



UNIVERSITI PUTRA MALAYSIA

***INDOOR AIR QUALITY AND PSYCHOSOCIAL FACTORS RELATED
TO SICK BUILDING SYNDROME AMONG OFFICE WORKERS IN
NEW AND OLD BUILDINGS IN UNIVERSITI PUTRA MALAYSIA,
SERDANG***

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**INDOOR AIR QUALITY AND PSYCHOSOCIAL FACTORS RELATED TO
SICK BUILDING SYNDROME AMONG OFFICE WORKERS IN NEW AND
OLD BUILDINGS IN UNIVERSITI PUTRA MALAYSIA, SERDANG**



BY

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**This thesis submitted in fulfilment of the requirement for the degree of Bachelor
Science (Environmental and Occupational Health) from the Faculty of
Medicine and Health Sciences, Universiti Putra Malaysia**

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In the name of God, the Almighty,

This thesis has taken weeks to finish. Therefore, in this section, I would like to acknowledge all whom were involved either directly or indirectly in helping and guiding me throughout the process of drafting and finishing this thesis.

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ABSTRACT

INDOOR AIR QUALITY AND PSYCHOSOCIAL FACTORS RELATED TO SICK BUILDING SYNDROME AMONG OFFICE WORKERS IN NEW AND OLD BUILDINGS IN UNIVERSITI PUTRA MALAYSIA, SERDANG

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A healthy working environment is important as it could affect workers' psychology in completing their task in office. Poor indoor air quality (IAQ) and work-related stress have been linked to the risk of building-related problems which collectively known as sick building syndrome (SBS). A cross-sectional comparative study was conducted among 120 office workers in new and old buildings in UPM. SBS symptoms and psychosocial factors were identified using validated questionnaires modified from IAQ and work symptoms survey, DOSH, 2010 and Job Content Questionnaire (JCQ). Meanwhile IAQ parameters measured using IAQ devices. This study found that the levels of physical parameters in new building were significantly higher compared to old building for air velocity ($z = -2.867$, $p < 0.05$) and air humidity ($z = -11.983$, $p < 0.001$), meanwhile for temperature ($z = -12.072$, $p < 0.001$), old building was significantly higher compared to new building. The levels of indoor air pollutants (IAP) were significantly higher in old building compared to new building for TVOC ($z = -11.969$, $p < 0.001$); UFP ($z = -11.970$, $p < 0.001$); $PM_{2.5}$ ($z = -9.579$, $p < 0.001$) and PM_{10} ($z = -9.498$, $p < 0.001$). The prevalence of SBS was significantly higher in old building compared to new building ($\chi^2 = 31.44$, $p < 0.001$). There were significant associations between SBS prevalence with temperature (OR=4.02, 95% CI=1.02-15.85), CO_2 (OR=4.34, 95% CI=1.21-15.53); TVOC (OR=4.55, 95% CI=1.12-18.48); UFP (OR=4.63, 95% CI=1.25-17.21); $PM_{2.5}$ (OR=5.06, 95% CI=1.36-18.89); PM_{10} (OR=4.80, 95% CI=1.33-17.29) in old building and job insecurity (OR=4.08, 95% CI=1.03-16.23) in new building. After controlling the confounders; age, health status and smoking status, the results showed that TVOC, UFP $PM_{2.5}$ and PM_{10} influenced the SBS symptoms in old building while job insecurity influenced SBS in new building. Result visibly showed that indoor air pollutants and psychosocial factors influence the prevalence of sick building syndrome among office staffs. This study suggested that, further assessment and preventive measures should be carried out to reduce the risk factors of SBS and work stressors in working environment.

Keywords: Sick Building Syndrome (SBS), Indoor Air Quality (IAQ), Indoor Air Pollutants (IAP), Psychosocial Stress, New and Old Buildings.

Research area: Occupational Health

ABSTRAK

KUALITI UDARA DALAM BANGUNAN DAN FAKTOR PSIKOSOSIAL BERKAITAN DENGAN SINDROM BANGUNAN SAKIT DALAM KALANGAN PEKERJA PEJABAT DI BANGUNAN BARU DAN LAMA DI UNIVERSITI PUTRA MALAYSIA, SERDANG

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Persekitaran kerja yang sihat amat penting kerana ia boleh mempengaruhi psikologi pekerja dalam menyelesaikan tugas mereka di dalam pejabat. Kualiti udara dalaman yang tidak baik dan tekanan di tempat kerja telah dikaitkan dengan masalah yang berkaitan dengan bangunan yang secara amnya dikenali sebagai sindrom bangunan sakit (SBS). Kajian perbandingan keratan rentas dilakukan di kalangan 120 pekerja pejabat di bangunan baharu dan lama di UPM. Simptom SBS dan faktor psikososial dikenal pasti menggunakan borang soal selidik validasi yang diubah suai dari tinjauan kualiti udara dalaman dan gejala kerja, DOSH, 2010 dan borang soal selidik kandungan pekerjaan (JCQ). Sementara itu, parameter IAQ diukur menggunakan instrumen kualiti udara dalaman. Kajian ini mendapati bahawa tahap parameter fizikal di bangunan baharu jauh lebih tinggi berbanding dengan bangunan lama untuk halaju udara ($z = -2.867$, $p < 0.05$) dan kelembapan udara ($z = -11.983$, $p < 0.001$). Sementara itu untuk suhu ($z = -12.072$, $p < 0.001$), bangunan lama jauh lebih tinggi berbanding bangunan baharu. Tahap pencemaran udara dalaman jauh lebih tinggi di bangunan lama berbanding bangunan baharu untuk TVOC ($z = -11.969$, $p < 0.001$); UFP ($z = -11.970$, $p < 0.001$); $PM_{2.5}$ ($z = -9.579$, $p < 0.001$) dan PM_{10} ($z = -9.498$, $p < 0.001$). Prevalens SBS jauh lebih tinggi di bangunan lama berbanding bangunan baharu ($\chi^2 = 31.44$, $p < 0.001$). Terdapat hubungan yang signifikan antara prevalens SBS dengan suhu (OR=4.02, 95% CI=1.02-15.85), CO_2 (OR=4.34, 95% CI=1.21-15.53); TVOC (OR=4.55, 95% CI=1.12-18.48); UFP (OR=4.63, 95% CI=1.25-17.21); $PM_{2.5}$ (OR=5.06, 95% CI=1.36-18.89); PM_{10} (OR=4.80, 95% CI=1.33-17.29) di bangunan lama dan ketidakselesaian pekerjaan (OR=4.08, 95% CI=1.03-16.23) di bangunan baharu. Selepas pengawalan faktor umur, status kesihatan dan status merokok, hasilnya menunjukkan bahawa TVOC, UFP, $PM_{2.5}$ dan PM_{10} mempengaruhi gejala SBS di bangunan lama manakala ketidakselesaian pekerjaan mempengaruhi prevalens SBS di bangunan baharu. Hasil kajian menunjukkan bahawa pencemaran udara dalaman dan faktor psikososial mempengaruhi berlakunya sindrom bangunan sakit di kalangan kakitangan pejabat. Kajian ini menunjukkan bahawa penilaian lebih lanjut dan langkah pencegahan harus dilakukan untuk mengurangkan faktor risiko SBS dan tekanan di tempat kerja.

Kata kunci: Sindrom Bangunan Sakit (SBS), Kualiti Udara Dalaman, Pencemar Udara Dalaman, Faktor Psikososial, Bangunan Baharu dan Lama.

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LIST OF ABBREVIATIONS

<	Less than
>	More than
CI	Confidence Interval
OR	Odd Ratio
IQR	Inter-Quartile Range
IAQ	Indoor Air Quality
IAP	Indoor Air Pollutants
SBS	Sick Building Syndrome
PM	Particulate Matter
UFP	Ultrafine Particles
TVOC	Total Volatile Organic Compounds
DOSH	Department of Occupational Safety and Health
WHO	World Health Organization
USEPA	United State Environmental Protection Agency
FS	Faculty of Science
FMHS	Faculty of Medicine and Health Sciences

CHAPTER 1

INTRODUCTION

1.1 Study Background

Indoor air quality is influenced by concentrations of outdoor air pollutants, indoor sources of pollution, characteristics of the building and the habits of the residents. (WHO, 2010). According to the Environmental Protection Agency (EPA), IAQ is defined as the air quality within and around the buildings especially its influence on human health and comfort. Poor IAQ may contribute to the risk of building-related problems which also known as sick building syndrome (SBS) (Id et al., 2018). Sources of indoor air contaminants that cause poor IAQ may come from physical, chemical and biological parameters (Kamaruzzaman & Sabrani, 2011). The problems of IAQ in a building can be influenced by the inadequate ventilation system, presence of indoor pollutants, high moisture and dampness, use of cleaning materials and human activities (DOSHS, 2010).

SBS is described as non-specific symptoms of illnesses experienced by the building occupants, which are categorized by the complaints of irritation of mucosal membrane and upper respiratory tract. (Md Saaad, Rasdi & Zainal Abidin, 2016). Usually, the building occupants who were working in a high level of indoor

contaminants tend to develop SBS symptoms only when they are in the building and the symptoms appear when they return home (Fauzan & Juliana, 2016). The available findings on SBS related to poor IAQ were mostly reported in office buildings where poor ventilation and high concentration of indoor air pollutants triggered the occurrence of SBS among workers (Norhidayah et al., 2013). In Malaysia, there are many studies conducted by previous researchers about the association between SBS and indoor air quality among office workers in new and old buildings. Poor IAQ in office buildings may affect the health of the workers (Jalaludin et al., 2014). A similar study conducted at two different offices in Selangor by Zamani et al., (2013), showed that the poor IAQ in office buildings could increase the risk of health problems among building occupants or also known as sick building syndrome.

Besides, there is a few evidence from a previous study that showed the association between SBS with work stressors and that stress appears from working in a poor indoor environment (Redman et al., 2011). The prevalence of depression and anxiety among Malaysian adults has increased from 12% in 2011 to 29% in 2015 (IPH, 2015). Factors of chemical exposures, poor physical and psychosocial environments were found to significantly contribute to stress among workers (Zuliza, Irniza & Emilia, 2017). The workers who exposed to chemical contaminants and work stressors were significantly associated with stress among workers. All of the SBS symptoms are influenced by personal, psychosocial, and environmental factors (Id et al., 2018). Metabolic disorder in the human body happened when workers were exposed to high indoor air pollution that developed symptoms of headache, dizziness, anxiousness, and difficulty sleeping. (Ooi et al., 1998).

Symptoms are associated with SBS, such as mucous membrane inflammation, allergic reactions and fatigue among stress employees. (Lunberg & Cooper, 2011).

Most recent studies on SBS have focused on indoor air quality without considering the job stressor faced by the workers. Thus, in order to clarify the factors associated with the prevalence of SBS, this study aimed to determine the association between indoor air quality and psychosocial factors with SBS among office workers in new and old buildings in UPM, Serdang.

1.2 Problem Statement

Sick building syndrome (SBS) could contribute a threat to people who spent most of their time indoors, for example, staff who worked in the office during working hours. The concern of this issue was that people have the possibility of having a symptom of SBS if they are exposed to indoor air pollutants. This problem was not only experienced in Malaysia but also globally. Besides, this study is concerned with two types of buildings that were fully ventilated with centralized air conditioning systems and may have a different pattern the quality of the indoor environment. This is because old buildings might have high levels of indoor air pollutants as compared to a new building, so the question asked which buildings are better in indoor air quality either new or old buildings and have less reported cases of SBS.

Most of indoor air pollutants start inside the building, for example photocopy machines which generate ozone, wood products like shelves or desks, carpeting which can give off formaldehyde, paints, cleaning chemicals and adhesives may emit volatile organic compounds (VOCs). Environmental tobacco smoke (ETS) also can contribute to indoor air pollution and cigarette contains a mixture of carcinogens that can cause severe health impact to human body (Mueller et al., 2011). In many years back, people might ignore about the importance of having a good quality of indoor environment due to the invisible of the existence of indoor air contaminants, it is supported by Pille, (2019) who says that most of the IAPs are invisible, odourless and they tend to be emitted at low levels which make them hard to track down. One of the well-known diseases resulted through the exposure to indoor air contaminants

is sick building syndrome. It is defined by the World Health Organization (WHO) as an irritation of the skin and mucous membranes and other symptoms including headache, fatigue, and difficulty concentrating, reported by the building occupants.

Stress among staffs in educational sector was gradually increased particularly in Research Universities to fulfil the institutions high expectation which include the requirement of high capabilities and skills in management, research and teaching methods (Mukosolu et al., 2015). Findings of a previous study indicated that the prevalence of work stress among Malaysian local university staffs was about 21.7% and this stress was found to be significantly associated with high job demand, low social support, depression and anxiety (Md Saad, Rasdi & Zainal Abidin, 2017). Sick building syndrome was identified to be related to stress among workers indirectly or directly (Redman et al., 2011). The symptoms that are found to be related to SBS among stress workers are such as mucosal irritation, allergies and fatigue, complaints of sleepiness, headache, weakness and skin irritations (Lundber et al., 2011).

The ignorance by the workers and even the employer himself due to the mentioned factors have made the indoor air quality and psychosocial factors became one of the important occupational health issues in the world. The building that is supposed to be a safe place for the workers has turned to be a risky area due to the exposure of indoor air pollutants among the workers. Studies related to psychosocial factors and SBS have been done in various occupation but less documented among office workers in public institutions. Other than that, considerable attention has

focused on SBS particularly its association with IAQ, SBS-related to psychosocial factors have not been well studied. In order to clarify the factors associated with the SBS, the present study examined the indoor air quality and psychosocial factors associated with the prevalence of SBS among office workers in new and old buildings in Universiti Putra Malaysia, Serdang.

1.3 Study Justification

Nowadays, the quality of the indoor working environment within the age of building in all education sectors became the focus of many researchers (Ahmad & Hassim, 2015). The effects of sick building syndrome appeared to be linked with the time spent in a ventilated building (EPA, 1991). However, there was no specific illness or causes that can be identified. In order to identify the symptoms of SBS, cooperation from building occupants is very important. The reason why this research has been conducted was due to a lack of scientific studies conducted by previous researchers about the IAQ and psychosocial factors in a different age of buildings in a public institution and its relationship with the prevalence of sick building syndrome among staff. With this study, it can become the baseline in the future for others to conduct research regarding the prevalence of sick building syndrome with different types of buildings in public higher educational institutions.

Today, many technology equipment was used in office settings plus the centralized air conditioning system being used at every building. The usage of printers, photocopy machines, and cleaning materials in the office could become the source of indoor air pollutants into the building environment. In order to identify

indoor air quality and psychosocial factors and its prevalence with SBS, this study must be carried out. From the data obtained, proper control measures can be made to improve the indoor air quality performance and psychosocial well-being in order to create a comfortable working environment for office workers. In this study, the parameter that have been studied are mainly chemical parameters (ventilation, temperature, relative humidity), physical parameters (PM₁₀, PM_{2.5}, UFP, CO₂, CO, TVOC), and psychosocial factors (job demand, decision latitude, social support, job insecurity).

1.4 Research Questions

- What is the level of concentration of PM₁₀, PM_{2.5}, UFP, CO₂, CO, TVOCs, air velocity, temperature, and relative humidity in new and old buildings?
- What is the level of psychosocial factors in the new and old buildings?
- What is the prevalence of SBS in new and old buildings?
- Is there any association between the level of indoor air quality with SBS among office workers in new and old buildings?
- Is there any association between the level of indoor air pollutants with SBS among office workers in new and old buildings?
- Is there any association between psychosocial factors with SBS among office workers in new and old buildings?
- What is the main predictor of the Sick Building Syndrome among study respondents after considering all the confounders?

1.5 Research Objectives

General objective

To determine the relationship between indoor air quality and psychosocial factors related to Sick Building Syndrome (SBS) among office staff in new and old buildings in Universiti Putra Malaysia, Serdang.

Specific objective

1. To identify the socio-demographic data of respondents from new and old buildings.
2. To compare the level of physical parameters between new and old buildings.
3. To compare the level of indoor air pollutants between new and old buildings.
4. To compare the psychosocial factors between new and old buildings.
5. To compare the prevalence of SBS in new and old buildings.
6. To determine the association between the level of physical parameters with SBS among office workers in new and old buildings.
7. To determine the association between the level of indoor air pollutants with SBS among office workers in new and old buildings.
8. To determine the association between psychosocial factors with SBS among office workers in new and old buildings.
9. To identify the main predictor of the Sick Building Syndrome among study respondents after considering all the confounders in this study.

1.6 Research Hypothesis

1. The concentration of physical parameters is significantly different between new and old buildings.
2. The concentration of indoor air pollutants is significantly different between new and old buildings.
3. The level of psychosocial factors is significantly different between new and old buildings.
4. The prevalence of SBS is significantly different between new and old buildings.
5. There is a significant association between level of physical parameters with prevalence of SBS among office workers in new and old buildings.
6. There is a significant association between level of indoor air pollutants with prevalence of SBS among office workers in new and old buildings.
7. There is a significant relationship between psychosocial factors with SBS among office workers in new and old buildings.
8. Exposure to the indoor air pollutants can influence the sick building syndrome among office workers in two different office building after controlling the confounders in this study.

1.7 Definition of variables

1.7.1 Conceptual definition

1. Indoor Air Quality

IAQ refers to the “quality of the air inside buildings as represented by the concentration of indoor air pollutants and thermal conditions that affect the health, comfort and performance of occupants”. (USEPA, 2012). By referring to Industry Code of Practice on Indoor Air Quality (2010), some parameters can be measured to indicate the quality of indoor working environment such as chemicals pollutants (CO₂, CO, formaldehyde and environmental tobacco smoke), physical conditions (temperature, air velocity, and humidity), biological agents (mites, virus and spores) and radiation.

2. Indoor Air Pollutant

By referring to ICOP (2010), indoor air pollutants consist of chemical contaminants, biological contaminants and ventilation performance indicators. Indoor air pollutions sources came from various origins such as exhalation, insufficient and broken materials used in the work process, cleaning activities, carpet, gases released from combustion, and cross-contamination (DOSH, 2010).

3. Psychosocial factors

Psychosocial defined as the interaction between social and psychosocial factors. Psychosocial factors at work refer to “interaction with the work environment, job content, organizational conditions and workers’ abilities, demand and culture that influence health, work performance and job satisfaction” (WHO, 2007).

4. Sick Building Syndrome

SBS defined “an excess of work-related irritations of the skin and mucous membranes and other symptoms which comprises a collection of non-specific symptoms reported by workers in modern buildings of a certain workplace” (WHO, 1983).

1.7.2 Operational Definition

1. Indoor Air Quality

To measure the indoor air quality, we use TSI Model 7575 Q-Trak IAQ Monitor and TSI Model 9596-A Velocicalc Multi-Function Ventilation Meter. TSI Model 7575 Q-Trak IAQ Monitor measure the carbon dioxide (CO₂), carbon monoxide (CO), temperature, relative humidity measurement (%RH). CO₂ is used in this study as an indicator to determine the fresh air supply from the diffuser, and the movement of air in and out from building (Zamani et al., 2013). The acceptable limit for CO₂ is C1000ppm according to DOSH (DOSH, 2010). Besides, TSI 9565-A Velocicalc Plus measure the velocity, temperature, and relative humidity. The acceptable range for air temperature is in the range of 23 to 26°C, relative humidity is 40 to 70% and air movement is 0.15 to 0.050 m/s (DOSH, 2010).

2. Indoor Air Pollutants

For total volatile organic compounds (TVOC), we use ppbRAE 3000 in determining the level of volatile organic compounds in the office. The acceptable limits for TVOC are 3ppm (DOSH, 2010). For particulate matter, we use the TSI Model 8532 DustTrak II Aerosol Monitor to measure the level PM₁₀, PM_{2.5}, PM_{1.0} and respirable size fraction. In contrast, TSI Model 8525 P-Trak Ultrafine Particle is used to measure the workplace ultrafine particulate level. The acceptable limit for respirable particulates is 0.15 mg/m³ (DOSH, 2010).

4. Psychosocial stress

Psychosocial factors listed in the 27 items of Job Content Questionnaire (JCQ) based on (Karasek et al., 1998). JCQ contains 27 questions which consist of decision latitude, peer support, work demand, and work insecurity (Md Saad, Rasdi, & Zainal Abidin, 2017).

5. Sick Building Syndrome

SBS was identified by using a modified published questionnaire of Indoor Air Quality Malaysia Code of Practice (DOSH, 2010). The respondents have answered the question based on the experience of having any symptoms listed in the questionnaire. The workers will be defined as having SBS if they had at least one symptom and appears at least once every week (Ooi et al., 1998).

1.8 Conceptual Framework

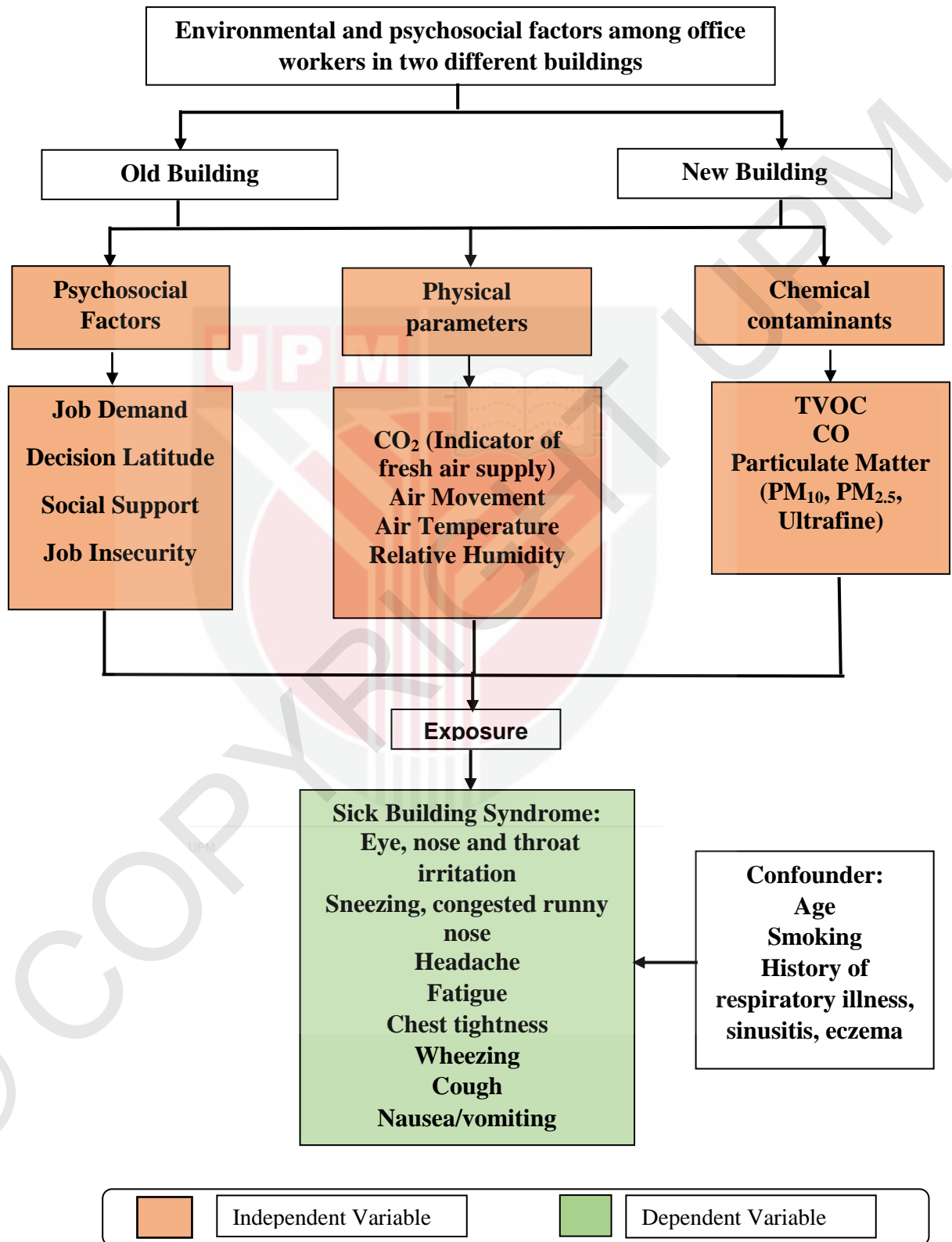


Figure 1.1: Conceptual Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Sick Building Syndrome

According to the terminology by Industrial Code of Practice in Indoor Air Quality (2010), Sick Building Syndrome (SBS) can be defined as the condition or situation in which the occupant who worked in an indoor environment had experienced acute health and discomfort which happened when spending time in the building. Poor indoor air environment especially contaminated air can caused the SBS symptoms consist of irritated symptoms from eyes, skin and upper airways (Jalaludin, Nordiyana, & Suhaimi, 2014). Sick building syndrome is used to describe a set of adverse health or discomfort symptoms that individuals experience when they spend time indoors, particularly in office buildings, and that lessen while away from the building. SBS symptoms do not indicate either a particular exposure or a specific disease (Levin, 1989).

Sick building syndrome symptoms are often classified by the affected region and system of the body. The classification are upper respiratory and mucosal symptoms, typically reported as dry, itchy, sore, burning, or otherwise irritated eyes, nose, sinus or throat; lower respiratory irritation or distress such as cough, tight chest, wheeze or difficulty breathing; neurophysiological symptoms including

headache, drowsiness, lethargy, tiredness, mental fatigue, dizziness, and skin irritation (Levin, 1989). Other than that, psychosocial factors also may contribute to sick building syndrome in the workplace (Id et al., 2018). Based on the study by Stenberg (1994), he stated that there was a suspected association between SBS and air humidification, recirculation of exhaust air at high outdoor-air flow rates and with natural or mechanical ventilation systems. The most common findings regarding to the poor indoor quality were seborrheic dermatitis, facial erythema, periorbital eczema and “itching folliculitis”. It is suggested that physical, chemical and psychosocial factors contribute in producing these symptoms (Stenberg, 1989).

In Malaysia, a study done by Zamani et al., (2013) shows that the prevalence of SBS cases is higher in old building compared to new building; 68.2% and 25.9%. This study found that high concentrations of CO₂, CO, TVOC, PM₁₀ and PM_{2.5} are important factors that can influence the prevalence of SBS in old building while UFP also need to be focus on in the new building. However, another study done by Nur Fadilah & Juliana, (2012) shows that the reported SBS cases in new building was higher compared to the old building; 47.5% and 33.8%. The concentration of PM₁₀, PM_{2.5}, TVOC and CO₂ were significantly higher in new building than old building and the was significant difference for the prevalence of SBS symptoms; stuffy/runny nose/ sinus, in new building compared to the old building. Exposure to paper dust and to fume from photocopier and printers (FPP) was associated with breathlessness, and upper respiratory infections (Jaakkola et al., 2007). Coughing, wheezing, chest tightness, shortness and shallow breathing and anxiety are the common signs and symptoms of asthma and it caused by breathing substances present at workplaces, such as chemical fumes, gases or dust which are irritating or sensitizing (Nag, 2019).

2.2 Conditions of Buildings

A building that was built to become an office has different features with varying qualities to meet the objective of the occupant. In higher education buildings, for example, university and college, the office criteria must meet the suitability and comfortability for staff including lecturer and managerial staff. The comfortable condition needed to be considered because it affected the productivity of staff who worked 8 hours in the office. According to a study by Lee (2011) stated that the workers' satisfaction and condition of building quality could be improved when the indoor air quality improved. The quality of indoor air and thermal comfort within the building were related to each other, which can affect worker's productivity and health problem in the workplace.

Aside from measuring IAQ parameters (physical, chemical and biological) the conditions of the building also need to be under consideration in determining the risk factors of SBS. There are many sources of pollution in a building for example, the history of renovation/remodelling, types of floors (tile or carpet covering), types of walls (plywood, vinyl or plastic covering), and history of painting (EPA, 2019). Central air-conditioning system, use of the photocopier, printer or fax machine for more than one hour daily and installation of new carpet in building environment could influence the prevalence of SBS (Afzan Zainal, Hashim, Jalaludin, Lim, & Hashim, 2019). Moisture problems can be caused by construction defects such as roof leakage, low wall permeability in controlling hot and humid temperatures and insufficient building pressure control (ASHRAE, 2018). Besides, the use of such

flooring can cause negative effects on the IAQ. Previous researches have concluded that there are many IAP (dust, allergens, bacteria and fungi) can built up in carpets floor compared with non-carpeted (Becher et al., 2018).

2.3 Psychosocial Stress

Stress in the workplace is a global major risk factor to worker's health, which triggers the workers to be poorly motivated and less productivity Zuliza, Irniza and Emilia (2017), conducted a cross-sectional study to determine the prevalence of sick building syndrome (SBS) and other factors contributing to probable mental health problems among university laboratory staffs. Data was collected using validated self-administrated questionnaires consists of the Job Content Questionnaire (JCQ), General Health Questionnaire (GHQ) and SBS. Results visibly showed that psychosocial factors and symptoms of SBS in their working environment contribute to probable mental health problems among laboratory staffs. The strongest predictors in this study were job insecurity. This study also found that the symptoms of SBS such as fatigue, drowsiness, headache, and skin rashes, were significantly associated with probable mental health problems among respondents.

In addition, Id, Tsai, Muo, & Kuo, (2018) conducted a study to examine the relation between SBS symptoms and its risk factors (personal, environmental and psychosocial factors). This study found that the psychosocial factors which caused the effect to lower respiratory tract infections while low support from a colleague was associated with upper respiratory tract infections. Although workers will strive

to work harder in the face of high workloads, this situation will result in psychological response and cause those with low threshold tolerance to bear the painful role (Ooi et al., 1998). Mukosolu et al. (2015) conducted a cross-sectional study among 511 of office employees to determine the prevalence of job stress and its associated factors. The results of this study show that the staff are exposed to various stressors at the workplace such as lack of support from colleagues and supervisors, heavy workload, mental stress such as depression and self-blame. High job demand is a major predictor of stress.

Kamaruzzaman & Sabrani (2011) conducted a study examining how indoor air quality (IAQ) affects psychological performance and health impact on the occupants in government high rise office buildings in Malaysia. The results showed that the majority of respondents from all office buildings indicated average rating for indoor ventilation satisfaction and comfort level of the buildings, work productivity and stress level of occupants in the buildings. If workers are unsatisfied with the current indoor ventilation, this will lead to an uncomfortable work environment and they cannot perform their tasks properly. This eventually would decrease the productivity of workers and affect their mental health (Kamaruzzaman & Sabrani, 2011).

2.4 Indoor Air Quality

By referring to Industrial Code of practice on Indoor Air Quality DOSH (2010), the assessment of indoor air quality shall include the measurement of specific physical parameters; air temperature, relative humidity and air movement, and indoor air contaminants which consists of chemical contaminants; carbon monoxide, formaldehyde, ozone, respirable particulates and TVOC, biological contaminants; total bacteria and fungi counts, and ventilation performance indicator; carbon dioxide. In order to obtain a good indoor environment and to avoid discomfort or health effect among building occupants, all parameters should not exceed and comply with the acceptable limits as recommended by the guideline.

The rapid development in Malaysia especially on the economic growth has not increased parallel with the number of studies regarding to the indoor air quality; as a result, the adverse health effects related to poor indoor air quality might increase which leads to the various symptoms of building related illnesses. Indoor environment encompasses homes and other residences, workplaces, transportation vehicles and other diverse enclosed settings where individuals spend a portion of their time daily (Stokols, 2018). Indoor air quality has a significant impact on human health (Norhidayah et al., 2013). Enclosed space inhabited by humans produce many effects such as low oxygen level, high concentration of carbon dioxide, increase in temperature, humidity, bio-aerosol and accumulation of air pollutants (Sharma & Suresh, 2014). There are three main mechanisms that allow outdoor air to enter and affect indoor environments which are mechanical ventilation, natural ventilation and

infiltration (Leung, 2015). Due to these three mechanisms, the air pollutants from outdoor can penetrate into the indoor environment, and can either be diluted or accumulated the indoor contaminants according to the ventilation condition.

In addition, there are many pollutants that may exist in the indoor environment which came from indoor sources. According to USEPA (1997), indoor air quality is constantly changing interaction of complex interaction that affect the levels of pollutants inside the buildings. These sources include the source of pollutants or odours, building design, maintenance of ventilation systems; moisture and humidity, and occupant activities inside the buildings (Id et al., 2018). The impact of the quality of indoor air on the health and well-being of building occupants has been the focus of research in the Public Health area since 1970 (WHO, 2000). Complaint reports related to health and environmental discomfort received from the building occupants as well as the high level of absenteeism, mood changes, dissatisfaction and poor work performance which caused by poor IAQ in work environment (Mukosolu et al., 2015). Ventilation system has a strong relationship with the usage of air conditioner in the building and the study done by Noh et al., (2008) found that ventilation performance can be increased when the momentum source like air-conditioner is used in the room with the mixing ventilation from natural sources. In addition, working in a building with ventilation systems is associated with a slight increase in reported health outcomes (Fauzan & Jalaludin, 2016). It is supported by the other study by Norhidayah et al., (2013) which stated that the poor ventilation and air distribution may lead to the accumulation of indoor air contaminants and these problems can arise from reduced airflow rates, or from improper maintenance of ventilation systems in the building.

2.5 Indoor Air Pollutants

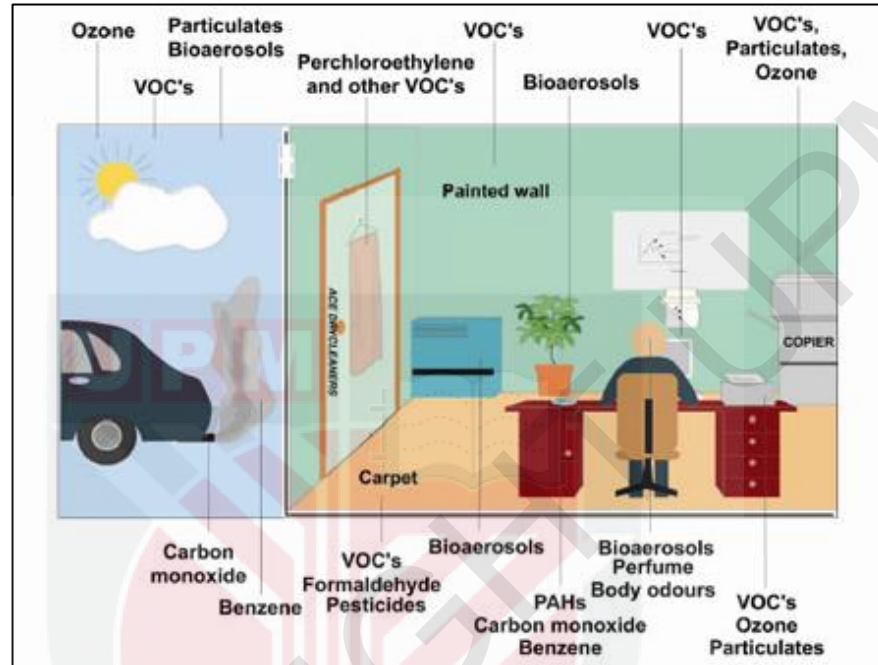


Figure 1.2: Primary source of indoor air pollutants

(Source from Sharma & Suresh, 2014)

Figure 1.2 shows that there are many pollutants that may exist in the indoor air and the major cause came from indoor sources. The pollutants are carbon dioxide, carbon monoxide, volatile organic compounds, particulate matters and ultrafine particles. Based on World Health Organization (2010), the major sources of indoor air pollution based on the worldwide terms are indoor combustion of solid fuels, tobacco smoking, outdoor air pollutants, lack maintenance of air conditioning and ventilation system and emissions from construction materials and furnishing. Nur Fadhilah & Juliana, (2012) says that the primary source of CO₂ in the office buildings is via respiration process by the building occupants. Mechanically ventilated and air conditioned buildings found a significant association between the increasing of CO₂ and the sick building syndrome symptoms (Michael et al., 2000).

The next pollutant can be volatile organic compounds (VOCs). VOCs are organic chemicals which can become gaseous at room temperature and like all organic compounds, they are composed primarily carbon and hydrogen. These chemicals are very important as indoor pollutants because they can easily enter a gaseous phase at room temperature, thereby making them potential to cause inhalation hazards (Kozicki et al., 2018). The principal causes of sick buildings syndrome in majority of cases are related to microbial effects and emissions of VOCs and formaldehyde from building materials or products used in buildings (Singh et al., 2010). Building materials release a wide variety of volatile organic compounds and they are absorbed into the body through respiratory system and the skin (Gostner et al., 2016). According to Wah, Yu, & Kim (2010) the effects of VOC have both odorous and irritant and the irritation effect including cough, dryness of mucous membrane, sneezing, hoarseness, skin erythema, and breathing changes pattern. It is recognized that such contamination is responsible for long-term health effects associated with the development of allergy or asthma and discomfort among occupants (Wolkoff, 1998).

Particulate matter (PM) is generic term to classify air pollutants comprising of suspended particles in air, varying in composition and size, resulting from various anthropogenic activities (Sherman, 1992). The part of respiratory system affected by PM depends upon the size of particle with diameter less than 0.1 μm (UFP), 2.5 μm ($\text{PM}_{2.5}$) and 10 μm (PM_{10}). PM upon inhalation instigates extra pulmonary effects on cardiovascular system by three pathways. First lung base cells release vasoactive molecules (microparticles; histamine) or proinflammatory mediators

(platelets, active immune cells, cytokins). Second particle interactions with nerves or lung receptors which result in alteration of ANS balance and heart rhythm. Third translocation of PM and particle constituents into systematic circulation (Rachida, 2018).

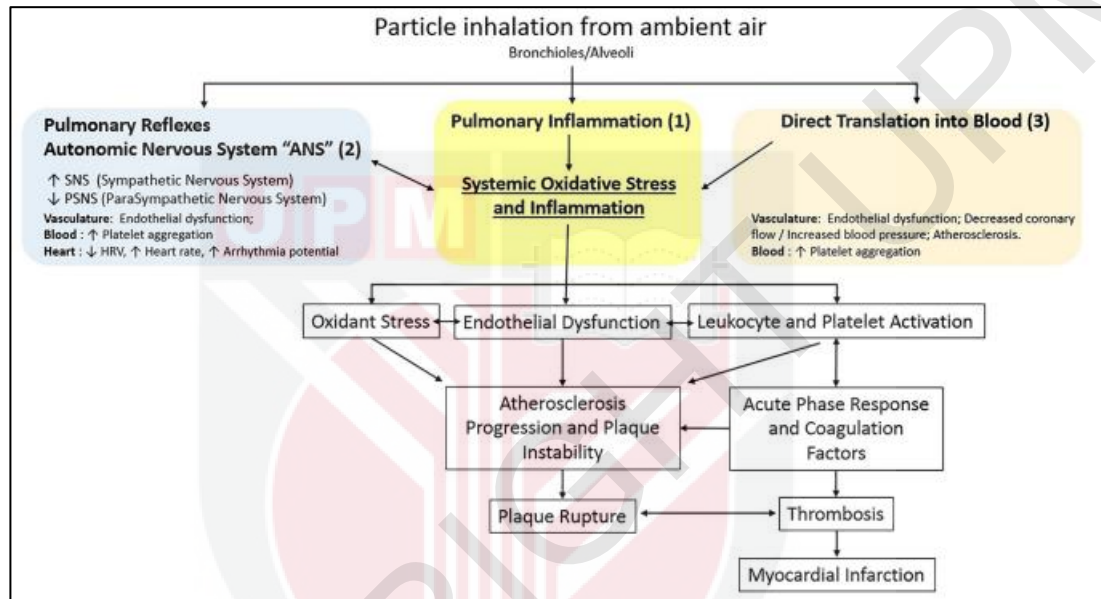


Figure 1.3: Possible mechanism of air pollutant in cardiovascular diseases.

(Source from Rachida, 2018)

EPA is concerned about fine particles which able to penetrate deeper into our lung and cause serious health problems such as it affects the bloodstream. According to US EPA (2018), the health effects that are linked to the exposure to particulates matter are irregular heartbeat, decrease lung function and increase respiratory symptom such as airways irritation, coughing and difficulty in breathing. In addition, particles less than 10 microns and 2.5 microns can worsen human's heart and induce breathing problem especially to the susceptible group (Schwartz, 1997). PM with diameter less than 2.5 μm ($\text{PM}_{2.5}$), originates from laser printers and photocopy machines are known indoor office sources (Zhu et al., 2015). Moreover, the indoor

office environment is usually linked to a high utilization of laser printers, which are known to emit ozone (O_3) (Salonen et al., 2018). exposure to PM particularly $PM_{2.5}$ and O_3 is also suspected as contributing to asthmatic disease in subgroups (Wolkoff, 2013) and also upper respiratory symptoms as a result of exposure to suspended PM, especially in an office environment (Azuma et al., 2018).

According to Lee and Hsu (2007), UFP could be emitted at high concentration during photocopying. Previous studies have shown that the effect of UFP particle is more dangerous as compared to PM_{10} and $PM_{2.5}$ due to its small size and able to penetrate deeper into the respiratory tract and cause chronic illness (Zamani et al., 2013). The toxicity of this particles is greater compared to PM_{10} or $PM_{2.5}$ due to the size and it can cause pathological change in the lung by narrowing the airways which can cause Chronic Obstruction Pulmonary Disease (COPD) (Klein, 2019).

CHAPTER 3

METHODOLOGY

3.1 Study Design

A cross-sectional comparative study was used as a research study design to make a complete assessment of environmental and psychosocial factors in two different buildings. There were two independent variables in this study which consist of psychosocial factors and indoor air quality. The level of indoor air quality in new and old building which is divided into physical parameter (air velocity, temperature and relative humidity), ventilation indicator (CO₂), and chemical contaminant (CO, TVOC, PM₁₀, PM_{2.5} & UFP). Next, for the psychosocial factors, it consists of decision latitude, job demand, social support and job insecurity. At the same time, the dependent variable is the prevalence of sick building syndrome.

3.2 Study duration

The sampling was conducted from December 2019 until February 2020. During the data collection, the important thing that need to be considered was climate as it could influence the data obtained. Therefore, the time frame for this research to be conducted was suitable for data collection.

3.3 Study Location

This study was conducted to determine the relationship between environmental and psychosocial factors related to Sick Building Syndrome (SBS) among office staff in new and old buildings in Universiti Putra Malaysia, Serdang (UPM). The criteria for building selection were based on its age, using centralized air conditioning system and number of occupancies. These criteria are adapted from the study by Jun et al., (2017). There were two buildings selected for this study which involved the Faculty of Science building as old building and the Faculty of Medicine and Health Sciences as new building. The old building is 48 years old and new building is 24 years old. Both the new and old buildings have almost similar number of occupants (97 vs 109) and were completely depend on the centralized ventilation system to provide sufficient air.

No.	Buildings	Office name	Floor	Category	Year of construction
1	Faculty of Sciences	Dean's Office, Administration, Finance & Human Resources	First floor of science physic building	Old building	1972
2	Faculty of Medicine and Health Sciences	Deputy Dean's Office	Second floor of administration building	New Building	1996

Table 1: List of selected buildings

3.4 Sampling

3.4.1 Sampling Population

The office workers which consists of male and female age of 20 to 60 years old with different background and race from new and the old building, were selected randomly as the study population.

3.4.2 Study Sample

The study samples were divided into two groups, which are staffs (male and female) from old building (Building A), and staffs (male and female) from the new building (Building B). The selection of respondents was followed the inclusion and exclusion criteria that have been chosen, such as office workers who have been working at least more than four months in the building and the range of age within 20 to 60 years old. This study excludes smokers and people who had a history of respiratory illness (asthmatic problem), sinusitis (allergic symptoms from eye/nose) and eczema.

3.4.3 Sampling Frame

List of staffs who work at both buildings were obtained from the secretary of the respective department.

3.4.4 Sampling Method

The random sampling method was used in this research. In this sampling method, firstly, the list name of staffs was obtained from the department's secretary. Then, the questionnaire was distributed to all staffs at the available department. The distributed questionnaire must be returned within one to two weeks from the day of distribution. In this study, two criteria, which are inclusion and exclusion criteria been constructed.

Inclusion criteria:

- Registered staffs (male and female)
- Age from 20 to 60 years old
- Staffs who have been working for at least more than four months in the building.

Exclusion criteria:

- Smoker
- People who had a history of respiratory illness (asthmatic problem), sinusitis (allergic symptoms from eye/nose), and eczema.

3.4.5 Sample Size Calculation

The sample size calculation in determining the number of respondents was chosen using the formula from Lemeshow et al. (1990) for group comparison between two types of buildings. The formula for calculating the 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 57.94% (Sulaiman et al., 2011)

P_2 = estimated proportion which is 32.35% (Sulaiman et al., 2011)

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

$$\bar{P} = (0.579 + 0.324)/2$$

$$\bar{P} = 0.452$$

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

n

$$= \frac{\left(1.96 \sqrt{2(0.452)(1-0.452)} + 0.842 \sqrt{0.579(1-0.579) + 0.324(1-0.324)} \right)^2}{(0.579 - 0.324)^2}$$

$$n = \frac{(1.96(0.704) + 0.842(0.681))^2}{0.065}$$

$$n = \frac{(1.96(0.69) + 0.842(0.68))^2}{0.065}$$

$$n = \frac{(1.380 + 0.573)^2}{0.065}$$

$$n = 58.68 \sim 60$$

Based on the sample size calculation for each type of buildings, a total of both staffs that participated in this research was 120 staffs. This population size showed the strength of the study for this research. The sample size will be increase by 20% by considering non-response and missing data. Thus, the total sample size was 144 staffs.

3.5 Instrumentation

3.5.1 Questionnaire

Questionnaire used in this research is based on the using modified questionnaire of Indoor Air Quality Malaysia Code of Practice (DOSH, 2010) and Job Content Questionnaire (JCQ). The contents of the questionnaire consist of socio-demographic and workstation environment, present symptoms at the workplace, and psychosocial factors.

From this questionnaire, the data was analysed using Statistical Package for the Social Sciences Version 25 (SPSS) as software for statistical analysis. SPSS was used to determine the significant association and its relationship between environmental and psychosocial factors with the prevalence of sick building syndrome among staff. In order to indicate whether the respondents are experiencing symptoms of SBS, they must be at least had one of the SBS symptoms listed in the questionnaire and the symptoms appear once a week.

3.5.1.1 Quality Control

Before conducting the research, a pre-testing questionnaire is performed to 20% of the target population in order to determine the validity and reliability of the question distributed. The result for Cronbach Alpha should be within the range.

3.5.2 Measurement of Indoor Air Quality and Indoor Air Pollutants

In this research, the parameter involved in measuring the IAQ are total volatile organic compounds (TVOCs), carbon dioxide (CO₂), carbon monoxide (CO), relative humidity (RH), temperature (°C), ventilation rate, respirable particulates and ultrafine particle (UFP). To measure all the parameters, there are equipments needed based on the sampling method mentioned in the Industrial Code of Practice on Indoor Air Quality (ICOP IAQ) by DOSH.

In order to measure the indoor air quality parameters, the equipment used by the researcher to conduct indoor air quality assessment are:

- a) TSI Model 9565-A Velocicalc Multi-Function Ventilation Meter
- b) TSI Model 7575 Q-Trak Indoor Air Quality Monitor
- c) ppbRAE 3000
- d) TSI Model 8532 DustTrak II Aerosol Monitor
- e) TSI Model 8525 P-Trak Ultrafine Particle

All the equipment used had its specific parameter in measuring the quality of indoor air. Before measurement, the equipment should be calibrated first to increase its sensitivity in order to get the best accurate data and also to decrease the error when taking the measurement. Besides, the data collection was conducted based on an 8-hour continuous measurement. All the sampling points were recorded on the layout plan to mark the location of which the measurement is taken.

3.5.2.1 TSI Model 9565-A Velocicalc Multi-Function Ventilation Meter



Figure 1.4: TSI Model 9555-A Velocicalc Multi-Function Ventilation Meter

(Source from www.tsi.com)

Velocicalc Multi-Function Ventilation Meter 9555-A is used to measure and data logs several ventilation parameters through a single probe with multiple sensors. One single probe can measure the velocity, temperature, humidity, differential pressure, barometric pressure and has inputs for two K alloy thermocouples. It measures continuously and has data logging, which allows logging 1394 samples with time and date stamp. After the measurement, the saved data can be downloaded and viewed by TSI downloading software. This equipment has a thermal sensor or

Pitot tube which functions to measure the air velocity in the indoor air. The collection of data was conducted based on an 8-hour continuous measurement. When measuring the air flow, the probe was placed at several slots to get the average value of air flow (ICOP, 2010).

3.5.2.2 TSI Model 7575 Q-Trak Indoor Air Quality Monitor



Figure 1.5: TSI Model 7575 Q-Trak Indoor Air Quality Monitor

TSI 8554 Q-Trak Plus Monitoring is used to measure several parameters involved in identifying the level of indoor air quality, which are carbon dioxide (CO_2), carbon monoxide (CO), temperature, relative humidity measurement (%RH). Measurements of carbon dioxide parameters are used as an indicator to identify the fresh air supply from diffusers; we can determine the quality of air in the building. Besides, it also can directly calculate the dew point, wet bulb, and percent outside air.

TRAKPRO™ data analysis software provided for data logging, analysis, and documenting results. This equipment allowed the real-time measurement and has

data logging capacity which provide the selectable logging interval and allows starting or stopping the data measurement at any time. It also can be measured through direct reading as for building survey. In this research, the direct measurement will be performed in an 8-hour continuous.

This equipment has many sensors for every parameter. According to TSI Inc. (2005), for detecting CO₂, it used Non-dispersive infrared (NDIR) sensor. It can detect the level of CO₂ in the range of 0 to 5000 ppm. For detecting CO, it used an electro-chemical sensor which detects the level of CO in the range of 0 to 500 ppm. For detecting temperature in indoor air, it uses a thermistor sensor which detects the temperature at the range of 0°C to 50°C. To detect relative humidity in indoor air, it uses a thin-film capacitive which detect humidity at the range of 5 to 95% of relative humidity. Data was collected based on an 8-hour continuous measurement.

3.5.2.3 ppbRAE 3000



Figure 1.6: ppbRAE 3000

The ppbRAE 3000 is an instrument that has Photo-ionization Detector (PID) which can monitor the level of VOC for parts-per-billion (ppb) detection contained in the indoor air. The PID detector is easy access to lamp and sensor for cleaning and replacement with using isobutylene gas for the accurate measurement. The detection of VOC is within the range of 1 ppb to 10000 ppm with three-second response time.

Besides, it contains optional built-in Mesh Radio that enables real-time monitoring of instrument readings wirelessly. Another option is Bluetooth, which can relay readings and alarm status up to 2 miles to a RAELink 3 wireless transmitter. Measurement of TVOC was conducted based on an 8-hour continuous measurement. The instrument was placed at the centre of the room and it placed at height of 75 cm from the floor. The concentration of TVOC will be read

instantaneously when the “ON” button is pressed. Then, after getting the reading, all data were entered into SPSS software for the analysis process. The level of contaminant also is compared to ICOP to identify its level either comply or not with the standard level provided.

3.5.2.4 TSI Model 8532 DustTrak II Aerosol Monitor



Figure 1.7: TSI Model 8532 DustTrak II Aerosol Monitor

Dusttrak II Aerosol Monitor 8532 is used in measuring the particle concentrations which are PM_{10} , $PM_{2.5}$, $PM_{1.0}$ and respirable size fractions with the 90° light scattering sensor type to detect in the range of 0.001 to 150 mg/m^3 . Dust-Trak is also suitable to be used at office settings and industrial workplaces, which can detect potential problems with airborne contaminants such as dust, smokes, fumes, and mists. This equipment is handheld battery-operated, data-logging, single-channel, light-scattering laser photometer that gives you real-time aerosol mass readings. It is easy to use as it can perform direct reading or program it with using advanced logging mode for long-term sampling. Besides, it also can program the start or stop times of measurement, recording intervals, and others parameters. In this

research, the sampling period was conducted based on an 8-hour continuous measurement.

Before starting data collection, Dust-Trak must be zero checked using zero filters to adjust the value at 0 mg/m^3 . Re-zeroing process will prevent getting negative mass concentration reading. The result produced at one-minute interval which consists of average, minimum and maximum reading. For analysis data, only the average reading included.

3.5.2.5 TSI Model 8525 P-Trak Ultrafine Particle



Figure 1.8: TSI Model 8525 P-Trak Ultrafine Particle

(Source from www.tsi.com)

P-Trak Ultrafine Particle is used to measure the workplace ultrafine particulate level. This equipment is commonly used to check the office equipment, and to help to eliminate the indoor air quality problem through detecting any leakage or emission from the source of exposure. It is a real-time ultrafine particulate detector for particles in diameter less than $0.1 \mu\text{m}$ (100 nm). P-Trak can also detect the not-so-obvious sources such as photocopy machines and printers in office settings.



Figure 1.9: Alcohol cartridge is insert into Fill Capsule that contains alcohol.

This equipment requires alcohol, which is 100% reagent-grade isopropyl for its sensitivity to detect ultrafine particles. Isopropyl alcohol was inserted into the alcohol fill capsule and immersed the alcohol cartridge in soaking up the alcohol. Make sure that the alcohol cartridge is placed before this device ready to take the reading. The P-Trak must be hold in a substantially level position during an operation to prevent false count or temporary efficiency counting loss due to tilt error. The tilt error message appeared at the screen if the instrument at the vertical position.

3.6 Data Collection Technique

3.6.1 Questionnaire

The prepared questionnaires were distributed to respondents. The contents of questionnaire include:

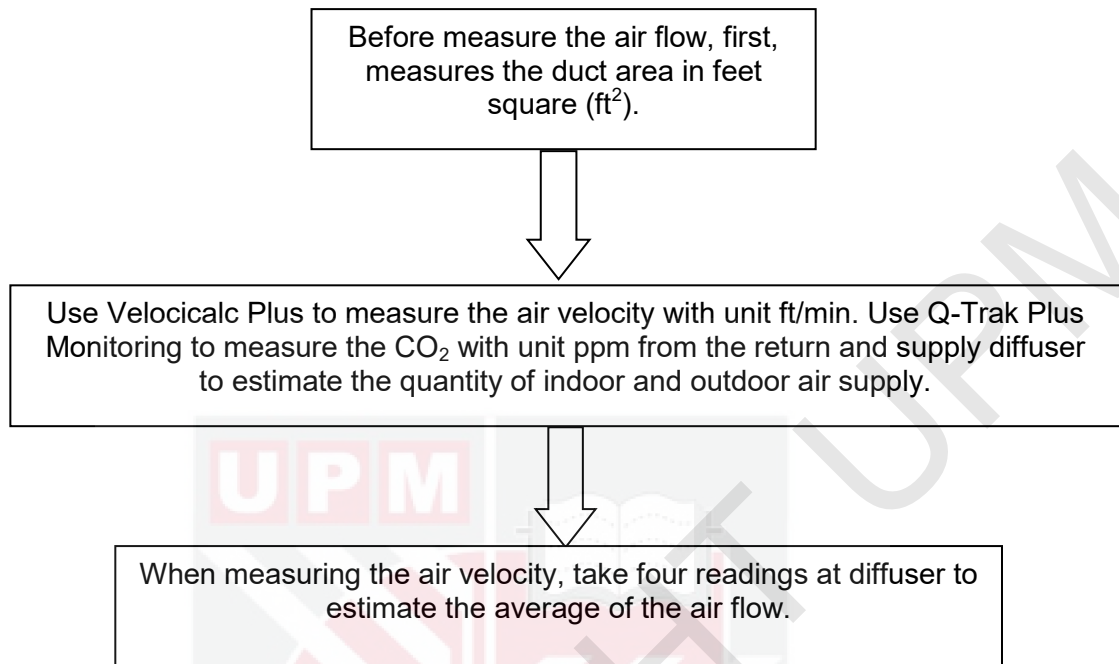
- a) Socio-demographic
- b) workstation environment
- c) Present symptoms at workplace
- d) Psychosocial factors

Most of the question was constructed as close-response format such as yes and no, not in the last 4 weeks and others. These types of questions would make the respondent easily encoded and analysed about their experience of having one or more sick building symptoms.

3.6.2 Measurement of Indoor Air Quality

Measurement of indoor air quality involved the CO₂ reading measurement. CO₂ is an indicator to determine the fresh air supply from the diffuser. CO₂ was measured by using Q-Trak. Temperature and humidity measured to indicate the thermal comfort of building occupants. Velocicalc measured the air flow, air velocity, temperature, and relative humidity.

The diagram flow of measuring the indoor air quality parameters is as follows:



By referring to ICOP IAQ (2010), for IAQ assessment, the minimum required numbers of sampling points are given in the table below:

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

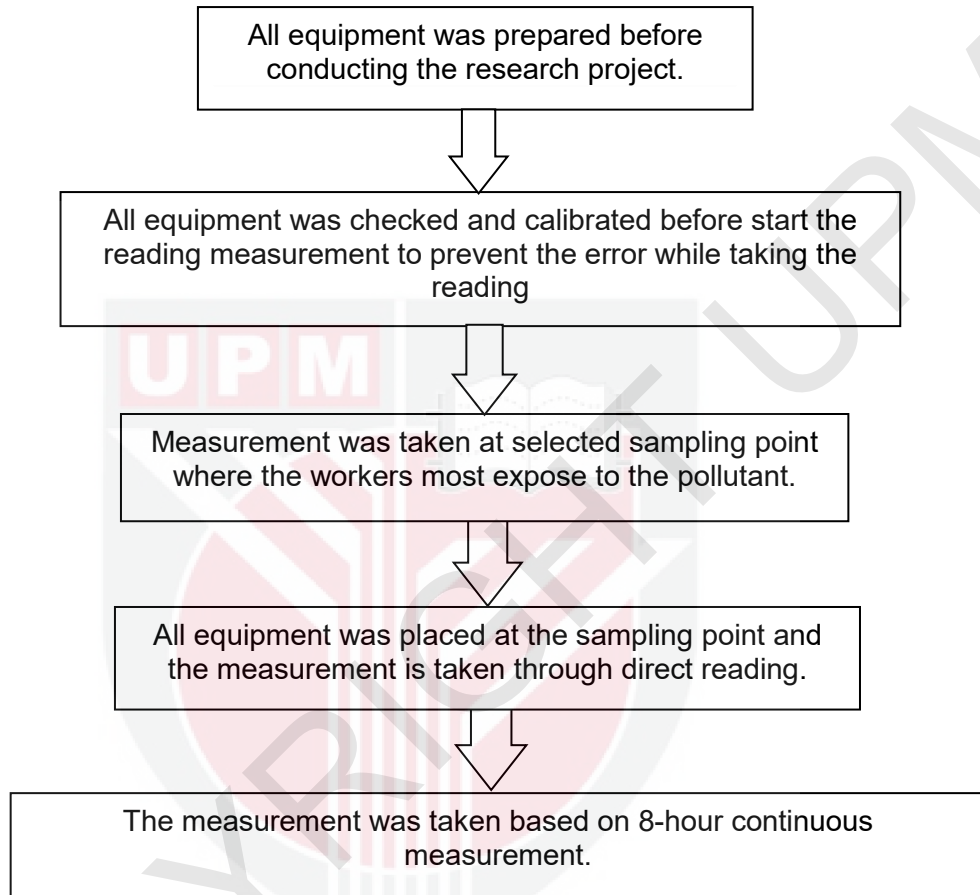
3.6.3 Measurement of Indoor Air Pollutant

The measurement method of an indoor air pollutant is conducted by referring to the Industrial Code of Practice on Indoor Air Quality DOSH (DOSHS, 2010), The sampling measurement was taken in four times a day which is in the morning, afternoon, early evening and late evening. This 8-hour continuous measurement represented the indoor air quality status inside the building for the whole day.

To measure VOC, ppbRAE 3000 is used to determine the level of VOC in the indoor air. To measure particulate matter, TSI Model 8532 Dust-Trak II Aerosol Monitor is used to measure the level of PM_{10} and $PM_{2.5}$. In contrast, TSI Model 8525 P-Trak Ultrafine Particle is used to measure the workplace ultrafine particulate level.

All sampling location is recorded and the procedure for taking a measurement using the specific procedure by IAQ, ICOP (DOSHS, 2005) and ventilation measurement using guideline given by (ASHRAE, 2003). The measurement taken in this study using the equipment was through direct reading. The measurement of VOC level could be higher if the instrument detected the smoke from cigarettes. When the level of VOC exceeds the limit, it gave a warning, showing that there are high concentrations of VOC detected in that area.

Below are the flows of data measurement using IAQ instrument during the data collection.



3.7 Flowchart of Progress

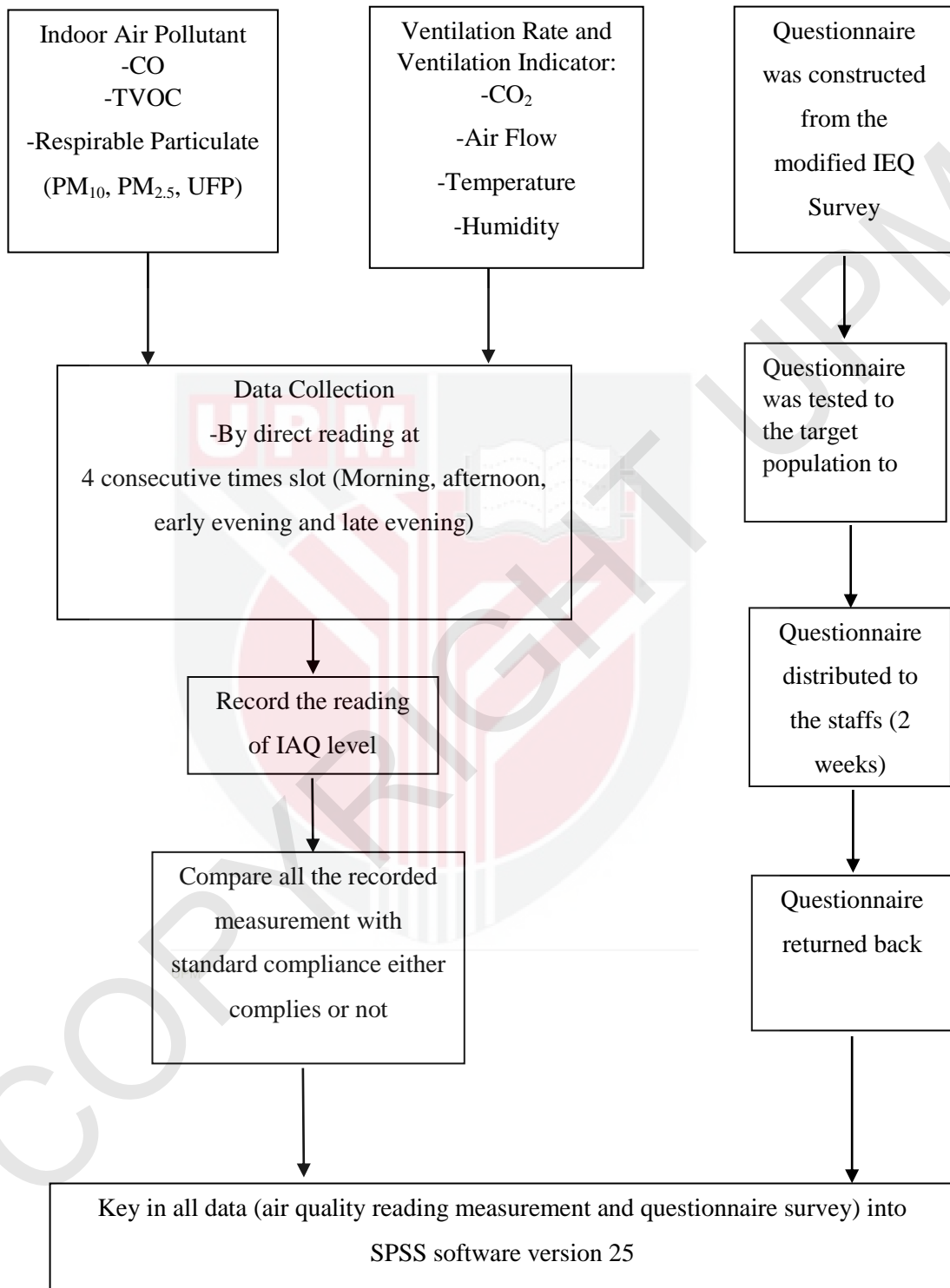


Fig 1.10 Sampling Method Flow Chart

3.8 Quality Control

Getting the result and start writing the result and discussion part for thesis writing.

Before operating the equipment, all equipment must be calibrated and checked first to prevent the measurement error. The procedure on how to operate the equipment was followed based on the operation manual provided. Standard Code of Practice IAQ by DOSH, Malaysia was used in order to compare the result from the assessment whether this study result below, within or above acceptable range in guideline.

The questionnaire had to be re-checked to prevent the respondents from leaving blank answers because these will affect the data calculation later on. Based on the returned questionnaire from the respondent, all questionnaires were submitted with no blank question, which means that the respondent answered all questions given. Pre-test of the questionnaire was performed 10% of the sample size to maximize the reliability of the questions.

3.9 Study Ethics

- i. Ethical approval was obtained from Medical Research Ethic Committee, Universiti Putra Malaysia dated 7 January 2020 (ref. no: UPM/TNCPI/RMC/JKEUPM/1.4.18.2).
- ii. Permission from the employer of the office buildings where the study conducted were obtained.
- iii. Written consents were obtained from the respondents.
- iv. Privacy of information was protected at all phases of the study.
- v. Confidentiality of respondents was upheld at all times of the study.

3.10 Statistical Analysis

All the data obtained was analysed using Statistical Packages for Social Sciences (SPSS) program version 25. The Kolmogorov-Smirnov statistic was used to test the normality of the data variables before the next step of analysis can be taken. The level of significant in this study was set up at $p < 0.05$.

3.10.1 To identify the socio-demographic data of respondents from new and old buildings

Statistical analysis:

Categorical data: Frequency and percentage (%)

3.10.2 To measure and compare the concentration of physical parameters in new and old buildings

Statistical analysis:

Parametric: Independent T-test

Non-parametric: Mann Whitney-U

3.10.3 To compare the level of indoor air pollutant between new and old buildings

Statistical analysis:

Parametric: Independent T-test

Non-parametric: Mann Whitney-U

3.10.4 To compare the level of psychosocial factors between new and old buildings

Statistical analysis:

Parametric: Independent T-test

Non-parametric: Mann Whitney-U

3.10.5 To compare the prevalence of SBS symptom in new and old buildings

Statistical analysis:

Parametric: Independent T-test

Non-parametric: Mann Whitney-U

3.10.6 To determine the association between the level of physical parameters with SBS among office workers in new and old buildings

Statistical analysis:

Chi-square

3.10.7 To determine the association between indoor air pollutants with SBS among office workers in new and old buildings

Statistical analysis:

Chi-square

3.10.8 To determine the association between psychosocial factors with SBS among office workers in new and old buildings

Statistical analysis:

Chi-square

3.10.9 To identify main predictor of the Sick Building Syndrome among study respondents after considering all the confounders.

Statistical analysis:

Categorical data: Multiple Logistic Regression



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CHAPTER 4

RESULTS

4.1 Socio-demographic of Respondents from new and old buildings

From the table 4.1, it has shown the distribution of male and female workers in both buildings where the percentages of workers in the new building (FPSK) were 36.4% male and 63.6% female while 53.8% male and 46.2% female in the old building (FS). In terms of races, the percentages recorded in new building were Malay 94.5%, and non-Malay were 5.5% while in old building, majority of respondents were Malay 93.8%, followed by non-Malay 6.2%.

In addition, there were 18.2% of the workers who are single, 63.6% married and 18.2% divorced in the new building while in the old building, 28.5% of the workers were single and 61.5% married. In the other aspect, Diploma level has shown the highest percentage regarding to the education level in the new and old buildings; 49.1% and 40.0% respectively. The new building had 5.5% smokers while the old building recorded 3.1% smokers. Majority the age of respondents in old building were 40-49 (49.2%) and 20-29 (36.4%) in the new building.

After performing chi-square for all the variables and from the result, there were no significant differences between new and old buildings for gender, races, marital status, educational level, smoking status and age group



Table 4.1: Socio-demographic characteristics of respondents from new and old buildings

Variables	Study Groups n (%)		χ^2	p
	Old building (n=65)	New building (n=55)		
Gender				
Male	30 (46.2)	20 (36.4)	3.69	0.055
Female	35 (53.8)	35 (63.6)		
Race				
Malay	61 (93.8)	52 (94.5)	2.10	0.350
Non-Malay	4 (6.2)	3 (5.5)		
Marital Status				
Single	25 (28.5)	20 (36.4)	0.056	0.813
Married	40 (61.5)	35 (63.6)		
Educational Level				
Degree	21 (32.3)	19 (34.5)	2.30	0.316
Diploma	26 (40.0)	27 (49.1)		
SPM	18 (27.7)	9 (16.4)		
Smoking Status				
Yes	2 (3.1)	3 (5.5)	0.42	0.516
No	63 (96.9)	52 (94.5)		
Age group				
20-29	6 (9.2)	20 (36.4)	3.12	0.085
30-39	21 (32.4)	12 (21.8)		
40-49	32 (49.2)	19 (34.5)		
50-59	6 (9.2)	4 (7.3)		
N = 120				

4.2 Health status

Table 4.2 has shown the health status among the respondents in both buildings. The variables in the health status included asthmatic, sinusitis, and eczema. Health status would explain the current health conditions among the workers in that particular period from the new and old buildings. In the new building, there were 1.8% of respondents had asthmatic, and 98.25% recorded no disease while 3.1% of the respondents had eczema, and 96.9% had no disease in the old building.

Table 4.2: health information of respondents

Variables	Study Group n (%)	
	Old building (n=65)	New building (n=55)
	Yes	Yes
Asthmatic	0 (0.0)	1 (1.8)
Sinusitis	0 (0.0)	0 (0.0)
Eczema	2 (3.1)	0 (0.0)
No disease	63 (96.9)	54 (98.2)

N = 120

4.3 Comparison of physical parameters in new and old buildings

The comparison between the levels of physical parameters in both buildings has been made and the normality test was performed in order to find the normality of the data distribution for both buildings. From the normality test, data from both buildings were not normally distributed and table 4.3 has shown the result of Mann-Whitney U test. The test reveals that the levels of physical parameters in the new building was significantly higher in air velocity and relative humidity compared to old building as air velocity ($Z = -2.867$, $p < 0.001$); and relative humidity ($Z = -11.983$, $p < 0.001$) while the level of temperature was significantly higher in the old building than new building ($Z = -12.071$, $p < 0.001$).

Table 4.3: comparisons of the physical parameters in new and old buildings

Parameters	Old building	New building	z	p
	(n=65)	(n=55)		
	Median (IQR)	Median (IQR)		
Air velocity (m/s)	0.06 (0.06-0.07)	0.17 (0.12-0.15)	-2.867	0.004*
Temperature (°C)	24.7 (24.5-24.6)	23.80 (23.78-23.85)	-12.072	0.001**
Relative humidity (%)	58.45 (58.31-58.78)	77.55 (77.43-78.23)	-11.983	0.001**

*Significant at $p < 0.05$

**Significant at $p < 0.001$

N = 120

4.4 Comparison of Indoor Air Pollutants in the new and old buildings

Table 4.4 has shown the result of the comparison of all parameters for IAP in the new and old buildings. After performing the normality test, all the parameters from both buildings were not normally distributed and the result of Mann-Whitney U test were recorded. The concentration of TVOC, UFP, PM_{2.5}, and PM₁₀ were significantly higher in the old building compared to the new building while there was no significant difference between the concentration of CO₂ in both buildings as TVOC (Z = -11.969, p<0.001); UFP (Z = -11.970, p<0.001); PM_{2.5} (Z = -9.579, p<0.001); and PM₁₀ (Z = -9.498, p<0.001).

Table 4.4: comparisons of the Indoor Air Pollutants in new and old buildings

Variables	Old building (n=65)	New building (n=55)	z	p
	Median (IQR)	Median (IQR)		
CO ₂ (ppm)	288.00 (292.20-301.18)	290.50 (288.48-298.67)	-1.044	0.297
TVOC (ppm)	15.43 (15.46-19.02)	5.69 (5.15-5.94)	-11.969	<0.001**
UFP (pt/cm ³)	6740 (6628-7569)	1250 (1354-1589)	-11.970	<0.001**
PM _{2.5} (µg/m ³)	80 (80-90)	23 (22-27)	-9.579	<0.001**
PM ₁₀ (µg/m ³)	120 (120-125)	54 (52-57)	-9.498	<0.001**

**Significant at p < 0.001

N = 120

4.5 Comparison of Psychosocial Factors in the new and old buildings

Table 4.5 has shown the comparison of psychosocial factors scores between new and old buildings. The Job Content Questionnaire (JCQ) was used to assess the psychosocial factors and staff's work tasks. JCQ included 27 questions consisted of job demand, decision latitude, social support, and job insecurity. By referring to JCQ and score manual, the level of each factors was dichotomized based on the median score to obtain high and low values. Chi-square has been performed and from the result, there was no significant difference between psychosocial factors scores in new and old building as job demand ($\chi^2 = 0.24$, $p = 0.624$); decision latitude ($\chi^2 = 2.07$, $p = 0.151$); social support ($\chi^2 = 0.24$, $p = 0.628$); and job insecurity ($\chi^2 = 0.03$, $p = 0.857$).

Table 4.5: comparisons of the psychosocial factors in new and old buildings

Variables	Study groups		OR (95% CI)	χ^2	p
	n (%)				
	Old building (n=65)	New building (n=55)			
Job demand					
High	29 (44.6)	27 (49.1)	1.20	0.24	0.624
Low	36 (55.4)	28 (50.9)	(0.58-2.46)		
Decision latitude					
High	59 (90.8)	45(81.8)	0.46	2.07	0.151
Low	6 (9.2)	10 (18.2)	(0.16-1.35)		
Social support					
High	56 (86.2)	49 (89.1)	1.31	0.24	0.628
Low	9 (13.8)	6 (10.9)	(0.44-3.95)		
Job insecurity					
High	11 (16.90)	10 (18.2)	1.09	0.03	0.857
Low	54 (83.1)	45 (81.8)	(0.43-2.80)		

N=120

4.6 Prevalence of Sick Building Syndrome (SBS)

The questionnaire survey has been distributed to the workers from both buildings in order to get the prevalence of sick building syndrome. The score of the SBS has been done regarding the symptoms experienced by the respondents. If one symptoms recorded nearly every day, one point would be given to the SBS scale, while if two symptoms reported every day, two scores would be given and so on. Table 4.6 has shown the number of respondents who has been categorized as having SBS based on the answered questionnaire. After performing chi-square on the prevalence of SBS in both buildings, the differences between the new and old buildings was statistically significant.

Table 4.6: Comparison of the prevalence of Sick Building Syndrome among office workers in new and old buildings

Variables	Prevalence of SBS N=120 (100%)		OR 95% CI	χ^2	p
	Yes	No			
Old Building N=65	52 (80.0)	13 (20.0)	9.75 (4.20-22.62)	31.44	<0.001**
New Building N=55	16 (29.1)	39 (70.9)			

**Significant at $p < 0.001$

N=120

4.7 Prevalence of Sick Building Syndrome (SBS) symptoms among office workers in new and old buildings

Table 4.7 has shown the symptoms of SBS from both buildings where difficulty in concentrating recorded the highest percentage; new building 27.27 % and old building 78.46%, followed by fatigue; new building 21.82 5% and old building 58.46 %. The lowest percentage of SBS symptoms in new building was dry or itching skin, 5.45 % followed by itching or irritation of eyes and irritated or stuffy nose; 10.19 % each. On the other hand, the lowest percentage of SBS symptoms in old building was heavy-headed; 29.23 %. Chi-square has been performed for all the symptoms of SBS and from the result, there were 10 symptoms that have shown significant differences between new and old building; fatigue, headache, nausea or dizziness, difficulties concentrating, itching or irritation of eyes, irritated or stuffy nose, hoarse and dry throat, cough, Scaling/itching scalp or ears and dry/itching skin. Other than that, there was no significant difference between new and old buildings for heavy-headed and dry or flushed facial.

Table 4.7: Comparison of the prevalence of Sick Building Syndrome symptoms among office workers in new and old buildings

Symptoms	Study groups n (%)		χ^2	p
	Old Building (n=65)	New Building (n=55)		
Fatigue				
Yes	38 (58.46)	12 (21.82)	16.46	0.001**
No	27 (41.54)	43 (78.18)		
Heavy-headed				
Yes	19 (29.23)	11 (20.00)	1.35	0.245
No	46 (70.77)	44 (80)		
Headache				
Yes	28 (43.08)	10 (18.18)	8.53	0.003*
No	37 (56.92)	45 (81.82)		
Nausea / Dizziness				
Yes	27 (41.54)	9 (16.36)	8.99	0.003*
No	38 (58.46)	46 (83.64)		
Difficulties concentrating				
Yes	51 (78.46)	15 (27.27)	31.54	0.001**
No	14 (21.54)	40 (72.73)		
Itching or irritation of eyes				
Yes	26 (40.00)	6 (10.91)	12.89	0.001**
No	39 (60.00)	49 (89.09)		
Irritated, stuffy nose				
Yes	23 (35.38)	6 (10.91)	9.74	0.002*
No	42 (64.62)	49 (89.09)		
Hoarse, dry throat				
Yes	39 (60.00)	10 (18.18)	21.56	0.001**
No	26 (40.00)	45 (81.82)		
Cough				
Yes	32 (49.23)	10 (18.18)	12.62	0.001**
No	33 (50.77)	45 (81.82)		
Dry or flushed facial skin				
Yes	24 (36.92)	12 (21.82)	3.24	0.72
No	41 (63.08)	43 (78.18)		
Scaling/itching scalp or ears				
Yes	22 (33.85)	8 (14.56)	5.92	0.015*
No	43 (66.15)	47 (85.45)		
Dry/itching skin				
Yes	28 (43.08)	3 (5.45)	22.01	0.001**
No	37 (56.92)	52 (94.55)		

*Significant at $p < 0.05$

**Significant at $p < 0.001$

N=120

4.8 Association of the Prevalence of Sick Building Syndrome (SBS) with the level of physical parameters in both buildings

Table 4.8 has shown the association of the prevalence of SBS with physical parameters level in the old and new buildings. Chi-square has been performed for all variables, and from the result, there was significant association between the level of physical parameters with the prevalence of SBS in the old building; Temperature (OR = 4.02, 95% CI = 1.02-15.85). On the other hand, there was no significant association between the higher and lower level of physical parameters with the prevalence of SBS in the new building.

Table 4.8: Association of the prevalence of Sick Building Syndrome with the level of physical parameters in both buildings

Types of building	Variables	Prevalence of SBS N=120 (100%)		OR	95% CI
		Yes	No		
Old					
	Air velocity				
	High (≥ 0.06 m/s)	49 (94.2)	12 (92.3)	1.36	0.13-14.27
	Low (< 0.06 m/s)	3 (5.8)	1 (7.7)		
	Temperature				
	High (≥ 24.7 °C)	45 (86.5)	8 (61.5)	4.02*	1.02-15.85
	Low (< 24.7 °C)	7 (13.5)	5 (38.5)		
	Relative humidity				
	High (≥ 58.45 %)	16 (30.8)	7 (53.8)	0.38	0.11-1.32
	Low (< 58.45 %)	36 (69.2)	6 (46.2)		
New					
	Air velocity				
	High (≥ 0.17 m/s)	9 (56.3)	22 (56.4)	0.99	0.31-3.21
	Low (< 0.17 m/s)	7 (43.7)	17 (43.6)		
	Temperature				
	High (≥ 23.8 °C)	11 (68.8)	22 (56.4)	1.70	0.50-5.83
	Low (< 23.8 °C)	5 (31.2)	17 (43.6)		
	Relative humidity				
	High (≥ 77.5 %)	8 (50.0)	23 (59.0)	0.70	0.22-2.24
	Low (< 77.5 %)	8 (50.0)	16 (41.0)		

*OR significant at 95% CI > 1
N=120

4.9 Association of the prevalence of Sick Building Syndrome (SBS) with the level of Indoor Air Pollutants (IAP) in both buildings

Table 4.9 has shown the association between the prevalence of SBS with indoor air pollutants in old and new buildings. Chi-square has been performed for all variables and from the result, there were significant association between the level of indoor air pollutants in old building; CO₂ (OR = 4.34, 95% CI =1.21-15.53), TVOC (OR = 4.55, 95% CI = 1.12-18.48), UFP (OR = 4.63, 95% CI = 1.25-17.21), PM_{2.5} (OR = 5.06, 95% CI = 1.36-18.89), and PM₁₀ (OR = 4.80, 95% CI = 1.33-17.29). For the new building, there was no significant association between SBS and indoor air pollutants.

Table 4.9: Association of the prevalence of Sick Building Syndrome with the level of Indoor Air Pollutants in both buildings

Types of building	Variables	Prevalence of SBS N=120 (100%)		OR	95% CI
		Yes	No		
Old					
	CO₂				
	High (≥ 288 ppm)	38 (73.1)	5 (38.5)	4.34*	1.21-15.53
	Low (< 288 ppm)	14 (26.9)	8 (61.5)		
	TVOC				
	High (≥ 15.43 ppm)	30 (57.7)	3 (23.1)	4.55*	1.12-18.48
	Low (< 15.43 ppm)	22 (42.3)	10 (76.9)		
	UFP				
	High (≥ 6740 pt/m ³)	35 (67.3)	4 (30.8)	4.63*	1.25-17.21
	Low (< 6740 pt/m ³)	17 (32.7)	9 (69.2)		
	PM_{2.5}				
	High (≥ 80 $\mu\text{g}/\text{m}^3$)	36 (69.2)	4 (30.8)	5.06*	1.36-18.89
	Low (< 80 $\mu\text{g}/\text{m}^3$)	16 (30.8)	9 (69.2)		
	PM₁₀				
	High (≥ 120 $\mu\text{g}/\text{m}^3$)	39 (75.0)	5 (38.5)	4.80*	1.33-17.29
	Low (< 120 $\mu\text{g}/\text{m}^3$)	13 (25.0)	8 (61.5)		
New					
	CO₂				
	High (≥ 290.50 ppm)	8 (50.0)	19 (48.7)	1.05	0.33-3.37
	Low (< 290.50 ppm)	8 (50.0)	20 (51.3)		
	TVOC				
	High (≥ 5.69 ppm)	5 (31.2)	29 (74.4)	0.16	0.04-0.56
	Low (< 5.69 ppm)	11 (68.8)	10 (25.6)		
	UFP				
	High (≥ 1250 pt/m ³)	6 (37.5)	20 (51.3)	0.57	0.17-1.88
	Low (< 1250 pt/m ³)	10 (62.5)	19 (48.7)		
	PM_{2.5}				
	High (≥ 23 $\mu\text{g}/\text{m}^3$)	14 (87.5)	32 (82.1)	1.53	0.28-8.32
	Low (< 23 $\mu\text{g}/\text{m}^3$)	2 (12.5)	7 (17.9)		
	PM₁₀				
	High (≥ 54 $\mu\text{g}/\text{m}^3$)	14 (87.5)	35 (89.7)	0.80	0.13-4.87
	Low (< 54 $\mu\text{g}/\text{m}^3$)	2 (12.5)	4 (10.3)		

*OR significant at 95% CI > 1

N=120

4.10 Association of the prevalence of Sick Building Syndrome (SBS) with psychosocial factors in both buildings

Table 4.10 has shown the association between the prevalence of SBS with the level of psychosocial factors, which consists of job demand, decision latitude, social support, and job insecurity. In the old building, there was no significant association between high and low levels of psychosocial factors with the prevalence of SBS. On the other hand, there was a significant association between one of psychosocial factors with the prevalence of SBS in the new building; job insecurity (OR = 4.08, 95% CI = 1.03-16.23).

Table 4.10: Association of the prevalence of SBS with the level of psychosocial factors in both buildings

Types of building	Variables	Prevalence of SBS N=120 (100%)		OR	95% CI
		Yes	No		
Old					
	Job demand				
	High	25 (48.1)	4 (30.8)	2.08	0.57-7.62
	Low	27 (51.9)	9 (69.2)		
	Decision latitude				
	High	48 (92.3)	11 (84.6)	2.18	0.35-13.46
	Low	4 (7.7)	2 (15.4)		
	Social support				
	High	45 (86.5)	11 (84.6)	1.17	0.21-6.43
	Low	7 (13.5)	2 (15.4)		
	Job insecurity				
	High	10 (19.2)	1 (7.7)	2.86	0.33-14.61
	Low	42 (80.8)	12 (92.3)		
New					
	Job demand				
	High	8 (50.0)	19 (48.7)	1.05	0.33-3.37
	Low	8 (50.0)	20 (51.3)		
	Decision latitude				
	High	13 (81.3)	32 (82.1)	0.95	0.21-4.24
	Low	3 (18.7)	7 (17.9)		
	Social support				
	High	13 (81.3)	36 (92.3)	0.36	0.07-2.02
	Low	3 (18.7)	3 (7.7)		
	Job insecurity				
	High	6 (37.5)	5 (12.8)	4.08*	1.03-16.23
	Low	10 (62.5)	34 (87.2)		

*OR significant at 95% CI >1

N=120

4.11 Multiple logistic regression of SBS in relation to indoor air quality and psychosocial factors

In the old building, Multiple Logistic Regression was run to get the adjusted OR for the level of physical parameters, indoor air pollutants and psychosocial factors after control the confounders such as age, medical condition and smoking status. Table 4.11a has shown the adjusted OR was lower for temperature than the crude OR and it showed no significant association after controlling the cofounders in this study. On the other hand, for the CO₂, TVOC, UFP, PM_{2.5}, and PM₁₀, the adjusted OR were lower compared to the crude OR, and it showed significant associations for all the parameters except for CO₂ after controlling the confounders. Multiple Logistic Regression was run as well to get adjusted OR for the level of physical parameters, IAP and psychosocial factors in the new building. Table 4.11b has shown the adjusted OR for job insecurity factor was higher compared to the crude OR and it showed significant association although after controlling the confounders.

Table 4.11 a: Multiple logistic regression of SBS in relation to indoor air quality and psychosocial factors in the old building

Factors	Parameters Category	Prevalence of SBS		OR (95% CI)	*OR (95% CI)
		N=65 (100%)			
		Yes n=52	No n=13		
IAQ	Temperature				
	High	45	8	4.02	3.58
	Low	7	5	(1.02-15.85)	(0.82-15.63)
IAP	CO₂				
	High	38	5	4.34	3.88
	Low	14	8	(1.21-15.53)	(1.05-14.39)
	TVOC				
	High	30	3	4.55	4.00
	Low	22	10	(1.12-18.48)	(1.01-16.61)
	UFP				
	High	35	4	4.63	4.13
	Low	17	9	(1.25-17.21)	(1.08-15.76)
	PM_{2.5}				
	High	36	4	5.06	4.51
	Low	16	9	(1.36-18.89)	(1.08-15.76)
PM₁₀					
High	39	10	4.80	4.32	
Low	13	3	(1.33-17.29)	(1.15-16.15)	

*Adjusted OR for age, medical condition and smoking status.

Table 4.11 b: Multiple logistic regression of SBS in relation to indoor air quality and psychosocial factors in the new building

Factor	Factor category	Prevalence of SBS		OR (95% CI)	*OR (95% CI)
		N=55 (100%)			
		Yes n=16	No n=39		
Psychosocial	Job insecurity				
	High	6	4	4.08	4.35
	Low	10	35	(1.03-16.23)	(1.21-22.24)

*Adjusted OR for age, medical condition and smoking status.

CHAPTER 5

DISCUSSION

5.1 Socio-Demographic of respondents

The research was started at the end of December 2019 until the end of March 2020, with the general objective to study the association between environmental and psychosocial factors with the prevalence of sick building syndrome (SBS) among office workers in the new and old buildings. The risk factors that influenced the symptoms of SBS were the number of building occupants, job tasks, work area design, and the age of the buildings (Nur Fadilah & Juliana, 2012). The higher percentage of the individuals presenting with SBS-related indoor symptoms are susceptible groups and most urban residents at any age (Norhidayah et al., 2013). The distribution of gender and age of respondents in new and old buildings also could influence the prevalence of SBS because these two variables may affect the psychosocial well-being of workers. Female and younger workers perceive a higher probability of losing their job or business than male and older workers (Klandermans et al., 2010).

Smoking status among the workers can lead to the development of similar symptoms of SBS, and smokers tend to have SBS symptoms faster than the non-smokers. Furthermore, Abdel-Hamid et al., (2013) say that exposure to ETS in the working environment is a main risk factor for SBS symptoms, especially with a high

prevalence of smoking and no restriction on smoking at the workplace. Thus, in order to determine the real causes of SBS occurrence, smoking status must be taken under consideration to ensure that the real cause of SBS prevalence.

5.2 Comparison of physical parameters level between new and old buildings

The physical parameters that have been measured in this study consist of air velocity, air temperature, and relative humidity. According to the Industrial Code of Practice on Indoor Air Quality (2010), the acceptable range for air velocity is 0.15 m/s - 0.50m/s, temperature is 23°C – 26°C, and for relative humidity is 40% -70%. Based on the result on the level of indoor air quality, it has shown the significant differences for the parameters; air velocity, temperature and relative humidity. The level of temperature was significantly higher in the old building compared to the new building while the level of air velocity and relative humidity was significantly higher in new building than the old building. In order to make a comparison between two buildings; new and old, the median value of indoor air quality parameters would be used due to the distribution of the data was not normal.

For the first parameter, the median value for air velocity in the old building was 0.06 m/s and the IQR 0.06 – 0.07 m/s, while in the new building the median of it was 0.17 m/s and the IQR was 0.12 – 0.15 m/s. The level of air velocity in the old building was lower than new building and below the acceptable range. It might be due to the high capacity of the workers and insufficient ventilation in that particular area. Besides, the median value of temperature was 24.7 °C and the IQR was 24.5 –

24.8°C for old building while in new building the median of it was 23.8°C and the IQR was 23.78 – 23.85°C. The level of temperature in the old building was higher compared to the new building but both values within the acceptable range. The finding of this study was consistent with the local study conducted by Nur Fadhilah & Juliana (2012), which claimed that the level of IAQ for ventilation and temperature showed a significant difference between new and old buildings. The level of relative humidity in new building was significantly higher compared to the old building ($Z = -11.983$, $p < 0.001$). This was caused by the insufficient performance of the air handling unit (AHU) due to the improper maintenance of it.

Humidity levels have the potential to increase the intensity of chemical pollutants in the surrounding air by changing the level of air circulation and also by the reaction between water and chemicals (Amin, Akasah & Razzaly, 2015). These findings were also similar to many previous studies as they reported the significant differences of physical parameters in new and old buildings (Norhidayah et al., 2013; Ahmad & Hassim, 2015; Fauzan & Jalaludin 2016). Due to the significant difference between the level of physical parameters in the new and old buildings, hypothesis 1 is true.

5.3 Comparison of indoor air pollutants in new and old buildings

There were several of equipment being used in order to assess indoor air pollutants in the new and old buildings involved in this study. Based on the results, it has shown the significant differences for several parameters; TVOC, UFP, PM_{2.5}, and PM₁₀. The level of TVOC, UFP, PM_{2.5}, and PM₁₀ were significantly higher in the old building compared to the new building.

For the first parameter, the total volatile organic compound (TVOC) has shown a significant difference between the new and old buildings where the concentration of TVOC was higher in the old building compared to the new building. The median value for TVOC in the old building was 15.43 ppm and the IQR 15.46-19.02 ppm which exceeded the acceptable range. By referring to ICOP on Indoor Air Quality (2010), the maximum limit of TVOC that can be exposed by the workers for eight hours is 3 ppm. From the result of TVOC in the old building, the exposure of the workers to the air contaminants was considered unsafe because it did not comply with the acceptable range. The accumulation of TVOCs in an enclosed building is close related to SBS and the main sources of these substances are from any processes that involve solvents, paints, new furniture and any chemicals (NPI, 2019). Based on observation, the high reading of TVOC came from the newly painted wall, new furniture, cleaning agents, volatile organic chemicals from the chemistry lab, and office partitions that made up from wood. Paints, carpets, adhesives, treated wood and wood products are expected to have a major impact on enclosed concentration levels of TVOC (Wah et al., 2010). In addition, the main

sources of TVOC, which include office furniture, floor finishing, vaporized organic chemicals, as well as exterior sources such as automobile emissions (Adebayo et al., 2018).

The second significant parameter was ultrafine particles (UFP) and the median of UFP for the old building was 6740 pt/cm^3 with the IQR $6628 - 7569 \text{ pt/cm}^3$ while in the new building the median of it was 1250 pt/cm^3 with IQR $1350 - 1588.547 \text{ pt/cm}^3$. The concentration of UFP was higher in the old building compared to the new building and this result can be due to poor ventilation system and rapid usage of photocopied machines in opened-area. The operation of laser printers and photocopier might also be associated with numerous health impacts arising from the high concentration of UFP released (Tang et al., 2012). From the observation being made in both building, high level of UFP in the old building was due to the UFP came from the frequent of the photocopying activities and was located in opened-area and closed to the workers and insufficient ventilation system to ensure that all pollutants can be expelled out from the building. Previous studies have shown that the effect of this UFP particle is more dangerous as compared to PM_{10} and $\text{PM}_{2.5}$ due to its small size and ability to penetrate deeper into the respiratory tract and cause chronic illness (Zamani et al., 2013).

In the measurement of indoor air pollutants, there are two important parameters that must be included; $\text{PM}_{2.5}$ and PM_{10} . In this study, the results on the concentrations of $\text{PM}_{2.5}$ and PM_{10} were significantly higher in the old building compared to the new building. The median of $\text{PM}_{2.5}$ in old building was $23 \mu\text{g/m}^3$

with the IQR 20.00-25.00 while in the new building, the median was $60 \mu\text{g}/\text{m}^3$. The other important parameter was PM_{10} where the median in old building was $28 \mu\text{g}/\text{m}^3$ while in the new building was $20 \mu\text{g}/\text{m}^3$. According to DOSH (2010), the acceptable limit of eight-hour time-weighted average airborne concentration of $\text{PM}_{2.5}$ and PM_{10} is $150 \mu\text{g}/\text{m}^3$ and based on the result in this study, the concentrations of $\text{PM}_{2.5}$ and PM_{10} did not exceed the acceptable limits. Based on observation, the source of indoor particulates matter came from tobacco smoke and combustion processes at the chemistry lab located near to the sampling point. Enclosed particulates could be produced from combustion processes, smoking, boiling as well as dust resuspension (Morawska et al., 2017). Due to the significant difference between indoor air pollutants level in the new and old buildings, hypothesis 2 is true.

5.4 Comparison of the psychosocial factors in new and old buildings

Based on the data obtained from the study, after performing Chi-square test, there was no significant difference between psychosocial factors levels in new and old buildings; job demand (z-score = -1.337, $p = 0.181$); decision latitude (z-score = -0.663, $p = 0.507$); social support (z-score = -1.143, $p = 0.253$); and job insecurity (z-score = -0.803, $p = 0.422$). The median score value for high job demand, high social support and high job insecurity were slightly higher in the new building compared to the old building. This can be due the higher percentage of female workers in new building (63.6%) compared to old building (46.2%). Female workers were significantly experienced high-stress level compared to male ($p=0.035$) (Nur Aqilah & Juliana, 2012). Other than that, the percentage of young workers age 20-29 years old also higher in the new building (36.4%) compared to the old building (9.2%). Women and young employees are more likely to lose their jobs or firms than men and older employees (Klandermans et al., 2010). Due to no significant difference between the levels of psychosocial factors in the new and old buildings, hypothesis 3 can be rejected.

5.5 Comparison of the prevalence of sick building syndrome in new and old buildings

The score of the SBS has been done regarding the symptoms experienced by the respondents. If one symptom recorded nearly every day, one point would be given to the SBS scale while if two symptoms reported every day, two score will be given and so on (Ooi et al., 1998). Based on the data obtained from the study, the old building recorded 80.0% of the prevalence of SBS while the new building has recorded only 29.1%. The total number of respondents involved from the old and new buildings were 65 and 55 respondents. There were 68 respondents from both buildings had a positive score of SBS while another 52 respondents were negative. Hence, the prevalence of SBS for both building was 56.7%. After performing chi square, the prevalence of SBS was significantly higher in the old building compared to the new building. This finding was supported by the study conducted by Zamani et al. (2013) stated that the prevalence of sick building syndrome was significantly higher in the old building compared to the new building and these happen because of high measurement of indoor air contaminants ($\chi^2=30.6$, $p<0.001$).

Based on observation, the source of indoor air contaminants in the old building came from paint, new furniture, photocopy machine, tobacco smoke and also vaporized chemicals from the chemistry laboratory. It is supported by a previous study where the majority of participants said that they had SBS symptoms when continuing to work in office buildings with insufficient ventilation systems. (Fauzan & Jalaludin, 2016). Mucosal symptoms have been positively associated with poor

indoor air quality, which includes formaldehyde, ultrafine particles and total volatile organic compounds (Afzan Zainal et al., 2019). In addition, CO₂, PM_{2.5}, PM₁₀ and TVOC tended to be positively related to the symptoms of sick building syndrome and the most commonly reported symptoms were nasal symptoms. (Chang et al., 2015). Due to the significant difference on the prevalence of sick building syndrome between the old and new buildings, hypothesis 4 is true.



5.6 Association between the prevalence of sick building syndrome and the physical parameters among office workers

From the result, there was only one parameter that has shown a significant association between the prevalence of sick building syndrome and the level of physical parameters in the old building; temperature (OR = 4.02, 95% CI = 1.02-15.85). A similar study has been conducted by Zuliza, Irniza and Emilia (2017) that stated a high level of temperature had shown a significant association between the prevalence of sick building syndrome and the indoor air quality. This shows that the office workers who were working in the office environment with high level of temperature; above 24.7°C, have the risk to develop the SBS 4.0 times higher than those who were working in office environment with the level of temperature below 24.7°C.

Although there was a significant difference on the level of physical parameters in both buildings, the association between the prevalence of SBS and IAQ levels cannot be obtained in the new building. This result was contradicted with the study conducted by Ahmad & Hassim (2015), who reported that there was significant association between the prevalence of SBS and the level of indoor air quality in the new and old buildings. Poor IAQ that influenced the sick building syndrome symptoms consist of eye and skin irritations and upper respiratory tract. (Jalaludin et al., 2014). As the result has shown that there was a significant association between the prevalence of SBS and the physical parameters in the old building only, hypothesis 5 can be rejected.

5.7 Association between the prevalence of sick building syndrome and the indoor air pollutants among office workers

From the result, there were five parameters have shown the significant associations between the prevalence of sick building syndrome and the indoor air pollutants in the old building; CO₂, TVOC, UFP, PM_{2.5} and PM₁₀, while in the new building, there was no significant association between the prevalence of SBS and the indoor air pollutants. For the first parameter, there was a significant association between the prevalence of SBS and CO₂ concentration in the old building (OR=4.34, 95 CI=1.21-15.53). This showed that the office workers who were working in the office environment with a high level of CO₂; 288 ppm, have the risk of having sick building syndrome 4 times higher than those who exposed to a low level of CO₂. The quality of the indoor environment in the old building was influenced by the number of building occupants which could contribute to the high level of CO₂ in most of the locations due to the exhalation (Nur Fadilah & Juliana, 2012). Based on my observation, the total number of office workers in the old building was greater than the new building and this can be one of the sources for high concentration of CO₂ released.

Furthermore, TVOC is one of the indoor air pollutants that has shown a significant association between the prevalence of sick building syndrome and the indoor air pollutants in the old building (OR=4.55, 95% CI=1.12-18.48). This showed that the risk of having SBS for the office workers who were exposed to a high concentration of TVOC;15.43ppm, was 5 times higher than those who were not

exposed. This result was supported by the study conducted by Hassan (2015) stated that there statistically significant association between exposure toward TVOC and SBS symptoms where the total percentage of a study group that exposure to these substances was higher in the old building as compared to the new building. Based on observation, vaporized organic chemicals from the chemistry lab, paints and new furniture were the main sources for VOCs in the old building. The effects of VOCs have both odorous and irritant; cough, dryness of mucous membrane, sneezing, hoarseness, skin erythema, and breathing pattern (Wah et al., 2010).

On the other hand, there was a significant association between the prevalence of SBS with the level of UFP concentration in the old building (OR=4.63, 95% CI=1.25-17.21). The office workers who exposed to high level of UFP; 6740 pt/cm^3 would have the risk of developing SBS 5 times higher than those who not exposed to a high level of UFP. This result was supported by the study conducted by Jalaludin et al., (2014) which claimed that office workers who worked in the old building with high level of ultrafine particles; above 12189.50 pt/cm^3 were 4 times more likely to develop respiratory health symptoms than those who worked in the office environment with exposure level below 12189.50 pt/cm^3 . Based on observation, the high concentration of UFP produced from printers, as they were not isolated from the workspace area and the operation of the laser printers and photocopiers may be linked to health effects resulting in the release of gaseous components UFP (Tang et al., 2012). Previous studies have shown that the effect of this UFP particle is more dangerous as compared to PM_{10} and $\text{PM}_{2.5}$ due to its small size and ability to penetrate deeper into the respiratory tract and cause chronic illness (Zamani et al.,

2013). Aerosolized toner powder particles more than 10 μ m in diameter can be released from printers (Jun et al., 2017).

Next, there was a significant association between the prevalence of SBS with the level of PM_{2.5} concentrations in the old building (OR=5.06, 95% CI=1.36-18.89). From the result, it showed that the office workers who were exposed to a high level of PM_{2.5}; 80 μ g/m³, have the tendency to develop SBS 5 times higher than those who were not exposed. The last parameter that has shown the significant association between the prevalence of SBS and the level of indoor air pollutants in the old building was PM₁₀ (OR=4.80, 95% CI= 1.33-17.29). It showed that the risk of having sick building syndrome for the office workers who exposed to high level of PM₁₀ concentration 120 μ g/m³, was 5 times higher than those who were not exposed. Similarly, Ezman et al. (2013) reported that the level of indoor air pollutants (CO₂, VOC, PM₁₀ and PM_{2.5}) in the old building was significantly higher as compared to the new building.

In the new building, there was no significant association between the prevalence of SBS with indoor air pollutants. This result was similar with the study conducted by Jalaludin et al., (2014) who stated that there was no significant association between level of indoor air pollutants and prevalence of respiratory health symptoms in new buildings for all parameter; Formaldehyde (OR = 2.27, 95%CI = 0.64 - 8.05), VOCs (OR = 3.50, 95%CI = 0.92 - 13.31), UFP (OR =1.12, 95%CI = 0.33 - 3.84). As a result, there was a significant association between indoor

air pollutants with sick building syndrome in the old building only, hypothesis 6 can be rejected.

5.8 Association between the Prevalence of Sick Building Syndrome and the psychosocial factors among office workers

Based on the result, there was only one factor has shown a significant association between a psychosocial factor and sick building syndrome which was job insecurity in the new building (OR=4.08, 95% CI= 1.03-16.23). It is meant that the risk of having sick building syndrome among office workers who faced high job insecurity was 4 times higher than those who not faced high job insecurity. Similar with the study conducted by Zuliza, Irniza and Emilia (2017) stated that there were a significant association between headache ($\chi^2 = 8.057$, $p=0.005$), fatigue ($\chi^2 = 7.802$, $p=0.005$), drowsiness ($\chi^2 = 8.712$ $p=0.013$) and skin rashes ($\chi^2 = 4.859$, $p=0.028$) with poor psychosocial well-being among respondents.

However, there was no significant association between psychosocial factors with SBS in old buildings. This result against the study conducted by Marmot et al., (2006) that stated the risk of having SBS symptoms was higher if the workers faced psychosocial problems (high job demand and low social support than environmental factors. Other than that, there was a significant relationship between having demand for work and lower respiratory problems; nausea, sore throat, wheeze, or chest pain; and upper respiratory distress was positively associated with lack social support (Id et al., 2018). Due to there was a significant association between the prevalence of

sick building and psychosocial factors in the new building only, hypothesis 7 can be rejected.

5.9 Multiple logistic regression between indoor air quality, indoor air pollutants and psychosocial factors with sick building syndrome

Multiple logistic regression was performed to determine the main factor that influenced the prevalence of sick building syndrome after controlling all confounders in this study; age of respondents, medical condition, and smoking status. All parameters and confounder mentioned were found to have a significant association with the prevalence of SBS except for temperature concentration in the old building (aOR=3.58, 95% CI=0.82-15.63). This finding was supported by the study conducted by Id et al., (2018) which stated that high temperature was related to a reduced the prevalence of SBS (aOR=0.29, 95% CI = 0.13–0.67). Based on the result, the main predictors of the prevalence of SBS was PM_{2.5} with an adjusted odds ratio of 4.51(95% CI=1.08-15.76). This result indicated that, it was 5 times more likely for office workers in the old building develop SBS symptoms if they exposed to a high concentration of PM_{2.5}; 80 µg/m³, compared to those who were not exposed. Besides that, the result also shows the main predictor for the prevalence of SBS in old building include CO₂, TVOC, UFP, PM₁₀, while in new building was job insecurity with adjusted OR 3.88(95% CI=1.05-14.39); 4.00(95% CI=1.01-16.61); 4.13(95% CI=1.08-15.76); 4.32(95% CI=1.15-16.15); and 4.35(1.21-22.24) respectively.

The findings for the association between indoor air quality with the prevalence of SBS in old building were in line with the study conducted by Zamani et al., (2013) that showed the concentration of CO₂, TVOC, PM₁₀ and PM_{2.5} influenced SBS after controlling the confounders. In contrast, this result against with the study conducted by Id et al., (2018) which claimed that the prevalence of SBS was related with physical parameter; low indoor air velocity (aOR = 2.88; 95% CI = 1.49–5.57), and psychosocial factors; lower social support (aOR = 2.98; 95% CI = 1.45–6.13) and work pressure (aOR = 7.17; 95% CI = 1.49–34.5). In new building, the result was supported by the study conducted by Klandermans et al., (2010) which stated the prevalence of SBS was related with job insecurity in new building (aOR= 1.87; 95% CI = 1.21–3.27). Female workers were significantly experienced high-stress level compared to male in new building (p=0.035) (Nur Aqilah & Juliana, 2012). Women and young employees are more likely to lose their jobs or firms than men and older employees (Klandermans et al., 2010).

This result can conclude that, office workers who were exposed to high concentration of indoor pollutants and high job insecurity were more likely to develop the symptoms of SBS, especially if they were exposed to a high concentration of PM_{2.5} compared to those who were not exposed. Due to the main predictor of the prevalence of Sick Building syndrome was indoor air pollutant, PM_{2.5}, hypothesis 8 is true.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

6.1 Conclusion

From the results obtained from the statistical analyses proved that:

- i. The level of physical parameters which consist of air velocity, temperature and relative humidity have shown the significant differences between the new and old buildings. The level of air velocity and relative humidity were higher in the new building compared to the old building while the level of temperature was higher in the old building than the new building.
- ii. The concentration of indoor air pollutants which consist of TVOC, UFP, PM_{2.5}, and PM₁₀ have shown the significant differences between the new and old buildings where the concentration of all parameters were higher in the old buildings compared to the new building.
- iii. There was no significant difference for level of psychosocial factors between the new and old buildings.
- iv. The prevalence of sick building syndrome has shown the significant difference between the new and old buildings where the old building showed higher prevalence compared to the new building.

- v. Prevalence of sick building syndrome can be influenced by exposure to high level of physical parameters; temperature, in the old building.
- vi. Prevalence of sick building syndrome can be influenced by exposure to high level indoor air pollutants; CO₂, TVOC, UFP, PM_{2.5} and PM₁₀, in the old building.
- vii. Prevalence of sick building syndrome can be influenced by psychosocial factor; job insecurity, in the new building.
- viii. The main predictor of sick building syndrome was indoor air pollutant; PM_{2.5}.

In overall, the level of temperature, TVOC, UFP, PM_{2.5} and PM₁₀ was significantly higher in old building compared to new building. All these parameters also showed significant association with the prevalence of sick building syndrome in the old building, meanwhile the level of job insecurity was significantly associated with the prevalence of sick building syndrome in the new building.

6.1.1 Study Limitation

This study also bounded with some limitations which are:

- i. The study provides only an estimate of the average relationship, although the relationship of SBS symptom prevalence with ventilation rate varies depending on the strength of indoor pollutant sources, the levels of outdoor air pollution, and other factors. For example, in buildings with high indoor pollutant source strengths ventilation rates may have a larger impact on SBS symptom prevalence rates than in buildings with weak indoor pollutant sources.
- ii. Most of the data are self-reported, leading to potential misreporting, affect bias (the tendency to report consistently positively or negatively to questionnaire items because of mood), and recall bias.
- iii. This study did not include data for biological monitoring (total bacteria and fungi counts) due to Movement Control Order (MCO).

6.2 Recommendation

6.2.1 Cooperative efforts between management and staffs

Involvement of the management of the building and staffs is very important in order to mitigate the indoor air quality and psychosocial problems among workers. The areas of responsibilities are:

- i. Staff training related to the prevention of indoor air quality and psychosocial problems

The awareness among the building occupants regarding the negative effects of poor indoor air quality and mental health need to be increased to ensure all occupants able to perform their work in a healthy working environment. The solution that can be done is by conducting a training that involves the management team and those who were working in the indoor environment. The main purpose of the training is to improve the level of consciousness among office workers on the exposure towards poor indoor air quality and work stressors and how to prevent from getting health problems.

- ii. Integrate indoor air quality concerns into purchasing decisions

The building management must take step to reduce the exposures to contaminants from cleaning products, paint, new furnishings and building materials when the strong odour released from these sources. The designers,

suppliers, and manufactures shall be informing to provide information on chemical emission from products and any potential associated respiratory hazards. The best way is always choosing eco-friendly products or any products which release less hazardous chemicals.

iii. Regular housekeeping

Particulates ($PM_{2.5}$, PM_{10} and UFP), carbon dioxide and chemical odours are the most common indoor air pollutants in most buildings especially old buildings. All the pollutants are float freely on the air throughout the building and eventually these particles are inhaled by the building occupants. The solution to most of this problems is by improving housekeeping procedures. Prompt clean-up of product spills; regular cleaning of all areas of the office especially the hidden area. Besides, remove the particulates in the HVAC filter regularly to minimize or reduce the actual production of particulates.

6.2.2 Sources reduction

The identification of the indoor pollutant sources will be the most cost effective approach in order to mitigate the indoor air quality problems. By controlling any point of source of indoor air contaminants, the concentration of indoor air pollutants can be decreased. The examples of sources control are:

- a) Prohibit indoor smoking among workers.
- b) Substitution of the building material or chemicals with those that emitting a less hazardous contaminant.
- c) Proper storage of vaporize chemicals that potentially can produce contaminants such as alcohol.
- d) Installation of air purification devices except devices producing or emitting ozone.
- e) Provide sufficient cooling air to mitigate higher humidity level in indoor environment.
- f) Isolate the photocopied machine and fax machine from the working area in the building to reduce the exposure to the ultrafine particles (UFP) among occupants.

6.2.3 Ventilation

Ventilation system is one of the important factors that can determine the level of pollutants in the building and poor maintenance of it will cause various problems especially to the workers' health. Ventilation can be used to control indoor air pollutants by diluting contaminants with outdoor air. This method can be done by improving air distribution and increasing the total quantity of supplied-air into the building. Other than that, air pollutants also can be controlled via isolation or removing contaminants by:

- i. Installation of effective local exhaust ventilation system

For old building (Faculty of Science), an effective local exhaust ventilation system is needed to be installed to ensure all of the indoor air contaminants can be expelled out efficiently. The level of contaminants may be different from time to time and the absence of proper ventilation system will cause the accumulation of indoor air pollutants; increase health problems related to the indoor air quality.

- ii. Avoid from opening the doors if it is not necessary in order to separate the zones.

The opening of doors unnecessarily will increase the possibilities of the penetration of the outdoor pollutants into the building especially in old building because the Dean office is located near to chemical laboratory.

An automatic open-close door system shall be applied in old building to

ensure the level of indoor air contaminants can be control and not increase drastically.

6.2.4 Psychological support and protection at workplace

The building management team must be informed and involved in the problems faced by their employees and the team should be able to deal with that problems as soon as possible. There must be a proper and accessible platform or channel for the workers to report their problems to the top management. Employees should be able to put themselves on the line, ask questions, seek feedback, report mistakes and problems, or propose a new idea without fearing negative consequences to themselves, their job or their career.

6.2.5 Future studies

More studies related to the environmental and psychosocial factors and its health effects on human shall be carried out in this country and the factors that must be included in the assessment are the total bacteria and fungi counts. Due to small sample size, this could be one of the limitations of this study because this assessment was not conducted at all faculties in UPM. In addition, the questionnaire might produce recall bias among the respondents, as a result, the researcher could not get the solid data regarding to the main predictor of sick building syndrome in old and new building.

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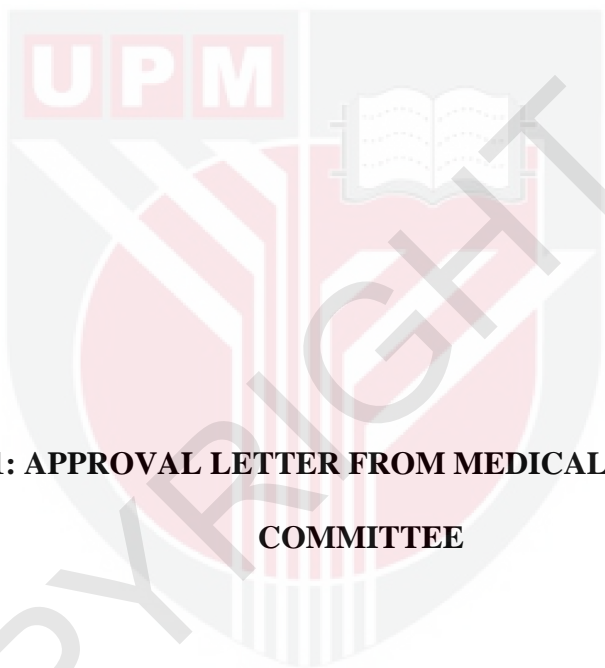
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**APPENDIX 1: APPROVAL LETTER FROM MEDICAL RESEARCH ETHIC
COMMITTEE**

**ETHICS COMMITTEE FOR RESEARCH INVOLVING HUMAN SUBJECTS
(JKEUPM)
UNIVERSITI PUTRA MALAYSIA**

Research title	: Environmental and Psychosocial Factors Related to Sick Building Syndrome among Office Workers in New and Old Building in Universiti Putra Malaysia, Serdang.
Study Site	: Universiti Putra Malaysia
JKEUPM Ref No.	: JKEUPM-2019-475
Researcher	: Nurfarina Zubir
Supervisor	: Assoc. Prof. Dr. Juliana Jaluddin

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 14/11/2019
2. Respondent Information Sheet & Consent (Malay), Version 2 dated 18/12/2019
3. Proposal (English), Version 2 dated 18/12/2019
4. Questionnaires/ Interviews (English), Version 1 dated 14/11/2019
5. Questionnaires/ Interviews (Malay), Version 1 dated 14/11/2019
6. Curriculum Vitae of:
 - a. Assoc. Prof. Dr. Juliana Jaluddin
 - b. Dr. Imiza Rasdi

The University Research Ethics Committee, Universiti Putra Malaysia (JKEUPM) operates in accordance to the ICH-GCP Guidelines.

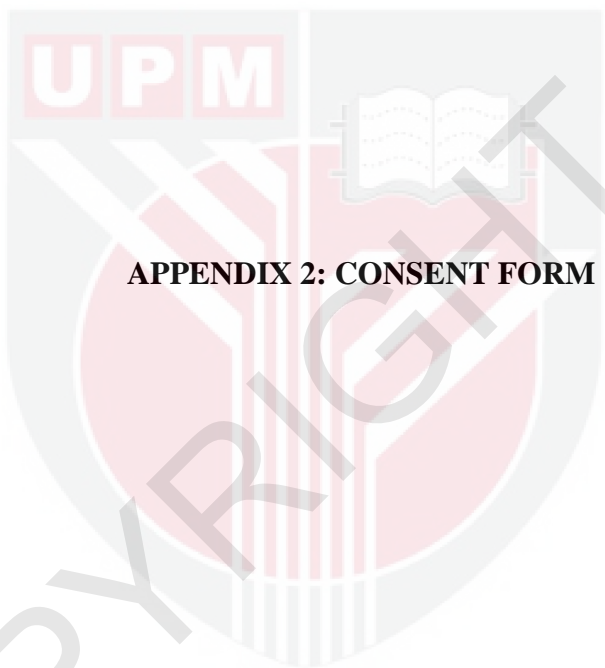
Decision by JKEUPM:

- Approved
- Permission **MUST BE OBTAINED** from the respective hospitals/ institutions before conducting the research
- Disapproved

Please note that the approval is **VALID UNTIL 7 JANUARY 2021**

Researchers should comply with the following:

- I. Complete a Study Final Report upon study completion (Form 3.2).
- II. Ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.



APPENDIX 2: CONSENT FORM



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

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

Faktor-Faktor Persekitaran dan Psikososial Berkaitan dengan Sindrom Bangunan Sakit dalam Kalangan Pekerja Pejabat di Bangunan Lama dan Baru di Universiti Putra Malaysia, Serdang.

2. PENGENALAN

Kajian ini dijalankan bertujuan untuk mengenal pasti hubungan di antara faktor-faktor persekitaran dan psikososial berkaitan dengan sindrom bangunan sakit dalam kalangan pekerja pejabat di bangunan lama dan baru di Universiti Putra Malaysia, Serdang. Sindrom bangunan sakit (SBS) dikenali sebagai gejala penyakit yang dialami oleh pekerja di dalam bangunan seperti iritasi kulit, kerengsaan membran mukosa dan saluran pernafasan, sakit kepala, pening, kesukaran bernafas dan gejala lain yang terdiri daripada koleksi simptom yang tidak spesifik yang dilaporkan oleh pekerja. Kajian ini melibatkan Bangunan Fakulti Sains (bangunan lama) dan Bangunan Fakulti Perubatan dan Sain Kesihatan (bangunan baru). Bangunan baru dan lama diklifikasikan berdasarkan usia bangunan tersebut. Kedua-dua bangunan ini dipilih kerana kedua-duanya menggunakan penghawa dingin berpusat, adanya aduan yang diterima berkaitan kualiti udara dan kurangnya data berkenaan kualiti udara dan punca tekanan di tempat kerja dari dua buah bangunan ini. Oleh itu, dari data yang akan diperoleh, cadangan untuk meningkatkan prestasi kualiti udara dalaman dan kesejahteraan psikososial pekerja dapat diberikan bagi mewujudkan persekitaran kerja yang sihat dan selesa untuk pekerja pejabat bekerja.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Anda dikehendaki untuk membaca dan memahami kajian yang hendak dijalankan ini melalui **HELAIAN PENERANGAN RESPONDEN** ini. Sekiranya anda mempunyai sebarang pertanyaan atau masalah untuk memahami kajian ini, anda dialu-alukan untuk mengemukakan sebarang soalan kepada penyelidik atau penyelia sebelum membuat sebarang keputusan. Kajian ini dijalankan secara sukarela dan tidak melibatkan sebarang pembayaran kepada responden. Setelah anda memahami dan bersetuju untuk terlibat sebagai responden di dalam kajian ini, anda dipersilakan untuk melengkapkan borang persetujuan dan menandatangani sebelum mengembalikannya semula kepada penyelidik.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Kualiti udara dalaman dan tekanan psikososial mempunyai impak yang sangat signifikan kepada kesihatan dan keselamatan pekerja. Berdasarkan kajian prevalen simptom-simptom yang berkaitan dengan bangunan, isu ini telah menjadi satu isu kesihatan yang bukan baru lagi di Malaysia. Kualiti udara dalam bangunan boleh dicemarkan oleh kemasukan bendasing yang boleh menjejaskan kesihatan manusia. Kemasukan pencemar ini boleh berlaku disebabkan oleh sistem ventilasi dan pengudaraan yang tidak baik atau rosak. Semua pekerja pejabat yang berusia 20 tahun hingga 50 tahun dan telah bekerja lebih dari 4 bulan di dalam bangunan tersebut akan dipilih untuk menyertai kajian ini manakala jika mereka termasuk dalam senarai di bawah, individu tersebut tidak akan dipilih untuk menyertai kajian ini.

Kriteria pengecualian :

- i. Perokok
- ii. Orang yang mempunyai sejarah masalah pernafasan (asma), sinusitis (gejala alergi dari mata / hidung) dan ekzema.

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a. KEPADA ANDA SEBAGAI PESERTA?

- i. Kajian ini adalah bertujuan mencari hubungkait yang kukuh di antara faktor persekitaran dan psikososial dengan prevalen berlakunya simptom-simptom yang berkaitan dengan bangunan.
- ii. Kajian ini juga diwujudkan dengan tujuan untuk menilai tahap tubuh badan anda dalam pendedahan kepada kualiti dan pencemaran udara dalaman serta tekanan psikososial.
- iii. Kajian ilmiah ini diharapkan dapat membantu meniali risiko anda terhadap pendedahan pencemar udara dan tekanan psikososial kepada status kesihatan sekaligus mencari langkah-langkah pencegahan untuk mengurangkan risiko berlakunya masalah kesihatan kepada diri anda.

b. KEPADA ANDA SEBAGAI PENYELIDIK?

- i. Melalui kajian ini penyelidik akan memperolehi maklumat tentang kadar sindrom bangunan sakit di kalangan pekerja pejabat serta akan mencadangkan langkah bagi mencegahnya dari terus bertambah parah pada masa akan datang.

6. ADAKAH IA BERISIKO?

Tidak, ini adalah kerana responden hanya akan disoal jawab dengan borang khas untuk menilai maklumat latar belakang dan persekitaran pekerjaan, gejala penyakit di tempat kerja dan faktor psikososial. Kajian ini hanya akan melibatkan penggunaan borang soal selidik ke atas responden.

7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?

Semua maklumat yang diberikan oleh responden dianggap sebagai rahsia dan sulit. Penyelidik dan penyelia akan memastikan semua data peribadi yang diperolehi hanya untuk tujuan rujukan dan penulisan thesis sahaja. Semua maklumat responden hanya akan diketahui oleh penyelidik dan penyelia kajian sahaja dan ianya akan digunakan untuk tujuan rujukan kajian ini sahaja. Tiada laporan bersifat individu

akan dibentangkan atau dibincangkan di dalam laporan atau thesis. Segala keputusan berkaitan kajian ini akan dimaklumkan secara individu di antara penyelidik dan responden sahaja. Penyelidik tidak akan mendedahkan kepada mana-mana pihak berkaitan sebarang maklumat individu tanpa kebenaran dari responden terlebih dahulu kecuali diperuntukkan/dikehendaki oleh undang-undang.

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

Sekiranya anda mempunyai sebarang pertanyaan atau soalan tambahan semasa mengikuti kajian ini, anda dialu-alukan untuk bertanya atau berjumpa dengan penyelidik atau penyelia kajian ini. Maklumat berkenaan penyelidik dan penyelia kajian ini adalah seperti berikut:

Penyelia kajian	Assoc. Prof. Dr Juliana Jalaludin Ketua Jabatan Kesihatan Persekitaran dan Pekerjaan Fakulti Perubatan dan Sains Kesihatan Universiti Putra Malaysia 43400 UPM, Serdang, Malaysia	03-89472401	juliana@upm.edu.my
Penyelidik kajian	Nurfarina Binti Zubir Bacelor sains (kesihatan persekitaran dan pekerjaan)	011-21376694	Farinazubir97@gmail.com

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

2. 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.

Saya 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
.....
(Responden)

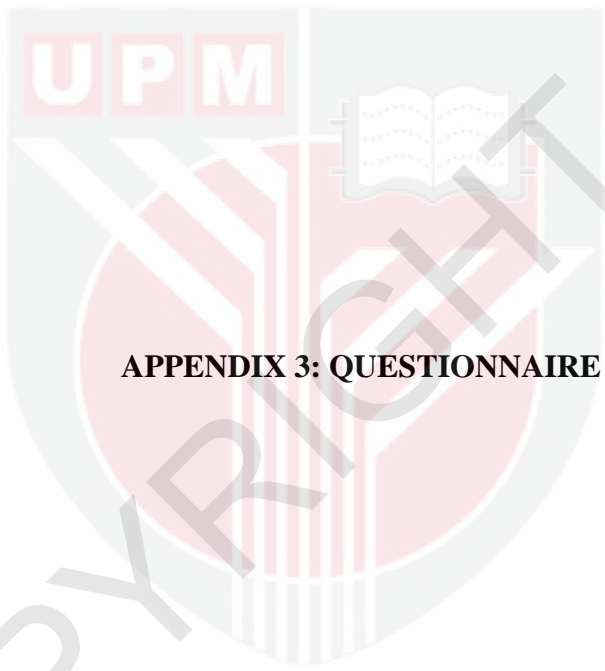
Tandatangan
(Saksi)

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)



APPENDIX 3: QUESTIONNAIRE



FACULTY OF MEDICINE AND HEALTH SCIENCES

QUESTIONNAIRE:

“ENVIRONMENTAL AND PSYCHOSOCIAL FACTORS RELATED TO SICK BUILDING SYNDROME AMONG OFFICE WORKERS IN NEW AND OLD BUILDING IN UNIVERSITI PUTRA MALAYSIA, SERDANG”

It is a pleasure for having you chosen as a respondent for this research. The objective of this research is to determine the relationship between environmental and psychosocial factors related to sick building syndrome (SBS) among office staffs in new and old building in UPM, Serdang. Please answer the questions as accurately, honestly, and completely as possible. All the answers are strictly confidential and for research purpose only. Thank you for your participation in this research.

Name of Researcher: Nurfarina Binti Zubir (188827)

B. Sc. (Environmental & Occupational Health)

Respondent No. :

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Date :

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Instructions

This questionnaire has 8 printed pages including the front page. Please answer ALL questions. Your feedback is very much appreciated.

Section A: Socio-demographic
Seksyen A: Maklumat latar belakang

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*):
- | | |
|--------------------------|------------------------------------|
| <input type="checkbox"/> | Malay (<i>Melayu</i>) |
| <input type="checkbox"/> | Chinese (<i>Cina</i>) |
| <input type="checkbox"/> | Indian (<i>India</i>) |
| <input type="checkbox"/> | Others (<i>lain-lain</i>): _____ |
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. What is your marital status (*Apakah status perkahwinan anda*)?
- Single (*Bujang*) Married (*Berkahwin*) Divorced (*bercerai*)
6. Smoking (*Adakah anda merokok*): Yes No
7. Other than you, is there anyone in your family smoking?
- | | |
|--------------------------|-----|
| <input type="checkbox"/> | Yes |
| <input type="checkbox"/> | No |

Section B: Workstation Environment
Seksyen B: Persekitaran Pekerjaan

8. 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)

9. 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 a day (<i>kira-kira sekali sehari</i>)	3-4 times a week (<i>3-4 kali seminggu</i>)	Less than 3 times a 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 pembetulan atau bahan kimia berbau kuat</i>)					

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

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

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 (<i>Gejala-gejala yang dialami sekarang</i>)	Yes, always everyday (<i>Ya, setiap hari</i>)	Yes, often (every week) (<i>[Ya, selalu (setiap minggu)]</i>)	Yes, sometime (2-3 times a week) (<i>[Ya, kadangkala (2-3 kali seminggu)]</i>)	No, never (<i>Tidak pernah</i>)
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 (
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 this symptom 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 dalaman?*)

Yes No

Section 3: Psychosocial factors
Seksyen 3: Faktor-faktor psikososial

Instructions: Please select the the best answer that suit your job. If you feel that there is no appropriate answer, please circle the nearest possible one.

Arahan: Sila tandakan pilihan jawapan yang paling sesuai dengan pekerjaan anda. Jika anda merasakan tiada jawapan yang paling tepat, sila bulatkan jawapan yang paling hampir.

Strongly disagree (Sangat tidak setuju)	Disagree (Tidak Setuju)	Likely agree (Seperti bersetuju)	Strongly agree (Sangat setuju)
1	2	3	4

C1	My job requires me to learn new things (Pekerjaan saya memerlukan saya mempelajari perkara baru)	1	2	3	4
C2	My job involves a lot of repetitive work (Pekerjaan saya banyak melibatkan kerja yang berulang-ulang)	1	2	3	4
C3	My job requires me to be active (Pekerjaan saya memerlukan kreativiti)	1	2	3	4
C4	My jobs allow me to make a lot of decisions on my own (Pekerjaan saya banyak membenarkan saya membuat keputusan sendiri)	1	2	3	4
C5	My job requires a high level of skill (Pekerjaan saya memerlukan kemahiran yang tinggi)	1	2	3	4
C6	On my job, my freedom to make my own decisions is very limited (Dalam pekerjaan, kebebasan saya membuat keputusan sendiri adalah amat terbatas)	1	2	3	4
C7	I get to do variety of things on my job (Semasa bekerja, saya berupaya melakukan berbagai perkara yang berlainan)	1	2	3	4
C8	I have a lot to say about what happens on my job (Saya banyak mengutarakan pendapat tentang pekerjaan saya)	1	2	3	4
C9	I have an opportunity to develop my own special abilities (Saya berpeluang untuk mengembangkan kebolehan saya)	1	2	3	4

C10	My job requires working very fast (<i>Pekerjaan saya memerlukan saya bekerja dengan sangat pantas</i>)	1	2	3	4
C11	My job requires working very hard (<i>Pekerjaan saya memerlukan saya bekerja lebih kuat</i>)	1	2	3	4
C12	My job requires lots of physical effort (<i>Pekerjaan saya memerlukan saya menggunakan kekuatan fizikal</i>)	1	2	3	4
C13	I am not asked to do an excessive amount of work (<i>Saya tidak diminta untuk melakukan kerja-kerja secara berlebihan</i>)	1	2	3	4
C14	I have enough time to get the job done (<i>Saya mempunyai masa yang cukup untuk menyudahkan kerja saya</i>)	1	2	3	4
C15	I am free from conflicting demands others make (<i>Saya bebas daripada tekanan-tekanan yang dibuat oleh orang lain</i>)	1	2	3	4
C16	My job security is good (<i>keselamatan kerja saya adalah baik</i>)	1	2	3	4
C17	People I work with are competent in doing their jobs (<i>Rakan-rakan sekerja saya berkemampuan dalam melakukan kerja mereka</i>)	1	2	3	4
C18	My colleague took advantage of me (<i>Rakan-rakan sekerja mengambil kesempatan ke atas saya</i>)	1	2	3	4
C19	People I work with are friendly (<i>Rakan-rakan sekerja saya peramah</i>)	1	2	3	4
C20	People I work with are helpful in getting the job done (<i>Rakan-rakan sekerja saya membantu bagi memastikan kerja-kerja disiapkan</i>)	1	2	3	4
C21	My supervisor is concerned about the welfare of those under him (<i>Penyelia saya mengambil berat mengenai kebajikan orang di bawah seliaan beliau</i>)	1	2	3	4
C22	My supervisor pays attention to the problems face by people under him (<i>Penyelia saya memberi perhatian terhadap masalah yang dihadapi oleh pekerja dibawah seliaan beliau</i>)	1	2	3	4
C23	My supervisor is helpful in getting the job done (<i>Penyelia saya memberi bantuan dalam memastikan kerja-kerja dapat disiapkan</i>)	1	2	3	4
C24	My supervisor is successful in getting people to work together (<i>Penyelia saya berjaya memastikan para pekerja di bawah seliaan beliau bekerjasama</i>)	1	2	3	4

Regular and	Seasonal	Frequent layoffs	Both seasonal and frequent
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steady (Tetap dan stabil)	(Bermusim)	(Kerap tergendala)	layoffs (Bermusim dan kerap tergendala)
1	2	3	4

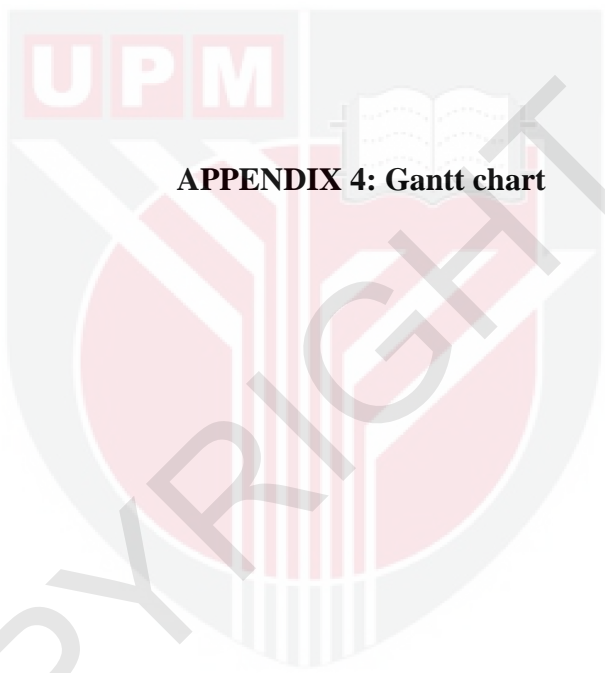
C25	How steady is your work? (Adakah pekerjaan anda tetap?)	1	2	3	4
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Never (Tidak pernah)	Faced possibility once (Pernah sekali)	Faced possibility more than once (Pernah lebih dari sekali)	Actually constantly (Sentiasa)
1	2	3	4

C26	During the past year, how often were you in a situation where you faced job loss or layoff? (Pada tahun lepas, berapa kerapkah anda berada dalam situasi di mana anda menghadapi kehilangan pekerjaan atau tidak bekerja?)	1	2	3	4
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Not at all likely (Sama sekali tidak mungkin)	Not to likely (Tidak mungkin)	Somewhat likely (agak mungkin)	Very likely (Berkemungkinan besar)
1	2	3	4

C27	Sometimes people permanently lose jobs they want to keep. How likely is it that during the next couple of years you will lose your present job with your employer? (Kadang-kala mereka kehilangan pekerjaan yang ingin mereka kekalkan. Bagaimanakah sekiranya dalam beberapa tahun akan datang anda akan kehilangan pekerjaan di tempat majikan anda sekarang?)	1	2	3	4
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APPENDIX 4: Gantt chart

No	Activities	2019			2020						
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	July.
1	Proposal Preparation	■	■								
2	Ethic Application		■								
3	Pre-Study		■								
4	Proposal Presentation										
5	Site Visit										
6	Data Collection (Air Sampling Assessment & Physiological Assessment)						■				
7	Data Analysis						■	■	■		
8	Data Interpretation							■	■		
9	Thesis Writing					■	■	■	■	■	
10	VIVA									■	■
11	Thesis Review										■
12	Thesis Submission										■

FINAL YEAR PROJECT (EOH 4999) GANTT CHART 2019/2020