



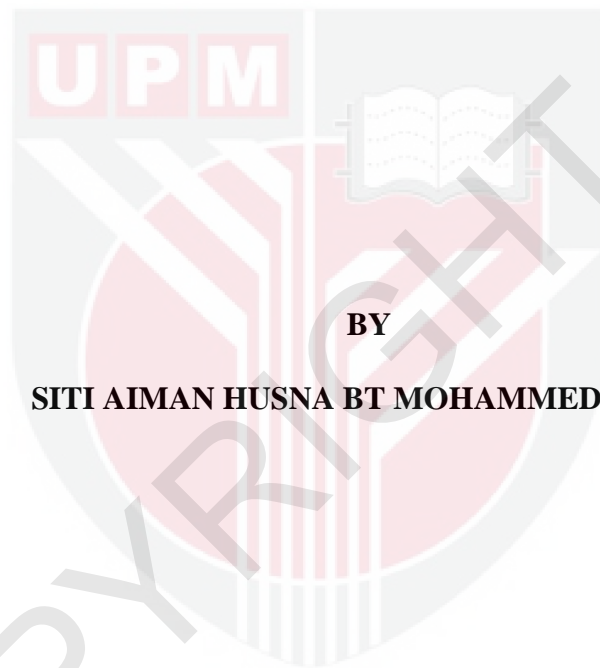
UNIVERSITI PUTRA MALAYSIA

***ASSOCIATION OF INDOOR AIR QUALITY AND RESPIRATORY
HEALTH SYMPTOMS AMONG CHILDREN AT DAY CARE CENTERS
IN PETALING JAYA, SELANGOR***

SITI AIMAN HUSNA BT MOHAMMED NAJIB

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HEALTH SYMPTOMS AMONG CHILDREN AT DAY CARE CENTERS IN
PETALING JAYA, SELANGOR**



BY

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

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ABSTRACT**ASSOCIATION OF INDOOR AIR QUALITY AND RESPIRATORY HEALTH SYMPTOMS AMONG CHILDREN AT DAY CARE CENTERS IN PETALING JAYA, SELANGOR****SITI AIMAN HUSNA BT MOHAMMED NAJIB**

Introduction: Indoor air quality in day care centers (DCCs) is an emerging research topics nowadays. Children spent most of their time indoor, long exposure to poor indoor air quality (IAQ) was believed to increase the risk of getting respiratory health symptoms among children. **Objective:** To determine association of indoor air quality and the respiratory health symptoms among children at urban day care center in Petaling Jaya. **Method:** A cross sectional study was carried out among 100 children age four to six years old. The research were conducted at five urban day care centers with different environmental characteristics. An indoor air quality assessment was conducted in selected DCCs that include parameters such temperature, humidity, air velocity, particulate matter less than $2.5\mu\text{g}/\text{m}^3$ and $10\mu\text{g}/\text{m}^3$ ($\text{PM}_{2.5}$, PM_{10}), carbon dioxide (CO_2), airborne bacterial and airborne fungi. A set of standardized questionnaire was distributed by researcher to obtain respondents' background information, exposure history, and respiratory health symptoms. The finding of this study indicate that indoor air pollution may have an impact on respiratory health symptoms. **Result:** All five DCCs investigated had at least one IAQ parameter that exceeding the recommended level of standard guidelines. There was significant different of median concentration of PM_{10} , $\text{PM}_{2.5}$, temperature and relative humidity in each DCCs. The finding also reported that $\text{PM}_{2.5}$ is significantly associated with cough and runny nose. **Conclusion:** Exposure to PM_{10} and $\text{PM}_{2.5}$ had increased the occurrence of respiratory health symptoms among children. A proper ventilation and regular housekeeping are beneficial in lowering the concentration of pollutants indoor.

Keywords: *Indoor air quality, day care center, children, respiratory health symptoms, urban*

ABSTRAK

HUBUNGKAIT ANTARA KUALITI UDARA DALAMAN DAN MASALAH KESIHATAN RESPIRATORI DALAM KALANGAN KANAK-KANAK DI PUSAT ASUHAN PETALING JAYA, SELANGOR

SITI AIMAN HUSNA BT MOHAMMED NAJIB

Pengenalan: Kualiti udara dalaman di pusat asuhan merupakan topik penyelidikan yang kian berkembang pada masa kini. Kanak-kanak menghabiskan sebahagian besar daripada masa mereka di dalam bangunan, pendedahan yang lama kepada pencemaran udara dalaman dipercayai meningkatkan risiko untuk mendapat masalah kesihatan respiratori dalam kalangan kanak-kanak. **Objektif:** Kajian ini bertujuan untuk mengkaji hubungkait antara kualiti udara dalaman dengan masalah kesihatan respiratori dalam kalangan kanak-kanak di pusat asuhan bandar, Petaling Jaya. **Metodologi:** Kajian keratan rentas telah dijalankan di kalangan 100 kanak-kanak berumur empat hingga enam tahun. Penyelidikan telah dijalankan di lima pusat asuhan harian bandar dengan ciri-ciri persekitaran yang berbeza. Penilaian kualiti udara dalaman telah dijalankan di pusat asuhan harian terpilih yang merangkumi parameter seperti suhu, kelembapan relatif, kelajuan udara, zarah partikal bersaiz kurang $2.5\mu\text{g}/\text{m}^3$ dan $10\mu\text{g}/\text{m}^3$ ($\text{PM}_{2.5}$, PM_{10}), carbon dioksida (CO_2), bakteria bawaan udara dan kulat bawaan udara. Satu set soal selidik piawai telah diedarkan oleh penyelidik untuk mendapatkan maklumat latar belakang responden, sejarah pendedahan, dan gejala masalah kesihatan respiratori. Dapatan kajian ini menunjukkan bahawa pencemaran udara dalaman mungkin memberi kesan kepada gejala kesihatan pernafasan. **Keputusan:** Kesemua lima pusat asuhan yang dikaji mempunyai sekurang-kurangnya satu parameter IAQ yang melebihi tahap garis panduan standard yang disyorkan. Terdapat perbezaan ketara bagi median PM_{10} , $\text{PM}_{2.5}$, suhu dan kelembapan relatif dalam setiap pusat asuhan. Penemuan juga melaporkan bahawa $\text{PM}_{2.5}$ dikaitkan dengan batuk dan hidung berair. **Kesimpulan:** Pendedahan kepada PM_{10} dan $\text{PM}_{2.5}$ telah meningkatkan kejadian gejala kesihatan pernafasan dalam kalangan kanak-kanak. Pengudaraan yang baik amatlah penting bagi mengurangkan pencemaran udara dalaman. Selain itu kerap melakukan pembersihan di dalam pusat asuhan juga dapat mengurangkan pencemaran udara dalaman di pusat asuhan.

Kata kunci: *kualiti udara dalam, masalah kesihatan respiratori, pusat asuhan harian, kanak-kanak, bandar*

TABLE OF CONTENTS

	Page
DECLARATION	iii
SIGNATURE OF SUPEVISOR/ INTERNAL EXAMINER	iv
ACKNOWLEDGEMENT	v
ABSTRACT	vi
ABSTRAK	vii
CONTENTS	viii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF APPENDICES	xii
LIST OF ABBREVIATIONS	xiii
CHAPTER 1: INTRODUCTION	
1.1 Background of Study	1
1.2 Problem Statement	3
1.3 Study Justification	5
1.4 Conceptual Framework	6
1.5 Research Questions	8
1.6 Research Objectives	9
1.7 Research Hypothesis	10
1.8 Definition of Variables	10
CHATER 2: LITERATURE REVIEW	
2.1 Indoor Air Quality	15
2.2 Indoor Air Pollutants	17
2.3 Factors Affecting Indoor Air Quality in Day Care Centers	19
2.4 Indoor Air Pollutants and Respiratory Health Implication of Children	23
CHAPTER 3: METHDOLOGY	
3.1 Study Design	25
3.2 Study Duration	25
3.3 Study Location	25
3.4 Study Population	26
3.5 Sampling Frame	27
3.6 Sampling Method	27
3.7 Sample Size	28
3.8 Research Instruments	30
3.8.1 Questionnaire	30
3.8.2 IAQ Exposure Monitoring	31
3.9 Statistical Analysis	36
3.10 Quality Control	36
3.11 Ethical Consideration	37
CHAPTER 4: RESULTS	
4.1 Response Rate	38
4.2 Respondents' Socio-demographic Data	38
4.3 Characteristic of Day Care Centers	40

4.4	Comparison of Indoor Air Quality between Day Care Centers	42
4.5	Prevalence of Respiratory Health Symptoms among Children	45
4.6	The Association of Indoor Air Pollutants with Respiratory Health Symptoms	47
4.7	Factors Influenced the Respiratory Health Symptoms after Controlling all Confounders	47

CHAPTER 5: DISCUSSIONS

5.1	Comparison of Indoor Air Quality between DCCs	50
5.2	Prevalence Respiratory Health Symptoms among Children in Study Areas	53
5.3	Association between Indoor Air Pollutants and Respiratory Health Symptoms among Children	54
5.4	Factors Influenced the Respiratory Health Symptoms among Children after Controlling all Confounders	55

CHAPTER 6: SUMMARY

6.1	Conclusion	57
6.2	Study Limitations	58
6.3	Recommendations	59

REFERENCES

63

APPENDICES

67

LIST OF TABLES

		Page
Table 1	Variables studied, type of sensor used, and detection limits	33
Table 2	Respondents' Socio-demographic Data	39-40
Table 3	Day Care Centers Characteristics	41
Table 4	Comparison of Median Concentration on Indoor Air Quality Parameters at 5 DCCs Monitored in Petaling Jaya, Selangor	44
Table 5	Association between indoor air pollutants with respiratory symptoms	48
Table 6	Main Factors Influenced Respiratory Health Symptoms after Controlling all the Confounder in This Study	49

LIST OF FIGURES

		Page
Figure 1	Conceptual Framework	7
Figure 2	Size of Particulate Matter, PM _{2.5} and PM ₁₀	18
Figure 3	Location of Petaling Jaya District	26
Figure 4	Q-trak plus Model 8554 to measure temperature, relative humidity and CO ₂	31
Figure 5	TSI Velocicalc Plus Model 8386 for measurement air velocity	32
Figure 6	TSI Model 8520 DustTrak Airborne Monitoring for PM _{2.5} and PM ₁₀	32
Figure 7	pbi DuoSAS Super 360 to obtain bacterial and fungi samples	32
Figure 8	The placement of TSI Model 8520 DustTrak in the room	33
Figure 9	Colony count using colony counter	35
Figure 10	The forming of fungal and bacterial after incubation	35
Figure 11	Prevalence of Respiratory Symptoms among Children at each Day Care Centre	46

LIST OF APPENDICES

		Page
1	Gantt Chart	68
2	Ethical Approval Letter	70
3	Explanation Letter and Consent Form	72-76
4	Questionnaire	78-85



LIST OF ABBREVIATIONS

ATS	American Thoracic Society
CO ₂	Carbon Dioxide
CFU	Colony Forming Unit
DCC	Day Care Center
DOE	Department of Environment
DOSH	Department Of Occupational Safety and Health
IAQ	Indoor Air Quality
ICOP	Industry Code of Practice
MOH	Ministry of Health
ppm	Part per million
PM ₁₀	Particulate Matter less or equal to 10µg/m ³
PM _{2.5}	Particulate Matter less or equal to 2.5µg/m ³
PEL	Permissible Exposure Limit
USEPA	United State Environmental Protection Agency
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Air pollution is a significant concern that could affect the health of many people in Malaysia. Clean air is a fundamental human's need in order to achieve good health. Building occupants are exposed to a wide range of contaminants in the form of particles and gases from office machines, cleaning products, construction activities, carpets and furnishings, perfumes, environmental tobacco smoke, water-damaged building materials, microbial growth (fungal and bacterial), insects and outdoor pollutants; indoor temperatures, ventilation and relative humidity level among other things that can influence how people react to their surroundings (NIOSH, 2006).

Poor indoor air quality can further degrade someone's health, the most susceptible group for the effect of exposure to indoor air pollutants are children, elderly, chronically ill persons especially those suffering with respiratory and cardiovascular disease (USEPA, 2014). Additionally, children are more sensitive to environmental exposure than adults since their bodies are still developing, they breathe more air, consume more food and drink more liquid in proportion to their body weight (USEPA, n.d.). Indoor environments represent outdoor and indoor pollutants mixed together. Outdoor pollutants can originate from vehicles and dust from industrial activity. Outdoor pollutants can enter the building through natural and mechanical

ventilation (Guo et al., 2008). Indoor pollutants were produced from indoor combustion such as cooking, furniture used and tobacco smoke.

This research was conducted in Petaling Jaya. Petaling Jaya has the total population over 619,925 people (MBPJ, 2020). Vehicle exhaust is identified to be the primary source of air pollution in Petaling Jaya. This is because Petaling Jaya is a mixed commercial-residential-industrial area. Hoon leh et al. (2014) states that the area with large industrial, infrastructure land and transportation is possibly more polluted. According to Jalaludin & Mawar (2015) most of the people in industrial area resided within 100 – 1000metres from the major roadways and less than 1000m away from factories. Urbanization and increasing traffic in surrounding area lead to indoor air pollution exposure (Choo et al., 2014). Children are a vulnerable group that has high susceptibility to get sick if exposed to poor indoor air quality. Moreover, children spend most of their time indoor.

Nowadays, parent prefer sending their child to day care center for temporary care since hiring personal care taker can be expensive. Poor indoor air quality at day care center due to inadequate ventilation, maintenance and temperature control had led to circumstances having short and long term respiratory health will later can effect children performance and productivity as they are particularly sensitive to environmental changes (Malik et al., 2020). Providing a healthy and comfortable indoor environment will help to reduce sick episodes for the children. A well designed building would have elements that promote health rather than increasing the likelihood of illness

1.2 Problem Statement

Indoor air quality have become an arising research topics since exposure to poor indoors air pollutants are more detrimental than outdoors. Various monitoring studies have signifies that concentration of pollutants are much higher indoors than outdoors. Exposure to poor indoor air quality and rising levels of indoor air pollutant were the risk variables that contributed to increasing report on respiratory diseases (Sarijuddin et al., 2017).

The increasing participation of women in labor force for the past decade had made day care center as a necessary place for the children to spend time while their parent is working. Children who attend day care centers are likely to spend their time between 9 to 11 hours per day depending on the time they arrive at and leave the day care centers. Young children are vulnerable to poor indoor air quality due to their immature immune systems, greater inhaled breath per unit mass, breathing zone near to the ground, and rapid growth (WHO, 2019). Children are at the greater risk because air pollution concentration in children breathing zone (CBZ) was higher, and the pollutant concentration remain over time (Tripathii & Laquatra, 2018). Poor indoor air quality and presence of airborne microbes at day care centers will raise the risk to respiratory illness, particularly asthma among children who exposed (Khamal et al., 2019).

This study was conducted in Petaling Jaya which was one of the busiest city in Selangor. Urban air are likely to be more polluted than rural air due congested and

dense ambience because of industrial activities and heavy traffic. Children attending day care centers located in urban are at high risk of getting respiratory problem. Based on previous study, the prevalence of respiratory symptoms was generally higher among urban preschool children as compared to suburban preschool children (Asrul & Juliana, 2017; Tezara et al., 2014; Khamal et al., 2019; Sarijuddin et al., 2017).

There still lack of research on indoor air quality in day care centers especially in urban areas. The usual pollutants that been included in previous study was particulates mattes (PM), carbon monoxide (CO), carbon dioxide (CO₂), and physical parameters (temperature, humidity and air velocity) but not much of them include microbiological pollutants in their research. Microbiological pollutants occur due to poor construction quality or building management. This research will include microbiological pollutants to identify if it's give significant effects on children respiratory health.

In Malaysian the authorities only created the guideline on indoor air quality in occupational setting which is Industry Code of Practice on Indoor Air Quality 2010 by Department of Occupational Safety and Health (DOSH). Most of study that doing research on indoor air quality in children microenvironment are referring to this guidelines. However the acceptable limit for indoor pollutants proposed in this guidelines are not appropriate to be used to compare with the finding from children microenvironment. This is because industry code of practice on indoor air quality was made specially for adult that work in office. The day care centers setting are not the same with office setting and also the children are vulnerable than the adults. Thus, this

study could help the authorities come out with the proper guidelines on indoor air quality in day care centers setting.

1.3 Study Justification

This proposed research aim to determine the association of indoor air quality with respiratory symptoms among children at day care centre in Petaling Jaya, Selangor. Petaling Jaya was chosen as location for this study because it is in urban and industrial area. The high polluted environment due to emission from heavy traffic and industrial activity has cause significant health effect to the surrounding community. In recent years, a rising amount of scientific research has suggested that air inside homes are more polluted that the air outside (US EPA, 2014). Children are especially has high susceptibility to experience respiratory illness because their spend most of their time indoor. WHO (2019) reported that 570,000 deaths are from respiratory infection, reducing environmental risk could prevent 1 in 4 child death. Thus, this study is relevant to public health as it focuses on association of indoor air quality with children's respiratory symptom. Day care centre is important environment for the children and it's their primary place for their social activity. It is important to assess children exposure to indoor pollutants in microenvironment where they spend most of their time.

This research will measured physical, chemical and biological parameter (relative humidity, temperature, air velocity, PM_{2.5}, PM₁₀, carbon dioxide, carbon monoxide, fungi and bacteria). Based on the literature review most study doesn't include biological parameter in their study. Despite that, biological parameter play an

important role in association of respiratory illnesses with indoor air quality. Khamal et al. (2019) report that the indoor air concentration and presence of microbes in day care centre increase the risk in exposing children for respiratory diseases, particularly asthma, later in life. The study on association of IAQ at day care with respiratory symptoms are still lacking in Malaysia this study will be useful for improving the indoor environment setting in Malaysia day care centre.

1.4 Conceptual framework

Figure 1.1 showed the conceptual framework of this study. It was general but clearer view of this research. This research will study on association between indoor air quality with respiratory health symptom among children at day care centers in Petaling Jaya, Selangor. The colored box represented the factors in concern in this study.

The children age two to six years old were chosen for the subject of this study. The location of day care centers was divided into three group urban, sub urban and rural. However the study will focused mainly on day care centers located in urban area with different environmental setting. The independent variables of this study is indoor air quality. The concentration of indoor air quality that been measured was physical parameter (temperature, humidity and air velocity, chemical pollutants (CO, CO₂, particulates matters) and biological pollutants (fungi and bacteria). Meanwhile the dependent variables were respiratory symptoms (Cough, phlegm, wheezing, runny nose, blocked nose, sneezing, sore throat and chest tightness)

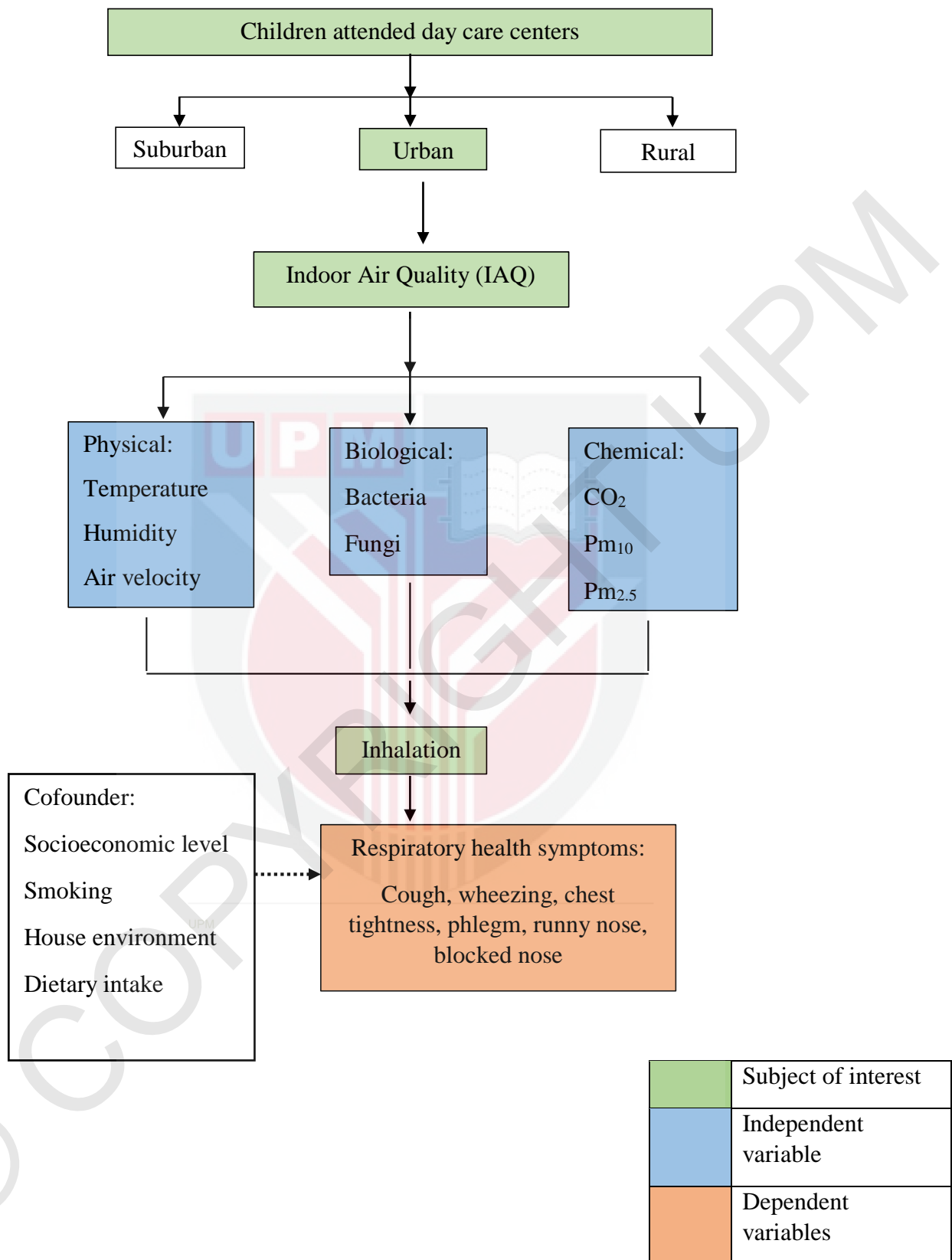


Figure 1.1: Conceptual Framework

1.5 Research Questions

The proposed research aims to answers the following research questions:

1. What is socio-demographic characteristic of children at day care centers in Petaling Jaya?
2. What is building characteristic of selected day care centers?
3. What is the level of concentration of temperature, humidity, air velocity, PM_{2.5}, PM₁₀, CO₂, airborne bacterial and fungal between day care centers?
4. What is the prevalence of respiratory health symptom between children at between day care centers?
5. Is there any association between level of indoor air pollutants (PM_{2.5}, PM₁₀, CO₂, airborne bacterial and fungal) with respiratory health symptoms (cough, wheezing, phlegm, chest tightness, runny nose, blocked nose) among day care center?
6. What is the main factors that influence indoor air pollutants and respiratory health symptoms among study respondents after controlling all the confounders?

1.6 Research Objectives

1.6.1 General Objective

To identify the relationship between exposures to indoor air pollutants with respiratory health symptoms among children at selected day care centers in Petaling Jaya, Selangor.

1.6.2 Specific Objectives

1. To determine socio-demographic characteristic of children at day care center
2. To determine the building characteristic of selected day care centers.
3. To determine and compare indoor air quality (temperature, humidity, air velocity, PM_{2.5}, PM₁₀, CO₂, airborne bacterial and fungal) between day care centers.
4. To compare the prevalence of respiratory health symptoms between children at day care centers.
5. To determine the association of indoor air pollutants concentration (PM_{2.5}, PM₁₀, CO₂, bacterial and fungal count) with respiratory health symptom among children in day care centers.
6. To identify the main factor that influences indoor air pollutants and respiratory health symptoms among study respondents after controlling the cofounders in this study.

1.7 Research Hypothesis

1. There is significant difference of indoor air quality (temperature, humidity, air velocity, PM_{2.5}, PM₁₀, CO₂, bacterial and fungal count) between day care centers.
2. There is significant difference of respiratory health symptoms among children between day care centers.
3. There is a significant association between indoor air pollutants concentration (PM_{2.5}, PM₁₀, CO₂, airborne bacterial and fungal) and prevalence of respiratory health symptoms among children between day care centers.
4. The main factor that influence the respiratory health symptom of children at day care center after considering all confounders will be PM_{2.5}, PM₁₀, CO₂, airborne bacterial and fungal.

1.8 Definition of Variables

1.8.1 Conceptual Definitions

a) Indoor air quality

“Indoor air quality (IAQ) refers to the air quality within and around buildings and structures, particularly as relates to the health and comfort of building occupants”(US EPA, 2014). According to Industry Code of Practice (DOSH, 2010) the parameter that can be measured to indicate the quality of an indoor environment are physical

parameter (temperature, relative humidity, air velocity), chemical parameter (CO, CO₂, formaldehyde and environmental tobacco smoke), biological pollutants (mites, virus, spores) and radiation such radon

b) Day care center

Day care center is an institution established for purpose of providing care or maintenance for children under the age of six (Shahidah et. al, 2017).

c) Respiratory symptoms

“Respiratory symptoms occur as a result of exposure to indoor air pollutants and can last up to seven to ten days; they often begin after one to three days of exposure to air pollutants and can last up to seven to ten days” (Oluchi, 2017). Cough, phlegm, wheezing, chest tightness, runny nose, blocked nose, sneezing, and sore throat are some of the respiratory symptoms (Asrul & Juliana, 2017).

d) Children age at day care center

Malaysia divides early childhood care and education in two age groups, 0-4 years old and 4-6 years old; Children under age of 24 months are classified in the infant group, toddler group for children aged 2-4 years old (nursery), preschooler group for children aged 4-6 years old (kindergarten) (Tezara, 2013)

1.8.2 Operational Definition

a) Particulate matter

Indoor assessment for particulate matter (PM_{2.5} & PM₁₀) was measured using TSI 8532 DustTrak™ II Aerosol Monitor. DustTrak™ II Aerosol Monitor is a handheld battery-operated instrument with data logging, single channel, light-scattering laser photometer that provides real time aerosol mass reading. It makes uses of a sheath air system to keep the optics clean and low maintenance by isolating the aerosol in the optics chamber. The instrument able to detect PM_{2.5}, PM₁₀ and respirable size fractions with the 90 light scattering sensor type to detect particles size in range between 0.001 to 150 mg/m³. The acceptable limit for PM_{2.5} and PM₁₀ set by DOSH (2010) is 75 ppm and 150 ppm in 24 hours exposure.

b) Temperature

TSI Model 7575 Q-Trak was used to assess temperature. Temperature was detected through sensor type thermistor. The recommended level set by the Department of Occupational Health for, temperature is 23°C to 26°C

c) Relative Humidity

TSI Model 7575 Q-Trak was used to measure relative humidity. The principle of detection of a wet bulb and dry bulb was used to compare the humidity ratio and

absolute humidity. The recommended level set by the Department of Occupational Health for relative humidity is 40% to 70%.

d) Carbon dioxide

Carbon dioxide was measured by using TSI Model 7575 Q-Trak. Dual-wavelength non dispersive infrared (NDIR) was used to measure CO₂. The recommended level set by the Department of Occupational Health for CO₂ is 1000 ppm (DOSH, 2010)

e) Air velocity

Air velocity will be measured using TSI Velocicalc Plus Model 8386. The recommended limit for indoor air velocity is between range 0.15ms to 0.50ms (DOSH, 2010)

f) Biological contaminants (bacterial and fungal)

Biological pollutant, bacterial and fungal will be collected through Pbi DuoSas Super 360 air sampler. The instrument was collecting air samples into petri dish containing medium, 500 volumes of air samples for 2 minutes was used during sampling. Isolation of fungi will use Sabaround Dextrose Agar (SDA) while isolation of bacteria using Tryptic Soy Agar (TSA). These agar later will be incubated and analysis was carried out.

g) Respiratory symptoms

Respiratory symptoms in this study were determined using constructed questionnaire based on internationally standardized and recognized questionnaire by American Thoracic Society, “Questionnaire ATS-DLD-C” and International Study of Asthma and allergies in childhood (ISAAC) that had been validated and used by previous local study (Zainudin et al., 2019).



CHAPTER 2

LITERATURE REVIEW

2.1 Indoor Air Quality

According to the United States Environmental Protection Agency (US EPA), indoor air quality is defined as the air quality within and around buildings and structures, particularly as it pertains to the health and comfort of the building occupants. Poor IAQ can be especially detrimental to vulnerable groups such as children, young adults, the elderly, and those suffering from chronic respiratory and/or cardiovascular diseases. In the past decade, daycare centers have become the primary choice for working parents to provide temporary care for their children while working. Most working Malaysian parents enroll their children in daycare centers run by a government or private agencies as early as three month old (Khamal et al., 2019).

Temperature, humidity and air movement play an essential role in regulating indoor air quality. A study by Rawi et al. (2015) claims that inadequate ventilation, high temperatures and humidity can cause indoor pollutants to accumulate. Providing good natural or mechanical ventilation is beneficial to health. Shahidah et al. (2017) describe the relation of indoor air pollutants levels and ventilation systems modes such as natural, hybrid, or without mechanical ventilation discovered that hybrid ventilation

system showed a decrease in the concentration of indoor pollutants. However, if it's not properly designed, installed, maintained, and operated ventilation can allow harmful particles or microbes to enter the building and degrade the indoor environment. The recommended level set by the Department of Occupational Health for the temperature is 23°C to 26°C. Meanwhile, in Guidance Note on Ventilation and IAQ for Residential Setting during Covid-19 Pandemic by Ministry of Health, 2021 its recommending relative humidity and air velocity should be in range 40% to 70% and 0.15m/s to 0.50m/s and air movement is 0.15ms to 0.50ms. Thus, it is recommended to frequently open the window and using air purifiers to lower the concentration of pollutants indoors.

The temperature and humidity of the environment can affect the size of bio-aerosol particles, the viability of airborne microorganisms, the growth of microorganisms on surfaces, and the amount of electrostatic charges on aerosols and surfaces. A particle in an environment above its CRH (or DRH if it was initially dry) will be larger and heavier and will settle faster than the same particle when the humidity is below the CRH. Bio-aerosol particles may also undergo an increase in size when the humidity increases due to water absorption and swelling of hygroscopic components.

For airborne viruses, survival decreases as air temperature increases (Ijaz et al. 2016; Tang 2009). Exposing most viruses to temperatures of 60°C or higher for 60 minutes will inactivate them, although the viruses can be somewhat protected if they are encased in organic material [Tang 2009] The survival of airborne bacteria also

decreases as air temperature increases; the survival of virtually all airborne bacteria declines when temperatures are above 24°C. Warm temperatures, wet substrates and humid air conditions favor the growth of fungi on surfaces [Eduard 2009; Tang et al. 2015. air temperature and humidity affect the viability of airborne fungi and fungal spores

2.2 Indoor Air Pollutants

Human exposure to indoor air pollutant is usually through inhalation. At the daycare centre, children exposed to various contaminants such as gaseous, particulate matter and microbiological agent. These pollutants are everywhere, and impossible to discard them entirely.

Among the pollutants that being investigated were particulate matter less than or equal to 2.5 and 10 ($PM_{2.5}$ and PM_{10}). Particulate matter is a fine particle suspended in the earth's atmosphere. PM_{10} are inhalable particles, with diameters that are generally 10 micrometers and smaller; and $PM_{2.5}$ are fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller (USEPA, 2016). Further USEPA (2016) also states that Particulate matter is made up of microscopic solids or liquid droplets that can be breathed and cause major health concerns if inhaled. Some particles with a diameter of less than 10 micrometres can penetrate deeply into your lungs, and some may even enter your bloodstream. Particles less than 2.5 micrometers in diameter, also known as fine particles or $PM_{2.5}$, pose the greatest risk to health.

Indoor particulate can be produced by cooking, combustion activities (such as candle burning, fireplace use, unvented space heater use and cigarette smoking) and some hobbies (US EPA, 2019). The level of PM₁₀ indoors fluctuate depending on the floor level and the closing of the window (Tezara et al., 2014). The acceptable limit for exposure to PM_{2.5} and PM₁₀ in 24 hours recommended by Malaysian ambient air quality (DOE, 2020) 100µg/m³ and 35µg/m³.

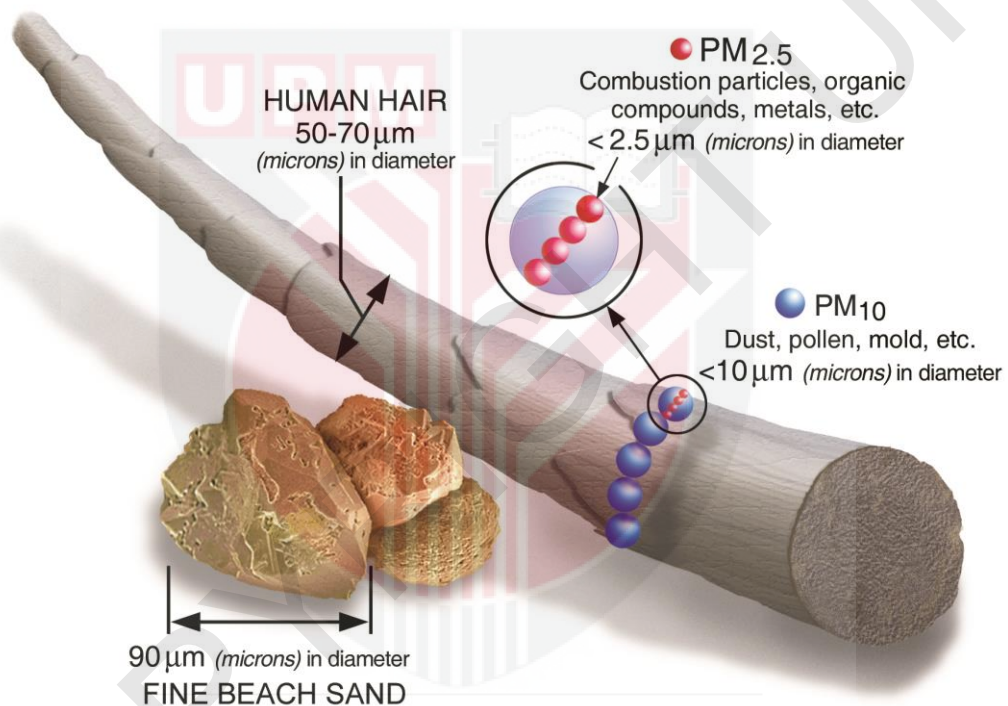


Figure 2.1: Size of Particulate Matter, PM_{2.5} and PM₁₀

(Source: USEPA, 2016)

Carbon dioxide are indoor air pollutants generated from combustion activity inside and outside the premises. The level of carbon dioxide indoor often correlated with the number of occupants (Tezara et al., 2014). The acceptable limit for CO₂ set by the Department of Occupational Health is 1000 ppm.

Biological contaminant comes from various sources such as cooking and cleaning activities, pet, dampness of the building and ventilation system. According to an acceptable limit set by (WHO), the standard set for exposure bacteria is 500 CFU/m³, while for fungi is 1000 CFU/m³ in 8 hour exposure. Bacteria are thought to be detrimental due to endotoxin production, which can cause inflammation of the airways, increase bronchial hyperactivity, and elicit asthmatic attacks, and this endotoxin generally produced by bacteria found in household dust (Ross et al., 2000). Besides, Hwang et al. (2017) stated that bacteria levels are remarkably higher indoors compared to outdoors.

The technique used to monitor indoor pollutants such PM_{2.5}, PM₁₀, CO, CO₂, fungi and bacteria were partially adopted from Industry Code of Practice on Indoor Air Quality 2010 the instrument must place at 0.6-10 meter above the floor to represent children breathing zone, more than 1 meter away from the wall, door, or any active heating system. According to Asrul & Juliana (2017), each room will had one sampling point and one point from the outdoors. The equipment must place at area were child spent most of their times, assuming that contaminants were distributed evenly. The method that will used to monitor indoor air pollutants were

2.3 Factors affecting Indoor Air Quality in Day Care Centers

Indoor air quality is determined by exposure from combination of countless pollutants that originated from various sources such as indoor smoking, cooking

activities, paint, wall, air cooling system and even outdoor air toward building residents (Tezara et al., 2014). The common indoor air pollutant detected in day care center varied from particulate matter, volatile organic compounds (VOCs), aldehydes, bacteria and fungi.

The location of day care center and the structure of the building plays a significant role in determining indoor air quality. Being located near to main road, industrial area and urban area affect local air quality in DCC. Rawi et al. (2015) reported that living close to busy highway was associated with increased personal exposure to particulate matter in children. Housing location as well as indoor and outdoor combustion activities had cause the high level of $PM_{2.5}$ and PM_{10} inside the house (Asrul & Juliana, 2017). Location of the preschool had substantial impact on the occurrence of respiratory health symptoms (Asrul & Juliana, 2017). Children may have exposed to contaminate from traffic that may enter the building through opening of window, door or crack wall. Dust produced from external sources from paved and unpaved roads potentially contributed to elevated levels of indoor particulate matter (Khamal et al., 2019). Motor vehicles are the primary source of particle pollution in urban air, releasing fine primary particles. Heavy traffic and vehicle combustion of fossil fuels caused to the high concentration of particulate matter especially during early in the morning and afternoon. $PM_{2.5}$ has a higher chance reaching the small airway and alveoli of the lungs than larger particles. The frequent exposure to $PM_{2.5}$ will cause chronic respiratory diseases.

Most of the day care center in urban area use air conditioning to provide comfortable environment to the children. The air conditioning usually installed at playroom and bedroom area. This area are occupied most of the time by the children. Despite the benefit of air conditioning inside the room, the study by Malik et al. (2020) found that children attending day care center served by air conditioning and mechanical ventilation had the highest risk of respiratory symptoms and the presence of moisture is a possible root cause of high indoor pollutant in DCC. This data also strengthen by study from Khamal et al. (2019) reported that air conditioned day care center experience much lower air exchange rates than naturally ventilated day care center. The rate of air exchange will have an effect on the penetration of outdoor pollutants (Guo et al., 2008).

Further, majority of domestic air conditioner lack of fresh air intake, which can significantly impact on the indoor air quality. In additional, closing all the window and door during the lesson to keep children inside resulting inadequate ventilation. Poorly ventilated area will fail to dilute pollutants produced by human, such as human associated bacterial levels, resulting in increased indoor pollution concentration indoor compared to outdoor. Study by Roda et al. (2011) suggested that hybrid ventilation can lower concentration of indoor pollutants by increase dilution of pollutants. Next, unsuitable level of humidity can bring harm to the children. Insufficient humidity in an area will generate static build, making people's skin feel dry, while too much humidity can make skin feel sticky (Rawi et al., 2015).

Microbes in indoor environment poses threat to children. In DCCs, children's activity such as talking, sneezing, coughing, walking, washing and toilet flushing can generate airborne biological particulate matter (Oh et al., 2014). Activity such as cleaning and cooking also can be source of bacteria in DCCs. Shahidah et al. (2017) stated that the microbial contaminant was associated with the particulate matter as the microbial contaminant will attach to particulate matter and travel through the air. Asrul & Juliana (2017) suggested that sources of PM₁₀ may promote the growth of gram negative bacteria in the air. A study by Khamal et al. (2019) reported that total bacteria counts exceeded acceptable limits in half of the DCC surveyed. Hwang et al. (2017) stated that the level of bacteria showed a significant positive association with building age and are of the building. Shahidah et al. (2017) also revealed that the total bacteria counts was highest at DCC in urban area compared to suburban area this might due to the occupancy factors. They also suggested that higher total bacteria and fungi count might correlated with a lower temperature and greater relative humidity, this condition created an ideal environment for bacteria and fungi to growth at faster rate. Water damage in day care wall and ceiling affect the growth of airborne bacteria and mold (Hwang et al., 2017). The particulate matter and damp area are such as kitchen and toilet showed positive correlation to the level of mold and bacteria indoor (Asrul & Juliana, 2017)

Carbon monoxide (CO) is generated indoors by combustion source (cooking and heating) and also introduced by carbon monoxide infiltration from outdoor air. A higher concentration of CO was mostly contributed by mobile cars particularly during peak hours, as well as location of building near to major road (Rawi et al., 2015). Other

than that, CO also can cause from faulty, incorrect installed, poorly maintained or poorly ventilated cooking or heating appliances that burn fossil fuels. Tobacco smoke also can be major source for indoor exposure to CO. A study by Tezara et al. (2014) reported that the level of CO is higher in DCC near to industrial area and major road area this is due to traffic emission from outdoor environment. Next, carbon dioxide concentration frequently utilized as a proxy for the rate of supply air from outside per occupant. Tezara et al. (2014), stated that indoor level of CO₂ inside day care are affected by outdoors and the density of occupants indoor. Another study by Tezara et al., (2014), reported that the mean concentration of CO₂ was highest for DCC located in KL, which is 739.22 ppm. Indoor CO₂ concentration more than 1000 ppm usually indicate that insufficient ventilation rate (Choo et al., 2014).

2.4 Indoor Air Pollutants and Respiratory Health Implication of Children

Health effects from indoor air pollutants can occur immediately after a single exposure or may occur years later after repeated exposure. The finding from previous study had shown a strong association of indoor air pollutants with respiratory infection among children at day care center. Factors that significantly associated with respiratory symptoms are age, ventilation system, DCC location, type of building, floor space, accessible to window or door, and temperature viable bacteria and fungi (Malik et al., 2020). Two third of parents felt that their children's symptoms were related to DCC and most of them will take leave if the children became ill (Malik et al., 2020). A study by Tezara et al. (2014) reported that day care center located in KL had highest level of CO₂ and PM₁₀, also had the highest rate of coughing and wheezing symptoms. The

also exposed that children at KL DCC becoming unwell more than four times per year. Khamal et al. (2019) reported prevalence of wheezing in their study is higher. There also significant association between wheezing with $PM_{2.5}$ and PM_{10} in study by Rawi et al. (2015). Study by Jalaludin & Mawar (2015) proclaimed that children exposed to elevated indoor $PM_{2.5}$ concentration had a statically significant higher risk of acquiring cough and chest tightness. They also stated that children live in industrial area are three times more likely to get cough compared to children live in non-industrial area. Particle with diameter $2.5\mu m$ or less are more harmful, especially ultrafine particle with diameter less than $1\mu m$ can penetrate tissues and organs, posing an even greater risk of systemic health impacts (WHO, 2019).

Data showed by Asrul & Juliana (2017) showed that urban preschool children are more frequent to get cough, phlegm, runny nose and blocked nose. Study by Sarijuddin et al. (2017) reveal that children living in single house has highest prevalence of chest illness, while children living in refurbished commercial building has high prevalence of phlegm. USEPA (2016) states that biological contaminant can trigger allergic reaction, including allergic rhinitis, asthma, and hyperactive airway diseases.

CHAPTER 3

METHODOLOGY

3.1 Study Design

Cross-sectional study design was conducted to determine the association of indoor air quality with respiratory health symptoms among children in day care center at Petaling Jaya, Selangor. The independent variable of this study is indoor air quality (temperature, relative humidity, air velocity, CO₂, CO, PM_{2.5}, PM₁₀, fungal and bacterial). The dependent variable of this study is the prevalence of respiratory symptom among children age 4 to 6 years old. Respiratory symptom observe are cough, phlegm, chest tightness, runny nose, blocked nose, and wheezing.

3.2 Study Duration

The duration of this study was from August until December 2021

3.3 Study Location

This study will be conducted in Petaling Jaya. This location was chosen because Petaling Jaya is urban area that have high concentration of air pollutant due to

the city was congested and dense ambience because of industrial activities and heavy traffic. The polluted outside environment will circulate and enter the building making the indoor air quality dropped. Thus, will increase the prevalence of people with respiratory illness due to indoor air pollutants, children are more susceptible to acquire respiratory symptoms.

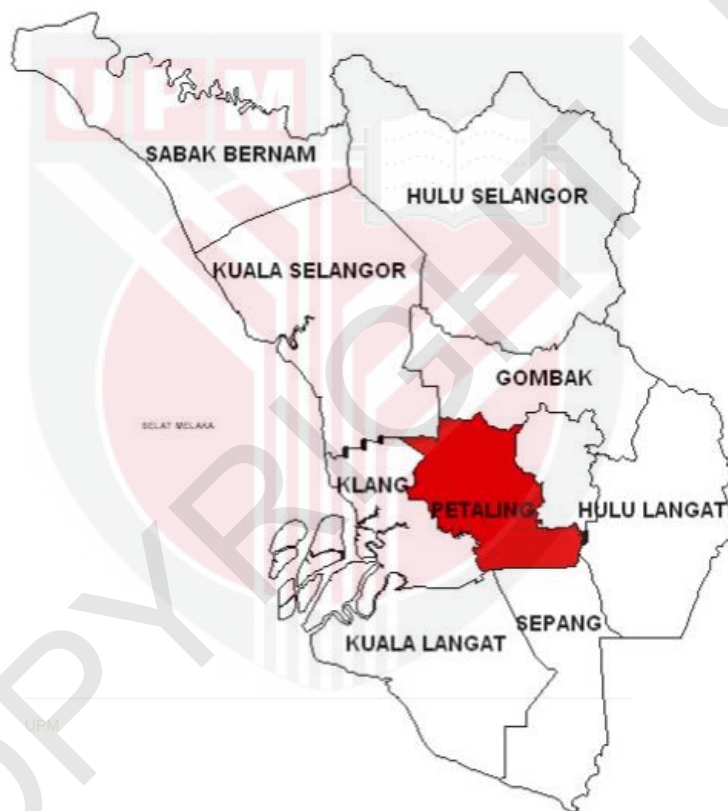


Figure 3.1: Location of Petaling Jaya District
(Source: *Portal Rasmi PDT Petaling, 2016*)

3.4 Study Population

This study recruited children that attending selected day care centers in Petaling Jaya, Selangor and fulfilled inclusion and exclusion criteria. This research

will determine the association between indoor air quality with respiratory health symptoms among children in day care centers

3.5 Sampling Frame

All male and female children at age zero to six years old with different background and race (Malay, Chinese, and Indian) who had attended the day care center at Petaling Jaya. The list day care centers located in Petaling Jaya were obtained from Ministry of Education website. The selection of day care centers was based on source of pollutants. The DCC that located near to major roadway, construction area and in dense population was selected for this study.

Then, the list of children from respective day care center were obtained from the day care center managements. The children who met inclusion and exclusion criteria and has obtain the consent from the parent will be selected as the study respondent.

3.6 Sampling Method

The list of day care center were obtained through e-prasekolah.moe.gov.my website from Ministry of Education. The private day care center were selected purposively. The inclusion criteria for selected DCC is:

1. Near to roadway
2. Near to consruction area

3. In area with dense population

Then, purposive sampling method were used to select the respondent from the list of children obtain through day care centers management with several inclusion exclusion criteria as below:

Inclusion criteria:

1. Male and female children
2. Children with age 2 to 6 years old
3. Children had attend the same day care center for the past 6 months

Exclusion criteria:

1. Children with history of doctor diagnosed with respiratory illness
2. Children without parent consent

3.7 Sample Size

This study will use the formula from Lemeshow (1990) to determine the number of respondent needed for group comparison between day care centers. The formula for calculating sample size was shown below:

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

Where,

n = Sample size

$Z_{1-\alpha/2}$ = Standard error associated with confidence interval (CI), 99% CI = 2.58

$Z_{1-\beta}$ = Standard error associated with power, 80% of power=0.84

P_1 = Prevalence of children with phlegm from the exposed group; 38.3% = 0.383

P_2 = Prevalence of children with phlegm from the comparative group; 18.3% = 0.183

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

$$\bar{P} = (0.383 + 0.183) / 2$$

$$\bar{P} = 0.283$$

Then, the \bar{P} value needs to be substitute into the formula to find n, the sample size.

$$\frac{\left(2.58\sqrt{2(0.283)(1 - 0.283)} + 0.80\sqrt{0.383(1 - 0.383) + 0.183(1 - 0.183)}\right)^2}{(0.383 - 0.183)^2}$$

$$n = 42$$

Therefore, 46 respondents will be recruited for each exposed and comparative group.

The sample size is increased to 18% for attrition bias and due to purposive sampling.

$$n = 18/100 \times 42$$

$$n = 7.56$$

$$n = 42 + 7.56$$

n = 49.56 respondents

n = 50 respondents

3.8 Research Instrumentation

3.8.1 Questionnaire

Constructed questionnaire based on internationally standardized and recognized questionnaire by American Thoracic Society, “Questionnaire ATS-78-C” that had been validated and used by previous local study (Zainudin et al., 2019). Questionnaire ATS-78-C will cover on respiratory symptoms and residential area while ISAAC questionnaire identify asthma and allergies in childhood. This questionnaire consist of 5 section which is socio-demographic background, health history, history of exposure, home characteristic (indoor and outdoor) and current respiratory symptoms. There were 5 respiratory health symptoms that will be focused in the questionnaire which is cough, phlegm, runny nose, wheezing, blocked nose and chest tightness. The questionnaire was in *Bahasa Melayu* for respondent to have easier understanding on the questionnaire. Before the distribution of the questionnaire the consent form was issued to the day care center owner and selected children parents. The privacy and confidentiality of respondents were guaranteed.

3.6.2 IAQ Exposure Monitoring

Indoor air parameters that were assessed in this study were physical parameters (temperature, relative humidity, air velocity) and indoor air pollutants (PM_{2.5}, PM₁₀, CO₂, total bacterial count and total fungal count). The monitoring instruments used were Q-trak plus Model 8554 to measure temperature, relative humidity and CO₂; TSI Velocicalc Plus Model 8386 for air velocity; TSI Model 8520 DustTrak Airborne Monitoring for PM_{2.5} and PM₁₀; and pbi DuoSAS Super 360 to obtain bacterial and fungi samples.



Figure 3.2: Q-trak plus Model 8554 to measure temperature, relative humidity and CO₂



Figure 3.3: TSI Velocicalc Plus Model 8386 for measurement air velocity



Figure 3.4: TSI Model 8520 DustTrak Airborne Monitoring for PM_{2.5} and PM₁₀



Figure 3.5: pbi DuoSAS Super 360 to obtain bacterial and fungi samples.

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

Variables	Instruments	Sensor Type / Technique	Detection Limit
PM _{2.5} and PM ₁₀	DustTrack™ DRX Aerosol Monitor 8534	90 light scattering laser diode at 1.4 and 2,4 litre per minute (L/min)	0.001 – 100 mg/m ³
CO ₂		Electro-chemical	0 to 5000 ppm
Temperature	TSI Model 7575 Q-Trak IAQ Monitor	Thermistor	0 to 60
Relative humidity		Thin-film capacitive	5 to 95%
Air velocity	TSI Velocicalc Plus Model 8386	Pitot tube	0 to 78.7 m/s
Bacterial			
Fungal	pbi DuoSAS Super 360	Collecting air sampler into petri dish containing agar medium	-

**Figure 3.6: The placement of TSI Model 8520 DustTrak in the room**

The instruments were placed within children breathing zone (0.5m to 1m) off ground level, out of children reach, 1 metre away from window, door, wall, shelves and any active heating system. The number of sampling point was one for each room and one from outdoor and the sample were taken three time at each sampling point. The equipment were placed in an area where the children spent the most time, presuming that contaminates were distributed evenly. The measurement were taken every one hour from 8.00 am to 12.00 pm except for biological sample. The method were adopted from Industry Code of Practice on Indoor Air Quality (DOSH, 2010).

For biological samples pbi DuoSaS Super 360 microbiological air sampler was used. The air sampler was used to drawn air from the surrounding onto culture agar. The air sampler will drawn air with sampling volume of 500 – 1000 litres. Culture agar used were Sabaround Dextrose Agar (SDA) to isolate mold/fungi. Tryptic Soy Agar (TSA) used to isolate bacterial. After sampling, all agar plates were sealed and transported to the laboratory for incubation. TSA were incubated at 37°C for 24 hour, SDA samples were left at room temperature for 5 days. After the end of incubation period the colony on agar was counted using colony counter then the calculation for colony forming unit was calculated as equation below;

$$X = \frac{\text{Pr} \times 1000}{V}$$

Where,

X = Colony Forming Unit per 1000 liters (1m³)

Pr = Probable count obtained from correction table to adjust colony counts from a 401-Hole impactor Using Standard 90mm Petri Dishes

r = Colony Forming Units counted on 90mm Petri Dishes

V = Volume of sampled air



Figure 3.7: Colony count using colony counter

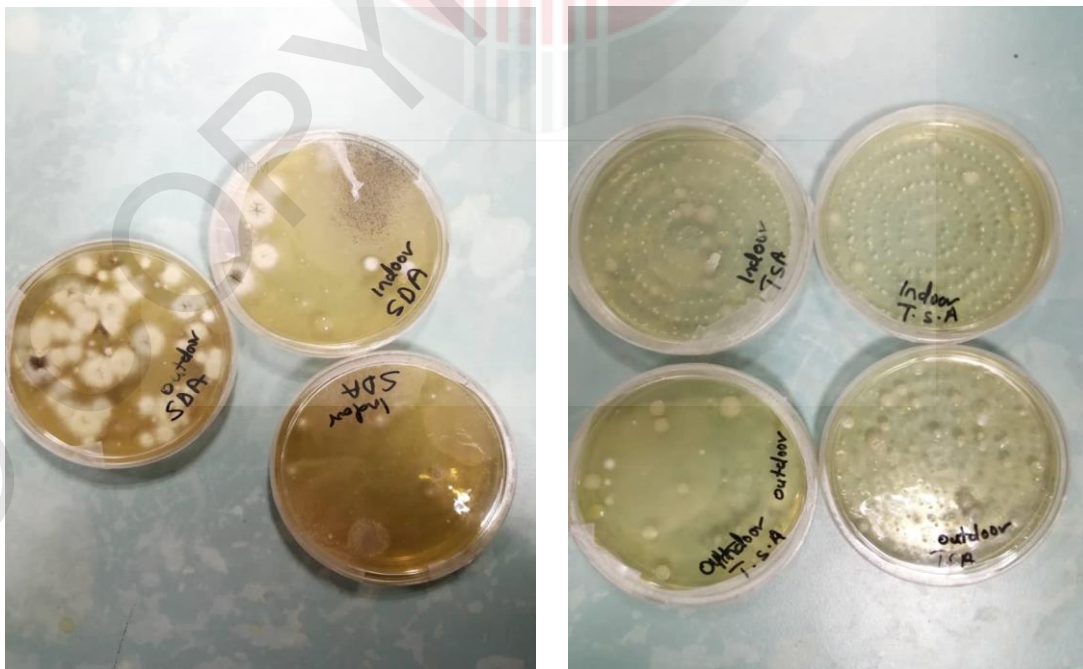


Figure 3.8: The forming of fungal and bacterial after incubation

3.9 Statistical Analysis

The collected data were entered, categorized, and analyzed using IBM Statistical Package for Social Science (SPSS) Version 22 and the response of questionnaire was graphical using Microsoft Word 2016. Normality test was conducted for all the continuous study variables. The data were not normally distributed based on significant p-value ($p > 0.05$) of Shapiro-Wilk. Descriptive analysis was done using frequencies for socio-demographic of the respondents. Kruskal-Wallis test were used for comparison of indoor air quality between day care centers in study areas. Chi-square tests were undertaken to measure prevalence of respiratory health symptoms and association of indoor air pollutants with respiratory health symptoms. Multiple logistics regression was used to identify the factors that influence the res-piratory health symptoms after all the confounder have been controlled. The level of significance was set at 0.05.

3.10 Quality Control

The instrument were calibrated before conducting the assessment to maintain instrument sensitivity and to prevent measurement error from occurring when reading is taken. The procedure on how to operate the instrument were based on the operation manual given by the manufacturer.

Before taking sample using pbi DuoSAS super 360 the inside area of sampler was disinfected first with alcohol to avoid contamination. During handling of

biological samples researcher was wearing mask and glove to avoid direct contamination of the agar plat and samples.

The questionnaires were pre-tested on 10% of the sample size by randomly selected children who attend day care centers that met inclusion and exclusion criteria. The questionnaire was validated by previous study to improve clarity of the questions and prevent the respondents from producing a bias answer (Zainudin et al., 2019). Lastly, the questionnaire was also tested for its reliability using IBM Statistical Package for Social Science (SPSS) Version 22 whereby the alpha Cronbach value was 0.9 which indicated its internal consistency.

3.11 Ethical Consideration

Ethical approval was obtained from the Ethics Committee for Research Involving Human Subjects in University Putra Malaysia with the reference number JKEUPM-2021-360. Further, permission to conduct IAQ monitoring in selected DCCs were asked from DCC owner directly since all the selected DCCs were private day care. The questionnaires were distributed with informed consent to the parent and the anonymity of the participants was maintained at all times

CHAPTER 4

RESULTS

4.1. Response Rate

The calculated sample size for this research was 100. A total 180 questionnaire and consent form were distributed to the targeted group. 160 questionnaire were returned back. Children who only meet inclusive criteria were included in this research. After filtering exclusion criteria only 100 questionnaires requisite with the inclusive criteria. Thus, the number of respondents gathered for DCCs are 100 which gave 100% response rate.

4.2 Respondents' Socio-demographic Data

Table 4.1 summarizes the characteristics of respondents in term of socio-demographic characteristics. Among 100 respondents, 57 are females and 43 are male which are most of them are Malay 81 and 19 are Chinese. Most of respondents live in apartment 67, while others live in terrace house 30 and bungalow 3. 75 of respondent live with 4 to 6 member in their house. 67 respondent use fan and air-conditioner as their home ventilation. 35 respondent house have moisture issues in last 5 year. Respondent that had painted their house in last 1 year were 36. Respondent that changed their house flooring in last 1 year were 15. Number of respondent that have furry pet in their house is 17 only. Respondent that had been exposed to environmental

tobacco smoke (ETS) are 23. Cleaning activities per week was divided into 3 category which are 1 to 3 times, 4 to 6 times and 6 times and above. 56 of respondent have 1 to 3 times cleaning activities per week inside their homes. For frequency of cooking activities per day inside respondent house are 67 respondents for 1 to 2 times per days.

Table 4.1: Respondents' Socio-demographic Data

Characteristics		n
Mean Age	4 – 6 years old	
Gender	Male	43
	Female	57
Race	Malay	81
	Chinese	19
Type of housing	Terrace	30
	Bungalow	3
	Apartment/Flat	67
Total household members	1-3	14
	4-6	75
	6 and above	11
Home ventilation	Fan	29
	Air-conditioner and fan	67
Moisture issues in the last 5 years	Yes	35
	No	65
Painted house in the last 1 years	Yes	36
	No	64
Changed flooring in Last 1 years	Yes	15
	No	85

Furry pets	Yes	17
	No	83
ETS exposure at home	Yes	23
	No	77
Cleaning activity per week	1-3 times	56
	4-6 times	12
	More than 6 times	32
Cooking activity per day	1-2 times	67
	3-4 times	30
	5 times above	3

N=100; Descriptive analysis

4.3 Characteristics of Day Care Centers

Table 4.2 explains sampling sites its environmental conditioned and furniture used at each day care centers. All the selected day care is private residential structured. The building age of DCC A is 15 years. They located in middle of residential area and have 48 occupants. Next, the building age of DCC B is 22 years, it located near to construction site <200m with number of occupants are 57. DCC C located at the roadside and near to construction site <500m, the build-ing age of DCC C is 8 years and they have 50 occupants. DCC D located on the side with busy road because <100m from primary school. The building age of DCC D are 18 years. The number of occupants inside DCC D is 40. Lastly, DCC E located near roadway, the building age is 23 years. DCC E has 41 occupants. Air conditioned and mechanical ventilation was used by each of selected DCCs. All centers were cleaned daily by mopping and/or vacuuming. Only DCC A and D have cooking activities insides the building.

Table 4.2: Day Care Centers Characteristics

DCC	Building Age (Year)	No of Occupants (2020/2021)	Type of Building	Environment characteristic	Furniture used
A	15	57	Private Residential	In the middle of residential area with cemented floor and not cemented courtyard	Fan, air conditioned, bed canvas(stackable bed), ceramic tiles, bookshelf, plastic table and chair, whiteboard and marker
B	22	48	Private Residential	In the middle of residential with fully cemented floor with small courtyard, 2 block from DCC building there are on-going renovation/construction of house (<200m)	Fan, air conditioned, mattress, wooden tiles, bookshelf, plastic table and chair, whiteboard and marker
C	8	41	Private Residential	On the roadside and <1km from on-going construction/ house renovation. With fully tiles floor without courtyard	Fan, air conditioned, wooden tiles, mattress, bookshelf, plastic table and chair, whiteboard and marker
D	18	40	Private Residential	On the side with busy road because <100m from primary school. Half cemented floor with small courtyard	Fan, air conditioned, carpet, mattress, bookshelf, plastic table and chair, whiteboard and marker, air purifier
E	23	50	Private Residential	On the side of roadway with tiled floor and courtyard	Fan, air conditioned, tiles, mattress, bookshelf, plastic table and chair, whiteboard and marker

Note: Numbers of occupants are including children, babysitter, administration and maid

4.4 Comparison of Indoor Air Quality between Day Care Centers in Study Areas

Table 4.3 shows median concentration for indoor air quality ($PM_{2.5}$, PM_{10} , CO_2 , indoor bacterial, indoor fungal, temperature, humidity, air velocity). Kruskal-Wallis test was used to compare indoor air quality level between selected DCC. The IAQ level for each DCCs also was compared with standard acceptable limit given by recognized organization such as World Health Organization (WHO), Department of Occupational Safety and Health (DOSH), Ministry of Health (MOH) and Department of Environment (DOE). The acceptable limit of PM_{10} and $PM_{2.5}$ was compared with Malaysian ambient air quality (DOE, 2020) which is $100\mu g/m^3$ and $35\mu g/m^3$ for 24 hour exposure. The exposure to PM_{10} for all day care are below limit. However, the concentration of $PM_{2.5}$ for all DCC exceed acceptable limit. The highest median concentration for PM_{10} and $PM_{2.5}$ can be seen in DCC B with $85.92\mu g/m^3$ and $43.26\mu g/m^3$ respectively. The lowest median concentration for PM_{10} and $PM_{2.5}$ are in DCC A which are $43.26\mu g/m^3$ and $36.19\mu g/m^3$.

The highest median concentration CO_2 is in DCC A, 708ppm while the lowest is in DCC C, 365ppm. Fortunately, CO_2 level in all DCC are still within acceptable range provided by Industry Code of Practice (ICOP) on IAQ (DOSH, 2010). The highest median concentration of airborne bacterial are in DCC E which is $559 CFU/m^3$ while the lowest is in DCC D, $243 CFU/m^3$.

For airborne fungal the highest median concentration are in DCC B, 350 CFU/m³ and the lowest is DCC E, 154 CFU/m³. According to acceptable limit given by WHO airborne bacterial and airborne fungal are below acceptable limit which are 500 CFU/m³ and 1000 CFU/m³ respectively. The temperature in all DCCs exceed acceptable range recommended by ICOP on IAQ (DOSH, 2010) which is between 23°C to 26°C. The hottest temperature are in DCC B with 29.65°C and the coolest temperature is in DCC E, 27.60°C. In, Guidance Note on Ventilation and IAQ for Residential Setting during Covid-19 Pandemic (MOH, 2021) its recommending relative humidity and air velocity should be in range 40% to 70% and 0.15m/s to 0.50m/s respectively. DCC E exceed recommended limit and has the highest relative humidity among others DCC which is 76.7%. For air velocity all DCC are within acceptable range and the highest median concentration of air velocity is in DCC C. Kruskal-Wallis test found significant difference between PM₁₀ (z=10.371, p=0.035) PM_{2.5} (z=13.788, p=0.008), temperature (z=22.769, p<0.001) and relative humidity (z=42.328, p<0.001) between studies DCCs.

Table 4.3: Comparison of Median Concentration on Indoor Air Quality Parameters at 5 DCCs Monitored in Petaling Jaya, Selangor

Variables	PEL	A	B	C	D	E	Z	p-value
		Median						
PM ₁₀ (µg/m ³)	^α 100	43.26	85.92	67.19	62.63	53.24	10.371	0.035*
PM _{2.5} (µg/m ³)	^α 35	‡ 36.19	‡ 56.26	‡ 50.85	‡ 48.37	‡ 44.94	13.788	0.008*
CO ₂ (ppm)	^δ 1000	708	634	365	453	691	5.953	0.203
Airborne Bacterial (CFU/m ³)	^x 500	355	363	412	243	‡ 559	6.887	0.142
Airborne Fungi (CFU/m ³)	^x 1000	223	350	244	180	154	3.485	0.480
Temperature (°c)	^ψ 23-26	‡ 29.10	‡ 29.65	‡ 29.05	‡ 29.10	‡ 27.60	22.769	<0.001**
Relative Humidity (%)	^ψ 40-70	64.10	61.09	65.45	58.32	‡ 76.7	42.328	<0.001**
Air Velocity (m/s)	^δ 0.15-0.50	0.21	0.25	0.32	0.26	0.17	1.163	0.884

Kruskall-Wallis; *p-value significant <0.05; **p-value significant <0.001; CFU = colony forming unit; ‡ Exceeded the acceptable limit;

PEL = permissible exposure limit

^α Malaysia Ambient Air Quality (DOE, 2020)

^δ ICOP on IAQ (DOSH 2010)

^x WHO

^ψ Guidance Note on Ventilation and Indoor Air Quality (AIQ) For Residential Setting During COVID-19 Pandemic, (2021)

4.5 Prevalence of Respiratory Health Symptoms among Children

Figure 4.1 presents the findings of reported respiratory health symptoms among children in each DCCs. Six respiratory symptoms were properly assessed using internationally standardized and recognized questionnaire by American Thoracic Society, "Questionnaire ATS-78-C" which are cough, phlegm, wheezing, chest tightness, runny nose and blocked nose. From the chi-square test, cough, wheezing and runny nose showed significant difference among the DCCs which are ($X^2=12.810$, $p=0.012$), ($X^2=11.130$, $p=0.025$), ($X^2=11.097$, $p=0.025$) accordingly. The most children having cough was in DCC B which is 11(55%). The most children having phlegm and chest tightness are in DCC E which are 2(25%) and 2(10%). 6(30%) children from DCC D are having wheezing as for most kid having wheezing. The most children with runny nose are from DCC E 17(85%) and most children with blocked nose are from DCC B and DCC D.

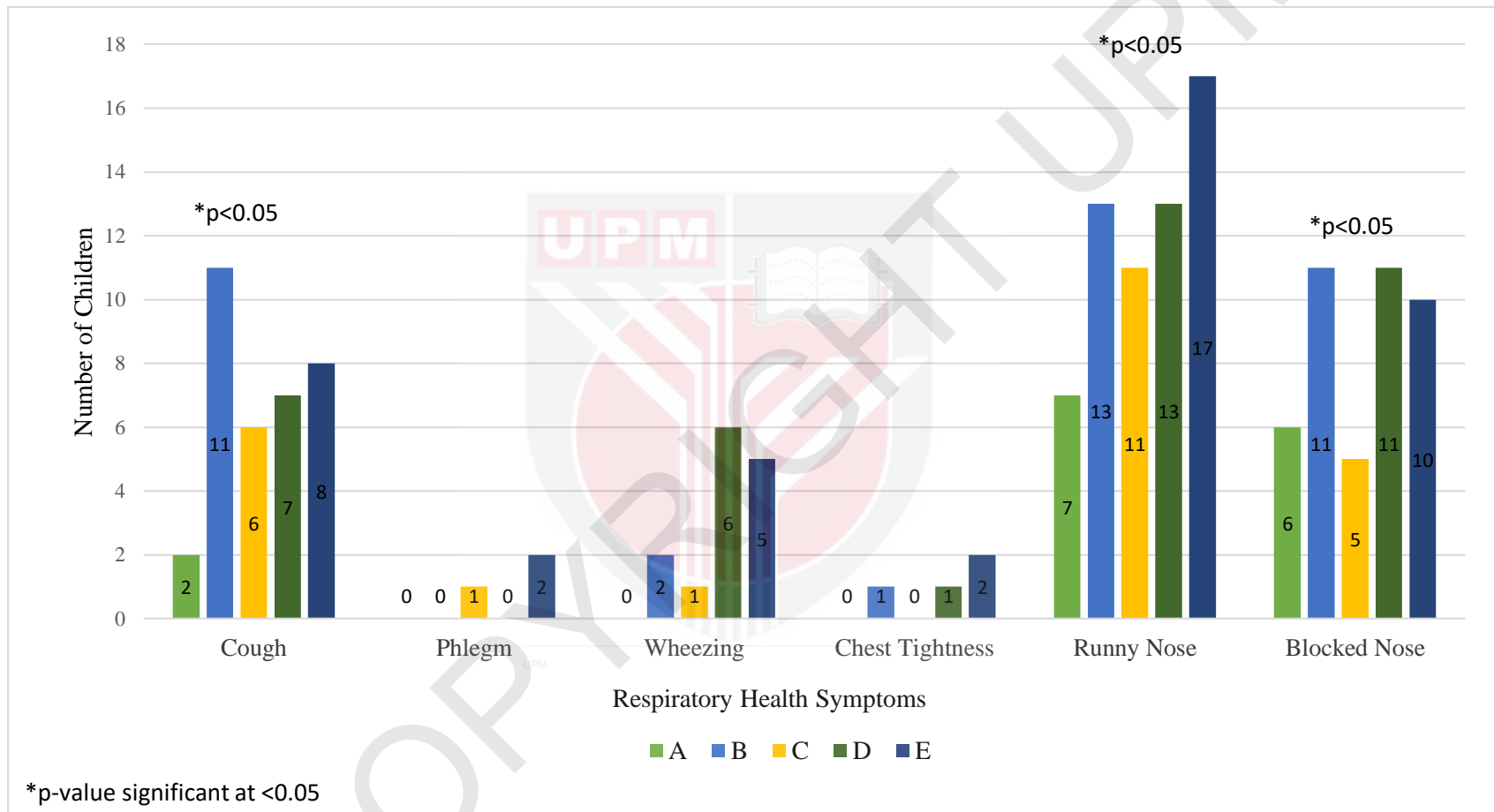


Figure 4.1 Prevalence of Respiratory Symptoms among Children at each Day Care Centre

4.6 The Association of Indoor Air Pollutants with Respiratory Health Symptoms

The chi square test was used to find the association of respiratory health symptoms with indoor air pollutants (PM_{2.5}, PM₁₀, CO₂, indoor bacterial, indoor fungal). The data was presented in odd ratio and 95% confidence interval. Based on finding shows in table 4.4 there is significant association of PM_{2.5} with cough and runny nose. Exposure to PM_{2.5} 6 times likely to have cough while 3 times likely to have runny nose.

4.7 Factors Influenced the Respiratory Health Symptoms after Controlling all Confounders

Multiple logistic regression was performed to determine the main factors that influenced respiratory health symptoms among children at DCC. Before proceeding to multiple logistic regression the all variable first was analysed in simple logistic regression to determine the significant factors that can proceed to multiple logistic regression. Only PM_{2.5}, PM₁₀, indoor airborne fungal, temperature and humidity was qualified to proceed in multiple logistic regression. The result for multiple logistic regression was shown in table 4.5. Table 4.5 shows that exposure of children towards high PM₁₀ and PM_{2.5} was significantly associated with risk of getting respiratory symptom among children (B=1.280, p=0.012, AOR=3.371, 95%CI=0.10-0.75), (B=1.467, p=0.004, AOR=4.34, 95%CI=1.59-11.83). The result shows 26% (Nagelkerke R² = 0.260) of respiratory health symptoms was influenced by PM₁₀ and PM_{2.5}.

Table 4.4: Association between indoor air pollutants with respiratory symptoms

Variables	Respiratory symptoms					
	OR (95%CI)					
	Cough	Phlegm	Wheezing	Chest tightness	Runny nose	Blocked nose
PM ₁₀ (>65µg/m ³)	1.87 (0.81-4.34)	0.74 (0.07-8.49)	0.36 (0.09-1.39)	0.49 (0.05-4.86)	0.93 (0.41-2.12)	0.82 (0.36-1.84)
PM _{2.5} (>40µg/m ³)	6.0 (1.30-27-65)	-	-	-	3.86 (1.38-10.82)	2.01 (0.70-5.75)
CO ₂ (>474.5ppm)	1.26 (0.44-3.63)	0.49 (0.04-5.66)	3.69 (0.45-30.00)	-	1.36 (0.51-3.67)	2.71 (0.90-8.18)
Airborne Bacterial (>313CFU/m ³)	0.77 (0.33-1.79)	0.32 (0.03-3.68)	0.14 (0.04-0.54)	0.21 (0.02-2.09)	0.36 (0.15-0.86)	0.52 (0.23-1.18)
Airborne Fungi (>206CFU/m ³)	0.20 (0.04-0.91)	-	-	-	0.25 (0.08-0.73)	0.61 (0.21-1.78)

Chi Square Test; N=100; OR= odd ratio; CI= confidence interval; OR significant if 95%CI ≥1

Table 4.5: Main Factors Influenced Respiratory Health Symptoms after Controlling all the Confounder in This Study

	B	S.E	p-value	AOR	95% CI
PM ₁₀ (µg/m ³)	1.280	0.518	0.012*	3.37	0.10-0.752
PM _{2.5} (µg/m ³)	1.467	0.512	0.004*	4.34	1.59-11.84

Adjusted factors: Socio-demographic of respondents; *Significant at $p < 0.05$; 95% CI = 95% Confidence Interval; B = Regression Coefficient; S.E = Standard Error; AOR = Adjusted Odds Ratio; Nagelkerke $R^2 = 0.260$

CHAPTER 5

DISCUSSION

5.1 Comparison of Indoor Air Quality between DCCs

All DCCs measured are in urban area with different environmental characteristics. The areas where DCCs were located and structure of building are important factors in determining IAQ (Tezara et al., 2014). Traffic and construction activities are the important sources generation of indoor and outdoor pollutions. Being located to close proximity to busy road and construction area causing rising of pollutants concentration inside the DCCs. DCC B shows the highest concentration of indoor PM_{10} ($85.92\mu\text{g}/\text{m}^3$) and $PM_{2.5}$ ($56.26\mu\text{g}/\text{m}^3$). DCC B was located less than 100m from construction area and DCC C was located less than 1km from construction area. This showing why the median concentration in DCC B are higher than DCC C. The pollutants from outside can penetrated through cracked wall, opening and closing of windows and door into DCCs indoor environment, which way the nearer DCCs with the sources of pollutants the higher concentration of pollutants indoor. This also why the median concentration of PM_{10} ($43.26\mu\text{g}/\text{m}^3$) and $PM_{2.5}$ ($36.19\mu\text{g}/\text{m}^3$) in DCC A is the lowest because it reside in the middle of residential area which away from busy road and others activities that possibly creating high pollutants concentration. DCC D and E reside on the side of roadway. DCC D has high concentration of PM_{10} ($62.63\mu\text{g}/\text{m}^3$) and $PM_{2.5}$ ($48.37\mu\text{g}/\text{m}^3$) compared to DCC E ($PM_{10}=53.24\mu\text{g}/\text{m}^3$, $PM_{2.5}=44.94\mu\text{g}/\text{m}^3$) this is because around vicinity of DCC D there is primary school

located less than 200m and row of food stalls nearby which causing the area having high traffic. This finding similar with study by Arifuddin et al. (2019) that reported high indoor concentration of PM₁₀ and PM_{2.5} in heavy traffic area school which is 84.9µg/m³ and 80.8µg/m³ respectively. Dust generated from paved or unpaved roads as outdoor sources might also contribute to high levels of indoor particulate matter (Khamal et al., 2019). Others than that, this study also suggested that high level of particulate matter inside the DCCs might influence by indoor activities (such as cleaning activities, cooking activities), shelf area and presence of curtain in study area, which were parallel with the findings by Kamarudin et al. (2017). Previous study by Rawi et al. (2015) stated that cooking activity inside the building contributed to high level PM_{2.5} since cooking can generate particles as small as <0.1µm. The cooking activities in DCCs occur thrice a day and the kitchen located near to the hall where children spent most of time there playing and resting, causing the children directly exposed to cooking smoke during the stay. Besides, the lack of proper ventilation system such as exhaust fan and kitchen hood displayed a poor environmental design that resulted in declining of indoor air quality. None of DCCs exceed acceptable limit for PM₁₀ but all DCCs exceed acceptable limit of PM_{2.5} recommended by Malaysia Ambient Air Quality (DOE, 2020). Chu & Yang (2021) state that indoor concentration of PM_{2.5} can be decreased as external wind and ventilation rate increased. The DCCs that has high air velocity is one of indicators of having good ventilation. Rawi et al. (2015) elucidate that preschool closed all the doors and windows during lessons as to keep children inside, resulting in poor ventilation. The inadequate ventilation may favor the accumulation of pollutants inside, combined with other additional indoor sources.

DCC A show the highest median concentration of CO₂ (708ppm). When compared to recommended CO₂ level by Industry Code of Practice on IAQ (DOSH, 2010) CO₂ level in all DCCs are still below the limit, 1000ppm. CO₂ level can be influenced by number of occupants inside the building. Tezara et al. (2014) states that high density population inside the building and pollution from traffic and industrial area are causing higher CO₂ level. DCC A have the highest occupants 57, which why the CO₂ level inside in DCC A is highest. A study by St-Jean et al. (2012) has reported that for each additional child on every cubic meter in room, there was an increase in CO₂ level nearly 70 ppm, higher level of CO₂ are linked to the number of children present particularly in area without mechanical ventilation system. Besides, the use of air-conditioner inside all DCCs and the door and windows always closing resulting less air exchange from the outside. Tezara et al. (2014) explains that high CO₂ and PM₁₀ concentration are indication of insufficient fresh air, which will further be interpreted as poor IAQ.

The acceptable concentrations recommended by World Health Organization (WHO) for indoor bacterial and fungal are 1000 CFU/m³ and 500 CFU/m³ respectively. The highest median concentration of indoor bacterial was recorded in DCC E, 559 CFU/m³. Meanwhile, the highest median concentration for indoor fungal was in DCC B, 350CFU/m³. DCC E has 51 occupants inside their building. Children activities such as talking, sneezing, coughing, walking, washing, and toilet flushing can generate airborne biological particulate matters (Oh et al., 2014). Thus, the more number of occupants produce high concentration of indoor bacterial. Shahida et al. (2017) stated that the microbial contaminant was associated with the particulate matter as the

microbial contaminant will attach to particulate matter and travel through the air. This can be correlate with median concentration of PM_{10} and $PM_{2.5}$ in DCC E ($PM_{10}=53.24\mu g/m^3$, $PM_{2.5}=44.94\mu g/m^3$) and DCC B ($PM_{10}=85.92\mu g/m^3$, $PM_{2.5}=56.26\mu g/m^3$) which can be consider as high due to its location. Asrul & Juliana (2017) also claims that sources of PM_{10} may promote the growth of bacterial in the air. These findings were also parallel with the study conducted by Oh et al. (2014) which had discovered that indoor total bacterial counts were depended on the concentration of indoor particles and the dynamics of the indoor environment. Hwang et al. (2017) stated that the level of bacterial showed a significant positive association with building age and area of the building and significant difference in level of fungal with water damage facilities. During measurement of IAQ we notice that DCC B and E had visible moisture problem in their ceiling. We also notice that the room that has toilet in it feel stuffy and has smelly air because there no exhaust fan installed in the toilet and making the room humidity arise. Hwang et al. (2017) explains that the level of microbial counts depend on temperature, relative humidity, air movement, number of occupants, activities inside the room and ventilation.

5.2 Prevalence Respiratory Health Symptoms among Children in Study Areas

Cough, wheezing and runny nose shows significant difference between DCCs. Staying near to main road and construction area might be related to an increase in prevalence of adverse respiratory problems. Study by Asrul & Juliana (2017) reported that respiratory health symptoms were significantly higher among children from urban area, which were 4 times likely to get cough (PR=4.34, 95%CI=2.06-9.11), 3 times

likely to get phlegm (PR=3.61, 95%CI=1.57-8.33), 2 times likely to get runny nose (PR=2.77, 95%CI=1.57-8.33) and 2 times likely to get blocked nose (PR=2.74, 95%CI=1.20-6.28). The finding by Zainudin et al. (2019) was correlate with this study, DCC D located on sideway of roadway has the highest number of children with wheezing, which based on Zainudin et al. (2019) overexposure towards road traffic and indoor pollutant exposure have contributed to a high prevalence of respiratory symptoms such as wheezing and chest tightness. The data reported that highest number of children from DCC E were having runny nose. DCC E is also located on the side of roadway. Study by Arifuddin et al. (2019) found that children in heavy traffic area had 6 times more likely to has runny nose compared to children from low traffic area. All DCCs in this study use air- conditioned. Study by Malik et al. (2020) found that children attending DCC with air conditioned and mechanical ventilation more prone to get persistent productive cough compared to natural ventilation DCC, this shows that there is correlation between type ventilation used with risk of getting cough. Thus, finding by Malik et al. (2020) parallel with this study since number of children getting cough in all DCCs were quite high. The reported data on respiratory health symptoms are aligned with previous studies that the prevalence of respiratory symptoms were generally higher among urban preschool children (Asrul & Juliana, 2017; Tezara et al., 2014; Khamal et al., 2019; Sarijuddin et al., 2017).

5.3 Association between Indoor Air Pollutants and Respiratory Health Symptoms among Children

Results from statistical analysis in this study showed significant associations between $PM_{2.5}$ with cough and runny nose. Statistical analysis also showed significant association between indoor fungal with cough. The children exposed to $PM_{2.5}$ were 6 times more likely to get cough. Study by Jalaludin & Mawar (2015) proclaimed that children exposed to elevated indoor $PM_{2.5}$ concentration had a significantly higher risk of acquiring cough and chest tightness. This study also reported that children exposed to $PM_{2.5}$ were 3 times more likely to get runny nose. Arifuddin et al. (2019) disclosed that the children in heavy traffic area are 6 times more likely to get runny nose compared to children from low traffic area. Kamarudin et al. (2017) states that living near to construction areas and road traffic might be related to an increase in getting respiratory health problems. Based on a review made by Choo et al. (2014), insufficient ventilation, improper temperature and inadequate maintenance causing deterioration of IAQ thus lead to short and long term respiratory health effects.

5.4 Factors Influenced the Respiratory Health Symptoms among Children after Controlling all Confounders

From the statistical analysis the risk of getting respiratory health symptoms were high when exposed to $PM_{2.5}$ and PM_{10} . Rawi et al. (2015) reported that living close to busy highway was associated with increased personal exposure to particulate matter in children. Housing location as well as indoor and outdoor combustion activities had cause the high level of $PM_{2.5}$ and PM_{10} inside the house (Asrul & Juliana, 2017). Khamal et al. (2019) states that motor vehicles are the primary source of particle

pollution in urban air, releasing fine primary particles. Heavy traffic and vehicle combustion of fossil fuels caused to the high concentration of particulate matter especially during early in the morning and afternoon. PM_{2.5} has a higher chance reaching the small airway and alveoli of the lungs than larger particles (Jalaludin & Mawar, 2015).



CHAPTER 6

SUMMARY

6.1. Conclusion

Total 5 day care centers was chosen to represent DCC available in Petaling Jaya, Selangor. Each selected day care centers have different environmental characteristics which influences the concentration level of pollutants indoors. The findings from this study indicated that exposure to poor indoor air quality and high levels of indoor air pollutants increased the respiratory health symptoms among children in day care centers. The occurrences of respiratory health symptoms depends on concentration level of pollutants inside the day care centers. In this study, cough, blocked nose and runny nose were reported has the high prevalence among the children in day care centers. The concentration of PM_{2.5} significantly increase the risk of getting cough and runny nose. Nonetheless, determining the exact causative agents is challenging due to various limitations in the study's design that will be discussed further in the limitations section.

Different statistical analysis was used to test the hypothesis in this and those proven to be true are as follows:

- 1) There is significant difference of indoor air quality (temperature, humidity, PM_{2.5}, PM₁₀) between day care centers.

- 2) There is significant difference of respiratory health symptoms (cough, wheezing and runny nose) among children at each day care centers.
- 3) There is a significant association between indoor air pollutants concentration ($PM_{2.5}$) and prevalence of respiratory health symptoms (cough and runny nose) among children at each day care centers.
- 4) The main factor that influence the respiratory health symptom of children at day care center after considering all confounders was $PM_{2.5}$ and PM_{10} .

6.2 Study Limitations

There are several limitations in this study, which are predominantly resulted from the design of study itself. For the nature of cross-sectional study, it was conducted in one single period which provides no signs of the series of the events occurring making causality difficult to prove because we couldn't determine whether respiratory health symptoms occurred before, during or after the onset of the exposure.

Next, even the inclusion criteria of this study was children age zero to six years olds. The submitted questionnaire was only from the children age four to six years old making this research finding cannot be used for the children age below two years old. The researcher had told the DCC management to remind the parent to fill in the questionnaire, but since this study was conducted in urban area where the parents might be too busy and forget to fill and submitting the questionnaire back.

There is possibility of recall and information bias from the parents or guardians. The questionnaire was self-reported by the respondent and different respondents may have interpreted the questions differently. Besides, the parents or guardians might not recall the accurate occurrence of actual experience of their children as they were filling in the questionnaires.

For indoor air quality assessment, there are no standards established for the indoor air quality in day care centers. This research used standard from industry code of practice (ICOP) on indoor air quality to compare the pollutants levels with acceptable limit in day care centre. However, these the recommended IAQ standard from ICOP was not suitable to be used in this study as the ICOP was used for adult in occupational setting. Indoor air quality standard established by WHO and MAAQS also may not suitable as these standard was used for outdoor pollutants in 24 hours exposure. But this study only conducted four hours IAQ exposure monitoring.

6.3 Recommendations

6.3.1 Management of Day Care Centers

It is recommended that regular housekeeping in the DCC should be done without the present of children, and it is suggested to do cleaning using microfiber mops or vacuum with clean high efficiency particulate air (HEPA) filter instead of broom to reduce exposure to the dust.

Lack of proper ventilation contributed to swift spread of communicable diseases. Frequent opening of window and the use of air purifier are suggested to lower the concentration of indoor pollutants. If the DCC are using air conditioned, the drip pans for air conditioning system should be kept clean and properly fixed to prevent leakage which can cause growth of mold. DCC management also should installed an environmental friendly mechanical kitchen ventilation such as kitchen hood or exhaust fan so that air pollutants emission from cooking activity will be transported out.

DCC management also should accommodate a proper number of children depending on the size of the rooms to avoid overcrowding. Overcrowding can increase the risks of children getting respiratory health problems. It was advisable to prevent children with any respiratory symptoms to not come to the DCC and have proper medical checkup first. So that the viruses will not further spread to others children.

Lastly, if DCC was located near to the source of pollutants the DCC management should avoid the children from spending more time outdoors.

6.3.2 Regulatory Bodies

From the observations made the sources of air pollutants in day care centers was primarily from outdoors instead of indoors. The location of DCC is an important factors that should be put into consideration as the outdoor air pollutants can enter DCC through opening of windows and doors or cracked walls. The responsible authorities can allocate a proper area to build a day care centers that away from the sources of pollutants.

Next, in an effort to reduce risk of indoor pollutants exposure to children, awareness should be raised to educate all parties about the risk of air pollutant and how to cope with it. Health Promotion Unit in District Health Office or Ministry of Health can collaborate with DCC management and communities to hold a campaign related to awareness of air pollutants, their health risk and control measures. The campaign may include activities to imitate the health effects that air pollutants could cause to human respiratory systems. Favorable attitudes on the issues could be developed among them by enlightening the entire community.

Other than that, Department of Environment may introduce standards for IAQ in day care centers, as this may help DCC management to maintain the environment in DCC within a specified limit. DOE also can come out with guidelines on IAQ in day care setting which focus more on exposure to the children.

6.3.4 Future Research

As explained in limitation sections, this study could be improved by using time series studies and analysis to be implemented to investigate IAQ condition in DCC under different climate and conditions and to identify to actual causation of children having respiratory health symptoms. Other than that, research should be conducted on larger human sample with various ethnicities and age range. The research also should include more DCC so that it can represent discuss more different environmental characteristic in study location.

Since there is no standards set for air quality in day care center in Malaysia, the researcher could come out with a guidebook that can promotes a safe air quality environments in day care centers. The guidebook may contain related information such as main issues of on indoor IAQ, air quality management plans and checklists for steps to be done in reducing impacts from exposure to poor indoor air quality.



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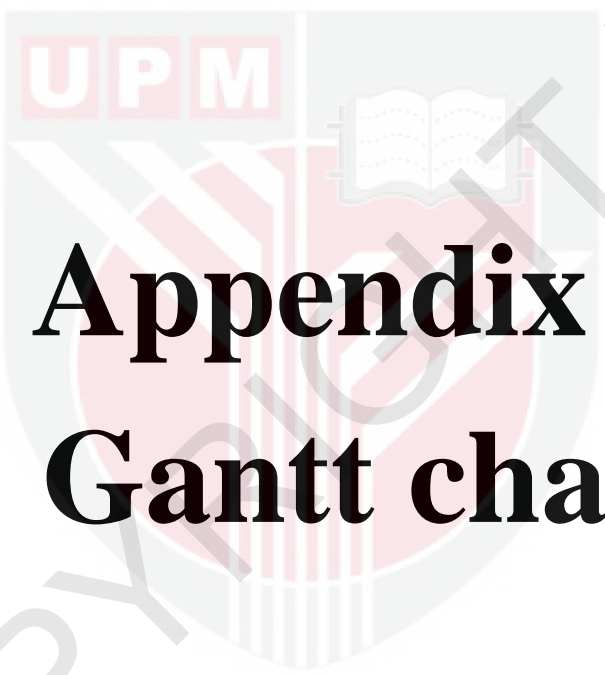
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Appendix 1
Gantt chart

Year		2021										2022
Research (Activities)		Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan
1.	Proposal Preparation											
2.	Proposal Presentation and Ethic Application											
3.	Pre-Study											
4.	Selection of day care centers											
5.	Data Collection (Questionnaire, Indoor air pollution monitoring)											
6.	Data Analysis											
7.	Thesis Writing											
8.	VIVA, Thesis Review, Thesis Submission											
Research (Milestone)		Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan
1.	Complete Proposal writing			*								
2.	Complete Presentation and Ethical Clearance				*							
3.	Complete Pre study				*							
4.	Complete Execution of Exposure to Industrial Air Pollutions and Outcomes Assessment (Questionnaire)									*		
5.	Complete Data analysis										*	
6.	Complete VIVA, Thesis review and Thesis Submission											*



Appendix 2
Ethical Approval
Letter

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

Research title	: Association Between Indoor Air Quality and Respiratory Health Symptoms Among Children at Day Care Centre In Petaling Jaya, Selangor.
Study Site	: Petaling Jaya, Selangor
JKEUPM Ref No.	: JKEUPM-2021-358
Researcher	: Siti Aiman Husna Binti Mohammed Najib
Supervisor	: Prof. Dr. Juliana Binti Jalaludin

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 14/6/2021
2. Respondent Information Sheet & Parents/Guardian Consent (Malay), Version 2 dated 27/7/2021
3. Proposal (English), Version 2 dated 10/9/2021
4. Questionnaire/Interviews (English), Version 1 dated 14/6/2021
5. Questionnaire/Interviews (Malay), Version 1 dated 14/6/2021
6. Curriculum Vitae of:
 - a. Prof. Dr. Juliana Binti Jalaludin

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 18 OCTOBER 2022**

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.
- III. Applicable for Clinical Trial Studies and Clinical interventional Studies only: Progress Report has to be submitted to JKEUPM at **every 6 months** from the date of approval (Form 3.1). Report occurrences of all Serious Adverse Events (SAEs), Suspected Unexpected Serious Adverse Reaction (SUSARs) and Protocol Deviation/ Violation at all JKEUPM approved sites to JKEUPM. SAEs are to be reported within 15 calendar days from awareness of event by



Appendix 3
Explanation Letter
and Consent Form



BORANG 2.5: PENERANGAN DAN PERSETUJUAN IBUBAPA/PENJAGA

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

1.TAJUK KAJIAN

Hubungkait antara kualiti udara dalaman dan simptom kesihatan respiratori dalam kalangan kanak-kanak di pusat asuhan harian di Petaling Jaya, Selangor.

2. PENGENALAN

Kualiti udara dalaman ialah udara dalaman yang semula jadi yang memberi kesan terhadap kesihatan penghuni bangunan tersebut (DOSH,2010). Terdapat banyak sumber pencemaran yang berlaku di dalam sesebuah bangunan. Sumber pencemaran udara dalaman terbahagi kepada dua iaitu dalaman (permaidani, perabot, mainan kanak-kanak, memasak, dan sebagainya) dan luaran (asap kereta, industri, dan sebagainya). Kanak – kanak cenderung untuk mendapat masalah respiratori kerana lebih terdedah kepada pencemaran udara dalaman jika dibandingkan dengan orang dewasa. Hal ini kerana, sistem imunisasi mereka masih belum matang, zon pernafasan mereka lebih dekat dengan tanah di mana kepekatan pencemaran lebih tinggi dan mereka masih lagi dalam proses tumbesaran yang cepat (WHO,2019). Oleh itu, kajian ini dilakukan untuk mengetahui hubungkait antara tahap pendedahan kualiti udara dalaman dan masalah kesihatan respiratori yang dihadapi oleh kanak – kanak di pusat asuhan harian, Petaling Jaya, Selangor.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Setiap kanak-kanak akan diberikan borang penerangan responden dan satu set borang soal selidik. Ibu bapa/penjaga kanak-kanak perlu menyatakan persetujuan anda untuk mengambil bahagian dalam kajian ini dengan menurunkan tandatangan di halaman 2 borang ini. Ibu bapa/ penjaga yang berminat dikehendaki untuk mengisi soal selidik serta menggenbalikan semula kepada penyelidik. Pengisian soal selidik hanya mengambil masa kira-kira 10 minit.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Kanak – kanak yang telah didiagnosis dan disahkan oleh doktor mempunyai masalah pernafasan sejak lahir.

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANAK/JAGAAN SAYA SEBAGAI PESERTA?

Kajian ini dapat memberi informasi tentang tahap kualiti dalaman di pusat asuhan harian yang akan mempengaruhi kesihatan respiratori kanak-kanak. Sekiranya tahap kualiti udara dalaman di pusat asuhan tidak memuaskan, langkah – langkah pengawalan perlu dirangka agar masalah ini dapat diatasi.

b) KEPADA PENYELIDIK?

Kajian ini dapat membantu penyelidik untuk mengenal pasti hubungkait antara tahap pendedahan kualiti udara dalaman dan masalah kesihatan respiratori yang dihadapi oleh kanak – kanak. Hasil kajian ini berpotensi menyumbang kepada langkah awal untuk mengurangkan risiko kesihatan terhadap pencemaran udara dalaman

6. ADAKAH IA BERISIKO?

Kajian ini tidak melibatkan sebarang risiko

7. ADAKAH MAKLUMAT DAN IDENTITI ANAK/JAGAAN SAYA KEKAL RAHSIA?

Segala maklumat serta identiti responden yang diberikan untuk kajian ini akan kekal sebagai sulit dan tidak akan didedahkan.

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

Sekiranya terdapat sebarang pertanyaan tentang kajian ini, sila kemukakan kemusykilan anda kepada penyelidik yang menjalankan kajian ini

Siti Aiman Husna Bt Mohammed Najib
Pelajar Sarjana Muda Sains Kesihatan Persekitaran dan Pekerjaan
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Universiti Putra Malaysia.
Email: Juliana@upm.edu.my

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

9. PERSETUJUAN

Saya..... No Kad Pengenalan.....
beralamat.....
.....dengan ini secara sukarela bersetuju membenarkan *anak / jagaan saya
..... menyertai **penyelidikan tersebut di atas *(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 yang tercatat dalam Helaian Penerangan). Saya memahami bahawa *anak / jagaan saya berhak menarik diri dari penyelidikan ini pada bila-bila masa tanpa memberi sebarang alasan. Saya juga memahami bahawa sebarang maklumat yang berkaitan identiti *anak / jagaan saya akan dirahsiakan.

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

I setuju/tidak bersetuju untuk imej/gambar/rakaman video/ rakaman suara berkaitan dengan anak/ jagaan saya digunakan dalam apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

*potong yang tidak berkenaan

Tandatangan Tandatangan
(Ibubapa/ Penjaga) (Saksi)

Tarikh : Nama :
No. K/P:

Saya mengesahkan bahawa saya telah menerangkan kepada ibubapa/penjaga responden mengenai sifat dan tujuan penyelidikan tersebut di atas.

Tarikh Tandatangan
(Penyelidik)



Appendix 4
Questionnaire

ID Responden (diisi oleh penyelidik)

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JABATAN KESIHATAN PERSEKITARAN DAN PEKERJAAN
FAKULTI PERUBATAN DAN SAINS KESIHATAN
UNIVERSITI PUTRA MALAYSIA

BORANG SOAL SELIDIK

TAJUK:

HUBUNGKAIT ANTARA KUALITI UDARA DALAMAN DAN DENGAN MASALAH
KESIHATAN RESPIRATORI PADA KALANGAN KANAK-KANAK DI PUSAT ASUHAN
KAWASAN SEKITAR PETALING JAYA

ASSOCIATION BETWEEN INDOOR AIR QUALITY (IAQ) AND RESPIRATORY SYMPTOMS
AMONG CHILDREN AT DAYCARE CENTRE, IN PETALING JAYA.

TARIKH SOAL SELIDIK DILENGKAPKAN:

		/				/				
Hari			Bulan				Tahun			

SOAL SELIDIK DILENGKAPKAN OLEH:

- 1. Ibu kanak-kanak
 - 2. Bapa kanak-kanak
 - 3. Ibu dan bapa kanak-kanak
 - 4. Penjaga kanak-kanak (lelaki)
 - 5. Penjaga kanak-kanak (perempuan)
- | |
|--|
| |
| |
| |
| |
| |

Terima kasih di atas kesudian anda untuk menyertai penyelidikan saintifik ini. Kerjasama daripada anda untuk memberikan jawapan yang jujur dan tepat adalah amat diperlukan bagi menjayakan kajian ini.

Semua maklumat yang diperolehi dalam kajian ini akan dirahsiakan dan hanyalah untuk tujuan penyelidikan kesihatan semata-mata.

SULITBORANG SOAL SELIDIKID : _____

BAHAGIAN A: BUTIRAN DIRI

1. Nama kanak kanak : _____
2. Alamat : _____
Poskod : _____ Bandar: _____
Negeri: _____
3. Jantina : 1. Lelaki 2. Perempuan
4. Tarikh Lahir : _____ (Hari/Bulan/Tahun)
5. Umur : _____
6. Sudah berapa lama tinggal di alamat sekarang : tahun bulan
7. Tahun berdaftar di sekolah ini :
8. Berat : kg Tinggi : cm
(Berat dan tinggi akan diisi oleh penyelidik)
9. Nama Ibu/Bapa/Penjaga Kanak-kanak : _____
10. No. Telefon Ibu/Bapa/Penjaga Kanak-kanak : _____ (h/p) _____ (rumah)
11. Pendidikan Bapa : 1. Tidak bersekolah 5. STPM/Diploma
2. Sekolah rendah 6. Ijazah
3. Tingkatan 3 7. Pasca siswazah
4. Tingkatan 5
12. Pendidikan Ibu : 1. Tidak bersekolah 5. STPM/Diploma
2. Sekolah rendah 6. Ijazah
3. Tingkatan 3 7. Pasca siswazah
4. Tingkatan 5

SULITBORANG SOAL SELIDIKID : _____

BAHAGIAN B: SEJARAH KESIHATAN

B1. BATUK/COUGH

1.	Adakah anak anda selalu mengalami batuk berserta selesema?		
2.	Adakah anak anda mengalami batuk sahaja tanpa selesema?		
Jika YA untuk Soalan 1 atau/dan 2			
3.	Adakah anak anda batuk pada kebanyakan hari (4 hari atau lebih dalam seminggu) selama 3 bulan berturut-turut dalam setahun?		
4.	Sudah berapa tahunkah anak anda mengalami batuk seperti ini?		tahun

B2. KAHAK/PHLEGM

		YA	TIDAK
1	Adakah anak anda kerap mengalami sesak nafas atau mengeluarkan kahak beserta selesema?		
2	Adakah anak anda mengalami batuk sahaja tanpa selesema?		
Jika YA untuk Soalan 1 atau/dan 2			
3	Adakah anak anda mengalami sesak nafas dan mengeluarkan kahak pada kebanyakan hari (4 hari atau lebih dalam seminggu) selama 3 bulan berturut-turut dalam setahun?		
4	Sudah berapa tahunkah anak anda mengalami kahak seperti ini?		tahun
5	Adakah anak anda pernah mengalami serangan batuk, sesak nafas atau berkahak dalam masa seminggu atau lebih dalam masa setahun?		
6	Jika YA (Soalan 5), sudah berapa lamakah masalah ini berlaku?		

B3. SIMPTOM-SIMPTOM HIDUNG/ NASAL SYMPTOMS

		YA	TIDAK
1	Pernahkah anda mempunyai masalah bersin, hidung berair serta tersumbat apabila anda TIDAK menghidapi selesema ataupun demam?		
2	Dalam 12 bulan yang lepas, adakah anda mempunyai masalah bersin, ataupun hidung berair atau tersumbat apabila anda TIDAK menghidapi selesema ataupun demam?		
3	Dalam 12 bulan yang lepas, pernahkah masalah hidung ini disertai dengan mata berair yang gatal?		

B4. DADA BERBUNYI/WHEEZING

1	Adakah anak anda selalu mengalami masalah pernafasan berbunyi di bahagian dada:		
	• semasa mengalami selesema?		
	• semasa tidak mengalami selesema?		
Jika YA untuk Soalan 1			
2	Sudah berapa lamakah anak anda mengalami masalah dada berbunyi ini?		tahun
3	Pernahkah anak anda mengalami serangan dada berbunyi sehingga menyebabkan dia mengalami masalah sesak nafas?		
4	Adakah anak anda pernah mengalami masalah ini setelah anak anda melakukan aktiviti seperti senaman atau latihan kecergasan?		

B5. KESAKITAN DADA/CHEST PAIN

SULITBORANG SOAL SELIDIKID : _____

		YA	TIDAK
1	Sejak 3 tahun lepas, adakah anak anda pernah mengalami kesesakan bahagian dada yang menghalang anak anda daripada melakukan aktiviti biasa selama 3 hari? Jika YA sila jawab soalan seterusnya.		
2	Adakah anak anda mengeluarkan kahak atau mengalami kesesakan nafas lain daripada keadaan biasa selain dari mengalami penyakit ini?		
3	Adakah anak anda pernah dimasukkan ke hospital kerana mengalami masalah jangkitan di dada yang serius sebelum berumur 2 tahun?		

B6. PENYAKIT-PENYAKIT LAIN/ OTHER DISEASES

		YA	TIDAK	Umur dikesan
1	Adakah doktor pernah mengatakan bahawa anak anda mengalami ekzema (gatal kulit) sebelum berumur 2 tahun?			
2	Adakah doktor pernah mengatakan anak anda menghidap asma?			
3	Adakah anak anda mempunyai penyakit-penyakit seperti di bawah? Jika YA , pada umur berapakah ia dikesan?			
		YA	TIDAK	Umur dikesan
	a) Campak			
	b) Bronkitis (Radang kerongkong)			
	c) Emfisema (Saluran pernafasan sempit)			
	d) Asma (lelah)			
	e) Pneumonia (jangkitan paru-paru)			
	f) Lain-lain			

B7. ALERGI/ALAHAN

		YA	TIDAK
1	Adakah doktor pernah mengatakan anak anda menalami alahan kepada debu?		
2	Adakah doktor pernah mengatakan bahawa kulit anak anda menalami alahan kepada detergen atau bahan kimia tertentu?		
3	Adakah anak anda mengambil suntikan untuk mengurangkan masalah alahan tersebut?		

B8. SIMPTOM –SIMPTOM KULIT

		YA	TIDAK
1.	Pernahkah anda mengalami ruam-ruam gatal yang selalu datang dan pergi pada sekurang kurangnya dalam tempoh 6 bulan?		
2.	Adakah anda mengalami ruam-ruam gatal ini pada bila-bila masa dalam 12 bulan yang lepas? Jika YA untuk Soalan 1 atau/dan 2		
3.	Adakah ruam-ruam gatal ini menyerang mana-mana bahagian ini?: belakang lutut, di hadapan pergelangan kaki, di bawah punggung, ataupun di sekeliling leher, telinga atau mata.		
4.	Pada umur berapakah ruam-ruam gatal ini mula berlaku? Bawah 2 tahun Umur 2-4 Umur 5 atau lebih		

B9. SEJARAH KESIHATAN KELUARGA

SULITBORANG SOAL SELIDIKID : _____

Adakah ahli keluarga seperti ibu bapa, adik beradik atau keluarga mengalami masalah-masalah berikut:

		YA	TIDAK
1	Bronkitis kronik		
2	Emfisema (saluran pernafasan sempit)		
3	Asma		
4	Barah paru-paru		
5	TB		
6	Batuk kronik yang berterusan (lebih dari 3 bulan)		
7	Lain-lain penyakit. Sila nyatakan : _____		

BAHAGIAN C: ZAMAN KANAK-KANAK SEBELUM MEMASUKI SEKOLAH

		YA	TIDAK
1	Adakah anak anda diberikan susu ibu ketika kecil? Jika YA, sehingga umur berapa?		
			tahun
2	Adakah sesiapa dalam keluarga yang merokok sejak anak anda lahir sehingga berumur setahun? • Baba • Ibu • Ahli keluarga lain		
3	Adakah anak anda dihantar ke tempat jagaan/nurseri? Jika YA, pada umur berapakah anak anda mula dihantar ke tempat jagaan/nurseri itu?		
			tahun

BAHAGIAN D: PERSEKITARAN RUMAH SEKARANG

- Apakah jenis rumah yang didiami sekarang?
 - Teres
 - Banglo
 - Apartmen
 - Flat
 - Kampung/Felda
 - Jenis-jenis Lain
- Jenis kawasan rumah:
 - Bandar
 - Sub-bandar
 - Luar Bandar
- Adakah anda tinggal di kediaman yang sama sejak anak anda lahir?
Jika TIDAK, pada tahun berapakah anda pindah ke kediaman sekarang? Ya Tidak
- Berapakah anggaran keluasan tempat kediaman anda? _____
- Bahan apakah yang digunakan dalam pembinaan rumah anda?
 - Batu

SULITBORANG SOAL SELIDIKID : _____

- Konkrit
- Batu-bata
- Papan
- Bahan-bahan lain: _____

6. Adakah bahagian dalam rumah anda yang dicat dalam tempoh 12 bulan lepas? Ya Tidak
7. Adakah lantai rumah anda ditukar sejak 12 bulan yang lepas? Ya Tidak
8. Adakah terdapat binatang peliharaan di dalam kediaman anda?
Jika YA, apakah binatang itu? _____
Ya Tidak
9. Adakah mana-mana yang berikut dikenal pasti berlaku di tempat kediaman anda dalam tempoh 12 bulan yang lepas?
- | | | |
|--|-----------------------------|--------------------------------|
| • Air bocor dan merosakkan dinding, lantai atau siling | Ya <input type="checkbox"/> | Tidak <input type="checkbox"/> |
| • Buih atau luntur kuning pada pelapik plastik lantai atau luntur hitam pada lantai yang berkarpet | Ya <input type="checkbox"/> | Tidak <input type="checkbox"/> |
| • Kulat tumbuh di dinding, lantai atau siling | Ya <input type="checkbox"/> | Tidak <input type="checkbox"/> |
| • Bau kulat di mana-mana bilik (kecuali di bilik bawah tanah) | Ya <input type="checkbox"/> | Tidak <input type="checkbox"/> |
| • Bau-bau lain di dalam rumah. | Ya <input type="checkbox"/> | Tidak <input type="checkbox"/> |
- Jika YA, nyatakan bau itu: _____
10. Adakah masalah kelembapan/kerusakan air berlaku di tempat kediaman anda dalam tempoh 5 tahun yang lepas? Ya Tidak
11. Adakah terdapat asap rokok di dalam rumah?
- | | |
|--|-----------------------------|
| • Ya, setiap hari | Ya <input type="checkbox"/> |
| • Ya, biasanya 1-4 kali seminggu | |
| • Ya, kadang-kadang dalam 1-3 kali sebulan | |
| • Tidak pernah | |
12. Berapakah bilangan bilik yang terdapat di dalam rumah ini? _____ bilik
13. Berapakah bilangan orang yang tinggal di dalam rumah ini? _____ orang
14. Kanak-kanak ini tidur/tinggal di dalam bilik
- | | | | |
|----------------------------|--------------------------|-----------------------------------|--------------------------|
| • Sendiri | <input type="checkbox"/> | • berkongsi dengan 2 orang | <input type="checkbox"/> |
| • berkongsi dengan 3 orang | <input type="checkbox"/> | • berkongsi dengan ≥ 4 orang | <input type="checkbox"/> |
15. Apakah bahan api yang digunakan untuk memasak di dalam rumah anda?
- | | |
|----------------|--------------------------|
| • Elektrik | <input type="checkbox"/> |
| • Minyak tanah | |
| • Kayu api | |
| • Gas | |
| • Arang | |
16. Berapa kali dalam sehari anda menggunakan bahan api di atas untuk memasak? _____ kali
17. Semasa memasak, adakah anda membuka tingkap atau pintu untuk membenarkan pengaliran udara di dalam rumah? 1. Ya 2. Tidak

SULITBORANG SOAL SELIDIKID : _____

18. Apakah alat yang digunakan untuk menyejukkan udara di dalam rumah?
- Penyeaman udara
 - Kipas
 - Lain-lain. Sila nyatakan _____
19. Adakah anda menggunakan bahan tertentu untuk mengelakkan serangan nyamuk? Ya Tidak
20. Jika YA, apakah jenis yang selalu digunakan?
- Lingkaran biasa
 - Elektrik
 - Semburan aerosol
 - Lain-lain. Nyatakan. _____
21. Berapa kerapkah anda menggunakannya dalam seminggu? _____ kali
22. Di manakah ia ditempatkan di dalam rumah?
- Ruang tamu sahaja
 - Bilik tidur
 - Bilik tidur dan ruang tamu
23. Apakah alat yang digunakan untuk membersihkan rumah anda? _____ kali
24. Berapa kerapkah anda membersihkan rumah anda dalam seminggu? _____ kali
25. Adakah anda menggunakan karpet di kediaman anda? Ya Tidak
26. Lokasi rumah dari jalan raya:
- < 100 meter dari jalan raya
 - > 100 – 500 meter dari jalan raya
 - > 500 – 1000 meter dari jalan raya
 - > 1000 meter dari jalan raya
27. Lokasi rumah dari kilang:
- < 1 kilometer dari kilang
 - > 1 – 1.5 kilometer dari kilang
 - > 1.5 – 3 kilometer dari kilang
 - > 3 kilometer dari kilang
28. Lokasi rumah dari stesen janakuasa:
- < 1 kilometer dari stesen janakuasa
 - > 1 – 1.5 kilometer dari stesen janakuasa
 - > 1.5 – 3 kilometer dari stesen janakuasa
 - > 3 kilometer dari stesen janakuasa
29. Apakah pendapat anda mengenai persekitaran di rumah anda?
- Sangat berhabuk
 - Sederhana berhabuk
 - Kurang berhabuk
30. Apakah kenderaan yang digunakan oleh anak anda untuk ke sekolah?
- Kereta
 - Bas
 - Basikal
 - Motosikal
 - Berjalan kaki

BAHAGIAN E: SIMPTOM SEMASA

Adakah anak anda mengalami simptom-simptom berikut dalam masa 3 bulan yang lepas?		Tidak pernah	Jarang sekali	Sekali seminggu	Lebih sekali seminggu
1.	Ruam di tangan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	Ruam di muka/tekak?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	Sakit kulit Jika YA, di mana? _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	Gatal-gatal di muka/tekak?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.	Gatal-gatal di tangan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6.	Radang mata (merah, kering, gatal)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7.	Bengkak kelopak mata	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.	Sakit kepala	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.	Loya	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.	Hidung berair/selesema	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11.	Hidung tersekat/tersumbat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12.	Tekak kering	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13.	Sakit tekak	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14.	Radang batuk	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15.	Susah bernafas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16.	Penat dan tak berdaya	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

1. Adakah simptom-simptom ini bertambah baik apabila anak anda balik dari sekolah? Ya Tidak Tidak Tahu
Jika YA, simptom yang mana?

2. Adakah simptom-simptom ini bertambah baik apabila berjauhan dari tempat tinggal? Ya Tidak Tidak Tahu
Jika YA, simptom yang mana?

TERIMA KASIH KERANA MELUANGKAN MASA ANDA UNTUK MENGGISI BORANG SOAL SELIDIKID INI