIVERSITI PUTRA MALAYSIA***

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**ASSOCIATION BETWEEN INDOOR AIR QUALITY (IAQ) AND SICK
BUILDING SYNDROME (SBS) SYMPTOMS AMONG LIBRARY STAFFS
IN UNIVERSITI PUTRA MALAYSIA**



**BY
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Science in Environmental and Occupational Health with Honours from the
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ABSTRACT

ASSOCIATION BETWEEN INDOOR AIR QUALITY (IAQ) AND SICK BUILDING SYNDROME (SBS) SYMPTOMS AMONG LIBRARY STAFFS IN UNIVERSITI PUTRA MALAYSIA

NUR SYUHADA BINTI MOHD AROBI

Introduction: Indoor air quality (IAQ) refers to the air quality inside and around buildings and structures, particularly as it pertains to occupant comfort and health. Poor indoor air quality can result in a significant impact on the health of building occupants which is sick building syndrome. A good indoor air quality in library is important to ensure the health of the people in the library. Library staff spend the most of their time working in the library. Therefore, there is a need to assure that the level of indoor air quality in the library is good to ensure a good health, work productivity and job satisfaction of library staff. **Objective:** To determine the association between indoor air quality and sick building syndrome symptoms among library staff in University Putra Malaysia. **Method:** A cross-sectional study was conducted among 143 library staff in University Putra Malaysia aged 18 to 60 years old from August 2021 to January 2022. A self-administered, validated and pretested questionnaire adapted from the Malaysia Industry Code of Practice on Indoor Air Quality 2010 (ICOP 2010) was used to collect data on SBS symptoms, workstation environment, and socio-demographic background of library staff. Indoor air quality parameters were measured using real-time instruments based on ICOP 2010 methods. **Result:** A higher percentage of SBS symptoms were reported among female (96.4%) compared to male (88.3%) library staff. Significant differences in cough ($\chi^2= 4.087$, $p=0.043$) was found, where it was more frequent reported by male library staff. SBS symptoms have a significant association with particulate matter diameter less than 2.5 micrometers ($PM_{2.5}$) ($p<0.05$, OR = 0.16) and particulate matter diameter less than 10 micrometers (PM_{10}) ($p<0.05$, OR = 0.16). The result from Multiple Logistic Regression shows the most significant predictors of SBS symptoms after controlling all possible confounders are $PM_{2.5}$ and PM_{10} . **Conclusion:** $PM_{2.5}$ and PM_{10} were significant risk factors of SBS symptoms among library staff in this study. To mitigate the indoor air pollutants, proper housekeeping and inspections need to be conducted to determine that all parts and functions of the centralised Mechanical Ventilation Air-Conditioning (MVAC) system are in good condition.

Keywords: Indoor air quality (IAQ); sick building syndrome (SBS); indoor air pollutants (IAP); library staff

ABSTRAK

HUBUNGAN ANTARA KUALITI UDARA DALAMAN (IAQ) DAN SINDROM BANGUNAN SAKIT (SBS) DALAM KALANGAN KAKITANGAN PERPUSTAKAAN DI UNIVERSITI PUTRA MALAYSIA

NUR SYUHADA BINTI MOHD AROBI

Pengenalan: Kualiti udara dalaman (IAQ) merujuk kepada kualiti udara di dalam dan sekitar bangunan dan struktur, terutamanya yang berkaitan dengan keselesaan dan kesihatan penghuni. Kualiti udara dalaman yang lemah boleh mengakibatkan kesan yang ketara kepada kesihatan penghuni bangunan iaitu sindrom bangunan sakit. Kualiti udara dalaman yang baik di perpustakaan adalah penting untuk memastikan kesihatan penghuni di perpustakaan. Kakitangan perpustakaan menghabiskan sebahagian besar masa mereka bekerja di perpustakaan. Oleh itu, terdapat keperluan untuk memastikan tahap kualiti udara dalaman di perpustakaan adalah baik bagi menjamin kesihatan yang baik, produktiviti kerja dan kepuasan kerja kakitangan perpustakaan. **Objektif:** Untuk menentukan perkaitan antara kualiti udara dalaman dan gejala sindrom bangunan sakit dalam kalangan kakitangan perpustakaan di Universiti Putra Malaysia. **Metodologi:** Kajian keratan rentas telah dijalankan dalam kalangan 143 kakitangan perpustakaan di Universiti Putra Malaysia berumur antara 18 hingga 60 tahun dari Ogos 2021 hingga Januari 2022. Soal selidik yang ditadbir sendiri, disahkan dan diprauji diadaptasi daripada Malaysia Industry Code of Practice on Indoor Air Quality 2010 (ICOP 2010) digunakan untuk mengumpul data mengenai gejala SBS, persekitaran stesen kerja, dan latar belakang sosio-demografi kakitangan perpustakaan. Parameter kualiti udara dalaman diukur menggunakan instrumen masa nyata berdasarkan kaedah ICOP 2010. **Keputusan dan Perbincangan:** Peratusan simptom SBS lebih tinggi dilaporkan dalam kalangan kakitangan perpustakaan wanita (96.4%) berbanding lelaki (88.3%). Perbezaan ketara dalam batuk ($\chi^2= 4.087$, $p=0.043$) didapati, di mana ia lebih kerap dilaporkan oleh kakitangan perpustakaan lelaki. Gejala SBS mempunyai perkaitan yang ketara dengan diameter bahan zarah kurang daripada 2.5 mikrometer ($PM_{2.5}$) ($p<0.05$, OR = 0.16) dan diameter bahan zarah kurang daripada 10 mikrometer (PM_{10}) ($p<0.05$, OR = 0.16). Keputusan daripada Regresi Logistik Berganda menunjukkan faktor paling signifikan yang dikaitkan dengan simptom SBS setelah mengawal semua kemungkinan faktor lain adalah $PM_{2.5}$ dan PM_{10} . **Kesimpulan:** $PM_{2.5}$ dan PM_{10} merupakan faktor risiko yang signifikan terhadap gejala SBS dalam kalangan kakitangan perpustakaan dalam kajian ini. Untuk mengurangkan pencemaran udara dalaman, pengemasan dan pemeriksaan yang betul perlu dijalankan untuk menentukan bahawa semua bahagian dan fungsi sistem Penyaman Udara Pengudaraan Mekanikal (MVAC) berpusat berada dalam keadaan baik.

Kata kunci: Kualiti udara dalaman (IAQ); sindrom bangunan sakit (SBS); bahan pencemar udara dalaman (IAP); kakitangan perpustakaan

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LIST OF ABBREVIATIONS

<	Less Than
>	More Than
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
SBS	Sick building syndrome
CO	Carbon monoxide
CO ₂	Carbon dioxide
DOSH	Department of Occupational Safety and Health
IAP	Indoor air pollutants
IAQ	Indoor air quality
ICOP	Industrial Code of Practise
ILO	International Labour Organization
MVAC	Mechanical Ventilation Air-Conditioning
NAAQS	National Ambient Air Quality Standard
PM _{2.5}	Particulate matter diameter less than 2.5 micrometers
PM ₁₀	Particulate matter diameter less than 10 micrometers
SPSS	Statistical Package for Social Science
TVOC	Total volatile organic compound
UPM	Universiti Putra Malaysia
US EPA	United State Environmental Protection Agency
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays, indoor air quality (IAQ) has become a major concern because people spend the majority of their time indoors. Normally, the term indoor air refers to non-industrialized environments such as office buildings and public buildings (International Labour Organization; ILO, 2011). A good indoor air quality is important for achieving a healthy indoor environment. In order to maintain a good IAQ, the indoor environment must have an adequate ventilation rate, acceptable temperature and relative humidity, and control of airborne contaminants (US EPA, 2021). According to the World Health Organization (WHO), concerns about indoor air quality affect up to 30% of new and refurbished buildings. The problem arises because more buildings are constructed to be tighter to save energy (ILO, 2011). Apart from that, a study conducted by Jafari et al. (2015) found that indoor air pollutants concentration are 2-4 times higher than the outdoor air pollutants concentration. They also found that the indoor air quality can be 2-5 times worse than outdoor air quality if it is not well handled. The concentration of indoor air pollutants are much higher than that of outdoor air because of the low ventilation rates and the higher release of pollutants from indoor sources (Zainal et al., 2019).

A poor IAQ can give a significant impact on the health of building residents such as 'sick building syndrome' (SBS), multi chemical sensitivity (MCS) or 'building related illnesses' (BRI). SBS is described by the International Labour Organization (ILO) as a syndrome that arises when 20% of respondents show symptoms related to their workplace, with a particular link to air quality (ILO, 2011). SBS was commonly studied in office employees, and symptoms include headaches, fatigue, and symptoms of the pupils, upper respiratory tract, and facial skin. The prevalence of similar symptoms in a group of respondents that are present when they are in the building and absent when they are not in the building is the most predictive of sick building syndrome. A study conducted in Malaysian buildings found that SBS symptoms were present in 68.8% of office workers in the old building and 36.1% of office workers in the new building (Jalaludin et al., 2009). In another study conducted by Fadilah and Juliana (2012) found that new and old building in University Putra Malaysia were concluded as having SBS because more than 20% of the building occupants experienced SBS during the research. This indicates that indoor environment gives a significant impact on the symptoms of SBS to occur.

Indoor air quality in library is important to ensure the health of the people in the library. Library has become one of the most popular places for students, lecturers, researchers, and visitors to go for the purpose of finding academic sources. Indoor air quality in libraries has a direct impact on the reading effect and physical health of college and university professors and students, as well as an indirect impact on the quality and level of library services (Yang, 2017). IAQ in library is affected by the indoor air pollutants that are released by various sources such as building decorations that emit volatile organic compound (VOC). Apart from that, IAQ in library is

influence by the level of relative humidity, temperature, and air velocity in the library (Sulaiman & Mohamed, 2011). Poor level of these physical parameters of IAQ indicates that the level of IAQ in the library is poor and has a high chance for occupants in the library to have SBS symptoms.

Library staffs is the most susceptible people to have SBS symptoms compared to the visitors at the library because library staffs work eight hours a day every day and will exposed to the indoor air contaminants in the library more frequently. If the level of IAQ in the library is poor, it will unable to regulate the indoor environment efficiently (Drougka et al., 2020). A study conducted by Sulaiman and Mohamed (2011) in two libraries in Johor Bahru, Malaysia, they found that the prevalence of SBS symptoms among the library occupants was 57.94% in Perpustakaan Sultanah Zanariah, while 32.35% in Perpustakaan Sultan Ismail.

The purpose of this study is to determine the association between indoor air quality and sick building syndrome symptoms among library staffs in Universiti Putra Malaysia (UPM). This study hopes to be able to act as a reference for a more detailed study in library settings in the future.

1.2 Problem Statement

Library staffs spend most of their time in the library. This has led the library staffs to have prolonged exposure to indoor air pollutants in the library. The level of indoor air quality in the library can affect the health of library staffs. Poor indoor air quality can cause several health effects and one of the impacts is the sick building

syndrome (SBS). The occurrence of SBS symptoms can affect library staff's job satisfaction, work stress, and productivity. The implication of SBS had resulted in increased absenteeism among library staffs and increased in healthcare cost.

Library is a place that is always full of students and researchers to find academic resources. The high density of students, visitors, and staffs in the library contribute to the level of indoor air pollution as physical bodies of humans will produce heat and moisture and discharge a vast variety of polluted substances, such as carbon dioxide, virus, and bacteria, through the skin, sweat glands, and respiratory tract (Yang, 2017). This will eventually affect the level of air quality in the library and library staffs may experience the SBS symptoms.

The source of indoor air pollutants can come from the decorative materials used inside the library such as carpets, paints, flooring, coatings, plywood, and adhesive. These materials will emit harmful substances such as benzene, formaldehyde, chloride, and others (Yang, 2017). These hazardous substances are mostly volatile organic compound (VOC). If the ventilation in the library is poor, those contaminants can remain indoor and affect the health of library staffs. Symptoms of SBS can occur such as irritation of the eyes, skin, throat, nose, and neurotoxic symptoms such as headache or mental fatigue (Fantuzzi et al., 1996).

There are limited studies that did research on the impact of IAQ on SBS symptoms among library staffs. Many research on IAQ were carried out in developed country while limited study are conducted in developing countries. Poor IAQ has become one of main public health issues in developing countries (Zainal et al., 2019).

Thus, this study is important to give a vision on the impact of IAQ on SBS symptoms among staffs working at the library.

1.3 Study Justification

This study is conducted to determine the association between indoor air quality and sick building syndrome symptoms among library staffs in University Putra Malaysia. Poor indoor air quality is widely known for causing sick building syndrome symptoms among building occupants. This study will determine the prevalence of sick building syndrome experienced by the library staffs in Perpustakaan Sultan Abdul Samad, University Putra Malaysia. Higher prevalence of sick building syndrome will affect library staff's work productivity. Symptoms experienced by library staffs related to poor indoor air quality will be looked at and determine the category of symptoms in the SBS.

This study will provide data on which indoor air parameters that affect the poor indoor air quality and give impact on sick building syndrome among library staffs. The concentration of indoor air parameters in the library will be compared with the acceptable limits based on the Industrial Code of Practise on Indoor Air Quality (ICOP) 2010 (Department of Occupational Safety and Health; DOSH, 2010). The acceptable limits of each parameter should be complied. Control measures can be planned and taken based on the results of this study to improve the level of indoor air quality in the library. The source of indoor air pollutants can be identified and control measures on reducing the releasing of contaminants can be applied.

Therefore, this study can provide a clear relationship between indoor air quality and sick building syndrome. The data from this study can be used by the authorities to update or change the existing legislation relating to dangerous indoor air emissions and human exposure. Findings from this study can give awareness to the community about the impact of poor indoor air quality to their health. People can be benefited from this study to learn and gain knowledge about the levels of indoor air pollutants they had been exposed to during their time spent indoors, the danger of indoor air pollutants imposed upon their health, and they can be more careful towards the exposure of indoor air pollution.

1.4 Study Variable

1.4.1 Dependent Variable

The dependent variables in this study are sick building syndrome symptoms which includes general, dermal, and mucosal symptoms.

1.4.2 Independent Variable

The independent variables are carbon monoxide (CO), carbon dioxide (CO₂), particulate matter diameter less than 2.5 micrometres (PM_{2.5}), particulate matter diameter less than 10 micrometres (PM₁₀), and total volatile organic compound (TVOC). Physical parameters for IAQ such as temperature, relative humidity, and air velocity are assessed.

1.5 Research Questions

1. What is the sociodemographic of the respondents?
2. Does the concentration of indoor air pollutants in the library exceeds the acceptable limit?
3. What is the prevalence of SBS symptoms among male and female library staffs at UPM?
4. What is the association between indoor air quality parameters and sick building syndrome symptoms among library staffs at UPM?
5. What is the main predictor that influence the SBS symptoms among library staffs in UPM?

1.6 Research Objectives

1.6.1 General Objective

To determine the association between indoor air quality and sick building syndrome symptoms among library staffs at University Putra Malaysia.

1.6.2 Specific Objectives

1. To determine the sociodemographic characteristics of the respondents.
2. To compare the concentration of CO, CO₂, PM_{2.5}, PM₁₀, TVOC, temperature, relative humidity, and air velocity with acceptable limit.

3. To compare the prevalence of sick building syndrome symptoms among male and female library staffs at UPM.
4. To determine the association between indoor air quality parameters and sick building syndrome symptoms among library staffs at UPM.
5. To identify the main predictor that influence SBS symptoms among library staffs in UPM.

1.7 Research Hypothesis

1. There is a significant difference between the concentration of CO, CO₂, PM_{2.5}, PM₁₀, TVOC, temperature, relative humidity, and air velocity with the acceptable limit.
2. There is a significant difference between the prevalence of sick building syndrome symptoms among male and female library staffs in UPM.
3. There is a significant association between each indoor air quality parameters and sick building syndrome symptoms among library staffs in UPM.
4. PM_{2.5}, PM₁₀, and TVOC are the main predictor that influence SBS among library staffs in UPM after controlling the confounders in the study.

1.8 Definition of Variables

1.8.1 Conceptual Definitions

1. Indoor Air Quality

Indoor air quality (IAQ) refers to the air quality inside and around buildings and structures, especially relating to occupant health and comfort. In terms of occupant

comfort and well-being, the component of indoor air influences the quality of indoor environments. Indoor air quality comprises of three components which is physical components such as relative humidity, temperature, and air velocity; chemical components such as CO, CO₂, TVOC, formaldehyde, respirable particulates, and ozone; and biological components such as bacteria and fungi (US EPA, 2014).

2. Sick Building Syndrome

Sick building syndrome is a set of symptoms that building residents suffer when they stay within the building, with the symptoms dissipating once they depart (US EPA, 2014).

3. Carbon Monoxide (CO)

CO is a tasteless, colourless, and almost odourless gas or liquid. It is caused by incomplete carbon oxidation during combustion. High CO concentrations in indoor air can be caused by incomplete oxidation during burning in gas ranges and unvented gas or kerosene heaters (US EPA, 2016).

4. Carbon Dioxide (CO₂)

Carbon dioxide is a colourless, odourless, slightly acidic-tasting, non-flammable gas at ambient temperature. Carbon dioxide is a waste product of regular cell function that is breathed out of the body via the lungs. When fossil fuels are burned, carbon dioxide is released as well (Bonino, 2016).

5. Particulate Matter Diameter Less Than 2.5 Micrometres (PM_{2.5})

PM_{2.5} are referred as fine particles. They have an aerodynamic diameter of less than 2.5µm, which is about 3% the diameter of a human hair. PM_{2.5} can originate from several different places. Power plants, automobiles, aircraft, domestic wood burning, forest fires, agricultural fires, volcanic eruptions, and dust storms are among them. They can potentially harm human health by releasing harmful substances and caused impaired vision. When these particles are inhaled, it can penetrate deep into the lung tissues, and some may even enter the bloodstream and affecting the health (US EPA, 2016).

6. Particulate Matter Diameter Less Than 10 Micrometres (PM₁₀)

PM₁₀ are particles with an aerodynamic of 10µm or less and coarse in nature. It is referred as inhalable particles. These particles are tiny enough to reach the lungs after passing through the throat and nose. The source of PM₁₀ in indoor environment is from smoking, cooking, incense burning, human activities and outdoor contribution, while source from outdoor environment is from dust from construction sites, landfills and agriculture, wildfires and brush/waste burning, and industrial sources (US EPA, 2016).

7. Total Volatile Organic Compound (TVOC)

Volatile organic compounds (VOC) are gases released by some solids or liquids. VOC are a group of compounds that can have short- and long-term health consequences. TVOC is a complex mixture of hundreds of low-level VOC. Indoor TVOC concentrations are frequently greater than outside TVOC concentrations. TVOC can be released from household products such as detergents, paints, and plastics (US EPA, 2014).

8. Temperature

The term temperature refers to how hot or cold the air is. When considering the thermal comfort of inhabitants and the design of building services systems, temperature can be a particularly relevant parameter in the built environment. As a result, many temperature measurements are meant to reflect people's thermal comfort, or some aspect of their thermal comfort (Crahmaliuc, 2021).

9. Relative Humidity

Relative humidity is a measure of the water vapour density of air compared to the water vapour density for saturated air at the same pressure and temperature. It is expressed as percentage. Relative humidity will influence the thermal comfort. Raising relative humidity limits the capacity to shed heat through sweat and evaporation, producing a comparable effect to increasing the temperature. Extremes in humidity can also cause other IAQ issues. Excessively high or low relative humidity can be uncomfortable, and excessive relative humidity can encourage mould and mildew growth (Humidity, 2014).

10. Air Velocity

Air velocity is the rate of motion of air in each direction. It is usually expressed in meter per second. The rate of heat transmission between the air and neighbouring surfaces is affected by air velocity. Heat transfer is increased as the velocity of air passing across a surface increase. People's thermal comfort is also affected by indoor air velocities. The heat exchange between individuals in a space and the air surrounding those increases as air velocity increases. The unit for air velocity is m/s (Indoor air velocity, 2016).

1.8.2 Operational Definitions

1. Sick Building Syndrome

Symptoms of sick building syndrome include dermal, mucosal, and general symptoms experienced by building residents on a daily or weekly basis (Zhang et al., 2011). General symptoms of SBS includes headache, feeling heavy-headed, fatigue or lethargy, drowsiness, dizziness, and nausea or vomiting. Dermal symptoms include skin rash or itchiness and scaling or itching scalp or ears. Mucosal symptoms include cough, stuffy or irritated nose, throat dryness and irritation, and eye irritation (Zainal et al., 2019). The respondents are categorized as having SBS if they had at least one SBS symptom and appeared at least once a week. The occurrence of the symptoms of SBS must be reported at least 1-3 days per week during the last four weeks and the symptoms disappear when the respondents away from workplace (Hodgson, 2002).

2. Carbon Monoxide (CO)

CO was measured using TSI Model 7575 Q-Trak IAQ Monitor. Electro-chemical sensor type was used to measure CO with a detection limit of 0 to 500 ppm. The acceptable limit of CO is 10 ppm based on the ICOP 2010.

3. Carbon Dioxide (CO₂)

CO₂ was measured using TSI Model 7575 Q-Trak IAQ Monitor. Dual-wavelength non-dispersive infrared (NDIR) was used to measure CO₂ which has the detection limit from 0 to 5000 ppm. The acceptable limit for CO₂ is 1000 ppm based on the ICOP 2010.

4. Particulate Matter (PM_{2.5} and PM₁₀)

Optical Particle Sizer (OPS) 3330 was used to measure the concentration of PM_{2.5} and PM₁₀. This instrument detects the aerosol concentration between the ranges of 0.3 to 10 micrometres. Single particle counting technology was used to measure particles from 0.3 to 10 µm in 16 user adjustable size channels. The acceptable limit for respirable particulates is 0.15 mg/m³ based on ICOP 2010.

5. Total Volatile Organic Compound (TVOC)

TVOC was measured using ppbRAE 3000. It used photo-ionization detector (PID) that measured VOC at ppb levels. VOC can be measured from the range 1 part per billion (ppb) to 10,000 parts per million (ppm). Based on ICOP 2010, the acceptable limit for TVOC is 3 ppm.

6. Temperature

Temperature was measured using TSI Model 7575 Q-Trak IAQ Monitor which it used the sensor type thermistor and have a range from 0 to 60°C. ICOP 2010 acceptable limit for indoor temperature is 23°C to 26°C.

7. Relative Humidity

Relative humidity was measured using TSI Model 7575 Q-Trak IAQ Monitor which used thin film capacity sensor type that can detect the relative humidity from 5 to 95%. The level of relative humidity in indoor environment was measured using the principle of detection of a wet bulb and dry bulb to compare the humidity ratio and absolute humidity. Acceptable limit for relative humidity in indoor environment based on ICOP 2010 is 40 to 70%.

8. Air Velocity

TSI Model 9565-A Velocicalc Plus was used to measure the air velocity. Air velocity can be measured from the range 250 to 15,500 ft/min (1.27 to 78.7 m/s). Based on ICOP 2010, the acceptable limit for air velocity is from 0.15 to 0.50 m/s.

1.9 Conceptual Framework

This study aims to study the association between indoor air quality and sick building syndrome symptoms experience by the library staffs in UPM. The independent variable in this study is the IAQ parameters which are physical parameters (relative humidity, temperature, and air velocity) and chemical parameters (CO₂, CO, TVOC, PM_{2.5} and PM₁₀). Meanwhile, the dependent variable is the sick building syndrome symptoms. IAQ parameters were measured using real-time instruments according to ICOP 2010. SBS symptoms were assessed using questionnaire adapted from ICOP 2010. Figure 1.1 shows the conceptual framework of this study.

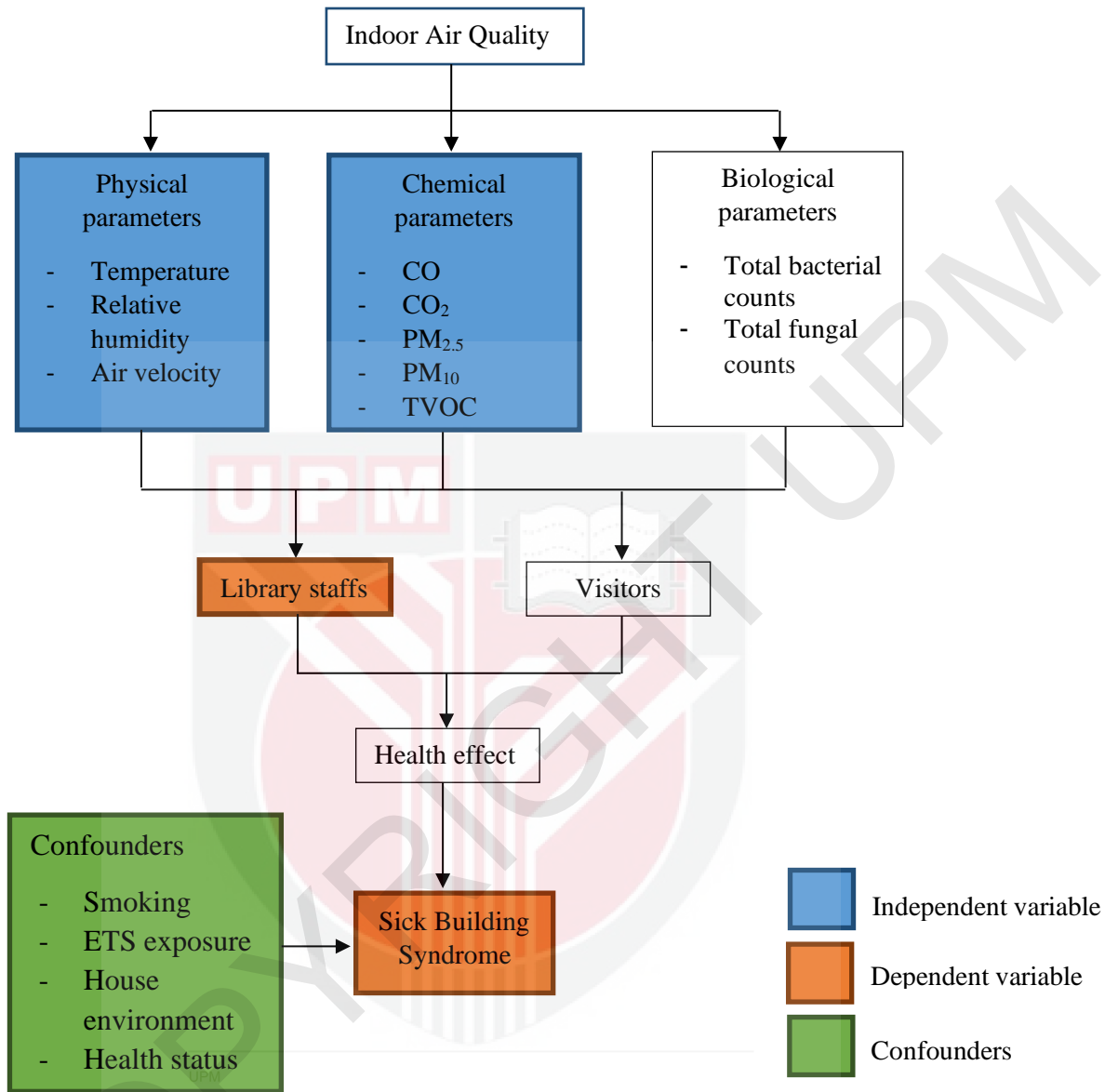


Figure 1.1: Conceptual Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Indoor Air Quality

Indoor air quality (IAQ) refers to the air quality inside and around buildings and structures, especially relating to occupant health and comfort (US EPA, 2014). Humans can be exposed to the indoor air pollutants by inhalation, dermal, and ingestion routes. Exposure to poor air quality can cause discomfort and also absenteeism and lower productivity in the workplace. Apart from that, poor air quality can affect human health such as asthma, allergy, Legionnaires' disease, Sick Building Syndrome (SBS) symptoms, and Building Related Illnesses. With the majority of people spending the bulk of their time indoors, indoor air is the most prevalent pathway for exposure to airborne pollution, and indoor air typically includes a variety of contaminants resulting from both indoor and outdoor sources (ASHRAE, 2020). According to the Department of Occupational Safety and Health (DOSH), IAQ problems arise in buildings with a mechanical ventilating and air conditioning (MVAC) system, including an air-cooled split unit (DOSH, 2017).

Indoor air quality is affected but not limited by air temperature, relative humidity, ventilation rates, bacteria, mould, and chemical exposure. Indoor air pollutants include particulate matter, carbon monoxide, formaldehyde, ozone, total

volatile organic compounds (TVOC), and biological contaminants such as bacteria and fungi. Koren et al. (1992) found that exposure to even moderate concentrations of volatile organic compounds (VOC) may result in inflammation and obstruction reactions in airways. The Department of Occupational Safety and Health Malaysia has published the Industry Code of Practise on Indoor Air Quality (ICOP) 2010 that proposed the selected indoor air quality parameters and their acceptable limits. The acceptable limit of each IAQ parameter must be complied in order to achieve a good IAQ. Table 2.1 and Table 2.2 below shows the acceptable range for specific physical parameters and acceptable limits of indoor air contaminants, respectively according to the ICOP 2010 (DOSH, 2010).

Table 2.1: Acceptable range for specific physical parameters

Parameter	Acceptable range
(a) Air temperature	23 - 26 °C
(b) Relative humidity	40 - 70%
(c) Air movement	0.15 – 0.50 m/s

Table 2.2: List of indoor air contaminants and the acceptable limits

Indoor Air Contaminants	Acceptable limits		
	ppm	mg/m ³	cfu/m ³
Chemical contaminants			
(a) Carbon monoxide	10	-	-
(b) Formaldehyde	0.1	-	-
(c) Ozone	0.05	-	-
(d) Respirable particulates	-	0.15	-
(e) Total volatile organic compounds (TVOC)	3	-	-
Biological contaminants			
(a) Total bacterial counts	-	-	500*
(b) Total fungal counts	-	-	1000*
Ventilation performance indicator			
(a) Carbon dioxide	C1000	-	-

2.2 Indoor Air Quality in Library

Righi et al. (2002) carried out a study in four libraries in the University of Modena and Reggio Emilia (Northern Italy) to assess the indoor air quality in the library. The physical parameters which is temperature, relative humidity, and ventilation were met with the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) standards. The concentration of formaldehyde in one library was below the detection limit, whereas the concentrations measured in the other libraries range from 5 to 30.7 $\mu\text{g}/\text{m}^3$. TVOC concentrations ranging from 203 to 749 $\mu\text{g}/\text{m}^3$, where library IV is the highest. Except for toluene, which was below the detection limit of 0.33 $\mu\text{g}/\text{m}^3$ in library II, all of the individual VOC were present in all libraries (Righi et al., 2002).

A study on indoor air quality assessment in a library in Greece conducted by Drougka et al. (2020) found that there is a higher mean temperature inside the library than the outside. The temperature was reduced by turning on the air conditioner, but the impact of opening the windows was minimal. The relative humidity, on the other hand, was less affected by the outside temperatures and remained nearly constant in the showcase, despite of the cooling process. Based on their findings, outdoor conditions had a significant impact on both the chemical concentrations and the thermal comfort parameters in the library, demonstrating the building's inability to control the indoor atmosphere, especially for gaseous organisms (Drougka et al., 2020).

A study conducted in two libraries in Johor Bahru, Malaysia by Sulaiman and Mohamed (2011) found satisfactory results of IAQ in both libraries, but there are some parameters that did not meet the acceptable limits at certain sampling points. The concentration of CO₂ exceeded the standard recommended value of 1000ppm set by ICOP 2010 and ASHRAE. This indicates that there was inadequate ventilation or there was a reasonably low spread of fresh air over the conditioned air-space. All indoor climatic measurements excluding respirable suspended particulates, formaldehyde, and air movement were substantially higher in both libraries. However, all indoor pollutant measurements were below the ICOP 2010 limits in general, indicating that the mechanical ventilation air conditioners (MVAC) in both libraries were well-maintained (Sulaiman & Mohamed, 2011).

2.3 Sick Building Syndrome

Sick building syndrome (SBS) is commonly used for illnesses that occur among occupants as a result of poor indoor air quality in building (DOSH, 2017). SBS refers to a condition in which building residents suffer acute health and/or comfort symptoms that tend to be due to time spent in a certain building, but there is no specific disease or cause (US EPA, 2021). The common symptoms that have been reported by residents of the "sick building" are irritation of the eyes and nose, fatigue, cough, rhinitis, nausea, headache, sore throat, or a combination of these. It is hard to tell if a worker is having SBS symptoms because of the wide range of symptoms. The symptoms may also be mistaken for those with other illnesses, such as a common cold. In order to differentiate it, majority of the complainants will feel relief shortly after

exiting the building. SBS has become one of the occupational hazard due to the increases absenteeism and decrease in productivity of employees (Joshi, 2008).

Symptoms of SBS can be grouped into three different group which is general symptoms, dermal symptoms, and mucosal symptoms (Zainal et al., 2019). General symptoms of SBS includes headache, feeling heavy-headed, fatigue or lethargy, drowsiness, dizziness, and nausea or vomiting. The headaches are identified as a mild pressure on the head, and they rarely progress to migraines or throbbing headaches. Dermal symptoms include skin rash or itchiness and scaling or itching scalp or ears. These signs are the most complex to link to SBS because they last for too long and may be caused by a variety of other causes or medical conditions. Mucosal symptoms include cough, stuffy or irritated nose, throat dryness and irritation, and eye irritation. The most frequent symptom in sick buildings is a blocked or "stuffy" nose, with sneezing and running nose being much less common. Throat inflammation, dry coughs, and a rise in thirst are also possible side effects. Users that are more vulnerable to the symptoms, such as people who wear contact lenses, can have more complications as a result of this (Rostron, 2005). People who have allergies or respiratory illness may find that the symptoms have become more severe. Asthmatic patients, for example, may be more susceptible to asthma attacks as a result of SBS.

There is no specific cause of SBS but there are variety of possible factors that might be responsible for SBS. The efficiency and efficacy of the internal ventilation system is thought to be the major cause of SBS (Passarelli, 2009). SBS can occur if the ventilation is poor, and the air circulation is inadequate. Poor ventilation results in low humidity and high temperatures that can create uncomfortable conditions for

employees and the public. High humidity levels can also affect the health of people working in the environment (Rostron, 1997). The key sources are thought to be air conditioning systems and emissions inside the environment from both inside and outside the building. Because of the high amount of air pollutants such as CO, CO₂, VOCs, and particulates, this emission is then circulated around the building, causing a detrimental impact on indoor air quality and will lead to the inability to remove the contaminants in the building. Inadequate ventilation can be a result of poor planning and layout of buildings with a large number of offices crammed into a small space in order to expand the saleable area (Joshi, 2008).

Other factor that may contribute to SBS is the releasing of chemical contaminants from outdoor and indoor sources. Air pollution from outside can enter a building through poorly located ventilation vents and windows. Building exhausts and pipes can also be contaminated by chemicals and flammable materials. Building openings that are intended to be airtight are often not. This issue is caused by the pollution from outside the building envelope which then collects and circulates around the occupants (Rostron, 1997). For indoor sources, synthetic materials in furnishings and the fabric of the house, which can release volatile organic pollutants, are the most common internal sources of contamination. Mechanical equipment, such as computers and fax/copy machines, can emit emissions and heat, which can raise pollution levels inside the workplace (Joshi, 2008). Tobacco smoke, respirable particulate matter, and combustion by-products from a burner, fireplace, or unvented space heater all contribute to chemical contaminants in the setting. Synthetic fragrances used in personal care items as well as cleaning and repair products add to pollution by releasing chemicals into the air (Passarelli, 2009).

2.4 Prevalence of Sick Building Syndrome

According to an article by Joshi et al. (2008) about SBS, they found that people with clerical jobs is more prevalent to SBS symptoms compared to managerial jobs since practitioners or managers have improved working environments. They also found that females are more common to have SBS compared to males. This is because more women likely to be more health conscious since they work in secretarial occupations, or a lower dosage of contaminants is expected to manifest the results. Air-conditioned building is found to be more frequent with SBS than in naturally ventilated building. The symptoms also found to be more common in public buildings than in private buildings (Joshi, 2008).

A study in Malaysia conducted by Zainal et al. (2019) on SBS among office workers in relation to office environment found that occurrence of SBS symptoms is significantly different between genders. In the study, the results showed a higher prevalence of SBS symptoms among females than in males. Gender differences in reporting SBS could be influenced by a variety of factors such as demographics, workplace environments, and career characteristics (Brasche, 2001). Mucosal symptoms (19.6%) and general symptoms (18.7%) were more frequently reported than dermal symptoms (10.2%) in this study. They found that people that has asthma was correlated with mucosal symptoms. Dermal symptoms were significantly correlated with the habit of smoking as smoking will increase a person's vulnerability and exposure. Besides, the use of fax machine, printers, or photocopiers for more than 1 hour per day were also positively associated with dermal symptoms. The equipment emits ozone, particulate matter and VOC. Installation of a new carpet in the office

environment also emit VOC and showed an increased in the SBS symptoms. Buildings with a centralized air conditioning system is more prevalent to SBS compared to split unit air conditioning system (Zainal et al., 2019).

A study in Iran that aims to associate between IAQ and SBS symptoms conducted by Sarkhosh et al. (2021) obtained the results of 70.10% prevalence of SBS among the office workers in the municipality office building with drowsiness, exhaustion, periodic headaches, a heavy sensation in the brain, fatigue, muscle pain, and skin dryness are the most common symptoms. A total of 154 office employees reported one or more symptoms (at least one symptom) associated with SBS, with 74.4% of women and 68.5% of men. This indicates that the prevalence of SBS symptoms is higher in women than in men. Symptoms disappeared at the end of working hours (65.5%) or after leaving the building (51.9%), according to office workers. The prevalence of SBS and current smoking had a clear significant correlation. Psychological conditions were found to be one of the other significant factors in rising the occurrence of SBS (Sarkhosh et al., 2021).

2.5 Association between Physical Parameters and Sick Building Syndrome

Physical parameters of indoor air quality are often associated with the prevalence of SBS in office buildings. Temperature, relative humidity, and air velocity have generally been used to represent thermal comfort (Seppanen et al., 2003). A study in Malaysia performed by Fadilah and Juliana (2012) comparing the physical parameters of an old and a new building found that the prevalence of SBS is 47.5% for new building while 33.8% for old building. The new building has a lower temperature

and comply with the ICOP 2010 standard. The occupants of the new building had lower prevalence of SBS compared to the old building which had a higher temperature range and slightly exceed the ICOP 2010 guidelines. The prevalence of SBS among the employees in old buildings was higher (Fadilah & Juliana, 2012).

Rohizan and Zainal Abidin (2015) conducted an assessment on thermal comfort among office workers at a public university and associate them with SBS. They found that the prevalence of SBS is 9.7% which relatively lower compared to other studies done in Malaysia. It is also reported that around 11% of the respondents reported that the thermal condition makes them uncomfortable. The range for temperature, relative humidity, and air velocity was within the standard limit set by ICOP 2010 for most offices in the laboratory complex. A few offices recorded that the temperature, relative humidity, and velocity were not below the appropriate ranges, but the percentages were minimal. Higher level of relative humidity was shown to be contributed to the occurrence of SBS. Lower temperature and higher level of relative humidity was found to be the significant contributor to the perception of comfort of office employees (Rohizan & Zainal Abidin, 2015).

2.6 Association between Indoor Air Contaminants and Sick Building Syndrome

Indoor air contaminants are a significant contributor to the occurrence of SBS. The concentration of indoor air contaminants sometimes does not exceed the acceptable limit; however, the building occupants often experience health problems. Sarkosh et al. (2021) found that SBS was more prevalent (60.15%) in rooms with air conditioning, and a high level of VOCs were also found in these rooms. The

concentrations of xylene, ethylbenzene, and particularly toluene was high among the 28 VOCs measured in the two office buildings. Even though these concentrations were not above the Ministry of Health and Medical Education of Iran's exposure limit requirements, they were significant in terms of continuous exposure time. Acute exposure to toluene has been linked to feelings of exhaustion, fatigue, headaches, and nausea, while prolonged exposure has been linked to depression, stimulation of the upper respiratory system and eyes, dizziness, sore throat, and headache. For xylene, eye, nose, and throat inflammation, as well as gastrointestinal and neurological symptoms, have been recorded for acute exposure, and neurological effects such as headache, drowsiness, nausea, tremors, and loss of coordination have been identified for chronic exposure. Respiratory symptoms such as throat inflammation, chest spasm, and irritation have been identified for acute ethylbenzene exposure, and neurological effects such as drowsiness and blood system impact have been reported for chronic ethylbenzene exposure (Sarkhosh et al., 2021).

A study conducted by Zainal et al. (2019) found that general symptoms of SBS were associated with CO₂, formaldehyde, respirable dust, and ultrafine particles. Besides, CO₂ and respirable dust were also correlated with mucosal symptoms. Dermal symptoms were strongly associated with the using of printers, fax machines, and photocopiers as these equipment may release indoor air contaminants namely VOC, respirable dust, and ozone. The largest cause of indoor air pollution is the release of contaminants from printing devices that are not separated from the work environment. The release of formaldehyde that come from the wall paint and carpet in the workplaces was also measured because indoor air contaminants such as VOC, PM₁₀, ultrafine particles, and formaldehyde, which were measured in this study, could come

from a source of building materials, new furniture, and new painting (Zainal et al., 2019).

2.7 SBS Symptoms

According to Sulaiman and Mohamed (2011), a self-administered questionnaire was given to the library staffs to evaluate their workplace environment and report the existence or absence of SBS symptoms. The questionnaire is based on the Malaysian Industry Code of Practice (ICOP) on Indoor Air Quality 2010, Department of Occupational Safety and Health. Based on the ICOP 2010, a symptom survey questionnaire must be included in the assessment of indoor air quality. The questionnaire is administered to assist in the identification of possible sources of indoor air pollutants as well as the detection of adverse health consequences associated with exposure to these pollutants. There are six parts in the questionnaire which are general information, background factor, nature of occupation, environmental conditions, past/ present diseases/ symptoms, and present symptoms. Symptoms of SBS will be reported in the last part which is present symptoms. Library staffs need to tick in the box that are applicable to them if they have experienced any of the symptoms. The questionnaires asked about frequency of a symptom and the alternative answers included “Yes, often (every week)”, “Yes, sometimes (2-3 times/week)”, and “No, never”. The respondents are categorized as having SBS if they had at least one SBS symptom and appeared at least once a week. The occurrence of the symptoms of SBS must be reported at least 1-3 days per week during the last four weeks and the symptoms disappear when the respondents away from workplace (Hodgson, 2002).

2.8 Methods of Measurement and Analysis of IAQ Parameters

Assessment of IAQ is conducted based on ICOP 2010 (Rohizan & Zainal Abidin, 2015; Jalaludin et al., 2009; Norhidayah et al., 2013; Fadilah & Juliana, 2012; Sulaiman & Mohamed, 2011; Zainal et al., 2019). Based on the ICOP 2010, the minimum required number of sampling point is shown in the table below.

Table 2.3: Minimum required numbers of sampling points based on ICOP 2010.

Total floor area (served by MVAC system) (m ²)	Minimum number of sampling points
<3,000	1 per 500m ²
3,000 - <5,000	8
5,000 - <10,000	12
10,000 - <15,000	15
15,000 - <20,000	18
20,000 - <30,000	21
≥30,000	1 per 1,200m ²

According to ICOP 2010, all IAQ parameters (excluding air movement) should be measured outdoors near the study areas' fresh air intakes at the same time because outdoor air measurement data may offer some indications on whether outdoor pollutants contribute to poor IAQ. A minimum of one sample should be collected. Samplers or monitor inlets should be placed roughly 1 meter away from the edge of the fresh air intake and enclosed in a suitable shelter to protect them from direct

sunlight and rain. If the fresh air intake is inaccessible, other representative places should be explored. When taking the measurement of the IAQ parameters, the instruments must be placed not in direct line of sight of air supply diffusers, induction units, floor fans, heaters, or the operator's exhaled breath at least 0.5 meter from corners or windows, walls, partitions, and other vertical surfaces, not in direct sunlight, since this will have an effect on the instruments, ideally not in corridors or passages, at least 1 meter away from localized sources such as photocopiers, printers, and fax machine, if sampled in a corridor or lobby, it must be at least 3 meters away from an elevator, not within 2 meters of any doors, not impeding or obstructing occupant egresses from the study area in regular or emergency conditions, and the sampler inlets of the instruments should be placed between 75 and 120 cm above the floor, ideally 110 cm.

The sampling period for the measurement of IAQ parameters should be conducted in a duration of eight hours. However, surrogate measurement (i.e. an intermittent measuring approach based on the average of half-hour measurements taken at four time-slots) is also approved when 8-hour continuous measurement is not feasible. When selecting the four time slots, the operating pattern of the structures should be considered. There are several studies that measure the IAQ parameters at four different time slot which includes morning, afternoon, early evening and late evening (Fauzan et al., 2016; Jalaludin et al., 2009; Zainal et al., 2019). Based on previous study, data for the morning were collected between the hours of 8 a.m. and 11 a.m. The afternoon data collecting window is from 11 a.m. to 1 p.m. The data was collected in the early evening between the hours of 1 p.m. and 3 p.m., with the final data collection taking place between the hours of 3 p.m. and 5 p.m. For commercial

buildings, the four time slots should be fairly spread during work hours, but for public locations, they should address the worst-case scenario, such as periods of greatest occupancy. Regardless of whether the 8-hour continuous or surrogate measurement method is employed, at least one reading should be obtained every 5 minutes at each sample point using a data logging device or correctly documented in a field data log sheet if a real-time monitor is utilized.

Based on ICOP 2010, sampling techniques for IAQ parameters can be conducted using any of the two types of assessment method which are real-time measurements and integrated sampling with subsequent laboratory analysis. Real-time monitors are used to identify the sources of contamination and offer information on contaminant level variations throughout the day. Integrated samples, which are often collected over the 8-hour workday for workplaces, can yield information on the entire exposure level of a certain indoor air pollutant. Regardless of the technique used, it is critical to guarantee appropriate equipment operation and sample handling, as well as strict quality assurance processes such as instrument calibrations in line with manufacturer instructions, duplicate samples, field and shipment sample blanks. The accuracy of the techniques for active and passive sampling analysis must be more than $\pm 10\%$ unless there is evidence that this is not technically achievable. The accuracy of real-time monitors must be more than $\pm 10\%$. Any instrument or techniques used should have a suitable detection range and detection limit to meet the objective of the assessment for a valid sampling procedure.

For physical parameters, several methods can be used for measuring air temperature, relative humidity, and air movement, ranging from a basic thermometer

for temperature and a wet and dry bulb thermometer for humidity to complex electronic devices. For measurement of air movements, the instrument should be placed at a sitting person's shoulder level or at the supply air at the seated person's height.

For chemical parameters, a real-time monitor, such as a non-dispersive infrared (NDIR) analyser or electrochemical oxidation device should be used to measure the concentration of CO and CO₂. For respirable particulates, the concentration can be determined either by using a gravimetric analysis method based on the NIOSH Method 0600 or other equivalent methods, or using a real-time monitoring method with analysers, such as optical scattering or piezoelectric monitors. TVOC can be measured by using analytical method or real-time monitoring. The analytical technique for continuous 8-hour sampling includes whole-air sampling with passivated canisters or solid sorbents, followed by direct flame ionization detection based on the NIOSH Method 2549, USEPA Compendium of Method TO-12, MS ISO 16017-1:2008, MS ISO 16017-2:2008, or MS ISO 16000-6:2008. Monitors such as a photo-ionization detector (PID) or a flame ionization detector (FID) might be employed for real-time monitoring. However, when utilizing a real-time PID device, caution must be exercised since the results might be influenced by the presence of other non-VOC chemicals such as anaesthesia or disinfection gases. The reference calibration gas for real-time monitor calibration should be isobutylene (2-methylpropene).

CHAPTER 3

METHODOLOGY

3.1 Study Location

This study was conducted in Perpustakaan Sultan Abdul Samad, Universiti Putra Malaysia among the library staffs. Perpustakaan Sultan Abdul Samad is the main library of Universiti Putra Malaysia. This library provides great facilities, services and resources to support the activities of learning, teaching, consultancy and research of Universiti Putra Malaysia. Students and lecturers can easily access to the library as it is located at the centre of university's main campus. The location of the library is at latitude of 3.0024201 and longitude of 101.705879. Perpustakaan Sultan Abdul Samad consists of two blocks with a combined floor area of approximately 19,007 square meters, with a capacity of approximately 2000 users at any given time. Both blocks equipped with mechanical ventilation air conditioning systems.

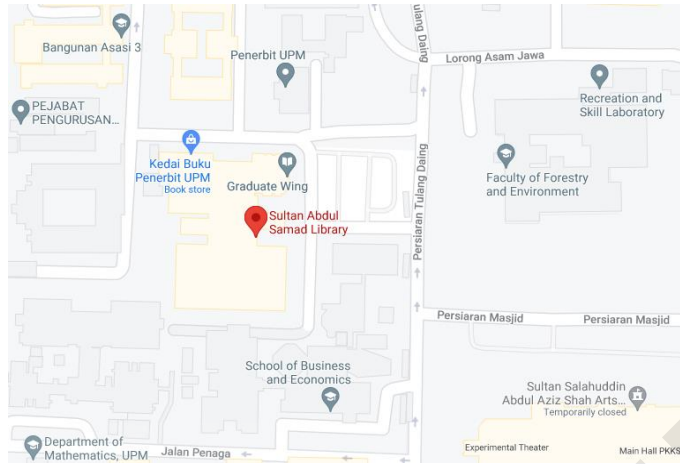


Figure 3.1: Map of Perpustakaan Sultan Abdul Samad
(Source: Google Maps)



Figure 3.2: Perpustakaan Sultan Abdul Samad
(Source: lib.upm.edu.my)



Figure 3.3: Inside of Perpustakaan Sultan Abdul Samad
(Source: lib.upm.edu.my)

3.2 Study Design

This was a cross-sectional study design aims to determine the association between indoor air quality and sick building syndrome symptoms among library staffs at Universiti Putra Malaysia. This study design was chosen because it consists of analysing data from a population which is among library staffs at Universiti Putra Malaysia at a particular time point. As observation is made, the existing correlation was demonstrated whether the exposure to indoor air pollutants correlated with the outcomes of sick building syndrome symptoms.

3.3 Study Duration

The duration of this study was from August 2021 until January 2022.

3.4 Study Sampling

3.4.1 Study Population

This study included library staffs in the selected library, which is Perpustakaan Sultan Abdul Samad, UPM. This research determined the prevalence of SBS symptoms among library staffs as a result of exposure to indoor air pollutants.

3.4.2 Sampling Frame

All male and female workers who work at the library and met the inclusion criteria were selected as study respondents. The list of library staffs was obtained from

Registrar Office UPM. The main purpose and procedures of the study were explained to the library staffs. Only library staffs who signed a written consent were selected as respondents.

3.4.3 Sampling Criteria

A library staffs with inclusive and exclusive criteria below were included in this study:

3.4.3.1 Inclusive Criteria

1. Male and female library staffs regardless of their race in Perpustakaan Sultan Abdul Samad, UPM.
2. Age between 18 to 60 years old.
3. Have worked for at least four months in the library

3.4.3.2 Exclusive Criteria

1. Smoker.
2. Have been diagnosed with respiratory disease such as asthma, chronic obstructive pulmonary disease (COPD), occupational lung diseases and pulmonary hypertension

3.4.4 Sampling Method

Selection of library staffs were done using purposive sampling. The procedures and the purpose of the study were made known to the library staffs before the distribution of consent form and questionnaire. Library staffs who met the inclusion criteria and have given their consent were selected to participate in the study.

3.4.5 Sample Size

The sample size calculation in determining the number of respondents was chosen using the formula from Lemeshow et al. (1990) for group comparison between genders. The formula for calculating sample size was shown below.

$$n = \frac{\left(Z_{1-\alpha/2} \sqrt{2\bar{P}(1-\bar{P})} + Z_{1-\beta} \sqrt{P_1(1-P_1) + P_2(1-P_2)} \right)^2}{(P_1 - P_2)^2}$$

Where,

$Z_{(1-\alpha/2)}$ = Standard error associated with confidential interval, 95% CI = 1.96

$Z_{(1-\beta)}$ = Standard error associated with power, 84.2% of power = 0.842

P_1 = estimated proportion which is 77.32% (Lim et al., 2015)

P_2 = estimated proportion which is 56.91% (Lim et al., 2015)

$$\bar{P} = (P_1 + P_2)/2$$

$$\bar{P} = (0.773 + 0.569)/2$$

$$\bar{P} = 0.671$$

Then, substitute the \bar{P} value into the formula:

$$n = \frac{(1.96 \sqrt{2(0.671)(1-0.671)} + 0.842\sqrt{0.773(1-0.773)} + 0.569(1-0.569))^2}{(0.773 - 0.569)^2}$$

$$n = \frac{(1.96(0.664) + 0.842(0.649))^2}{0.042}$$

$$n = \frac{(1.96(0.66) + 0.842(0.65))^2}{0.042}$$

$$n = \frac{(1.294 + 0.547)^2}{0.042}$$

$$n = 80.7 \sim 81$$

Based on the sample size calculation for each gender, total of respondents that will be recruited in this research is 162 library staffs. After taking into consideration the 10% non-response rate, the minimum number of respondents need to be recruited in this study is 178 respondents.

3.5 Study Instruments

A self-administered questionnaire was used for data collection on sociodemographic characteristics and SBS symptoms. The questionnaire used was adapted from the Malaysia Industry Code of Practice on Indoor Air Quality 2010 that has been validated and translated from previous research to obtain background information and SBS symptoms of the respondents (Rasdi et al., 2016).

3.5.1 Questionnaire

All respondents were given a self-administered questionnaire for them to answer. The questionnaire collected information about their sociodemographic characteristics such as age, gender, smoking status, and nature of occupation. The questions also included health status and SBS symptoms, weekly time spent in the building, position of the job, the prevalence of SBS and the air quality inside buildings. There were 12 questions for SBS symptoms which were divided into three different groups which is general, dermal, and mucosal symptoms. General symptoms included questions on headache, feeling heavy-headed, fatigue/lethargy, drowsiness, dizziness, and nausea/vomiting. Dermal symptoms included questions on skin rash/itchiness and scaling/itching scalp or ears. Mucosal symptoms included questions on cough, stuffy/irritated nose, throat dryness, and eye irritation. The questionnaires asked about frequency of a symptom and the alternative answers included “Yes, often”, “Yes, sometimes”, and “No, never”. If the respondents had at least one SBS symptom and appeared at least once a week, they were categorized as having SBS. Furthermore, the occurrence of the symptoms of SBS must be reported at least 1-3 days per week during the last four weeks and improvements showed from the symptoms when the respondents away from workplace (Hodgson, 2002). The privacy and confidentiality of respondents were guaranteed. This was done by giving each respondents an ID number and their names were not collected in the questionnaire.

3.5.2 IAQ Measurement

Four direct reading instruments were used for real-time monitoring of IAQ parameters. TSI Model 7575 Q-Trak IAQ Monitor was used to measure the concentration of CO₂, CO, temperature, and relative humidity. TSI Model 9565-A Velocicalc Plus was used to measure the air velocity, temperature, and relative humidity. PM_{2.5} and PM₁₀ were measured by using Optical Particle Sizer (OPS) 3330. Lastly, ppbRAE 3000 was used to measure the concentration of TVOC in the library. All instruments were calibrated according to the manufacturer's standard to ensure the accuracy of the results. To avoid tampering with the results, standard operating and sampling protocols were followed. Table 4 shows the variables studied, type of sensor used for each instrument, and their detection limits.

3.5.2.1 TSI Model 7575 Q-Trak IAQ Monitor

Temperature and relative humidity were measured using TSI Model 7575 Q-Trak IAQ Monitor. Temperature was measured using the sensor type thermistor and have a range from 0 to 60°C. ICOP 2010 acceptable limit for indoor temperature is 23°C to 26°C. Relative humidity was measured using thin film capacity sensor type that can detect the relative humidity from 5 to 95%. The level of relative humidity in indoor environment was measured using the principle of detection of a wet bulb and dry bulb to compare the humidity ratio and absolute humidity. Acceptable limit for relative humidity in indoor environment based on ICOP 2010 is 40 to 70%. This instrument also measured the concentration of CO and CO₂. Dual-wavelength non-dispersive infrared (NDIR) was used to measure CO₂ which has the detection limit from 0 to 5000

ppm. CO was measured using electro-chemical sensor type with a detection limit of 0 to 500 ppm. ICOP 2010 acceptable limit for CO and CO₂ are 10 ppm and 1000 ppm, respectively.



Figure 3.4: TSI Model 7575 Q-Trak IAQ Monitor (Source: TSI Website)

3.5.2.2 TSI Model 9565-A Velocicalc Plus Multifunction Ventilation Meter

Air velocity was measured using TSI Model 9565-A Velocicalc Plus. This instrument is portable and handheld. Air velocity was measured from the range 250 to 15,500 ft/min (1.27 to 78.7 m/s). Based on ICOP 2010, the acceptable limit for air velocity is from 0.15 to 0.50 m/s.



Figure 3.5: TSI Model 9565-A Velocicalc Plus (Source: TSI Website)

3.5.2.3 Optical Particle Sizer (OPS) 3330

Particles with diameters ranging from 0.3 to 10 micrometres may be measured in a light, portable, and precise manner using this instrument. The Optical Particle Sizer (OPS), which can detect particle concentration and particle size distribution as often as once per second (1 Hz), is a useful instrument in a variety of applications, including filter testing, industrial assessments, and indoor monitoring. The OPS employs single particle counting technology to measure particles with diameters ranging from 0.3 to 10 μm in 16 user-adjustable size channels. The particles that are detected can also be collected on a built-in filter for further analysis. The instrument may be used for up to 20 hours on a single charge, and its huge colour touchscreen is simple to operate. The acceptable limit for respirable particulates is 0.15 mg/m^3 based on ICOP 2010.



Figure 3.6: Optical Particle Sizer (OPS) 3330 (Source: TSI Website)

3.5.2.4 ppbRAE 3000

The ppbRAE parts per billion (ppb) VOC monitor is a photo-ionization Detector (PID) that measured VOC at ppb levels. VOC was measured from the range 1 part per billion (ppb) to 10,000 parts per million (ppm). Data was obtained and downloaded using the proRAE Remote software. Based on ICOP 2010, the acceptable limit for TVOC is 3 ppm.



Figure 3.7: ppbRAE 3000 (Source: sps.honeywell.com)

Table 3.1: Variables studied, type of sensor used, and detection limits.

Variables	Instruments	Sensor type	Detection limit
CO ₂		Dual-wavelength NDIR (non-dispersive infrared)	0 - 5000 ppm
CO	TSI Model 7575 Q-Trak IAQ Monitor	Electro-chemical	0 - 500 ppm
Temperature		Thermistor	32 - 140°F (0 to 60°C)
Relative humidity		Thin-film capacitive	5 - 95% RH
Air velocity	TSI Model 9565-A Velocicalc Plus	Pitot tube	250 - 15,500 ft/min (1.27 to 78.7 m/s)
PM _{2.5}	Optical Particle Sizer 3330	Single particle counting technology	0.3 to 10 µm
PM ₁₀			
TVOC	ppbRAE 3000	Photoionization sensor	1ppb - 10,000 ppm

3.6 Data Collection

3.6.1 Questionnaire

The questionnaire that has been prepared were distributed to the respondents. Study objectives and procedures were explained to the respondents and a consent form were given prior to beginning of the data collection process to ensure their willingness to participate in the study. The respondents were given two weeks to answer the questionnaire during the data collection. The majority of the questions were in a close-response format, such as yes or no, not in the previous 4 weeks, and so on. These kinds of questions allow the respondent's experience with one or more sick building symptoms to be readily encoded and analysed. However, there are a few questions that respondents must answer, such as their age, department, and how many years/months they have been employed. Respondents have access to their results and have the right to access to their records. The researcher is serving only as investigator in this research.

3.6.1.1 Quality Control

The questionnaire's content was validated, and amendments were made accordingly by an expert in the field. A pilot study with 10% of the entire sample size was undertaken to test if they could understand the questionnaire and to rule out any unusual questions. In addition, for the purpose of confidentiality, the questionnaire was labelled with a distinctive respondent code. Cronbach Alpha of 0.74 was found in the reliability analysis of each section of the questions.

3.6.2 IAQ Measurement

IAQ assessment were conducted according to Malaysia Industrial Code of Practice on Indoor Air Quality (ICOP) 2010. By referring to the ICOP 2010, ten sampling points

were required for the monitoring of IAQ. The measurement was taken four times a day for two weeks during working days, as suggested by ICOP 2010 (DOSH, 2010). The physical parameters were measured in the morning (8 and 11 a.m.), afternoon (2 p.m.), and evening (5 pm). For each parameter in each location, three measurements were recorded. This represented the status of indoor air quality for workers in one day. Measurement of IAQ parameters were taken in each floor. The IAQ instruments were placed between 75 and 120 cm from the floor. All sampling points were recorded and the measurement of IAQ parameters were conducted according to ICOP 2010. Flowchart below shows the procedure of data measurement using IAQ instrument during the data collection.

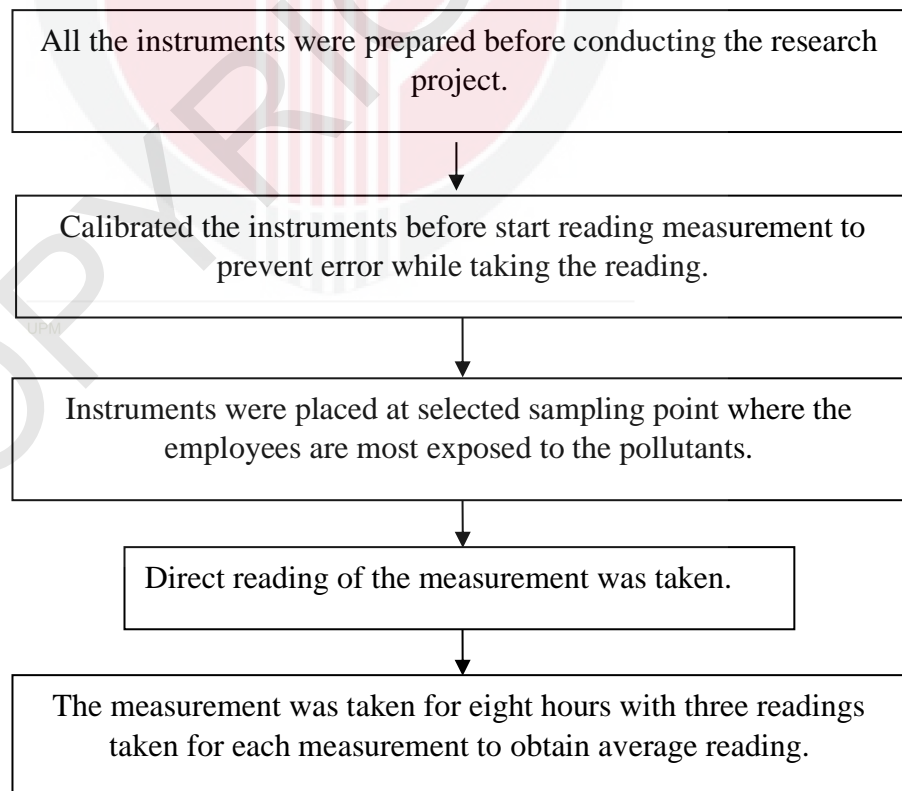


Figure 3.8: Procedure on data measurement of IAQ parameters

3.6.2.1 Quality Control

Before using the equipment, all instruments were calibrated and checked to retain their sensitivity and avoid measurement errors while taking readings. The technique for operating the equipment was based on the operation manual that was acquired from the internet as well as the handbook that was supplied. The instruments were pre-run for 5 to 10 minutes to stabilize the instruments before the measurement of indoor air pollutants are taken. The equipment was kept at room temperature and were not subjected to excessive heat. To avoid instrument damage due to battery leaking, batteries were removed from the instruments after data collection.

3.7 Data Analysis

Using IBM's Statistical Package for Social Sciences (SPSS) software Version 26, data collected from respondents were analysed based on the specific objectives of the study. The association and difference were analysed between IAQ and prevalence of SBS symptoms of library staffs. The background of respondents was analysed using descriptive statistics (univariate analysis) which include mean, median, mode, and standard deviation. The association and differences between study variables were tested using bivariate analysis which is chi-square test. Multiple logistic regression test (multivariate analysis) was used to determine the main variables which influenced the SBS symptoms of library staffs. The level of significance is set at $p < 0.05$ in this study.

The following statistical analysis were used to analyse the study's objectives:

1. To determine the sociodemographic characteristics of the respondents.

Parametric: Mean and standard deviation (SD)

Non-parametric: Median and interquartile range (IQR)

Categorical data: Frequency and percentage (%)

2. To compare the concentration of CO, CO₂, PM_{2.5}, PM₁₀, TVOC, temperature, relative humidity, and air velocity with acceptable limit.

Parametric: Mean and standard deviation (SD)

Non-parametric: Median and interquartile range (IQR)

Categorical data: Frequency and percentage (%)

3. To determine the prevalence of sick building syndrome symptoms among male and female library staffs in UPM.

Non-parametric: Chi-square test

Categorical data: Frequency and percentage (%)

4. To determine the association between indoor air quality parameters and sick building syndrome symptoms among library staffs in UPM.

Non-parametric: Chi-square test

Categorical data: Frequency and percentage (%)

5. To identify the main predictor that influence SBS among library staffs in UPM.

Non-parametric: Multiple logistic regression

3.8 Study Ethics

This research involves human as the respondents, so ethical considerations need to consider before proceeding in conducting the study. Approval was obtained from Ethic Committee for Research Involving Human Subjects (JKEUPM) University Putra Malaysia for permission to conduct the study. Once permission had been granted, informed consent was obtained from the respondents to give them the freedom of choice whether they voluntarily participate in this research or not. Respondents were told that they are free to withdraw their participation at any time and that the data gathered during the research were kept private and confidential. The respondents' anonymity and confidentiality were assured. Respondents were fully informed of what they may be questioned for, how the results may be used, and what consequences may occur (if any). In this research, participants were told that their socio demographic data were collected, and they need to answer a questionnaire regarding SBS symptoms.

CHAPTER 4

RESULT

4.1 Response Rate

At the beginning of the study, 178 questionnaires were delivered, but only 153 questionnaires were returned, which was about 86% of the response rate. Ten respondents (6.5%) were excluded from the study because they are smokers. The participation of respondents was voluntary based in this study. Before data collection was conducted, the library staffs were informed and invited to participate in the study through email or notice made by assistant librarian. During the day of the data collection, announcements were made, and face-to-face invitation was conducted to invite library staffs to participate in the study. At the end, a total of 143 library staffs (80%) fulfilled the study criteria and agreed to enrol in the study. All these 143 library staffs recruited in answering questionnaire on SBS symptoms.

4.2 Normality Test

Normality test was conducted for all the continuous study variables. The data were normally distributed based on insignificant p-value ($p > 0.05$) of Shapiro-Wilk and using skewness and kurtosis absolute values. The distribution was considered normal if skew value within ± 2 or kurtosis value within ± 7 (Kim, 2013). All IAQ parameters

were normally distributed as shown in Table 4.1. Hence, parametric tests were used for these study variables.

Table 4.1: Normality distribution of study variables

Variables	Shapiro-Wilk	Skewness	Standard error of skewness	Kurtosis	Standard error of kurtosis	Normality
CO2	0.194	-1.266	0.687	1.524	1.334	Normally distributed
PM2.5	0.224	1.225	0.687	2.426	1.334	Normally distributed
PM10	0.216	1.225	0.687	2.220	1.334	Normally distributed
TVOC	0.000	1.779	0.687	1.406	1.334	Normally distributed
Air velocity	0.583	0.615	0.687	-0.098	1.334	Normally distributed
Temperature	0.019	-1.411	0.687	1.007	1.334	Normally distributed
RH	0.073	-1.101	0.687	0.099	1.334	Normally distributed

4.3 Characteristics of the Library Staffs

4.3.1 Socio-demographic

Table 4.2 shows the socio-demographic background of the respondents. All library staffs were from Malay ethnicity. Out of 143 respondents, there were 60 males (42.0%) and 83 females (58.0%) that participated and responded the questionnaire. The age of

this study population ranged from 27 to 52 years old with an average of 36 (standard deviation= 6.6). About 11% of the respondents had graduated from high school, 22.4% had either diploma, STPM or certificate, 45.5% had degree, and 21% had either Master or PhD. Twenty-seven percent of the staffs were single, 71.3% were married and a few of them were divorced (1.4%). For socioeconomic background, B40 represents the bottom 40% of income earners, M40 refers to the middle 40%, and T20 is the top 20% of income earners. In this study, 31.5% of the respondents were in B40 category, 62.2% were in M40 category, and 6.3% were in T20 category. All respondents were not a smoker as smokers were already excluded from participated in the study.

Table 4.2: Socio-demographic characteristics of the library staffs (N = 143)

Variable		Total (N=143), n (%)
Gender	Male	60 (42.0)
	Female	83 (58.0)
Age	18-30	35 (24.5)
	31-40	80 (55.9)
	41-50	21 (14.7)
	51-60	7 (4.9)
Marital status	Single	39 (27.3)
	Married	102 (71.3)
	Divorced	2 (1.4)

Household income	B40	45 (31.5)
	M40	89 (62.2)
	T20	9 (6.3)
Educational level	SPM	16 (11.2)
	Diploma/ STPM/ Matriculation	32 (22.4)
	Bachelor degree	65 (45.5)
	Master/PhD	30 (21.0)

4.3.2 Workstation Environment

Table 4.3 shows the current workstation environment characteristics. More than half of the library staffs work in closed room concept of workstation (51.0%). The air conditioning system in the library is mainly using central unit (84.6%). Most of the library staffs worked for 7 to 8 hours in a day (56.6%), meanwhile 35.7% worked more than 8 hours in a day. More than half of the staffs had worked for more than four years in the library (55.2%). Almost all staffs used office equipment while working in the library, which were photocopier (91.3%), laser printer (69.2%), facsimile (9.8%), and handling of cleanser, glue, correction fluid or other strong-smelling chemical (59.4%).

Table 4.3: Workplace environment of library staffs (N=143)

Variable		Total (N=143), n (%)
Workstation	Open concept	70 (49.0)
	Closed room	73 (51.0)
Air-conditioning	Split unit	22 (15.4)
	Central unit	121 (84.6)
Working hour, a day	< 1 hour	-
	1-2 hours	-
	3-4 hours	-
	5-6 hours	-
	7-8 hours	62 (43.4)
	> 8 hours	81 (56.6)
Employment years	< 4 years	64 (44.8)
	> 4 years	79 (55.2)
Office equipment	Photocopier	133 (91.3)
	Laser printer	99 (69.2)
	Facsimile	14 (9.8)
	Cleanser, glue, correction fluid or other strong-smelling chemical	85 (59.4)

4.4 Library IAQ Measurement

Table 4.4 shows the percentage, mean, standard deviation, and range of the IAQ parameters for ten locations in Perpustakaan Sultan Abdul Samad. The average relative humidity, PM₁₀, CO₂, and TVOC level were within and under acceptable limit suggested by Department of Occupational Safety and Health (DOSH) in Industry Code of Practice on Indoor Air Quality 2010 for all ten locations in the library. However, for air velocity only one location that was within and under acceptable limit which is 0.15-0.50 m/s. Two locations in the library had indoor temperature within and under the recommended level which is 23 to 26°C. Meanwhile, four locations were within the acceptable limit and six locations were above the standard for PM_{2.5}. The concentration of CO was not reported because the concentration was under detection limit.

Table 4.4: IAQ measurement in the library (n=10)

Variable		n=10	Mean ± Std. deviation	Min-max
PM_{2.5} ($\mu\text{g}/\text{m}^3$)	Within standard	4	58.17 ± 22.63	30.1 – 109.6
	Above standard	6		
PM₁₀ ($\mu\text{g}/\text{m}^3$)	Within standard	10	59.95 ± 22.93	32 – 111.6
	Above standard	-		
CO₂ (ppm)	Within standard	10	295.18 ± 44.07	235 - 339
	Above standard	-		
	Within standard	10	0.2 ± 0.42	0 - 1

TVOC (ppm)	Above standard	-		
Air Velocity (m/s)	Within standard	1	0.092 ± 0.03	0.05 – 0.15
	Above standard	9		
Relative Humidity (%)	Within standard	10	58.54 ± 2.81	53.2 – 61.3
	Above standard	-		
Temperature (°C)	Within standard	2	25.68 ± 2.21	21.2 – 28.0
	Above standard	8		

4.5 Prevalence of SBS Symptoms

Table 4.5 shows the comparison of SBS symptoms among male and female library staffs. The reported prevalence of SBS symptoms among library staffs were high among female (96.4%) compared to male (88.3%). There was no significant difference between the prevalence of sick building syndrome symptoms among male and female library staffs in UPM ($p=0.126$).

Table 4.6 presents prevalence of SBS symptoms and comparison of SBS symptoms between male and female library staffs. Fatigue (78.3%) was the most frequent reported general symptoms, which were followed by difficulties concentrating (71.3%), headache (53.1%), feeling heavy-headed (46.9%) and nausea (17.5%). For mucosal symptoms, the highest prevalence was irritated, stuffy or runny nose (42.0%) and dry throat (39.2%), followed by cough (37.1%) and itching, burning or irritation of the eyes (27.3%). As for dermal symptoms, dry or flushed facial skin (28.7%) was the most reported symptoms among the library staffs, followed by dry,

itching or red hands (28.7%) and itching scalp or ears (19.6%). Overall, SBS symptoms were not significantly different between male and female except for cough ($p = 0.043$) was significantly more frequent reported by male library staffs. However, it was observed that female have slightly higher prevalence of other SBS symptoms compared to male, especially for general symptoms.

Table 4.5 Comparison of SBS symptoms among gender

Variables	Prevalence of SBS (N=143)		X ²	p-value	OR (95%CI)
	Yes (%)	No (%)			
Male (n=60)	53 (88.3)	7 (11.7)	2.344	0.126	0.28 (0.07-1.15)
Female (n=83)	80 (96.4)	3 (3.6)			

*Significant at $p < 0.05$, By X² test with Yates' correction for expected value < 5

Table 4.6: Prevalence of SBS symptoms, stratified for gender

SBS Symptoms	Total (n=143)	Gender		X ²	p-value	OR (95%CI)
		Male (n=60) (%)	Female (n=83) (%)			
General						
Fatigue						
Yes	112	49 (81.7)	63 (75.9)	0.681	0.409	1.41 0.62 – 3.23
No	(78.3)	11 (18.3)	20 (24.1)			
Feeling heavy-headed						
Yes	67 (46.9)	25 (41.7)	42 (50.6)	1.117	0.291	0.70 0.29 – 1.24
No		35 (58.3)	41 (49.4)			
Headache						
Yes	76 (53.1)	28 (46.7)	48 (57.8)	1.743	0.187	0.64 0.33 – 1.25
No		32 (53.3)	35 (42.2)			

Nausea/ dizziness						
Yes	25 (17.5)	7 (11.7)	18 (21.7)	2.424	0.120	0.48
No		53 (88.3)	65 (78.3)			0.19 – 1.23
Difficulties concentrating						
Yes	102 (71.3)	41 (68.3)	61 (73.5)	0.454	0.501	0.78
No		19 (31.7)	22 (26.5)			0.38 – 1.62
Mucosal						
Itching, burning or irritation of the eyes						
Yes	39 (27.3)	12 (20.0)	27 (32.5)	2.757	0.097	0.52
No		48 (80.0)	56 (67.5)			0.24 – 1.13
Irritated, stuffy or runny nose						
Yes	60 (42.0)	24 (40.0)	36 (43.4)	0.163	0.687	0.87
No		36 (60.0)	47 (56.6)			0.44 – 1.71
Hoarse, dry throat						
Yes	56 (39.2)	27 (45.0)	29 (34.9)	1.479	0.224	1.52
No		33 (55.0)	54 (65.1)			0.77 – 3.01
Cough						
Yes	53 (37.1)	28 (46.7)	25 (30.1)	4.087	0.043*	2.03
No		32 (53.3)	58 (69.9)			1.02 – 4.05
Dermal						
Dry or flushed facial skin						
Yes	41 (28.7)	16 (26.7)	25 (30.1)	0.203	0.652	0.84
No		44 (73.3)	58 (69.9)			0.40 – 1.77
Scaling/itchi ng scalp or ears						
Yes	28 (19.6)	9 (15.0)	19 (22.9)	1.377	0.241	0.59
No		51 (85.0)	64 (77.1)			0.25 – 1.43
Hands dry, itching, red skin						
Yes	41 (28.7)	18 (30.0)	23 (27.7)	0.089	0.765	1.12
No		42 (70.0)	60 (72.3)			0.54 – 2.33

*Significant at $p < 0.05$

4.6 Association between IAQ Parameters and SBS Symptoms

Table 4.7 shows the association between IAQ parameters in library and SBS symptoms among library staffs. Temperature was found positively associated with SBS symptoms among library staffs ($p = 0.034$). In addition, indoor level of $PM_{2.5}$ and PM_{10} in the library was also positively associated with symptoms of SBS reported ($p = 0.012$). Other IAQ parameters were not significantly associated with the prevalence of SBS symptoms (p value > 0.05).

Table.4.7: Association between IAQ parameters and SBS symptoms

Variables	Prevalence of SBS (N=143)		χ^2	p-value	OR (95% CI)
	Yes (%)	No (%)			
Physical Parameters					
Air velocity^a					
High (> 0.50m/s)	119 (89.5)	10 (100)	0.279	0.597	0.92 (0.88-0.97)
Low (0.15-0.50m/s)	14 (10.5)	-			
Relative humidity					
High (> 70%)	-	-	Na	Na	Na
Low (40-70%)	133 (100)	10 (100)			
Temperature^a					
High (> 26°C)	106 (79.7)	7 (70.0)	4.496	0.034*	1.68 (0.41-6.94)
Low (23-26°C)	27 (20.3)	3 (30.0)			
Indoor Air Pollutants					
CO₂^a					
High (295.18 ppm)	77 (57.9)	9 (90.0)	2.772	0.096	0.15 (0.19-1.24)
Low (<295.18 ppm)	56 (42.1)	1 (10.0)			
PM_{2.5}^a					
High (58.17 $\mu\text{g}/\text{m}^3$)	36 (27.1)	7 (70.0)	6.239	0.012*	0.16 (0.04-0.65)
Low (<58.17 $\mu\text{g}/\text{m}^3$)	97 (72.9)	3 (30.0)			

PM₁₀^a					
High (59.95 µg/m ³)	36 (27.1)	7 (70.0)	6.239	0.012*	0.16
Low (<59.95 µg/m ³)	97 (72.9)	3 (30.0)			(0.04-0.65)
TVOC^a					
High (0.2 ppm)	27 (20.3)	-	1.353	0.245	1.09
Low (< 0.2 ppm)	106 (79.7)	10 (100)			(1.04-1.16)

*Significant at $p < 0.05$, ^aBy X² test with Yates' correction for expected value <5, Na= Not available

4.7 Factors that influence SBS Symptoms among library staffs after controlling all confounders

Table 4.8 shows the significant factors that influenced SBS symptoms among the library staffs after all confounders in this study have been controlled. Logistics regression was used to assess the factors that could influence the SBS symptoms of library staffs who participated in this study after controlling all confounders. The risk of getting SBS symptoms was significantly increased among library staffs with high level of PM_{2.5} and PM₁₀ in the library (B= 1.838, $p= 0.010$, AOR= 6.287, 95% CI= 1.54-25.64).

Table 4.8: Factors that influence SBS symptoms among library staffs after considering all confounders

Variables	B	SE	p-value	Adjusted OR	95% CI
Temperature	0.171	0.696	0.806	1.186	0.30-4.64
PM _{2.5}	1.838	0.717	0.010*	6.287	1.54-25.64
PM ₁₀	1.838	0.717	0.010*	6.287	1.54-25.64

Adjusted factors: Gender, Age, Ethnicity. Variables significant with $p < 0.05$; B= regression coefficient, SE= Standard Error, AOR= Adjusted Odd Ratio; Nagelkerke $R^2 = 12.6\%$. Overall percentage= 92.7%.

CHAPTER 5

DISCUSSION

5.1 Characteristics of the library staffs

5.1.1 Socio-demographic background

This study was carried out to determine the association between indoor air quality and sick building syndrome symptoms among library staffs in UPM. Approval was sought from the Ethics Committee of UPM to conduct this study. A total of 124 library staffs aged between 18 to 60 years old participated in this study. This study was carried out in main library of UPM which is Perpustakaan Sultan Abdul Samad.

As summarized in Table 4.2, the majority of the library staffs in this study were females and average age of the study population was 36 years old. Most of them were married. Other studies that conducted among staffs in Malaysian public universities found that more than 60% of the university staffs were females (Rohizan & Zainal Abidin, 2015; Fadilah & Juliana, 2012), majority were married (Fadilah & Juliana, 2012; Sulaiman & Mohamed, 2011) and the mean age of the staffs was about 34 years old (Zainal et al., 2019).

Most of the library staffs had bachelor degree (45.5%) as their highest education level. Most staffs appear to be unaware of sick building syndrome since they assumed it had nothing to do with their health because they felt better after leaving the library. This might relate to the educational level of the library staffs. Fadilah and Juliana (2012) found that the greater the education level, the more conscious employees are of their health condition in relation to their workplace environment, particularly when it is in a bad indoor air environment. For socioeconomic background of the respondents, most of them were in M40 category, while just a few of them were in T20 category.

5.1.2 Workstation environment

This study was carried out in main library of UPM. Thus, almost all respondents were working in offices with 51.0% of them worked in closed room concept and 49.0% worked in open concept. An article by Samani and Alavi (2020) stated that due to the emergence of Coronavirus Disease 2019 (COVID-19), there is a need to focus even more on open concept office designs in order to avoid and minimise the spreading of the virus. The air conditioning system in the library was mainly using central unit. A central unit air-conditioning system must be effective in terms of ventilation and pollutant desorption in indoor air. A poorly ventilated room may be even worse if it is not adequately maintained since pollutants are not eliminated and tend to concentrate throughout the building.

COVID-19 virus particles are more likely to spread among people indoors than outdoors. This is because the concentration of virus particles is often high indoors, and the particles are blown away due to restricted or no air flow, reducing the concentration of virus in the air. Therefore, it is essential to ensure that ventilation systems are protective and help reduce virus levels on the premises. Whenever possible, using natural ventilation is an effective and inexpensive way to dilute virus levels in the air (DOSH, 2021). According to Guidance Note on Ventilation and Indoor Air Quality for Non-residential Setting during COVID-19 Pandemic by the Department of Occupational Safety and Health (DOSH) and Ministry of Human Resources, inspection need to be perform to ensure that all components and controls of the centralized mechanical ventilation and air conditioning system (MVAC) components like Chillers, Air Handling Unit (AHUs), Fan Coil Unit (FCUs), Primary AHU (PAHUs), supply and exhaust fans are maintained and functioning as designed (DOSH, 2021). The use of filters with MERV 13 or higher MERV values can be considered. The use of greater MERV filters must take into account the capabilities of the MVAC systems (DOSH, 2021).

Most of the staffs worked for 7 to 8 hours in the library in a day (56.6%). Half of the study respondents had worked in the library for more than 4 years. Based on the questionnaire, staffs that worked more than 4 years were more likely to report SBS symptoms compared to staffs that worked less than 4 years. This is because staffs that worked more than 4 years had longer exposure to indoor air pollutants in the library compared to staffs that worked less than 4 years. Almost all library staffs had used office equipment, which most of them were using photocopiers (91.3%) when working in the library. This result is consistent with the result from a study by Zainal et al.

(2019) where 72.2 % of the workers used office equipment less than one hour and 27.8% used more than one hour, which were positively associated with dermal symptoms.

5.2 Library IAQ measurement

The mean concentration of all the IAQ parameters were within the acceptable limit of ICOP 2010 (DOSH, 2010) except for air velocity that had mean lower than the acceptable range, 0.15 – 0.50 m/s, and PM_{2.5} that had mean concentration higher than 35µg/m³ based on National Ambient Air Quality Standard (NAAQS) by USEPA. IAQ parameters were within the acceptable limit in all ten locations in the library except for air velocity and temperature, where nine and eight locations were not under the acceptable limit respectively.

5.2.1 Physical parameters of IAQ

These physical parameters of IAQ are important in providing thermal comfort to the library staffs. Relative humidity in the library is within the acceptable range which is 40 to 70%. The air velocity and temperature in the library were not within the acceptable limit because the library just recently started to operate after a year because of the Movement Control Order (MCO). The air-conditioning system in the library were not operated efficiently. A well-ventilated indoor environment can reduce the risk of getting SBS symptoms. The inefficiency of the building's ventilation can result in failure to dilute the volume of air pollutants created and released within the indoor

environment of the library. Air pollution created outside can be carried inside a building through the ventilation system in some instances.

A study by Atikah Rohizan & Zainal Abidin (2015) stated that further study suggests that the issue in the MVAC system was the likely source of the temperature, RH, and velocity being discovered to be beyond the allowed range in the offices that were found to have temperature, RH, and velocity above or below the acceptable range. Some of the rooms' MVAC systems lacked a proper outlet for the air-conditioning system because the ventilation system was not properly redesigned when modifications were made to the office.

5.2.2 Chemical parameters of IAQ

The indoor air pollutants (IAP) measurements in the library were found to be generally satisfactory as all chemical parameters of IAQ were within the acceptable limit except for PM_{2.5}. The mean and standard deviation of indoor concentration of CO₂ was 295.18 ± 44.07 ppm. The level of CO₂ was compared with acceptable value set by ICOP 2010. The indoor concentration of CO₂ in the library did not exceed the recommended standard. This implies that fresh air was distributed evenly across the conditioned air area and the ventilation rate was sufficient. This might be due to maintenance performed on the library. The library has had the indoor air quality checked every two months, and there has also been a monthly assessment of the AHU room and the HVAC system. The space inside the library was large and not crowded. CO₂ is produced as a byproduct of human breathing. According to Sulaiman and Mohamed (2011), higher CO₂ levels indicate a lack of fresh outside air. It should be

highlighted that the presence of relatively high CO₂ levels may be associated with regions of stagnant air caused by insufficient ventilation, which is low air change per person or poor ventilation within the area. CO₂ levels exceeding 1000 ppm indicate a lack of proper ventilation, which may cause a sense of stuffiness owing to CO₂ buildup. Most people will experience tiredness and decreased productivity as CO₂ levels rise. The finding on CO₂ concentration in this study is consistent with a study from Zainal et al. (2019) that found CO₂ concentration of 303 ppm in the office building at an academic institution in Malaysia. However, the CO₂ level in this study is lower compared to other previous study because there were not many people in the library at the time of measurement (Sulaiman & Mohamed, 2011). This is because the library was just started to operate after the Movement Control Order (MCO) due to COVID-19, thus not many students and staff were returning to the university yet.

The mean and standard deviation of indoor PM_{2.5} concentrations was $58.17 \pm 22.63 \mu\text{g}/\text{m}^3$. There are no standards set for the indoor concentration of PM_{2.5} in Malaysia, therefore the measurement was compared with a period of 24 hours exposure from National Ambient Air Quality Standard (NAAQS) which is $35 \mu\text{g}/\text{m}^3$. Meanwhile, the mean and standard deviation of indoor concentration of PM₁₀ in the library was $59.95 \pm 22.93 \mu\text{g}/\text{m}^3$. The level of PM₁₀ in this study was compared with other standard for a period of 24-hour exposure from International Standard, USEPA, WHO, Malaysian Ambient Air Quality Standard (2015), and ICOP 2010. The mean concentration of PM₁₀ in the library was within the recommended level. However, the concentration recorded for PM_{2.5} exceeded the acceptable limit. The source of particulates in the library might be caused by laser printers, cleaners, photocopiers, laminators, aromatic sprayers, or even cigarette smoke. The library's greater level of

particulates might be attributed to the open area for photocopiers and fax machines, use of aromatic sprayers, and installation of new carpet. According to He et al. (2007) and Wang and Morawska (2008), the particles are often released during the use of office equipment such as printers. Because the printing machines in the workstation were not segregated from the work area, they may have been a substantial source to indoor air pollution. Furthermore, most staff had their own printer on their desk, whereas photocopiers were situated in specified locations and were typically shared by staff from many departments. Juliana et al. (2014) discovered that a high concentration of particulates in the indoor office environment was substantially linked with the occurrence of respiratory health symptoms such as cough, wheezing, and stuffy and runny nose.

This study found that the indoor level of TVOC was 0.2 ± 0.42 ppm. The result did not exceed the acceptable value when compared with ICOP 2010 standard recommended threshold level of TVOC which is not more than 3 ppm. The source of TVOC is from office equipment such as printers, photocopiers, and facsimile, and from decorative materials used inside the library such as carpets, paints, flooring, coatings, plywood, and adhesive. Even though some part of the library underwent some modifications, the level of TVOC was not high. The level of CO in this study is low and below detection limit. This result was consistent with other studies conducted by Sulaiman and Mohamed (2011) and Juliana et al. (2009), who stated that the concentration of CO was low at the range 0.01 to 3 ppm.

5.3 Prevalence of SBS symptoms among library staffs

This study found that female library staffs reported higher prevalence of SBS symptoms compared to male library staffs. Respondents were considered to have SBS if they had at least one SBS symptom and appeared at least once a week reported in the questionnaire. Brasche et al. (2001) stated that gender differences in reporting SBS could be influenced by a variety of factors such as demographics, workplace environments, and career characteristics. Females often reported more work-related and environmental problems than males, which may explain the respondents' relatively high frequency of complaints (Fadilah & Juliana, 2012). The findings from this study supported by previous studies where they found higher reported SBS symptoms among female workers (Zainal et al., 2019; Brasche et al., 2001).

General symptoms were the most reported symptoms among library staffs and were more prevalent towards female compared to male library staffs. Fatigue was the most frequent reported general symptoms. High temperature above the acceptable limit by ICOP in the library can induce general symptoms such as fatigue and headaches, as well as impair performance and concentration. Mucosal symptoms also frequently reported by the library staffs with irritated, stuffy or runny nose being the most symptoms reported. High temperature in the library can reduced the air quality and triggered mucosal symptoms to occur. Dermal symptoms were the least reported symptoms, where library staffs often felt dry or flushed facial skin. The use of fax machine, printers, or photocopiers for more than 1 hour per day were positively associated with dermal symptoms as the equipment emit ozone, particulate matter and TVOC.

The findings from this study were consistent with a study from Zainal et al. (2019) where they found that mucosal symptoms (19.6%) and general symptoms (18.7%) were reported more frequently than dermal symptoms (10.2%). A Japanese office research by Azuma et al. (2015) found that general symptoms were the most often reported work-related symptoms (61%) among office employees, whereas dermal symptoms were the least reported symptoms (28.1%). This indicates that the workers were exposed to poor indoor air quality and the symptoms arise due to work-related environment as the symptoms disappeared after the workers left the workplace. Therefore, the library needs to maintain the temperature value in the library between 23°C and 26°C, the relative humidity value between 40% and 70% and the air velocity value between 0.15 m/s and 0.50 m/s to ensure good indoor air quality is achieved.

5.4 Association between IAQ Parameters and SBS Symptoms

In this study, the levels of indoor air pollutants (CO₂, CO, PM₁₀, PM_{2.5} and TVOC) were classified as high and low based on the mean value of each pollutant measured. The standards values were used for air velocity, relative humidity, and temperature. There is an increased risk of developing SBS if library staffs exposed to PM_{2.5}, PM₁₀, and temperature resulted from p-value less than 0.05. Office equipment may be a source of indoor pollutants such as particulate matter, and volatile organic compounds, which are released during the copying and printing operations when heat is generated. The capability of PM_{2.5} to enter the alveolar membrane after inhalation has a greater negative impact on people than larger particles, resulting in the prevalence of mucosal symptoms (Jiang & Lu, 2010). Indoor PM₁₀ was found to be

positively linked with the development of dermal, mucosal, and general symptoms in a longitudinal investigation of SBS among Chinese students (Zhang et al., 2014).

A study by Atikah and Emilia (2015) found that temperature was significantly associated with the reporting of SBS symptoms. Temperature affects the thermal comfort of library staffs. In addition to air temperature, thermal comfort is affected by a variety of environmental parameters such as air velocity and relative humidity. Indoor humidity is influenced by ventilation rates, where lower ventilation will increase the indoor moisture levels (Rohizan & Zainal Abidin, 2015). Temperature has been correlated to SBS, which may also be associated to the presence of mould since the growth of mould is aided in environments with low temperatures and high relative humidity (Engvall et al., 2001).

5.5 Factors that influence SBS Symptoms among library staffs after controlling all confounders

The fifth objective in this study was to identify the factors that influence the SBS symptoms after all the confounders have been controlled using multiple logistics regression. The independent variables were taken into consideration for the SBS symptoms, while the adjusted factors include gender, age, and ethnicity.

Statistical analysis showed that $PM_{2.5}$ and PM_{10} ($p=0.010$, $AOR= 6.287$) was found to associate with the prevalence of SBS symptoms. This finding concludes that the main predictor of SBS after controlling all confounders was indoor $PM_{2.5}$ and PM_{10} ($p=0.010$, $AOR= 6.287$). A study conducted by Masri (2015) at libraries in UiTM Shah

Alam and UiTM Puncak Alam also found that increasing PM_{2.5} level may influence the occurrence of SBS among librarians. Therefore, the library staffs who were exposed towards indoor PM_{2.5}; $\geq 58.17 \mu\text{g}/\text{m}^3$ and PM₁₀; $\geq 59.95 \mu\text{g}/\text{m}^3$ are more likely to develop SBS compared to those who were not exposed.



CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In conclusion, this study found a higher prevalence of SBS symptoms among female library staffs from exposure to indoor air pollutants. However, there was no significant difference between the prevalence of sick building syndrome symptoms among male and female library staffs in UPM. Association between each SBS symptoms and gender were analysed in order to determine the association between these variables. The results found that cough was reported higher among male library staffs. This study also found that there is an increased risk of developing SBS if the library staffs exposed to PM_{2.5}, PM₁₀ and temperature resulted from p-value less than 0.05. Besides, it can be found that PM_{2.5} and PM₁₀ are the most significant factors in increasing the prevalence of SBS symptoms among library staffs after controlling all confounders.

Different statistical analysis was used to test the hypothesis in this study and the results showed that:

1. All IAQ parameters were within the acceptable limit suggested by Department of Occupational Safety and Health (DOSH) in Industry Code

of Practice on Indoor Air Quality 2010 except for temperature and air velocity.

2. There is no significant difference between the prevalence of sick building syndrome symptoms among male and female library staffs in UPM.
3. There is a significant association between temperature, $PM_{2.5}$ and PM_{10} with sick building syndrome symptoms among library staffs in UPM.
4. The main variables that influence SBS symptoms among library staffs after considering all the cofounders are $PM_{2.5}$ and PM_{10} .

6.2 Study limitations

There are several limitations in this study. As this study was done in a single time and was cross-sectional, it gives no evidence of a series of events occurring, making causality hard to identify because we could not accurately ascertain whether the symptoms occurred before, during, or after the commencement of exposure in the library. Following that, this study contains a subset of the library staff's population in the study area. However, the only method to obtain an accurate estimation of association is to have all of the library staffs in the study area included in the study.

Furthermore, due to COVID-19 situation in Malaysia, library staff need to work in a hybrid method, thus only 80% response rate was achieved for the questionnaire. In addition, to reduce information bias, the questionnaire used in this study was constructed in a close-response format. Nonetheless, because the questionnaire was self-reported by the participant and various respondents may have viewed the questions differently, there is a risk of recall and information bias.

Apart from that, this study could not rule out the potential that a causal agent for symptoms reported in the questionnaire was evacuated out of the building before indoor air sampling commenced due to a one-to-three-week time lag between the administration of questionnaires and the indoor air measurements due to logistic and administrative issues.

6.3 Recommendations

This study advises that frequent housekeeping, such as cleaning the carpet, be maintained in the library to reduce IAP exposure and ensure the working space is clear of dust or debris. Furthermore, the return and supply air diffusers must be serviced on a regular basis, and the temperature, relative humidity, and air velocity in the library must be kept at the recommended value by ICOP. Moreover, a detailed inspection of the ventilation system should be conducted in order to establish the efficiency of the ventilation system, as poor ventilation cannot eliminate pollutants from the building.

A pleasant work environment is crucial since it might impact the library staffs' motivation to complete their tasks at the workplace. Controlling the exposure is critical since good IAQ helps improve the health and comfort of library staff, as well as their performance and productivity at work. To eliminate $PM_{2.5}$ and PM_{10} in the library, it is strongly recommended to have proper housekeeping and to keep printers and photocopier machines apart from the main workspace, as both were sources of particulates.

As for post-pandemic recommendations, this study advises the library to increase outdoor-air ventilation to the greatest extent possible. In addition, changing or rearranging air flows can reduce viral transmission between individuals indoors. This may involve steps such as venting all restrooms directly to the outside and, if possible, diverting airflows so that they do not blow straight from person to person. The library must facilitate in physical distancing practices to reduce crowding or occupancy and reduce maximum occupancy in the library. As for the MVAC system, ascertain that there is no air leakage into any occupied space such as water seals, cracks in pipes or ducts, and wall gaps. Any issues that develop should be resolved as quickly as feasible.

6.4 Future research

This study might be improved with several modifications, as stated in the limitations section. This study did not measure the biological parameters of indoor air quality, which is total fungal counts and total bacterial counts, thus, future study is recommended to include biological parameters to obtain a better association of SBS symptoms and indoor air quality. Furthermore, more research on larger library staff respondents with diverse races and study locations is needed to better understand the association between indoor air quality in library and SBS symptoms. The data obtained by these improvements will be indicative of Malaysia's library staff whole population variety. Future research in the Perpustakaan Sultan Abdul Samad should focus on how indoor air pollutants are transported and how they affect the library staffs in terms of chronic health effects from long-term exposure. Because knowledge on the

health impacts of indoor air pollution on the library staffs is limited in Malaysia, additional study may be necessary to assess the degree of indoor air pollutants exposure and its impact on library staff's general health.



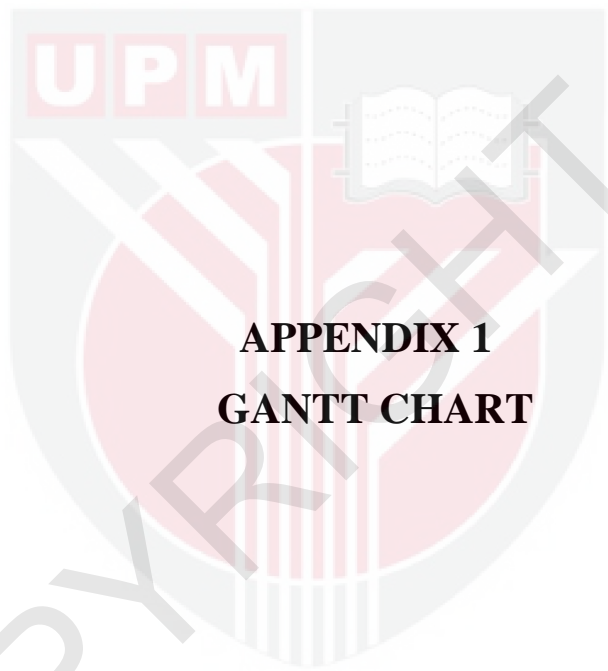
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**APPENDIX 1
GANTT CHART**

No	Research activities	2021										2022	
		Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
1.	Proposal preparation												
2.	Ethic application												
3.	Pre-study												
4.	Proposal presentation												
5.	Site visit												
6.	Data collection (Questionnaire & IAQ assessment)												
7.	Data analysis												
8.	Data interpretation												
9.	Thesis writing												
10.	VIVA												
11.	Thesis review												
12.	Thesis submission												



APPENDIX 2
ETHICAL APPROVAL LETTER



APPENDIX 3
EXPLANATION LETTER AND CONSENT FORM



UPM
UNIVERSITI PUTRA MALAYSIA

**JAWATANKUASA ETIKA UNIVERSITI UNTUK
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA**

FORM 2.4: RESPONDENT'S INFORMATION SHEET AND INFORMED CONSENT FORM

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. STUDY TITLE

Association Between Indoor Air Quality and Sick Building Syndrome Symptoms among Library Staff at Universiti Putra Malaysia.

2. INTRODUCTION

This study is conducted to determine the association between indoor air quality and sick building syndrome symptoms among library staff in Universiti Putra Malaysia.

3. WHAT WILL YOU HAVE TO DO?

You are required to read and understand this study to be conducted through this RESPONDENT INFORMATION'S SHEET. If you have any questions or problems in understanding this study, you are welcome to submit any questions to the researcher or supervisor before making any decision. Once you understand and agree to be involved as a respondent in this study, you are welcome to complete the consent form and sign it before returning it to the researcher.

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

Indoor air quality and sick building syndrome have a very significant impact on employee health and safety. Based on the study of the prevalence of sick building syndrome symptoms, this issue has become a health issue that is not new in Malaysia. Indoor air quality can be polluted by the ingress of contaminants that can affect human health. The ingress of these pollutants can occur due to poor or damaged ventilation and ventilation systems. All library staff included in the list will be selected to participate in this study.

Inclusion criteria

- i. Male and female library staff regardless of race in Perpustakaan Sultan Abdul Samad, UPM

- ii. Age between 18 to 60 years old
- iii. Have worked for at least four months in the library

Exclusion criteria

- i. Smoker
- ii. Have been diagnosed with respiratory disease such as asthma, chronic obstructive pulmonary disease (COPD), occupational lung diseases and pulmonary hypertension

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

This study is conducted to determine the indoor air pollutants that contribute to the sick building syndrome symptoms of library staff. It is hoped that this scientific study can help assess your risk of exposure to indoor air pollutants and sick building syndrome to your health status as well as find preventive measures to reduce the risk of health problems to yourself. This study will provide information on air quality in library and their association with health status of library staff. If the air pollution are severe, early prevention measures must be taken.

(b) TO THE INVESTIGATOR?

Through this study, researchers will obtain information on the rate of sick building syndrome among office workers and will suggest measures to prevent it from getting worse in the future. Overall, the results of this study have the potential to contribute to the early stages of reducing the health effect of indoor air pollutants in the UPM library.

6. WHAT ARE THE POSSIBLE RISKS?

This study does not bring any health risks to respondents. Respondents will only be questioned with a special form to assess background information and work environment, and symptoms of illness in the workplace. This study will only involve the use of questionnaires on respondents.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

All information provided by respondents is considered confidential. Researchers and supervisors will ensure that all personal data is obtained for reference purposes and thesis

writing only. All respondents' information will only be known by the researcher and supervisor of the study and it will be used for reference purposes of this study only. No individual reports will be presented or discussed in the report or thesis. All results related to this study will be communicated individually between the researcher and the respondent only. The researcher will not disclose to any relevant party any individual information without the prior permission of the respondent unless provided/required by law. No compensation will be given to respondent as this study does not involve clinical studies and no treatment is given to respondents. This study only involves the distribution of questionnaire.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

If you have any questions or additional questions while following this study, you are welcome to ask or meet with the researcher or supervisor of this study. Information regarding the researcher and supervisor of this study is as follows:

Supervisor	Prof. Dr Juliana Jalaludin Department of Environmental and Occupational Health Fakulty of Medicine and Health Sciences Universiti Putra Malaysia 43400 UPM, Serdang, Malaysia	017-683 4103/ 03-97692401	juliana@upm.edu.my
Researcher	Nur Syuhada Mohd Arobi Bachelor of Science (Environmental and Occupational Health)	013-7120097	syuhada.arobi99@gmail.com

Please initial here if you have read and understood the contents of this page _____

9. CONSENT

I Identity Card No.
address.....
.....hereby voluntarily agree to take part in
the research stated above *(clinical /drug trial/video recording/ focus group/interview-based/
questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible
adverse
effects and complications (as written in the Respondent's Information Sheet). I understand
that I have the right to withdraw from this research at any time without giving any reason
whatsoever. I also understand that this study is confidential and all information provided with
regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me
be used in any form of publication or presentation (if applicable)

* delete where necessary

Signature Signature
(Respondent) (Witness)

Date : Name :
I/C No. :

I confirm that I have explained to the respondent the nature and purpose of the above-
mentioned research.

Date Signature



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**JAWATANKUASA ETIKA UNIVERSITI UNTUK
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA**

BORANG 2.4: PENERANGAN DAN PERSETUJUAN RESPONDEN

Sila baca maklumat berikut dengan teliti. Sekiranya anda mempunyai sebarang pertanyaan, sila kemukakan kepada penyelidik.

1. TAJUK KAJIAN

Hubungan Antara Kualiti Udara Dalam dan Gejala Sindrom Bangunan Sakit di Kalangan Kakitangan Perpustakaan di Universiti Putra Malaysia.

2. PENGENALAN

Kajian ini dilakukan untuk mengetahui perkaitan antara kualiti udara dalam dengan gejala sindrom bangunan sakit di kalangan kakitangan perpustakaan di Universiti Putra Malaysia.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Anda diminta membaca dan memahami kajian ini yang akan dilakukan melalui HELAIAN PENERANGAN RESPONDEN ini. Sekiranya anda mempunyai pertanyaan atau masalah dalam memahami kajian ini, anda boleh mengemukakan sebarang pertanyaan kepada penyelidik atau penyelia sebelum membuat keputusan. Setelah anda memahami dan bersetuju untuk terlibat sebagai responden dalam kajian ini, anda boleh melengkapkan borang persetujuan dan menandatangani sebelum mengembalikannya kepada penyelidik.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Kualiti udara dalam dan sindrom bangunan sakit memberi kesan yang sangat besar terhadap kesihatan dan keselamatan pekerja. Berdasarkan kajian mengenai prevalensi gejala sindrom bangunan sakit, isu ini telah menjadi masalah kesihatan yang bukan perkara baru di Malaysia. Kualiti udara dalam boleh tercemar oleh kemasukan bahan cemar yang boleh menjejaskan kesihatan manusia. Masuknya bahan pencemar ini boleh berlaku kerana sistem pengudaraan dan pengudaraan yang lemah atau rosak. Semua staf perpustakaan yang termasuk dalam senarai akan dipilih untuk mengambil bahagian dalam kajian ini.

Kriteria kemasukan

- i. Kakitangan perpustakaan lelaki dan wanita tidak kira bangsa di Perpustakaan Sultan Abdul Samad, UPM
- ii. Berumur antara 18 hingga 60 tahun
- iii. Telah bekerja di perpustakaan lebih empat bulan

Kriteria pengecualian

- i. Perokok
- ii. Telah didiagnosis dengan penyakit pernafasan seperti asma, penyakit paru-paru obstruktif kronik (COPD), dan hipertensi pulmonari.

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANDA SEBAGAI PESERTA?

kajian ini dijalankan untuk mengetahui pencemaran udara dalaman yang menyumbang kepada gejala sindrom bangunan sakit kakitangan perpustakaan. Diharapkan kajian ilmiah ini dapat membantu menilai risiko anda terdedah kepada pencemaran udara dalaman dan sindrom bangunan sakit terhadap status kesihatan anda serta mencari langkah pencegahan untuk mengurangkan risiko masalah kesihatan pada diri anda. Kajian ini akan memberikan maklumat mengenai kualiti udara di perpustakaan dan hubungannya dengan status kesihatan kakitangan perpustakaan. Sekiranya pencemaran udara teruk, langkah pencegahan awal mesti dilakukan diambil.

b) KEPADA PENYELIDIK?

Melalui kajian ini, para penyelidik akan mendapatkan maklumat mengenai kadar sindrom bangunan sakit di kalangan pekerja pejabat dan akan mencadangkan langkah-langkah untuk mencegahnya menjadi lebih buruk di masa depan. Secara keseluruhan, hasil kajian ini berpotensi untuk menyumbang pada peringkat awal mengurangkan kesan kesihatan pencemaran udara dalaman di perpustakaan.

6. ADAKAH IA BERISIKO?

Kajian ini tidak mendatangkan risiko kesihatan kepada responden kerana responden hanya akan disoal dengan borang khas untuk menilai latar belakang maklumat dan persekitaran kerja, dan gejala penyakit di tempat kerja. Kajian ini hanya akan melibatkan penggunaan soal selidik terhadap responden.

7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?

Semua maklumat yang diberikan oleh responden dianggap sulit. Penyelidik dan penyelia akan memastikan bahawa semua data peribadi diperolehi untuk tujuan rujukan dan penulisan tesis sahaja. Semua maklumat responden hanya akan diketahui oleh penyelidik dan penyelia kajian dan ia akan digunakan untuk tujuan rujukan kajian ini sahaja. Tidak ada laporan individu yang akan dibentangkan atau dibincangkan dalam laporan atau tesis. Semua hasil yang berkaitan dengan kajian ini akan disampaikan secara individu antara penyelidik dan responden sahaja. Pengkaji tidak akan mendedahkan kepada pihak mana-mana maklumat individu tanpa kebenaran terlebih dahulu daripada responden melainkan jika diperuntukkan / dikehendaki oleh undang-undang. Tiada pampasan akan diberikan kepada responden kerana kajian ini tidak melibatkan kajian klinikal dan tiada rawatan diberikan kepada responden. Kajian ini hanya melibatkan pengedaran soal selidik.

8. SIAPA YANG SAYA PERLU HUBUNGI SEKIRANYA SAYA MEMPUNYAI SOALAN TAMBAHAN SEMASA MENGIKUTI PENYELIDIKAN INI?

Sekiranya anda mempunyai pertanyaan atau pertanyaan tambahan semasa mengikuti kajian ini, anda boleh bertanya atau berjumpa dengan penyelidik atau penyelia kajian ini. Maklumat mengenai penyelidik dan penyelia kajian ini adalah seperti berikut:

Penyelia kajian	Prof. Dr Juliana Jalaludin Kesihatan Persekitaran dan Pekerjaan Fakulti Perubatan dan Sains Kesihatan Universiti Putra Malaysia 43400 UPM, Serdang, Malaysia	017-683 4103/ 03-97692401	juliana@upm.edu.my
Penyelidik kajian	Nur Syuhada Mohd Arobi Bacelor sains (kesihatan persekitaran dan pekerjaan)	013-7120097	syuhada.arobi99@gmail.com

Sila tandatangan di sini sekiranya anda telah membaca dan memahami kandungan halaman ini _____

9. PERSETUJUAN

Saya..... No Kad Pengenalan.
beralamat.....
.....dengan ini bersetuju untuk mengambil bahagian secara
sukarela dalam penyelidikan yang tersebut di atas *(~~kajian klinikal/percubaan ubat-
ubatan/rakaman video/kumpulan sasaran/temuduga/~~ soal selidik).

Saya telah diberi penjelasan secara menyeluruh mengenai penyelidikan ini dari segi
metodologi, risiko dan komplikasi (seperti tertulis pada Helaian Penerangan Responden).
Saya memahami bahawa saya berhak menarik diri dari penyelidikan ini pada bila-bila masa
tanpa memberi sebarang alasan.Saya juga memahami bahawa sebarang maklumat yang
berkaitan identiti saya akan dirahsiakan.

Saya* berminat / tidak berminat untuk mengetahui keputusan kajian yang melibatkan saya.

I setuju/tidak bersetuju untuk imei/gambar/rakaman video/ rakaman suara digunakan dalam
apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

*potong yang tidak berkenaan

Tandatangan Tandatangan
(Responden) (Saksi)

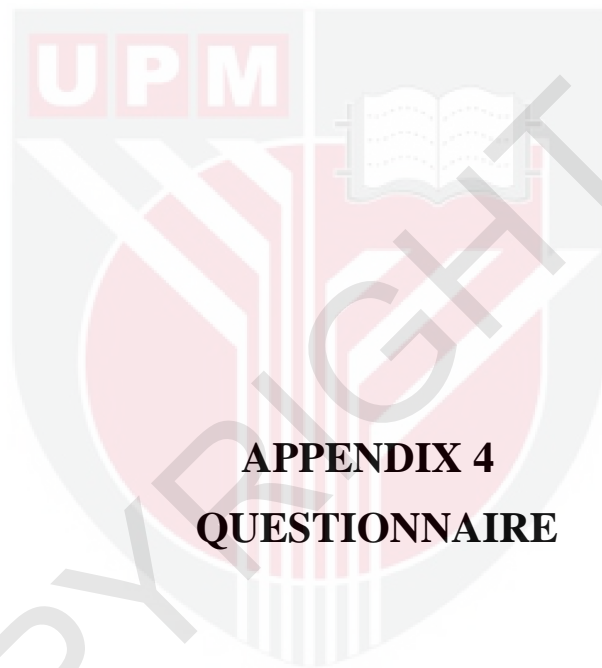
Tarikh : Nama :

No. K/P:

Saya mengesahkan bahawa saya telah menerangkan kepada responden ini sifat dan tujuan
penyelidikan yang tersebut di atas.

Tarikh

Tandatangan
(Penyelidik)(Researcher)



APPENDIX 4
QUESTIONNAIRE

Date/Tarikh:

ID No.:



QUESTIONNAIRE/*BORANG KAJI SELIDIK*

RESEARCH TITLE/TAJUK KAJIAN:	ASSOCIATION BETWEEN INDOOR AIR QUALITY AND SICK BUILDING SYNDROME AMONG LIBRARY STAFF AT UNIVERSITI PUTRA MALAYSIA HUBUNGAN ANTARA KUALITI UDARA DALAMAN DAN SINDROM BANGUNAN SAKIT DALAM KALANGAN KAKITANGAN PERPUSTAKAAN DI UNIVERSITI PUTRA MALAYSIA
RESEARCHER NAME/NAMA PENGKAJI:	NUR SYUHADA BINTI MOHD AROBI

Instructions/Arahan

This short questionnaire has been given to you to facilitate the identification of potential sources of indoor air quality (IAQ) pollutants and to identify adverse health effects that may be associated with exposure to these pollutants. Your answers will remain confidential. Please complete the form as accurately as possible before returning to us.

Soal selidik ringkas ini diberi kepada anda untuk membantu pengenalpastian punca berpotensi bagi bahan pencemaran kualiti udara dalam (IAQ) dan untuk mengenal pasti kesan memudaratkan ke atas kesihatan yang mungkin berkaitan dengan pendedahan bahan pencemaran ini. Jawapan anda akan kekal sulit. Sila lengkapkan borang ini setepat yang mungkin sebelum mengembalikannya kepada kami.

Section A: Socio-demographic and Workstation Environment
Seksyen A: Maklumat latar belakang dan Persekitaran Pekerjaan

Arahan: Sila tandakan pilihan jawapan dan isikan tempat kosong untuk soalan-soalan di bawah.

1. Age (*umur*): _____
2. Gender (*Jantina*): Male(*lelaki*) Female(*Perempuan*)
3. Ethnicity (*kaum*):
 Malay (*Melayu*)
 Chinese (*Cina*)
 Indian (*India*)
 Others (*lain-lain*): _____
4. Highest education level (*Tahap pendidikan tertinggi*):

<input type="checkbox"/>	Doctor of Philosophy	<input type="checkbox"/>	Diploma
<input type="checkbox"/>	Master Degree	<input type="checkbox"/>	STPM/Matriculation
<input type="checkbox"/>	Degree/ Bachelors	<input type="checkbox"/>	SPM
5. Smoking (*Adakah anda merokok*) : Yes No
6. Other than you, is there anyone in your family smoking?
 Yes
 No
7. What is your marital status (*Apakah status perkahwinan anda*)?
 Single (*Bujang*) Married (*Berkahwin*) Divorced (*Bercerai*)
8. Household income (*Pendapatan isi rumah*) RM _____
9. Number of family members (*Jumlah tanggungan*) _____
10. Workstation (*Jenis stesen kerja*)
 Open concept (*Konsep terbuka*) Enclosed room (*Bilik tertutup*)
 - i. Position (*Jawatan*) _____
 - ii. Division (*Bahagian*) _____
 - iii. Shift work (*Kerja syif*): Yes No

- iv. Working hours in a day (Masa kerja dalam sehari) _____hours(*jam*)
- v. Working days in a week (Hari bekerja dalam seminggu) _____ days(*hari*)
- vi. Working hours in the office (Masa kerja di dalam ofis) _____hours(*jam*)
- vii. How long have you been at your current job? (*Berapa lama anda bekerja di tempat kerja anda sekarang?*) _____years (*tahun*) _____months(*bulan*)
- viii. Number of people sharing your workstation (*Bilangan orang berkongsi tempat kerja dengan anda*): _____
- ix. How is your area air-conditioned? (*Bagaimanakah kawasan anda dinyamanudarakan?*)
- Local / split unit (unit setempat / pisah)
- Central unit (unit pusat)

11. How often do you use the following at work? Tick (/) the appropriate area for each item (*Berapa kerapkah anda menggunakan perkara berikut di tempat kerja?*)

Tandakan (/) di kawasan yang sesuai untuk setiap item)

	Several times a day (<i>Beberapa kali sehari</i>)	About once day (<i>kira-kira sekali sehari</i>)	3-4 times a week (<i>3-4 kali seminggu</i>)	Less than 3 times per week (<i>kurang dari 3 kali seminggu</i>)	Never (<i>Tidak pernah</i>)
Photocopier (<i>mesin fotokopi</i>)					
Laser Printer (<i>mesin pencetak laser</i>)					
Facsimile (<i>faksimili</i>)					
Cleanser, glue, correction fluid or other strong-smelling chemical (<i>Pembersih, gam, cecair pembedulan atau bahan kimia berbau kuat</i>)					

Section B: Present symptoms at workplace
(Seksyen B: Gejala penyakit di tempat kerja)

No.	Previous/Present diseases (Penyakit/Gejala lampau/Sekarang)	Yes (Ya)	No (Tidak)	If YES, during the last year? (Jika YA, adakah dari tahun lepas?)	
				Yes (Ya)	No (Tidak)
1	How you ever had asthmatic problems? (Adakah anda pernah mempunyai masalah asma?)				
2	Have you ever suffered sinusitis where allergic symptoms from eyes and/or nose? (Adakah anda pernah mengalami sinusitis iaitu gejala alahan mata dan/atau hidung?)				
3	Have you suffered from eczema? (Adakah anda mengalami eczema?)				

During the last three (3) months, have you had any of the following symptoms at work (Answer every question even if you have not had any symptoms)?

Dalam tempoh tiga (3) bulan yang lepas, adakah anda mempunyai mana-mana gejala berikut di tempat kerja (Sila jawab setiap soalan berikut walaupun anda tidak mempunyai sebarang tanda-tanda)

No	Present symptoms (Gejala-gejala yang dialami sekarang)	Yes, always everyday (Ya, setiap hari)	Yes, often (every week) [Ya, selalu (setiap minggu)]	Yes, sometime (2-3 times a week [Ya, kadangkala (2-3 kali seminggu)]	No, never (Tidak pernah)
1	Fatigue (Keletihan / lesu)				
2	Feeling heavy-headed (Rasa berat kepala)				
3	Headache (Sakit kepala)				
4	Nausea / Dizziness (Loya / Pening)				
5	Difficulties concentrating (Kesukaran menumpukan perhatian/mengantuk)				

6	Itching, burning or irritation of the eyes (Gatal-gatal, terbakar atau kerengsaan mata)				
7	Irritated, stuffy or runny nose (Hidung tersumbat / berair, merengsakan)				
8	Hoarse, dry throat (kering tekak, kesat)				
9	Cough (Batuk)				
10	Dry or flushed facial skin (Kulit muka kering atau kemerahan)				
11	Scaling/itching scalp or ears (Mengelupas / gatal-gatal kulit kepala atau telinga)				
12	Hands dry, itching, red skin (Ruam / gatal kulit)				
13	Other (Lain-lain):				

Please answer question 14,15 & 16 if you have any of the above symptom(s) at work.

Sila jawab soalan 14,15 & 16 jika anda mempunyai mana-mana gejala di tempat kerja seperti di atas.

14. No. of days absent last month based on symptoms above. *(Bilangan hari anda tidak datang bekerja dalam bulan lalu kerana masalah di atas):* _____days(hari)

15. When these symptoms start? *(Bilakah masalah ini berlaku?)*

- Morning (*Pagi*)
- Afternoon (*Tengahari*)
- Uncertain trend (*Tiada trend yang ketara*)

16. When did you feel relief from this problem? *(Bilakah anda berasa lega daripada masalah ini?)*

- After leaving the workstation (*Selepas meninggalkan stesen kerja*)
- After leaving the building (*Selepas meninggalkan bangunan*)
- Uncertain trend (*Tiada trend yang ketara*)

17. If female, are you pregnant? (*Jika perempuan, adakah anda sedang hamil?*)

Yes

No

18. Has your company carried out any assessment related to Indoor Air Quality? (*Pernahkah syarikat anda menjalankan apa-apa penilaian yang berkaitan dengan Kualiti Udara Dalam?*)

Yes

No



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