UNIVERSITI PUTRA MALAYSIA

***INDOOR AIR QUALITY AND ITS ASSOCIATION WITH RESPIRATORY HEALTH AMONG PRESCHOOL CHILDREN IN URBAN AND SUBURBAN AREA***

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# ABSTRACT

## INDOOR AIR QUALITY AND ITS ASSOCIATION WITH RESPIRATORY HEALTH AMONG PRESCHOOL CHILDREN IN URBAN AND SUBURBAN AREA

Asrul Bin Supu

**Background:** Indoor air quality (IAQ) has become a major concern nowadays because of the universality of exposure and its potential negative impact on human health. Among the different age groups, IAQ can affect the health of preschool children significantly because children's lungs are still growing and their immune system is not fully developed so, infections are common. **Objective:** To study the association between indoor air quality with respiratory health among preschool children in urban and suburban area. **Method:** A cross-sectional comparative study was carried out among Malay preschool children in urban (N= 60, Puchong) and suburban (N=60, Hulu Langat) areas. . Indoor air quality assessment was conducted in 12 preschools and 60 houses which include parameters of $PM_{2.5}$, $PM_{10}$, VOCs, mold, bacteria, Gram-negative bacteria, humidity, temperature and air velocity. A set of standardized questionnaire was distributed to obtain respondents' background information, exposure history and respiratory health symptoms. Spirometry test was carried out and the data obtained were analyzed to determine the lung function of the respondents **Results:** There was a significant difference between IAQ in urban and suburban preschools for all parameters measured ($p<0.05$). Level of $PM_{2.5}$, $PM_{10}$ and mold in houses shows significant difference ($p<0.05$) between the urban and suburban area. Most of the pollutants were significantly associated with respiratory health symptoms (cough, phlegm, runny nose and blocked nose). There was a significant association of level of indoor pollutants with the lung function (FVC% and $FEV_1$%) abnormalities among the respondents. Even though this study is the first to take Gram-negative bacteria as an indoor air pollutant, the finding also shows that there is a significant association between exposure of Gram-negative bacteria with lung function abnormalities and higher reported respiratory symptoms among the respondents. **Conclusion:** The finding concluded that exposures indoor air pollutants especially $PM_{2.5}$ increases the risk of getting lung function abnormality and respiratory health symptoms among respondents.



**Keywords:** Indoor air quality, $PM_{2.5}$, $PM_{10}$, VOCs, mold, bacteria, Gram-negative bacteria, lung function, respiratory health symptoms.

**ABSTRAK**

**KUALITI UDARA DALAMAN SERTA HUBUNGKAIT KEPADA KESIHATAN PERNAFASAN DALAM KALANGAN KANAK-KANAK PRASEKOLAH DI KAWASAN BANDAR DAN PINGGIR BANDAR**

Asrul Bin Supu

**Pengenalan:** Kualiti udara dalaman (KUD) telah menjadi kebimbangan utama pada masa kini kerana pendedahan yang umum dan kesan negatif yang berpotensi ke atas kesihatan manusia. Di kalangan kumpulan umur yang berbeza-beza, KUD boleh memberi kesan kepada kesihatan kanak-kanak prasekolah dengan ketara kerana paru-paru golongan ini masih sedang berkembang dan sistem imun mereka tidak kuat sepenuhnya. Oleh itu, jangkitan adalah perkara yang menjadi kebiasaan. **Objektif:** Mengkaji hubungan antara kualiti udara dalaman dengan kesihatan pernafasan dalam kalangan kanak-kanak prasekolah di kawasan bandar dan pinggir bandar. **Metodologi:** Satu kajian perbandingan keratan rentas telah dijalankan dalam kalangan kanak-kanak prasekolah Melayu di kawasan bandar (N= 60, Puchong) dan kawasan pinggir bandar (N= 60, Hulu Langat). Penilaian kualiti udara dalaman telah dijalankan pada 12 buah prasekolah dan 60 buah rumah yang merangkumi parameter $PM_{2.5}$, $PM_{10}$, VOC, kulat, bakteria, Gram -negatif bakteria, kelembapan, suhu dan halaju udara. Satu set borang soal selidik telah diedarkan untuk mendapatkan maklumat latar belakang responden, sejarah pendedahan dan gejala pernafasan yang pernah dialami. Ujian spirometri telah dijalankan dan data yang diperolehi telah dianalisis untuk menentukan fungsi paru-paru responden. **Keputusan:** Terdapat perbezaan yang signifikan di antara KUD prasekolah di kawasan bandar dan pinggir bandar untuk semua parameter yang diukur ($p<0.05$). Tahap parameter $PM_{2.5}$, $PM_{10}$ dan kulat di rumah menunjukkan perbezaan yang signifikan ($p<0.05$) di antara kawasan bandar dan pinggir bandar. Kebanyakan bahan pencemar dikaitkan dengan gejala respiratori kesihatan (batuk, kahak, hidung berair dan hidung tersumbat). Terdapat hubungan yang signifikan di antara tahap pencemar dalaman dengan ketidaknormalan fungsi paru-paru (FVC% dan $FEV_1$%) di kalangan responden. Walaupun kajian ini yang pertama untuk mengambil bakteria Gram-negatif sebagai pencemar udara dalaman, hasil kajian juga menunjukkan bahawa terdapat hubungan yang signifikan antara pendedahan bakteria Gram-negatif dengan ketidaknormalan fungsi paru-paru dan gejala pernafasan di kalangan responden. **Kesimpulan:** Hasil kajian mendapati bahawa pendedahan kepada bahan pencemar udara dalaman terutamanya $PM_{2.5}$ meningkatkan keabnormalan fungsi paru-paru dan simtom respiratori di kalangan responden.

**Kata Kunci:** Kualiti udara dalaman, $PM_{2.5}$, $PM_{10}$, VOC, kulat, bakteria, Gram-negative bacteria, fungsi paru-paru, gejala-gejala kesihatan pernafasan.

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| | |
|---|---|
| < | Less than |
| > | More than |
| $\mu g/m^3$ | Microgram per metre cube |
| $\beta$ | Regression Coefficient |
| ATS | American Thoracic Society |
| CDC | Centres for Disease Control |
| $CFU/m^3$ | Colony Forming Unit per metre cube |
| CI | Confidence Interval |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| DOSH | Department of Occupational Safety and Health |
| $FEV_1$ | Forced Expiratory Volume in 1 Second |
| FVC | Forced Vital Capacity |
| G-ve Bac | Gram-negative Bacteria |
| IAQ | Indoor Air Quality |
| IQR | Interquartile Range |
| ISAAC | International Study of Asthma and Allergies in Childhood |
| km | Kilometre |
| m | Metre |
| MAPI | Malaysian Air Pollution Index |
| MOE | Ministry of Education |
| NIOSH | National Institute of Occupational Safety and Health |
| OR | Odd Ratio |
| $PM_{2.5}$ | Particulate matter with up to 2.5 micrometres aerodynamic diameter |
| $PM_{10}$ | Particulate matter with up to 10 micrometres aerodynamic diameter |
| ppb | Parts per billion |
| ppm | Parts per million |
| POR | Prevalence Odd Ratio |

| | |
|---|---|
| PR | Prevalence Rate |
| RMAQG | Recommended Malaysian Air Quality Guideline |
| RTI | Respiratory Track Infection |
| SD | Standard Deviation |
| SE | Standard Error |
| SPSS | Statistical Package for Social Science |
| UPM | Universiti Putra Malaysia |
| USEPA | United States Environmental Protection Agency |
| VOC | Volatile Organic Compound |
| WHO | World Health Organization |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Airborne pollution has become a major concern nowadays because of the universality of exposure and its potential negative impact on human health. As the average human spend approximately 90% of their time indoors (Brasche and Bischoff, 2005), the indoor environment is highly influenced the total exposure towards air pollutants. Based on United State Environmental Protection Agency (USEPA), Indoor Air Quality (IAQ) refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. Among the different age groups, IAQ can affect the health of preschool children significantly (Institute Of Medicine, 2000). Children's lungs are still growing and they breathe differently from adults. Their immune system are not fully developed, and so infections are common (British Lung Foundation, 2014).

In Malaysia, most of the parents have sent out their children to be in the kindergarten or preschool as a preparation of early education before entering to the primary school. The Malaysian statistics on preschool education shows the existence of 15,627 preschool classes in government preschools and 17,899 in government agencies preschools and the average class ratio of 1 teacher to 24 children and a class size of 23 children (Ministry of Education, 2013). The children are enrolled in classes and spent at least half a day everyday during weekdays. Inside the classes, children can be exposed to various types of indoor pollutant including other type of illness carried and transmitted by their own classmates.

The common parameters in indoor air quality are CO, $CO_2$, VOC, PM, bacteria and fungi. CO gas is a product of incomplete combustion of carbon material such as coal, wood, tobacco, petrol and natural gas. Exposures to CO have been associated with hypoxia due to the production of carboxyhemoglobin (WHO, 2009). $CO_2$ on the other hand is one of the by-products from human during exhalation. In general, $CO_2$ measurements in school suggest a significant proportion of classroom probably do not meet the ASHRAE Standard 62-2007 for minimum ventilation, at least part of the time (Ismail et al., 2010). VOCs are organic chemicals such as benzene, xylene and toluene and are generally vaporised at room temperatures due to their low boiling point. VOCs have been reported to elicit allergic and inflammatory responses seen in asthma (Nel et al., 2001).

Particulate matter or PM is an air-suspended mixture of both solid and liquid particles that vary in number, size, shape, surface area, chemical composition, solubility and origin (Chow, 1995). The fractions of particles within an aerodynamic size range have specific relevance to inhalation, deposition, sources and toxicity. Last but not least, bacteria and fungi both are biological contaminant that can be found indoor. The risk of illness from environmental bacteria increases when these bacteria enter buildings in inappropriate numbers or multiply in indoors (Tsai et al., 2002). At the same time, indoor fungal exposure may lead to allergies such as fungal rhinitis, hypersensitivity, pneumonia and asthma (Crook & Burton, 2010).

Exposure to indoor air pollutants can give various health effects towards children such as asthma, allergies and respiratory infection. Asthma is a chronic disease characterized by recurrent attacks of breathlessness and wheezing, which vary in severity and frequency from person to person (WHO, 2012). Asthma may be broadly grouped into allergic asthma and non-allergic asthma. Some asthmatics may have both types. In Malaysia about 80 to 90% are allergic asthma mostly noted in children and young adults, and 20% are non-allergic asthma that is frequently found in middle-aged and elderly individuals (Yadav, 2009). On the other hand, indoor air pollutants also can cause allergies in children. Allergy can be defined as an inappropriate response to an innocuous foreign substance (Janeway et al, 2001). In Malaysia, it is estimated that one out of three Malaysians is currently suffering from some form of allergy (Malaysian Society of Allergy and Immunology, 2007). As 60% of all allergies appear during the first year of life (Liptay et al, 1992), it is only logical for allergy prevention to be focused on infants and young children. In fact, it is estimated that 35% of children are affected by allergy (Beasley et al, 1998).

Last but not least, exposure to indoor air pollutants can cause respiratory health infection which is the major concern in IAQ. Based on National Health Services, respiratory tract infections (RTIs) are any infection of the sinuses, throat, airways or lungs. Children tend to get more upper RTIs than adults because they haven't built up immunity to the many viruses that can cause these infections.

## 1.2 Problem Statement

Poor indoor air quality can result in significant adverse impacts on human health and the environment. In recent years, comparative risk studies performed by the USEPA and its Science Advisory Board have consistently ranked indoor air pollution among the top five environmental risks to public health (USEPA, 1993). As children spend time indoor more than an adult, their health would directly be affected.

Poor indoor air quality also can affect children's growth. When babies were born, their lung is not fully developed. Lung growth continues after birth as alveolar number continues to increase. 80% of the alveoli being formed after birth (Johnson et al., 1978). For these reasons, air pollutants affect growing children more than healthy adults.

As mention earlier, the prevalence of respiratory illness such as asthma, allergy and respiratory infection among children is also high and increases by day. Because of that, monitoring and study of asthma and allergy have been established around the globe. A project called the International Study on Asthma and Allergy in Childhood or ISAAC study developed a standardized case definition, questionnaire and methodology, and established databases for asthma and allergy in various research centers worldwide. The information gathered in the ISAAC database enabled spatial and temporal comparisons of asthma and allergy prevalence among 6-7 and 13-14 year old children. In Malaysia, most recent studies have found that the structural and environmental characteristics of buildings significantly affect the occurrence of allergies, acute exacerbations of asthma, and non-specific respiratory symptoms among occupants (Marzuki et al., 2010; Salleh et al., 2013; Yahaya et al., 2014; Ayuni et al., 2014; Nurul Anis et al., 2013; Ithnin et al.,2013). Therefore, it is important to constantly assess the indoor environmental quality, especially in preschools or schools setting so that, exposure to indoor air pollutants among our children could be monitored and further action can be applied to reduce the health risk.

Besides that, Malaysia is a tropical country with a hot and humid weather throughout the year. This is the most favorable condition for the microbiological organism to grow. Therefore, research on biological pollutants such as mold and bacteria need to be taken into consideration because there is still lack of studies regarding of these types of pollutants in Malaysia even though they also possess health risks in human, especially among the young children.

Last but not least, bacteria are divided into two categories which are Gram-positive bacteria and Gram-negative bacteria. Gram-negative bacteria have become a major concerned now because of their ability to produce lethal toxins called endotoxin. The inhaled endotoxin has been associated with many pulmonary diseases. More than 10 $ng/m^3$ of endotoxin can cause airway inflammation, 100

$ng/m^3$ gives systemic effects and 200 $ng/m^3$ shows toxic pneumonitis (Rylander, 1997). Although a proposed guideline for airborne endotoxin is available in the western country, but there is still no guideline for the Gram-negative bacteria; which is the agent that produce it.

## 1.3 Study Justification

The purpose of this study is to determine the association between indoor air quality with respiratory health among preschool children in urban and suburban area. This study will add to knowledge and benefits to the topic.

Other than that, there is less study that had been carried out among the study population which is preschool children. By using preschool children as the respondents, lot of confounders can be controlled. One of them is smoking. Preschool children are non-smoker, as smoking can be related to a lot of diseases, having entirely non smoker respondents could be an advantage. Other than that, preschool children also not exposed to occupational environment as they spent most of the time in home or school. So, the pinpoint of indoor air pollutant exposure will be directed to either home or school. Besides that, preschool children are also very sensitive towards air pollutant. They are in the phase of developing their own immune system against the agent that resulted in adverse health effect.

On the other side, this study also hopefully will give benefit to regulatory bodies. It can be used to identify strategies or intervention by health care professionals for improving the quality and overall health safety of the childcare center, kindergarten or school. The exposure of Gram-negative bacteria from this research can be used as a baseline data for future research as this is the first study to take Gram-negative bacteria as an indoor air pollutant.

## 1.4 Conceptual Framework

The aim of this study is to determine the association between indoor air quality and the respiratory health among preschool children in Puchong and Hulu Langat, Selangor. From the conceptual framework (Figure 1), the studied pollutants are $PM_{2.5}$, $PM_{10}$, VOCs, mold, total bacteria and Gram-negative bacteria. Exposure to these pollutants is from preschool and the house. There are three main routes of exposure which are; ingestion, inhalation and direct contact. The exposure from inhalation is being highlighted because it is the main route for air pollutants and will give adverse health effect to children's respiratory system.

This research has focused on the effect of pollutant to the preschool children's' respiratory health, where the exposure level of pollutant through inhalation during school time will be measured by the suitable instruments. The respiratory health will be assessed and determined by using lung function test and modified questionnaire for respiratory health symptoms such as flu, wheeze, cough, sore throat and allergy.

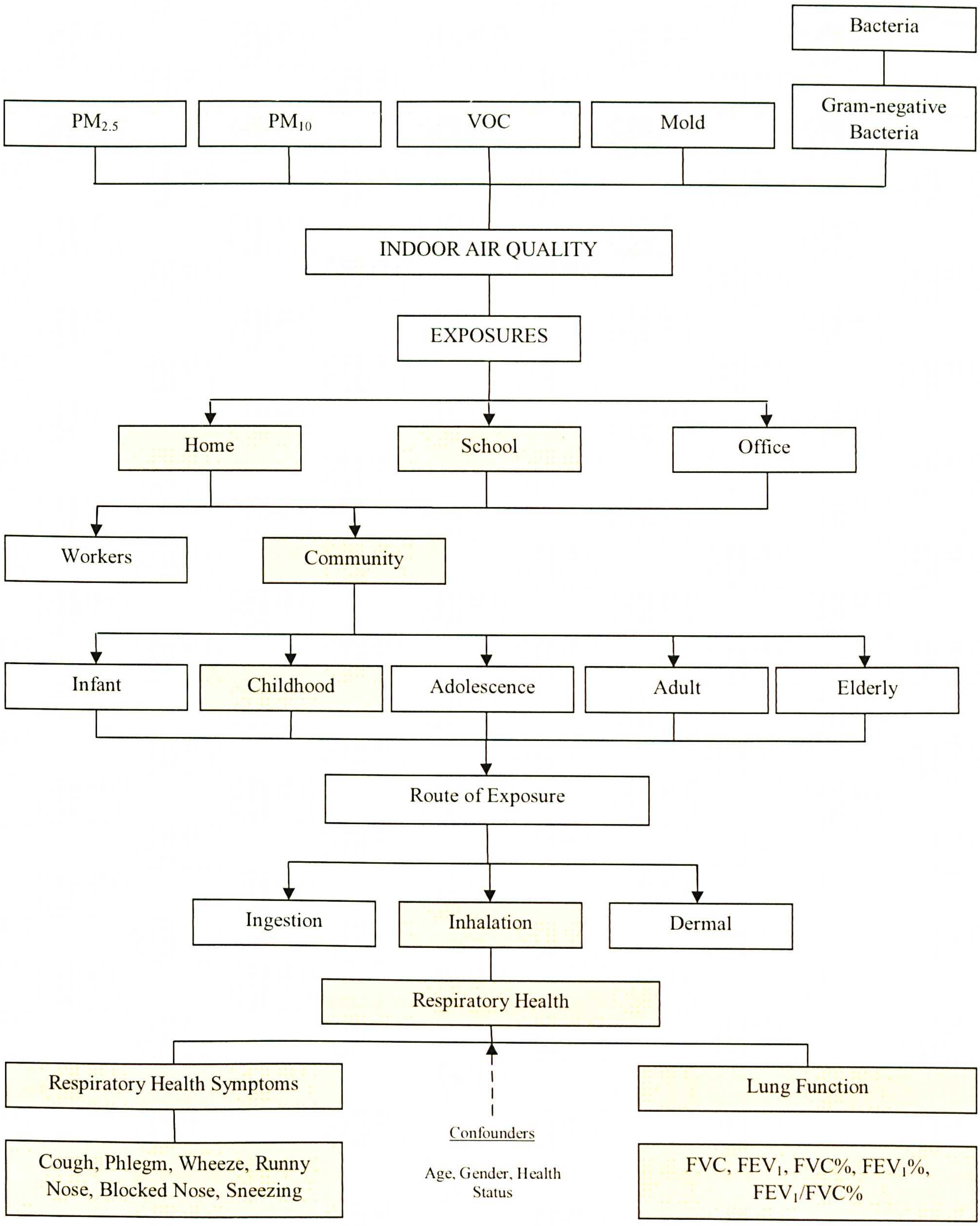
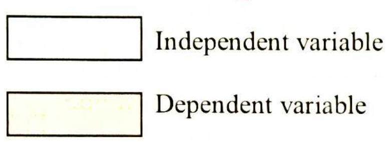



**Figure 1: Conceptual Framework of research activities.**



## 1.5 Study Objective

### 1.5.1 General Objective

To study the association between indoor air quality with respiratory health among preschool children in urban and suburban area.

### 1.5.2 Specific Objective

1. To determine the socio demographic data of preschool children.
2. To compare the level of indoor air pollutants between study and comparative group of preschool children.
3. To compare the respiratory health symptoms between study and comparative group of preschool children.
4. To compare the lung function between study and comparative group of preschool children.
5. To determine the association between level of indoor air pollutants in preschool and residential with respiratory health symptoms among preschool children.
6. To determine the association between levels of indoor air pollutants in preschool and residential with lung function among preschool children.

## 1.6 Study Hypothesis

1. The exposures of indoor air pollutants are significantly higher in the study group compare to the comparative group of preschool children.
2. The respiratory health symptoms are significantly higher in the study group compared to the comparative group of preschool children.
3. There is a significant different between lung function between the study and comparative groups of preschool children.
4. There is a significant association between exposures of indoor air pollutants in preschools and residential with respiratory health symptoms among preschool children.
5. There is a significant association between exposures of indoor air pollutants in preschools and residential with lung function abnormalities among preschool children.

## 1.7 Definition of Variables

### 1.7.1 Conceptual Definition

**Indoor Air Quality**

Indoor Air Quality (IAQ) refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants (EPA, 2015). Indoor air quality is assessed by measuring the pollutant inside a building. Common indoor air pollutant in all regions of the world includes benzene, CO, formaldehyde, naphthalene, nitrogen dioxide, PAH, radon, trichloroethylene and tetrachloroethylene (WHO, 2010).

### Gram-negative Bacteria

Gram-negative bacteria are a group of bacteria that do not retain the crystal violet stain used in the Gram staining method of bacterial differentiation (Baron et al., 1996). As endotoxin is a component of the outer membrane of Gram-negative bacteria, inhalation of airborne endotoxin or its pure form, lipopolysaccharide, in low doses has been related to acute and chronic inflammation, fever malaise, dysfunction and lung malfunction (ACGIH, 1999).

### Respiratory Health Symptom

The respiratory system is a biological system consisting of specific organs and structures used for the process of respiration in an organism. The respiratory system is involved in the intake and exchange of oxygen and carbon dioxide between an organism and the environment. Respiratory health is when this system works with its normal function (Maton et al., 2010). Symptoms of respiratory illness commonly include cough, sore throat, runny nose, nasal congestion, headache, low grade fever, facial pressure and sneezing. The onset of symptoms usually begins 1 to 3 days after exposure. The illness usually lasts 7 to 10 days (Eccles et al., 2007).

**Forced Expiratory Volume in 1 Second ($FEV_1$)**

The $FEV_1$ is the maximum volume of air exhaled in the first second of a forced expiration from the position of full inspiration, expressed in liters of body temperature and ambient pressure saturated with water vapor (ATS, 2005).

**Forced Vital Capacity (FVC)**

The FVC refers to the maximum volume of air exhaled with maximally forced effort from a maximum expiration, expressed in liters at body temperature and ambient pressure saturated with water vapor (ATS, 2005).

### 1.7.2 Operational Definition

**Indoor Air Quality**

In this study, indoor air quality is assessed by measuring the indoor air pollutant in the studied preschool including temperature and humidity. Indoor air pollutants that will be studied are $PM_{2.5}$, $PM_{10}$, TVOC, mold and bacteria. These pollutants are measured by using respective suitable indoor air quality instrument.

**Gram-negative Bacteria**

Gram-negative bacteria are one of the additional pollutants that being studied in this research. This type of bacteria is isolated on MacConkey agar, a type of selective and differential culture medium designed to selectively isolate Gram-negative bacteria. The sample is taken by using DUO SAS 360 instrument.

**Respiratory Health Symptom**

Respiratory health is the dependent variable in this study and will be presented with respiratory health symptoms and also lung function. The data is taken by using a modified questionnaire from The International Study of Asthma and Allergies in Childhood (ISAAC) based on related symptoms that appear in preschool children for the past two weeks history and also by using lung function test.

**$FEV_1$ %**

The value of $FEV_1$ % is calculated by dividing the measured $FEV_1$ value (obtained from the spirogram) with its normal value (derived from standard equation) and then multiplies it with 100.

**FVC %**

The value of FVC % is calculated by dividing the measured $FEV_1$ value (obtained from the spirogram) with its normal value (derived from standard equation) and then multiplies it with 100.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Exposure of Indoor Air Pollutant and Its Effect among Children

Indoor Air Quality (IAQ) refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants (EPA, 2015). School provides a major indoor environment for children away from their home as they may spend 10 hours per day at school (Zhang et al., 2006). As general, the IAQ in schools is characterized by complexity of various pollutants such as VOC, particulate matter, aldehydes, bacteria and moulds (Madureira et al., 2012) to the health and comfort of building occupants. Understanding and controlling common pollutants indoors can help reduce human risk of indoor health concerns. Health effects from indoor air pollutants may be experienced soon after exposure or, possibly years later.

Particles behavior for each indoor pollutant depends on its size. Larger particles can rapidly settle down compared to smaller particles where they remain as airborne for a long period of time in the atmosphere (Oberdorster et al., 2004). Many studies have reported the levels of particle number and mass concentration in different microenvironments such as residential homes, schools and workplaces. A comprehensive risk assessment study of the global burden of disease (GBD) in 2010, ranked ambient particle pollution as the $9^{th}$ risk factor by the attributable burden of disease (Lim et al., 2012).

One extensive study of indoor air quality among preschool children in Singapore found that, in air-conditioned and ACMV (air-conditioned and mechanically ventilated) children care centers (CCC), the lower ventilation rates resulted in the increase in the concentration levels of indoor generated pollutants but lower ingress of outdoor pollutants (Zuraimi, 2007). In Malaysia, the largest study of Malaysian children's exposure to indoor air pollution and respiratory health consisting 2,164 school children from Kuala Lumpur and Negeri Sembilan found that, the WHO 2005 Air Quality Guideline for $PM_{2.5}$ (25 $\mu$g/m3 for 24-hour exposure) was exceeded for most of the semi-rural schools while almost all of the urban schools exceeded the annual exposure limit for $NO_2$ (40 $\mu$g/m3) (Zainal Abidin, 2008).

Common indoor air contaminants and its sources include: VOC that emitted by building, furniture materials, cleaning solvents and tobacco smoke; microorganism that associated with improperly maintained ventilating and wetted building materials; CO and particulates generated by both inside and outside sources or combustion; and also radon from natural decay of uranium in soil (WHO, 2010).

Indoor air pollutants can cause or contribute to short term and long term health problems (Annesi-Maesano et al., 2013). According to Global Health Risk, mortality and burden of disease attributable to selected major risks indoor air pollution are responsible for 2.7% of the global burden of disease. However, in high mortality developing countries, 3.7% of disease burden are due to indoor air pollution. In 2000, indoor air pollution risk factor was responsible for more than 1.5 million deaths after malnutrition, HIV/AIDS, lack of safe water and poor sanitation (WHO, 2009).

Exposure of indoor allergen such as dust mite and cat allergens among children can cause severity in asthma and allergy (Gent et al, 2009). Asthma and allergy are two of the most prevalent diseases in children (Pearce et al., 2000). Meanwhile, exposures of PM, VOCs and CO were associated with increasing risk of getting lung function abnormality and respiratory problems among preschool children (Azwani et al, 2014). Moreover, indoor air pollutant can provoke discomfort and reduce school attendance and productivity (Mendell and Heath, 2005).

## 2.2 Children as a Susceptible Population

Children's exposures to air pollutants are of particular concern for several reasons. Compared to adults, young children have a higher resting metabolic rate. Rate of $O_2$ consumption per unit body weight is also high due to their larger surface area per unit body weight and because of that, they breathe in relatively greater air volume than adults (Bearer, 1995 and WHO, 2005).

Moreover, children's airways are also narrower, thus irritation caused by air pollutants that would produce only a slight response in an adult can result in a potentially significant obstruction in the airways of a young child. Furthermore, there is a considerable growth of children's lungs after birth which continues well into adolescence. There is about a 23-fold increase in lung volume from birth (150-200 ml) to adulthood (5,000 ml) translating into a comparable increase in the absorptive surface area (Selevan et al., 2000) with 80% of the alveoli being formed after birth (Johnson et al., 1978).

Furthermore, children spend up to 80% of their time indoors and therefore also highly exposed to indoor air contaminants. Their breathing zone is lower than adults so they are more exposed to heavier pollutants that concentrate at lower levels in the air such as $PM_{10}$ and VOC (Maduirera et al., 2015).

## 2.3 Gram-negative Bacteria as an Indoor Air Pollutant

Developed in the 1800s by Hans Christian Gram, the Gram staining is a method for classifying different types of bacteria using a chemical stain and viewing through a microscope the results on the bacteria's protective cell wall. Most bacteria are classified into two groups: Gram-positive or Gram-negative; depending on whether they retain a specific stain color. Gram-positive bacteria retain a purple-colored stain, while Gram-negative bacteria appear pinkish or red (NIAID, 2012).

Gram-negative bacteria are the specific type of bacteria in biological pollutants and should be considered as well in IAQ assessment because first of all, many Gram-negative bacteria is in the range of size 1-5 $\mu$m and allow deepest penetration into human lungs (Hood, 1990). The size is literally half of the size of $PM_{10}$ and with the known of its serious respiratory health effect, imagines how alive pollutants with the size smaller than $PM_{10}$ could do to human lungs. Moreover, Gram-negative bacteria survive best in the moist environment and are more readily transferred via damp than dry surfaces (Gould and Chamberlain, 1994). Preschools with high indoor humidity will become the reservoir for these Gram-negative bacteria and will eventually affect the preschool children. Other than that, *Legionella. pneumophila* that can cause Legionellosis is a Gram-negative bacterium. Most people with Legionellosis will have pneumonia since the Legionella bacteria grow and thrive in the lungs (CDC, 2015).

Gram-negative bacteria have a small peptidoglycan layer but have an additional membrane, the outer cytoplasmic membrane. This creates an additional permeability barrier and results in the need for transport mechanisms across this membrane. A major component of the cytoplasmic membrane that is unique to Gram negatives is endotoxin. This component is essential for bacterial survival. Endotoxin is responsible for sepsis which may be fatal. Sepsis is characterized clinically by confusion, fever, drop in blood pressure and ultimately multi-organ failure (Lowy, 2011)

Endotoxin is also fever causing and has many pathophysiological effects associated with Gram-negative bacterial infection and bacteremia (gehring, 2001). Response to endotoxin exposure varies with dose, site, route and rapidity of release into the blood system. The inhaled endotoxin has been associated with many pulmonary diseases (Yang, 2003). Endotoxin has been thought to be responsible for the adverse health effects after inhalation of organic dust. Some inhalation studies showed that endotoxin can cause fever, cough, dyspnea, headache, nose and throat irritation, diffuse aches, nausea, shortness of breath, chest tightness, acute air flow obstruction and airway inflammation. The endotoxin exposure may also result in low lung function (Rylander, 1994 & 1997).

Furthermore, endotoxin release may trigger a number of local and systemic reactions. It only takes 100 ng of purified endotoxin to prompt fever in human being; doses of several milligrams can lead to death (Metzger et al., 2002). In the home environment, higher house-dust endotoxin level has been found to correlate with increased medication used and greater airflow obstruction in asthmatic adults, in children both with and without asthma and even with an infant wheezing in the first year of life (Douwes et al., 2000; Park et al., 2001; Gehring et al.,2001).

One longitudinal analysis about wheezing among young children due to exposure to house dust endotoxin (HDE) stated that; exposure to high concentrations of HDE of greater than the median level (81.3 EU/mg) was associated with an increased risk for wheezing over the period of observation (multivariate relative risk, 1.52; 95% CI, 1.07-2.14), but this risk rapidly decreased over time (p= 0.005)

(Litonjua, 2002). From this study, endotoxin can be seen to give acute effect to children.

Besides that, a cohort study among 881 infants conducted in New Zealand has found that; wheezing was significantly associated with higher endotoxin levels (odds ratio [OR], 1.54; 95% CI, 1.03-2.30), particularly among infants with a parental history of allergic disease (OR, 1.67; 95% CI, 1.07-2.60). Higher endotoxin concentrations were also strongly associated with recurrent itchy rashes (OR, 1.87; 95% CI, 1.14-3.05), particularly among infants who were atopic (OR, 4.64; 95% CI, 1.56-13.77) or had a parental history of allergic disease (OR, 2.10; 95% CI, 1.22-3.61) (Gillespie et al., 2006).

For lung function, a case-control study conducted among children and adolescent in Humboldt, Saskatchewan (rural area) shows that lower forced expiratory volume in 1 s ($FEV_1$) was associated with higher mattress endotoxin load among female cases. There was a trend toward lower forced vital capacity (FVC), which was associated with higher play area endotoxin load among cases with high tobacco smoke exposure (Lawson et al., 2011). On the other hand, a study in 15 and 10 Spanish, Dutch and Finnish primary schools with and without moisture, dampness and visible mold respectively show that, $FEV_1$ and $FEF_{25\text{-}75\%}$ tended to be higher in children attending damaged schools or classrooms with higher endotoxin levels. $FEV_1$ was 39 (95%CI 5-72) ml higher in Dutch children attending damaged schools and in Finland, $FEV_1$ significantly increased with increasing endotoxin exposure. In

Spain, $FEF_{25-75\%}$ tended to be somewhat lower, but not statistically significant, in relation to school moisture status and increased endotoxin levels (Jacobs et al., 2012).

Last but not least, endotoxin not only can affect children but also an adult. Cyprowski et al., (2015) in their study among sewage workers have stated that, despite low levels of endotoxin, it had significant impact on the observed across-shift decline in $FEV_1$ among the respondents. Even in the low level of endotoxin exposure can affect healthy workers, imagine what it will cause towards physically developed children.

## 2.4 Respiratory Health Symptoms

Indoor air quality in schools can have a substantial impact on children's health, as an important environment where children may be exposed to pollutants and allergens (Zhang et al., 2006). A study from Portugal among 1134 school children stated that high levels of total VOC, acetaldehyde, $PM_{2.5}$ and $PM_{10}$ were associated with higher odds of wheezing in respondents. Thus, indoor air pollutants, some even at low exposure levels, were related to the development of respiratory symptoms (Maduirera et al., 2015).

Dampness in home, school or workplace can contribute to high mold and bacteria growth. For particular interest, asthma and allergies have been reported to be associated with different indicators of residential dampness in preschool children (IOM, 2004). For asthma, in a cross-sectional study involving 2568 Finnish preschool children, Jaakkola et al (2005) documented higher prevalence odds of persistent wheeze (POR: 2.6; 95% CI: 1.4-4.9), current asthma (POR: 1.1; 95% CI: 0.5-2.2) and nasal congestion (OR: 2.4; 95% CI: 1.2-5.0) for children exposed to dampness.

Using a case-control study in Singapore, child care attendance was associated with wheeze at night, wheeze on waking, longer time since first ever asthma and higher mean coughs at night (Connett et al., 1994). One study in Selangor by Azwani et al., (2014) has found that, PM and CO levels were significantly higher in studied preschools compared to the comparative preschools. Exposure to these pollutants was significantly associated with wheezing and lower lung function among the respondents.

## 2.5 Mechanism of How Particulate Material Deposited in Human Body

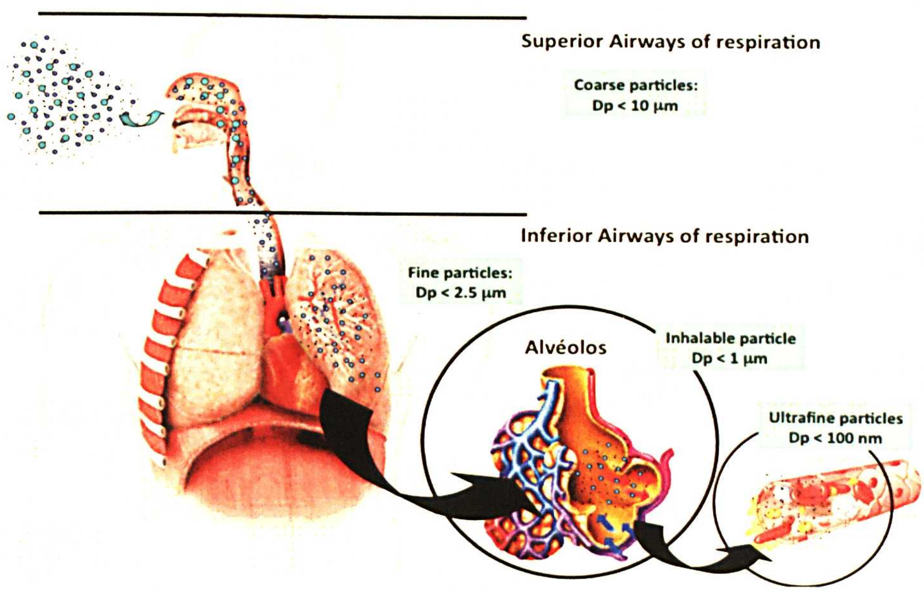



**Figure 2: Mechanism of Particulate Material in Human Body**

**(Source: http://www.intechopen.com/)**

Exposure to particulate material can affect human heart and lungs, especially the fine particles which contained microscopic solids or liquid droplets that are so small that they can get deep into the lungs and cause serious health problems (EPA, 2002). EPA is concerned about particles that are 10 micrometers in diameter or smaller ($PM_{10}$) because those are the particles that can pass through the human throat and nose. Once it passes through, these particles affect the heart and lungs and can cause serious health effects.

EPA groups classified particle pollution into two categories which are; coarse particles and fine particles. The coarse particle is particle with size larger than 2.5 micrometers diameter whereas fine particle is a particle with size smaller than 10 micrometers in diameter. These particles will deposit into head region of the airway when inhaled. The fine particles on the other hand, will deposit further into the tracheobronchial region (Lilian and Aline, 2013).

However, researchers consider two other categories as well named inhalable particles and ultrafine particles. Inhalable particles are smaller than 1 $\mu$m, these particles can deposit into the pulmonary alveoli. Ultrafine particles on the other side are 100 nanometers in diameter and smaller. They comprise a high concentration of organic compounds in their composition and can be deposited in the alveolar region and also get into the bloodstream (Lilian and Aline, 2013).

## 2.6 Pathogenesis of Bacteria in Lower Respiratory Tract

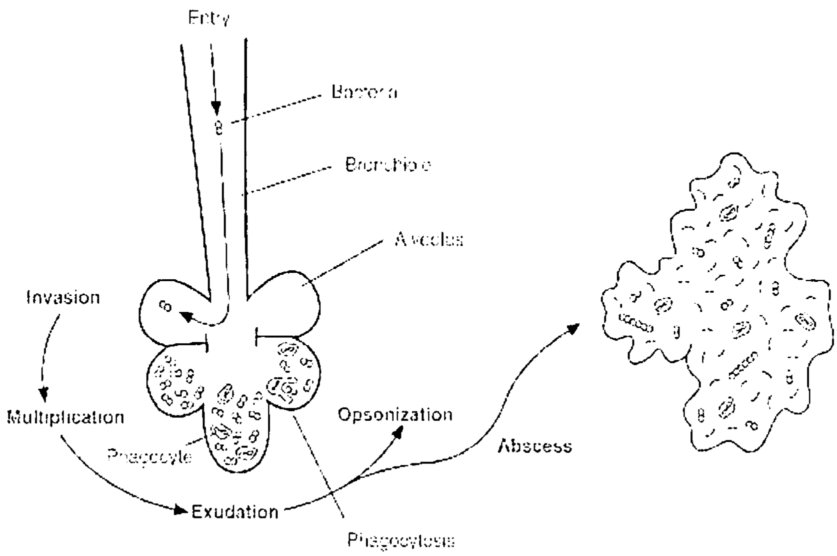



**Figure 3: Pathogenesis of Bacteria in Alveolus**

**(Source: http://slideplayer.com/slide/4636240/)**

Indoor bacteria such as *Legionella pneumophila* can cause pneumonia in human. Pneumonia is a common lung infection caused by bacteria, a virus or fungi. Its symptoms can vary from mild to severe (American Lung Association, 2016). There are six stages of pathogenesis of bacterial pneumonia which are entry, invasion, multiplication, exudation, opsonization and resolution or abscess formation.

In the first stage, bacteria that escape from upper respiratory tract defense mechanism travel into alveoli. After that, bacteria invade the alveolus and start to duplicate itself in the invasion and multiplication stage. In exudation stage, fluid that contains phagocyte will be released as a natural human defense mechanism. Phagocyte starts to engulf the bacteria and coated it with immunoglobulin in opsonization stage. Finally, the dead bacteria and phagocyte will be cleared or remain as an abscess. Excess abscess however, can lead to pneumonia (Martin, 1991).

# CHAPTER 3

# METHODOLOGY

## 3.1 Study Design

This research was a cross sectional comparative study design to determine the association of indoor air quality with respiratory health among preschool children in urban and suburban area.

## 3.2 Study Location

Six preschools were chosen from Puchong representing urban area and another six from Hulu Langat representing suburban area. These preschools were selected randomly after carrying out site survey studies.

## 3.3 Sampling

### 3.3.1 Sample Population

A total of 120 preschool children aged 5 to 6 years old from preschools in Puchong as study area and Hulu Langat as the comparative area were included in this study. From that, both male and female students were selected. Only Malay preschool children were included in this study to homogenize the sample and to avoid genetic as a confounding factor.

### 3.3.2 Sampling Frame

Sampling frame includes all boys and girls students registered at selected preschool in Puchong and Hulu Langat with their parents' consent to participate in the study. All respondents were 5 to 6 years old. List of registered students is obtained from the teachers of respective preschool.

### 3.3.3 Study Sample

In this study, 60 preschool children were selected in six preschools from urban area while another 60 from preschool that represent suburban area. The total number of study sample is 120 respondents.

### 3.3.4 Sample Size Calculation

The objective of the study is to estimate the mean difference of respiratory health symptoms and lung function from exposure of indoor air pollutants in preschool at two different areas. The symptom in the study is coughing among children and the estimation is calculated with a reasonable level of precision. It is confident that 95 % of the case sample estimates will fall within 1.96 standard errors ($Z_{1-\alpha/2}$) of the specified population value, if it is true value. Therefore, the sample size calculation is based on Lemeshow et. al. (1990) formula for group comparison study using the combined (or pooled) standard deviation for the two groups as follows:

Formula,

$$n = \frac{2 \; X \; 2 \; \delta^2 [Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}]^2}{(\mu 1 - \mu 2)^2}$$

Where,

$2\,\sigma^2$ = Estimated standard deviation (assumed to be equal to each group)

$\mu 1$= Estimated mean (larger)

$\mu 2$= Estimated mean (smaller)

$Z_{1-\frac{\alpha}{2}}$ = Standard error associated with confident interval, 95% CI=1.96

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

Prevalence of reported coughing among study group:

$$n = \frac{4(0.402)^2[1.96 + 0.84]^2}{(0.34\text{-}0.022)^2}$$

n = 50 (Andrew and Juliana, 2015)

Based on the formula, 50 respondents are needed for each study area. Thus, the total number of respondents is 100. The number is increased by 20% for the strength of analysis of the study and to take account for non-responsive respondents, missing data and errors. Overall, the total number of samples that should include in this study is 120 samples.

### 3.3.5 Sampling Method

This study applies a stratified random sampling method. The chosen preschools were randomly selected from the list. Then all students in the selected preschool were recruited based on willingness to participate after parents' approval and after taking consideration of inclusive and exclusive criteria. Incomplete questionnaires and children without parents' approval will be excluded.

### 3.3.6 Inclusive and Exclusive Criteria

**Inclusive Criteria:**

1. Preschool children
    - Boys and girls
    - Registered in the studied preschool
2. Malay ethnic
    - To homogenized the respondents so that no confounding by genetic factors which may influence the validity of results.
3. Free from respiratory illnesses
    - No history of diagnosed respiratory illnesses to ensure the results are based on studied exposure and not influenced by medical history status.

**Exclusive Criteria:**

1. Respondents other than Malay ethnic.
2. Respondents with history of diagnosed respiratory illnesses.

### 3.4 Study Instrumentation

#### 3.4.1 Questionnaire

This study used modified questionnaire based on two internationally standardized and recognized questionnaires which are questionnaire set by the American Thoracic Society (ATS) and also questionnaire on asthma, allergies and respiratory symptoms from the International Study of Asthma and Allergies in Childhood (ISAAC) study. The ATS questionnaire is used to obtain data on demographic and socioeconomic background of the respondents as well as data on school and home environment with the respondents' respiratory health. On the other hand, ISAAC questionnaire will be used to gather data on the respondents' recurrent respiratory symptoms.

#### 3.4.2 Indoor Air Quality (IAQ) Assessment

This IAQ assessment was conducted to measure the quality of air and presence of indoor pollutants in preschool indoor environment. The parameters that being measured in this study were $PM_{2.5}$, $PM_{10}$, VOC, mold and bacteria. As general, all these parameters were taken at 0.6 to 1.0 meter above the floor to represent the breathing zone level of the preschool children and also more than 1 meter from the wall, door and any active heating system.

Number of sampling point was 1 for each classroom plus one point from outdoor. The instruments were placed at a location that the children spent time the most and assuming even distribution of pollutants. The measurement will be taken every one hour from 8.00 am till 12.00 pm except for mold and bacteria.

### Measurement of $PM_{2.5}$ and $PM_{10}$

DustTrak™ DRX Aerosol Monitor 8534 (Figure 4) was used to measure $PM_{2.5}$ and $PM_{10}$ in the preschool. This device is a handheld battery-operated, data-logging, light-scattering laser photometer that gives real-time aerosol mass readings. It uses a sheath air system that isolates the aerosols in the optics clean for improved reliability and low maintenance. It is suitable for clean office settings as well as harsh industrial workplaces, construction and environmental sites, and other outdoor applications. The DustTrak™ DRX Aerosol Monitor 8534 measures aerosol contaminants such as dust, smoke, fumes and mists corresponding to $PM_1$, $PM_{2.5}$, Respirable or $PM_{10}$ size fraction with a concentration range from 0.001 to 150 $mg/m^3$.

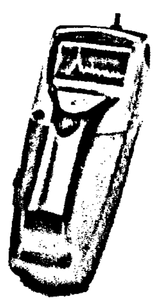


**Figure 4: DustTrak™ DRX Aerosol Monitor 8534**

**(Source: TSI Website)**

### Measurement of Temperature and Humidity

TSI Q-Trak™ Indoor Air Quality Monitor 7575 (Figure 5) was used to measure temperature and humidity in the ambient indoor air.

**Figure 5: TSI Q-Trak™ Indoor Air Quality Monitor 7575**

**(Source: TSI Website)**

### Measurement of VOC

PpbRAE parts per billion Volatile Organic Compound (VOC) Monitor model PGM-7240 (Figure 6) was used to measure VOC in the study area. This instrument is an extremely sensitive Photo-ionization Detector (PID) for real time monitoring of volatile organic compounds (VOCs) at ppb levels. With its highly compact design, it is used as a broad VOC gas monitor and data logger for work in hazardous environments. The new RAE patented PID sensor has an increased sensitivity down to a few ppb, with reduced humidity interference, improve linearity and an easily accessible lamp and sensor. The device is capable of measuring VOCs concentration ranging from 1 part per billion (ppb) up to 10 000 part per million (ppm).

**Figure 6: ppbRAE**

**(Source: RAE System Website)**

**Assessment of Fungi and Bacteria**

Pbi DuoSAS Super 360 (Figure 7) was used to drawn air from the study area onto culture agar to get the bacteria and fungi. This device is a twinhead surface air sampler for simultaneous sampling or can also be used for one type of sampling at one time. Using the principle of surface air system (SAS), certain volume of air is aspired at a fixed speed for variable time through a cover which has been machined with a series of small holes of a special design. The microbial contaminants in this study are measured based on 500 liters of air sampled with duplicate measurement: one reading around 9.00 am and another reading around 11.00 am. The measurement will be taken simultaneously for mold and bacteria.

For culture agar, Tryptic Soy Agar (TSA) was used to isolate bacteria and Sabaroud Dextrose Agar (SDA) to isolate mold. All samples were then being sealed and transported to the laboratory for incubation. TSA was incubated at 37$^{o}$C for 24 hours before calculation for total colony whereas for DSA, samples were left at room temperature for 5 days before conduct the colony counting (European Standard, 2000). Quantification of mould and bacteria levels was performed by naked eye count according to EN 13098: 2000 and ISO 4833:2013..

**Figure 7: DuoSAS Super 360**

**(Source: International pbi spa Website)**

### 3.4.3 Assessment of Gram-negative Bacteria

Gram-negative bacteria are another additional parameter in this study as the concern of its ability to produce endotoxin which is a chemical that could elicit strong pro-inflammatory responses in the human respiratory tract (Alex et. al, 2004). pbi DuoSAS Super 360 (Figure 7) was also be used to isolate Gram-negative bacteria onto the agar plate.

For culture agar, MacConkey agar was used to grow these bacteria. MacConkey agar is a selective and differential culture medium for bacteria designed to selectively isolate Gram-negative and enteric (normally found in the intestinal tract) bacilli and differentiate them based on lactose fermentation (Anderson, 2013).

The measurement based on 500 liters of air sampled with triplicate measurement: one reading around 8.00 am, 10.00 am and 12.00 pm.

All of these samples were sealed and transported to the lab for 24 hours incubation at 37°C. Then, colony counting was carried out.

### 3.4.4 Indoor Air Quality (IAQ) Assessment in Houses

IAQ assessment was also conducted in the residential area of respondents. Subsamples of 60 houses were selected among all 120 respondents only with the permission and approval from parents. Sampling method and procedure were the same as in IAQ assessment in preschool but the sampling point was only in the living hall as children spent most of their time at.

### 3.4.5 Spirometry

Spirometry is an evaluation of lung function by using a spirometer. It is one of the simplest, most common pulmonary function tests and may be necessary to determine how well the lungs receive, hold and utilize air, to monitor lung disease, to monitor the effectiveness of treatment, to determine the severity of a lung disease and to determine whether the lung disease is restrictive (decreased airflow) or obstructive (disruption of airflow).

Prior to spirometry test, anthropometric measurement was first obtained where the height of respondents was measured by using height scale model "SECA 208 Body Meter". The respondents need to stand in a straight position and barefooted. Then, body weight was measured by using an electronic weighing scale. The weighing scale was placed on a flat surface during measurements.

During the spirometry test, respondents were asked to breathe through a mouthpiece attached to the spirometer (Figure 8). In order to obtain the best results, all of the respondents were performed the test for 3 times. The information result was printed out on a chart called spirogram. As for calculation, the $FEV_1/FVC$ ratio was calculated. FVC or Force Vital Capacity is the total amount of air exhaled during the test while $FEV_1$ or Force Expiratory Volume is the amount of air the respondents exhale forcefully in 1 second. In this study, evaluation of lung function test was performed by comparing the obtained value with normal value which is a standard value.

Based on study by Azizi (1994), predicted value was calculated from the predictive equation as shown in Table 1. The evaluation of lung function (normal or abnormal) was done based on American Thoracic Society (1991) classification as shown in Table 2.

Table 1: Normal value of lung function parameters among children in Malaysia

| Lung Function Test | Boy | Girl |
|---|---|---|
| **FVC** | $4.1120 \times 10^{-6}(\text{Height})^{2.6421}$ | $6.0777 \times 10^{-7}(\text{Height})^{3.0112}$ |
| **$FEV_1$** | $6.2523 \times 10^{-6}(\text{Height})^{2.5388}$ | $5.7588 \times 10^{-7}(\text{Height})^{3.0067}$ |

Source: Azizi and Henry (1994)

Table 2: Evaluation of lung function

| **Obstructive Disease** | **$FEV_1$ %** |
|---|---|
| Normal | ≥80 |
| Mild | 70-79 |
| Severe | 60-69 |
| Very severe | < 60 |
| **Restrictive Disease** | **FVC %** |
| Normal | ≥80 |
| Mild | 70-79 |
| Severe | 60-69 |
| Very severe | < 60 |

Source: American Thoracic Society (1991)

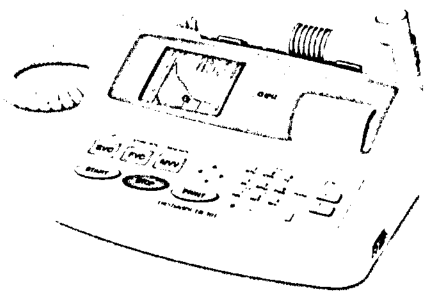


**Figure 7: Chestgraph HI-101 Spirometer**
**(source: Prometheus Healthcare Website)**

### 3.5 Data Collection Technique

First of all, permission from the related department (Jabatan Kemajuan Masyarakat Negeri Selangor) was obtained to carry out this research in preschool. Then, the purpose of this study was explained to the preschool teachers and parents before data collection to get their cooperation and also approval to take the preschool children as the respondents.

With that, consent letter and questionnaire were distributed. Parents whom agreed to get their children participate in this study need to fill in the questionnaire and return it back once it is completed. Based on inclusive and exclusive criteria outline in the research, respondents were recruited.

After that, data collection assessment such as indoor air quality assessment and lung function test were conducted but only with the approval of preschool management and parents. Finally, data analysis was carried out before thesis writing.

### 3.6 Data Analysis

All data were analyzed by using Statistical Package for Social Science (SPSS) Version 21.0. The descriptive test was used to calculate mean, median, mode and standard deviation. Meanwhile, Kolmogorov Smirnov test and skewness was used to determine the normality of the data. This test is very crucial in determining the appropriate test that will be used for further data analysis. Below are the tests that will be used to analyze the objectives of the study:

**Objective 1:** To determine the socio demographic data of respondents.

Statistical Analysis: Descriptive test and Chi square test for comparison

**Objective 2:** To compare the level of indoor air pollutants between study and comparative group of preschool children.

Statistical Analysis: Mann-Whitney U Test

**Objective 3:** To compare the respiratory health symptoms between study and comparative group of preschool children.

Statistical Analysis: Chi square test

**Objective 4:** To compare the lung function between study and comparative group of preschool children.

Statistical Analysis: Independent t test (parametric) or Mann-Whitney U test (Non-parametric test)

**Objective 5:** To determine the association between level of indoor air pollutants in preschool and residential with respiratory health symptoms among preschool children.

Statistical Analysis: Chi square test

**Objective 6:** To determine the association between levels of indoor air pollutants in preschool and residential with lung function among preschool children.

Statistical Analysis: Chi square Test

## 3.7 Quality Control

### 3.7.1 Questionnaire

The modified questionnaire used in this research was pre tested on 10% of the total respondents to ensure its reliability and validity. The result was tested by using Cronbach's Alpha Test where value of 0.7 and above shows acceptable reliability and validity.

### 3.7.2 Indoor Air Quality (IAQ) Assessment

All equipment used in this research was calibrated first according to the manufacturer's standard to avoid any error or bias.

### 3.7.3 Biological Sample

Researcher wore mask and glove in handling the agar plate and samples in order to avoid cross contamination. The incubation and colony counting procedure was following European Standard (2000); EN 13098: 2000 and ISO 4833:2013.

Besides that, laboratory media blank and field blank also were prepared for every sample set for QA and QC measures.

## 3.8 Ethical Approval

Ethical approval for this study was obtained from the Research Ethic Committee of Universiti Putra Malaysia. Approval to conduct research in preschool was obtained from related department (Jabatan Kemajuan Masyarakat Negeri Selangor) and preschools' management. Besides that, consent letter and information about the research was distributed and briefed to the preschool teacher and parents during data collection. All data collected were kept confidential between the researcher and the institution and only used for research and scientific publication purposes.

# CHAPTER 4

# RESULT AND DISCUSSION

The aim of this study was to determine the association between indoor air quality with respiratory health among preschool children in urban and suburban area. This study was successfully conducted according to plan to achieve the objectives.

## 4.1 Socio-Demographic Data of Respondents

From the questionnaire that had been distributed earlier for parents, there were total 120 respondents recruited in this study with the fraction of 60 respondents from the studied area, while another 60 respondents from the comparative area. Table 3 shows the respondents' distribution of age, gender and parents' educational background. For studied group, 31 (51.7%) respondents were girls and another 29 (48.3%) were boys. As for comparative group, the gender fraction is equal which is 30 (50%) respondents were girls and another 30 (50%) were boys. For respondents' age range, this study only included 5 and 6 years old respondents. For studied group, 35 (58.3%) respondents were 5 years old and another 25 (41.7%) were 6 years old. As for comparative group, 28 (46.7%) respondents were 5 years old and another 32 (53.3%) were 6 years old.

Table 3 also showed education level for respondents' parents. The level had been categorized into three groups which were primary, secondary and higher education. Result obtained from chi-square test shows that, there were no significant difference in parents' educational level for both studied and comparative groups (p=0.443).

For both studied and comparative groups, most of the father's education level was secondary education for 47 (78.3%) and 40 (66.7%) respectively followed by higher and primary education. The same situation also happened in mother's education level for both studied and comparative groups. There were no significant difference in their education level as p=0.128, where most of the respondents' mother in both groups were at the level of secondary education 38 (63.4%) and 32 (53.4%) respectively followed by higher and primary education.

**Table 3:** Distribution of respondents' socio demographic data between study areas.

| Variables | Urban (n=60) | Suburban (n=60) | $\chi^2$ value | p value |
|---|---|---|---|---|
| | Number (%) | | | |
| **Age** | | | | |
| 5 years old | 35 (58.3) | 28 (46.7) | 1.637 | 0.201 |
| 6 years old | 25 (41.7) | 32 (53.3) | | |
| **Gender** | | | | |
| Boy | 29 (48.3) | 30 (50.0) | 0.330 | 0.855 |
| Girl | 31 (51.7) | 30 (50.0) | | |
| **Education Level (Father)** | | | | |
| Primary Education | 3 (5.0) | 7 (11.6) | | |
| Secondary Education | 47 (78.3) | 40 (66.7) | 1.628 | 0.443 |
| Higher Education | 10 (16.7) | 13 (21.7) | | |
| **Education Level (Mother)** | | | | |
| Primary Education | 2 (3.3) | 8 (13.3) | | |
| Secondary Education | 38 (63.4) | 32 (53.4) | 4.114 | 0.128 |
| Higher Education | 20 (33.3) | 20 (33.3) | | |

N=120

Significant at $p<0.05$

Besides that, this study also took into account respondents' residential background to compare the type and location of their houses for both studied and comparative groups as it might influence the concentration of pollutants inside their houses. Variables that included in this part were; type of housing, house distance from the main road and house distance from the nearest factory. The result is tabulated in Table 4 and from the table, for the studied group, most of the respondents live in flat type housing (N=34, 56.7%) followed by terrace house and apartment for 16 (26.7%) and 10 (16.7%) respondents respectively.

On the other hand, for comparative group, distribution of their housing type was much more varied. However, most of the respondents live in village settlement (N=24, 40%). 17 (28.3%) of them live in terrace house, 13 (21.7%) in flat housing and only 1 to 3 respondents live in villa and apartment. Even with all of these variations, chi-square test shows that there was no significant difference of housing types in both studied and comparative groups as p=0.525.

For distance of house from the main road, for studied group, 46 (76.7%) of respondents live in less or equal 500 meters from the main road and for the rest (N=14, 23.3%), they live more than 500 meters from the road. The almost same situation also happened in comparative group whereas 45 (75%) of them live in less or equal 500 meters from the main road and the other 15 (25%) respondents live more than 500 meters from the road. There was no significant difference in distance of respondents' house from the main road as p=0.605 for both studied and comparative groups.

Furthermore, for distance of house from the nearest factory, for studied group, 23 (38.3%) of respondents live in less or equal 1.5 kilometers from the nearest factory and for the rest (N=37, 61.7%), they live more than 1.5 kilometers from the nearest factory. For comparative group, 15 (25%) of them live in less or equal 1.5 kilometers from the nearest factory and the other 45 (75%) respondents live more than 1.5 kilometers from the nearest factory. However, there was no significant difference in distance of respondents' house from the nearest factory as p=0.470 for both studied and comparative groups.

**Table 4:** Distribution of respondent's residential background between study areas.

| Variables | Urban (n=60) | Suburban (n=60) | $\chi^2$ value | p value |
|---|---|---|---|---|
| | Number (%) | | | |
| **Types of Housing** | | | | |
| Terrace House | 16 (26.7) | 17 (28.3) | 9.075 | 0.525 |
| Villa | 0 (0.0) | 2 (3.3) | | |
| Apartment | 10 (16.6) | 3 (5.0) | | |
| Flat | 34 (56.7) | 13 (21.7) | | |
| Village Settlement | 0 (0.0) | 24 (40.0) | | |
| Other | 0 (0.0) | 1 (1.7) | | |
| **Distance from Main Road** | | | | |
| < 100 meters | 25 (41.7) | 20 (33.3) | 1.185 | 0.605 |
| 100-500 meters | 21 (35.0) | 25 (41.7) | | |
| 500-1000 meters | 9 (15.0) | 7 (11.7) | | |
| > 1000 meters | 5 (8.3) | 8 (13.3) | | |
| **Distance from Factory** | | | | |
| < 1000 meters | 12 (20.0) | 8 (13.3) | 2.530 | 0.470 |
| 1000-1500 meters | 11 (18.3) | 7 (11.7) | | |
| 1500-3000 meters | 13 (21.7) | 17 (28.3) | | |
| > 3000 meters | 24 (40.0) | 28 (46.7) | | |

N=120

Significant at p<0.05

## 4.2 Home Sources for Possible Exposure to Indoor Air Pollutants

From the questionnaire distributed to respondents' parents, data on possible indoor air pollutants sources at their house was also obtained to compare of its status in both studied and comparative groups. The variables that were assessed including the usage of mosquito coil, indoor smoking, presence of pets, usage of carpet, painting activity within the last 12 months and the presence of mould stain on the wall or ceiling.

Chi-square test was used to compare these variables between the studied and comparative groups. The result is tabulated in Table 5. From the result, there was no significant difference for all the variables between studied and comparative group as randomization and matching had been done in study design to control for the possible confounders.

**Table 5:** Comparison of the indoor air pollutants sources in home among preschool children between study areas.

| Variables | Urban (n=60) | Suburban (n=60) | $\chi^2$ value | p value |
|---|---|---|---|---|
| | Number (%) | | | |
| **Mosquito Coil** | | | | |
| Yes | 3 (5.0) | 6 (10.0) | 1.081 | 0.298 |
| No | 57 (95.0) | 54 (90.0) | | |
| **Indoor Smoking** | | | | |
| Yes | 27 (45.0) | 29 (48.3) | 1.222 | 0.269 |
| No | 33 (55.0) | 31 (51.7) | | |
| **Pets** | | | | |
| Yes | 14 (23.3) | 18 (30.0) | 0.682 | 0.409 |
| No | 46 (76.7) | 42 (70.0) | | |
| **Carpet Usage** | | | | |
| Yes | 26 (43.3) | 18 (30.0) | 2.297 | 0.130 |
| No | 34 (56.7) | 42 (70.0) | | |
| **House Painting within 12 Months** | | | | |
| Yes | 18 (30.0) | 22 (36.7) | 0.600 | 0.439 |
| No | 42 (70.0) | 38 (63.6) | | |
| **Mould Stain on Wall/Ceiling** | | | | |
| Yes | 6 (10.0) | 7 (11.7) | 0.860 | 0.769 |
| No | 54 (90.0) | 53 (88.3) | | |

N=120

*Significant at $p<0.05$

## 4.3 Comparison of Indoor Air Quality in Preschools and Houses between Study Areas

Measurement of indoor air quality was done in every of the 12 preschools and 60 houses in this study. Parameters that being measured were $PM_{2.5}$, $PM_{10}$, VOCs, mold, bacteria, Gram-negative bacteria, temperature, relative humidity and air velocity. All measurements were done for 4 hours as represent schooling period and the result is Tabulated in Table 6(a) for indoor air quality in preschools and Table 6(b) for indoor air quality in houses. These results were compared between the study areas by using Mann-Whitney U test as all data were not normally distributed.

From Table 6(a), for physical parameters, temperature was recorded higher in studied preschools as compared with the comparative preschools. However, for humidity and air velocity, these parameters were slightly higher in comparative area instead of the studied area. This might be due to the differences of the use of mechanical ventilation such as fan in both areas. As outdoor environment also influences the indoor environment by 10%, humidity and velocity in comparative area were slightly higher due to less tall building and more plantations around this area. For building occupants' comfortability, Industry Code of Practice on Indoor Air Quality 2010 by Department of Occupational Safety and Health (DOSH) stated that, for air temperature, relative humidity and air velocity, the acceptable range would be 23-26 °C, 40-70% and 0.15-0.50 m/s respectively. However, this range is less practical to be used in preschools setting as the standard was designed specifically for air conditioned and commercial building.

Meanwhile, for indoor air pollutants, $PM_{2.5}$, $PM_{10}$, VOCs, mold, bacteria and Gram-negative bacteria were significantly different between preschools in studied and comparative areas as ($Z= -4.213$, $p= <0.001$), ($Z= -6.847$, $p= <0.001$), ($Z= -5.286$, $p= <0.001$), ($Z= -5.793$, $p= <0.001$), ($Z= -8.705$, $p= <0.001$) and ($Z= -8.471$, $p= <0.001$) respectively.

This result means that, the concentration of indoor air pollutants was significantly higher in preschools of studied area compare to the comparative area. However, when compared to Malaysia Ambient Air Quality Guidelines for 24 hours averaging time, the value of $PM_{2.5}$ and $PM_{10}$ in studied preschool with median 67 $\mu g/m^3$ and 74 $\mu g/m^3$ respectively were still within the standard ($PM_{2.5} = 75\ \mu g/m^3$ and $PM_{10} = 150\ \mu g/m^3$). The same situation is also happening for VOCs (Median= 0.0054 ppm) where the value was still within the Canada Residential Indoor Air Quality Guidelines for 24 hours averaging time which is 1 ppm.

For mold and bacteria, WHO IAQ guidelines set standard 500 $CFU/m^3$ (8-hour exposure) for both biological pollutants. Mold (Median= 402 $CFU/m^3$) did not exceed the standard value and for bacteria (Median= 550 $CFU/m^3$), it exceeded the standard. However, this measurement was based on 4-hour measurement and the value might be lower as for 8-hour measurement. Study has shown that mold and bacteria have a positive relationship with dampness and settled dust (Wickman et al, 1999). These two parameters are the main problem in the studied preschools as most of the studied preschools have toilet and kitchen in it that serve as damp area and particulate matter that relatively high in the urban area.

Nevertheless, the level of Gram-negative bacteria also showed a significant difference in both studied and comparative area as ($Z= -8.471$, $p= <0.001$). As this is the first study to take Gram-negative bacteria as an indoor air pollutant, the value was hard to be compared with other national study as most of the studies assessing on endotoxin; the toxin produced by the Gram-negative bacteria. However, a study by Traversi (2011) shows that, the level of Gram-negative bacteria was associated with the level of $PM_{10}$ in urban, rural and farm areas. As the level of $PM_{10}$ and Gram-negative bacteria in studied area were significantly higher compared to the comparative area, it is suggested that, the sources of $PM_{10}$ also trigger the growth of Gram-negative bacteria.

For exposure of pollutants in house setting (Table 6(b)), only $PM_{2.5}$, $PM_{10}$ and mold that show significant difference in both studied and comparative groups as ($Z= -11.333$, $p= <0.001$), ($Z= -11.762$, $p= <0.001$) and ($Z= -2.198$, $p= 0.028$) respectively. Nonetheless, as compared with the value of pollutants in schools, level of $PM_{2.5}$ (Median= 94 $\mu g/m^3$), $PM_{10}$ (Median= 116 $\mu g/m^3$) and VOCs (Median= 0.04 ppm) in the houses of studied group is higher compared to studied preschools with median 67 $\mu g/m^3$, 74 $\mu g/m^3$ and 0.0054 ppm respectively. It is suggested that, house locations have contributed to the concentration of the particulates. The location of houses as well as outdoor and indoor combustion activities is the major contributor to the high level of indoor $PM_{2.5}$ and $PM_{10}$ in the houses of studied area. Besides that, USEPA (2012) stated that, indoor air pollutants such as $PM_{10}$ and VOCs may come from sources such as carpet, house paints, paved or unpaved roads from outside.

All of the findings above were consistent with the local study by Andrew and Juliana, (2015) and Azwani et al., (2014) in the urban area which the level of $PM_{2.5}$, $PM_{10}$, VOCs, mold and bacteria was said to be higher in studied group as compared to the comparative group. As the location was influences the level of pollutants inside the preschools, unique characteristics to preschools such as abundant use of sorptive material (drapes, toys, bedding and carpets) as part of its furnishings, children's habits and activities also greatly influence the concentrations of indoor air pollutants (Branco et al., 2014).

**Table 6(a):** Comparisons of indoor air quality between preschool in study areas.

| **Variables** | **Urban (n=60)** | **Suburban (n=60)** | **Z value** | **p value** |
|---|---|---|---|---|
| | **Median (IQR)** | | | |
| $PM_{2.5}$ ($\mu g/m^3$) | 67.00 (16.1) | 48.00 (7.3) | **-4.213** | **<0.001$^{**}$** |
| $PM_{10}$ ($\mu g/m^3$) | 74.00 (19.6) | 51.00 (5.0) | **-6.847** | **<0.001$^{**}$** |
| VOCs (ppm) | 0.0054 (0.089) | 0.0 (0.0) | - | - |
| Mold (CFU/$m^3$) | 402.0 (260.0) | 252.0 (135.0) | **-5.793** | **<0.001$^{**}$** |
| Bacteria (CFU/$m^3$) | 550.0 (350.0) | 221.0 (200.0) | **-8.705** | **<0.001$^{**}$** |
| Gram-negative Bacteria (CFU/$m^3$) | 60.0 (45.0) | 25.0 (20.0) | **-8.471** | **<0.001$^{**}$** |
| Temperature (°C) | 31.19 (3.0) | 30.64 (2.3) | **-2.374** | **0.018$^{*}$** |
| Relative Humidity (%) | 70.5 (4.6) | 76.3 (3.5) | **-4.213** | **<0.001$^{**}$** |
| Air Velocity (m/s) | 0.2115 (0.028) | 0.2975 (0.087) | **-6.847** | **<0.001$^{**}$** |

N=120

**$^{*}$Significant at p<0.05, $^{**}$ Significant at p<0.001**

**Table 6(b):** Comparisons of indoor air quality between houses in study areas.

| Variables | Urban (n=30) | Suburban (n=30) | Z value | p value |
|---|---|---|---|---|
| | Median (IQR) | | | |
| $PM_{2.5}$ ($\mu g/m^3$) | 94.0 (39.0) | 48.00 (22.0) | **-11.333** | **<0.001*** |
| $PM_{10}$ ($\mu g/m^3$) | 116.0 (39.0) | 53.0 (24.0) | **-11.762** | **<0.001*** |
| VOCs (ppm) | 0.04 (0.13) | 0.00285 (0.08) | -1.136 | 0.256 |
| Mold (CFU/$m^3$) | 275.0 (235.0) | 247.5 (70.0) | **-2.198** | **0.028*** |
| Bacteria (CFU/$m^3$) | 142.5 (280.0) | 137.5 (70.0) | -0.873 | 0.383 |
| Gram-negative Bacteria (CFU/$m^3$) | 17.5 (22.5) | 10.0 (18.3) | -1.146 | 0.252 |
| Temperature (°C) | 29.42 (1.57) | 29.87 (1.84) | -0.473 | 0.636 |
| Relative Humidity (%) | 72.95 (15.67) | 70.27 (9.12) | -1.752 | 0.080 |
| Air Velocity (m/s) | 0.215 (0.118) | 0.214 (0.123) | -1.014 | 0.310 |

N=60

***Significant at $p<0.05$**

## 4.4 Comparison of Respiratory Health Symptoms among Respondents between Study Areas

Table 7 shows the comparison of reported respiratory symptoms between the studied and comparative group. Eight respiratory symptoms were assessed in this study, including cough, phlegm, wheezing, chest tightness, runny nose, blocked nose, sneezing and sore throat by using constructed questionnaire based on the American Thoracic Society (ATS) and International Study of Asthma and Allergy in Childhood (ISAAC) standard questionnaire.

From the chi-square test, only cough, phlegm, runny nose and blocked nose show significant difference between both studied and comparative groups as p= 0.026, p= 0.015, p= 0.001 and p= 0.002 respectively. For cough (PR= 4.34, 95% CI= 2.06-9.11), 31 (51.7%) respondents from studied group having the symptoms with just only 19 (38.3%) respondents from the comparative group. It is suggested that, the preschool children in studied area have 4.34 times more likely to experience respiratory health symptom of cough than preschool children in comparative area. Besides that, for phlegm (PR= 3.61, 95% CI= 1.57-8.33), 23 (38.3%) respondents from the studied group having the symptoms with just only 11 (18.3%) respondents from the comparative group, thus, the preschool children in studied area have 3.61 times more likely to experience respiratory health symptom of phlegm than preschool children in comparative area.

On the other hand, for runny nose (PR= 2.27, 95% CI= 1.25-6.13), 30 (50.0%) respondents from studied group having the symptoms with just only 13

(21.7%) respondents from the comparative group. So, it is suggested that, the preschool children in studied area have 2.27 times more likely to experience respiratory health symptom of runny nose than preschool children in comparative area. Last but not least, for blocked nose (PR= 2.74, 95% CI= 1.20-6.28), 27 (45.0%) respondents from studied group having the symptoms with just only 11 (18.3%) respondents from the comparative group, thus, the preschool children in studied area have 2.74 times more likely to experience respiratory health symptom of blocked nose than preschool children in comparative area.

To simplify, the prevalence of respiratory symptoms was generally higher among urban preschool children as compared to suburban preschool children. Only four respiratory symptoms (cough, phlegm, runny nose and blocked nose) show a significant difference between the studied and comparative groups with cough has the highest prevalence rate followed by phlegm, runny nose and blocked nose. It is suggested that there is an association between respiratory symptom occurrence in preschool children and the location of the preschool they attend. Preschool children from highly polluted areas (urban preschools) have shown a higher prevalence of respiratory symptoms compared to preschool children from a less polluted area (suburban preschools). According to Chen et al. (1998), the adverse respiratory health impact experienced by children who live in urban areas may be attributed to their exposure to an assortment of air pollutants produced by mobile sources.

The finding of this study that the location of the preschool significantly contributed in the prevalence of respiratory health symptoms also supported by the findings from the local studies by Nazariah et al., (2013), Andrew and Juliana, (2014), Anis et al., (2014), Arasyi et al., (2014) and Chua et al., (2015) where prevalence of respiratory health symptoms was higher among children in the urban area as compared to the suburban or rural area.

**Table 7:** Occurance of respiratory symptoms among preschool children.

| **Variables** | **Urban (n=60)** | **Suburban (n=60)** | **$\chi^2$ value** | **p value** | **PR** | **95% CI** |
|---|---|---|---|---|---|---|
| | **Number (%)** | | | | | |
| **Cough** | | | | | | |
| Yes | 31 (51.7) | 19 (38.3) | **4.937** | **0.026*** | 4.34 | 0.206-0.911 |
| No | 29 (48.3) | 41 (61.7) | | | | |
| **Phlegm** | | | | | | |
| Yes | 23 (38.3) | 11 (18.3) | **5.910** | **0.015*** | 3.61 | 0.157-0.833 |
| No | 37 (61.7) | 49 (81.7) | | | | |
| **Wheezing** | | | | | | |
| Yes | 8 (13.3) | 5 (8.3) | 0.776 | 0.378 | 0.59 | 0.182-1.923 |
| No | 52 (86.7) | 55 (91.7) | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 3 (5.0) | 3 (5.0) | - | 1.000** | - | - |
| No | 57 (95.0) | 57 (95.0) | | | | |
| **Runny Nose** | | | | | | |
| Yes | 30 (50.0) | 13 (21.7) | **10.474** | **0.001*** | 2.77 | 0.125-0.613 |
| No | 30 (50.0) | 47 (78.3) | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 27 (45) | 11 (18.3) | **9.859** | **0.002*** | 2.74 | 0.120-0.628 |
| No | 33 (55) | 49 (81.7) | | | | |
| **Sneezing** | | | | | | |
| Yes | 9 (15.0) | 6 (10.0) | 0.686 | 0.408 | 0.63 | 0.209-1.895 |
| No | 51 (85.0) | 54 (90.0) | | | | |
| **Sore Throat** | | | | | | |
| Yes | 27 (45.0) | 19 (31.7) | 2.256 | 0.133 | 0.56 | 0.269-1.193 |
| No | 33 (55.0) | 41 (68.3) | | | | |

N=120

***Significant at p<0.05**, **Fisher Exact Test

## 4.5 Comparison of Lung Function among Respondents between Study Areas

Lung function of preschool children was assessed based on FVC% predicted, $FEV_1$% predicted and $FEV_1$/FVC% predicted. FVC% predicted and $FEV_1$% predicted were obtained based on the prediction equation for the normal value of lung function parameters among children in Malaysia developed by Azizi and Henry in 1994. The result is tabulated in Table 8.

T-test analysis was used to compare the values of FVC (liter) and $FEV_1$ (liter) between the studied and comparative group as the data were normally distributed among the respondents. The test reveals that FVC (liter) and $FEV_1$ (liter) among the studied group were significantly lower compared to the comparative group as ($t = -3.710$, $p = <0.001$) and ($t = -4.027$, $p = <0.001$) respectively. Meanwhile, Mann-Whitney U test was used to compare the values of FVC%, $FEV_1$% and $FEV_1$/FVC % between the studied and comparative group as the data were not normally distributed among the respondents. As a result, FVC% and $FEV_1$% among the studied group were significantly lower compared to the comparative group as ($Z = -2.866$, $p = 0.004$) and ($Z = -3.139$, $p = 0.002$) respectively. However, only the value of $FEV_1$/FVC % between the groups was not significantly different ($Z = -1.205$, $p = 0.228$).

From the value of FVC%, $FEV_1$% and $FEV_1$/FVC %, lung function abnormalities among preschool children was then determined by categorizing them in normal or abnormal status based on American Thoracic Society (2005) classification. The result is tabulated in Table 9.

Chi-square test was used to compare the lung function abnormalities between the studied and comparative groups. Only FVC% and $FEV_1$% show a significant difference as p= <0.001 for both groups. For FVC%, 40 (66.7%) respondents from studied group having abnormal status with just only 15 (25.0%) respondents from the comparative group. For $FEV_1$%, 38 (63.3%) respondents from studied group having abnormal status with just only 12 (20.0%) respondents from the comparative group. $FEV_1$/FVC % values were normal for all respondents. It is suggested that exposure to a pollution from heavy traffic may contribute to lower FVC and $FEV_1$ among urban preschool children. Brunekreef et al. (1997) stated that, children who stay close by highways may suffer from impaired lung function as a result of being exposed to road vehicle related air pollution.

The finding above was also supported by the local studies by Azwani et al., (2014), Chua et al., (2015) and Anis et al., (2015) that shows the location of the preschool primarily in urban area or near to the petrochemical industry was significantly contributed in lower lung function among the preschool children.

**Table 8:** Comparison of lung function among preschool children.

| Variables | Urban (n=60) | Suburban (n=60) | Z/t value | p value |
|---|---|---|---|---|
| | Mean±S.D/Median±IQR | | | |
| FVC (Liter)[a] | 0.61 ± 0.20 | 0.75 ± 0.19 | -3.710 | **<0.001[*]** |
| $FEV_1$ (Liter)[a] | 0.59 ± 0.19 | 0.74 ± 0.19 | -4.027 | **<0.001[*]** |
| FVC %[b] | 67.69 ± 42.64 | 88.35 ± 19.10 | -2.866 | **0.004[*]** |
| $FEV_1$ %[b] | 71.54 ± 40.87 | 93.72 ± 20.14 | -3.139 | **0.002[*]** |
| $FEV_1$/FVC %[b] | 107.08 ± 2.23 | 107.73 ± 1.31 | -1.205 | 0.228 |

N=120

[a]T-test , [b]Mann-Whitney U Test

[*]**Significant at p<0.05**

**Table 9:** Lung function abnormalities among preschool children

| Lung Function | Urban (n=60) | | Suburban (n=60) | | $\chi^2$ | p value |
|---|---|---|---|---|---|---|
| | Normal (%) | Abnormal (%) | Normal (%) | Abnormal (%) | | |
| FVC % | 20 (33.3) | 40 (66.7) | 45 (75.0) | 15 (25.0) | 20.979 | **<0.001[*]** |
| $FEV_1$ % | 22 (36.7) | 38 (63.3) | 48 (80.0) | 12 (20.0) | 23.177 | **<0.001[*]** |
| $FEV_1$/FVC % | 60 (100.0) | 0 (0.0) | 60 (100.00) | 0 (0.0) | - | - |

N=120

[*]**Significant at p<0.05**

## 4.6 Associations between Exposures of Indoor Air Pollutants in Preschool and Residential with Lung Function among Respondents

In order to associate indoor air pollutants with lung function, all pollutants were categorized based on their median value of studied group. A value that was higher than median was categorized as high while the value that was lower than median was categorized as low. Table 10(a) shows the association between indoor air pollutants in schools and lung function (FVC%) among preschool children in both studied and comparative areas.

The chi-square result shows a significant association between all pollutants ($PM_{2.5}$, $PM_{10}$, VOCs, mold, bacteria and Gram-negative bacteria) with FVC% abnormality among the respondents as (p= 0.028, PR= 2.37, 95% CI= 1.09-5.15), (p= 0.028, PR= 2.37, 95% CI= 1.09-5.15), (p= 0.003, PR= 3.27, 95% CI= 1.48-7.22), (p= 0.026, PR= 2.59, 95% CI= 1.10-6.07), (p= 0.008, PR= 3.14, 95% CI= 1.32-7.49) and (p= <0.001, PR= 4.75, 95% CI= 1.90-11.87) respectively.

It is suggested that, odds of preschool children who exposed to high level of $PM_{2.5}$ and $PM_{10}$ to get abnormal FVC% was 2.37 times higher than those who did not expose. Odds of preschool children who exposed to high level of VOCs to get abnormal FVC% was 3.27 times higher than those who did not expose.

Furthermore, for biological pollutants, odds of preschool children who exposed to high level of mold, bacteria and Gram-negative bacteria to get abnormal

FVC% were 2.59, 3.14 and 4.75 times higher than those who did not expose respectively.

Table 10(b) shows the association between indoor air pollutants in schools and lung function ($FEV_1$%) among preschool children in both studied and comparative areas. From the result, $PM_{2.5}$, $PM_{10}$, VOCs, mold, bacteria and Gram-negative bacteria shows a significant association with $FEV_1$% abnormality among the respondents as ($p = 0.013$, PR= 2.66, 95% CI= 1.22-5.79), ($p = 0.013$, PR= 2.66, 95% CI= 1.22-5.79), ($p = 0.001$, PR= 3.67, 95% CI= 1.66-8.13), ($p = 0.019$, PR= 2.72, 95% CI= 1.16-6.35), ($p = 0.005$, PR= 3.29, 95% CI= 1.39-7.77) and ($p = <0.001$, PR= 4.91, 95% CI= 2.00-12.04) respectively.

It is suggested that, odds of preschool children who exposed to high level of $PM_{2.5}$ and $PM_{10}$ to get abnormal $FEV_1$% was 2.66 times higher than those who did not expose. Odds of preschool children who exposed to high level of VOCs to get abnormal $FEV_1$% was 3.67 times higher than those who did not expose.

Besides that, for biological pollutants, odds of preschool children who exposed to high level of mold, bacteria and Gram-negative bacteria to get abnormal $FEV_1$% were 2.72, 3.29 and 4.91 times higher than those who did not expose respectively.

The finding of this study was consistent with the local study by Chua et al., (2015) and Azwani et al., (2014) in Petaling Jaya and Balakong respectively, where a significant association was found between indoor $PM_{2.5}$, $PM_{10}$ and VOCs with lower lung function among children in urban area. It is suggested that, due to a very small size of these pollutants, they can reach deeper inside the children's lung and interfere with normal function of the lung in gaseous exchange (American Lung Association, 2016).

Another study conducted in four cities in China shows that, an increase 10 $\mu g/m^3$ of $PM_{2.5}$ and $PM_{10}$ was associated with decreases of 3.5 ml FVC and 2.7 ml $FEV_1$ in lung function of school children (Ananya et al., 2014). A study in southern California by Gauderman et al., (2004) stated that, exposure to particulate matter especially $PM_{2.5}$ affects the growth of the lungs during the rapid lung development between the ages of 10 and 18 years old.

The results also were supported by an international study among school children in Portugal, where a significant association was found between indoor bacteria and fungi with lower $FEV_1$ value although quantitatively determined concentration of microbiological agents do not show a consistent association with respiratory health outcomes in different studies (Madureira et al,. 2015). A study among healthy adults by Henberg et al., (2014) in Finland indicated that mold odor exposure was related to lower lung function levels among non-asthmatic adults, especially among women. It is suggested that, microbial contaminant such as fungi and bacteria also produce toxins and irritants with suspected effects on respiratory health (WHO, 2009).

For Gram-negative bacteria, many Gram-negative bacteria are in the range of size 1-5 $\mu$m and when inhaled, it can penetrate deeper into human lungs (Hood, 1990). As the only agent that can produce endotoxin, higher house-dust endotoxin level has been found to correlate with increased medication used and greater airflow obstruction in asthmatic adults, in children both with and without asthma and even with an infant wheezing in the first year of life (Douwes et al., 2000; Park et al., 2001; Gehring et al.,2001).

On the other hand, the association between indoor air pollutants inside 60 respondents' houses and their lung function (FVC%) test also been carried out and from the result (Table 11(a)), only $PM_{2.5}$ (p= 0.032, PR= 2.56, 95% CI= 1.553-7.473) and $PM_{10}$ (p= 0.018, PR= 3.23, 95% CI= 1.240-8.421) shows significant association with FVC% abnormality as the concentration is higher compared to the concentration in schools.

Nevertheless, for the association between indoor air pollutants inside respondents' houses with their lung function ($FEV_1$%) (Table 11(b)) only $PM_{2.5}$ (p= 0.003, PR= 3.02, 95% CI= 1.59-15.59), $PM_{10}$ (p= 0.003, PR= 3.55, 95% CI= 1.98-16.69) and Gram-negative bacteria (p= 0.016, PR= 3.79, 95% CI= 1.26-11.46) shows a significant association with $FEV_1$% abnormality.

According to Yahaya and Juliana (2014), indoor air pollutants in homes are an important influencing factor of lung function. Prolonged exposure to particulate matter in ambient air has been associated with a noticeable decrease in lung function (Schwartz and Neas, 2000). Although very limited study had been done about airborne Gram-negative bacteria on human, this study shows a significant association between the exposures of Gram-negative bacteria both in preschools and houses with lung function abnormalities among the respondents. In line with that, a type of Gram-negative bacterium known as *Legionella pneumophila* is suggested can cause Legionellosis in human. Most people with Legionellosis will have pneumonia since the Legionella bacteria grow and thrive in the lungs (CDC, 2015).

**Table 10(a):** The association between exposure of indoor air pollutants in preschools and lung function (FVC%) among preschool children.

| Variables | Lung Function | | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Abnormal | Normal | | | | |
| **$PM_{2.5}$** | | | | | | |
| High (>67$\mu g/m^3$) | 24 | 16 | **4.850** | **0.028*** | 2.371 | 1.091-5.153 |
| Low (<67$\mu g/m^3$) | 31 | 49 | | | | |
| **$PM_{10}$** | | | | | | |
| High (>74$\mu g/m^3$) | 24 | 16 | **4.850** | **0.028*** | 2.371 | 1.091-5.153 |
| Low (<74$\mu g/m^3$) | 31 | 49 | | | | |
| **VOCs** | | | | | | |
| High (>0.0051ppm) | 26 | 14 | **8.878** | **0.003*** | 3.266 | 1.477-7.223 |
| Low (<0.0051ppm) | 29 | 51 | | | | |
| **Mold** | | | | | | |
| High (>402CFU/$m^3$) | 19 | 11 | **4.434** | **0.026*** | 2.591 | 1.103-6.086 |
| Low (>402CFU/$m^3$) | 36 | 54 | | | | |
| **Bacteria** | | | | | | |
| High (>550CFU/$m^3$) | 20 | 10 | **6.993** | **0.008*** | 3.143 | 1.318-7.497 |
| Low (>550CFU/$m^3$) | 35 | 55 | | | | |
| **Gram-negative Bacteria** | | | | | | |
| High (>60CFU/$m^3$) | 22 | 8 | **12.185** | **<0.001*** | 4.750 | 1.901-11.869 |
| Low (>60CFU/$m^3$) | 33 | 57 | | | | |

N=120

***Significant at $p<0.05$**

**Table 10(b):** The association between exposure of indoor air pollutants in preschools and lung function ($FEV_1$%) among preschool children.

| Variables | Lung Function | | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Abnormal | Normal | | | | |
| **$PM_{2.5}$** | | | | | | |
| High (>67$\mu$g/m$^3$) | 23 | 17 | **6.189** | **0.013*** | 2.656 | 1.218-5.791 |
| Low (<67$\mu$g/m$^3$) | 27 | 53 | | | | |
| **$PM_{10}$** | | | | | | |
| High (>74$\mu$g/m$^3$) | 23 | 17 | **6.189** | **0.013*** | 2.656 | 1.218-5.791 |
| Low (<74$\mu$g/m$^3$) | 27 | 53 | | | | |
| **VOCs** | | | | | | |
| High (>0.0051ppm) | 25 | 15 | **10.714** | **0.001*** | 3.667 | 1.655-8.126 |
| Low (<0.0051ppm) | 25 | 55 | | | | |
| **Mold** | | | | | | |
| High (>402CFU/m$^3$) | 18 | 12 | **5.531** | **0.019*** | 2.719 | 1.164-6.351 |
| Low (>402CFU/m$^3$) | 32 | 58 | | | | |
| **Bacteria** | | | | | | |
| High (>550CFU/m$^3$) | 19 | 11 | **7.726** | **0.005*** | 3.287 | 1.390-7.772 |
| Low (>550CFU/m$^3$) | 31 | 59 | | | | |
| **Gram-negative Bacteria** | | | | | | |
| High (>60CFU/m$^3$) | 21 | 9 | **13.211** | **<0.001*** | 4.908 | 2.001-12.040 |
| Low (>60CFU/m$^3$) | 29 | 61 | | | | |

N=120

***Significant at p<0.05**

**Table 11(a):** The association between exposure of indoor air pollutants in houses and lung function (FVC%) among preschool children.

| Variables | Lung Function | | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Abnormal | Normal | | | | |
| **$PM_{2.5}$** | | | | | | |
| High (>94$\mu g/m^3$) | 17 | 8 | **4.578** | **0.032*** | 2.56 | 1.553-7.473 |
| Low (<94$\mu g/m^3$) | 14 | 21 | | | | |
| **$PM_{10}$** | | | | | | |
| High (>116$\mu g/m^3$) | 16 | 7 | **5.599** | **0.018*** | 3.23 | 1.240-8.421 |
| Low (<116$\mu g/m^3$) | 15 | 24 | | | | |
| **VOCs** | | | | | | |
| High(>0.04ppm) | 13 | 12 | 0.002 | 0.965 | 1.023 | 0.366-2.858 |
| Low (<0.04ppm) | 18 | 17 | | | | |
| **Mold** | | | | | | |
| High (>275CFU/$m^3$) | 12 | 10 | 0.115 | 0.734 | 1.200 | 0.419-3.439 |
| Low (>275CFU/$m^3$) | 19 | 19 | | | | |
| **Bacteria** | | | | | | |
| High (>142CFU/$m^3$) | 16 | 11 | 1.133 | 0.287 | 1.745 | 0.624-4.884 |
| Low (>142CFU/$m^3$) | 15 | 18 | | | | |
| **Gram-negative Bacteria** | | | | | | |
| High (>18CFU/$m^3$) | 14 | 8 | 1.993 | 0.158 | 2.162 | 0.735-6.357 |
| Low (>18CFU/$m^3$) | 17 | 21 | | | | |

N=60

***Significant at $p<0.05$**

**Table 11(b):** The association between exposure of indoor air pollutants in houses and lung function ($FEV_1$%) among preschool children.

| Variables | Lung Function | | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Abnormal | Normal | | | | |
| **$PM_{2.5}$** | | | | | | |
| High (>94$\mu g/m^3$) | 15 | 7 | **8.735** | **0.003*** | 3.022 | 1.585-15.591 |
| Low (<94$\mu g/m^3$) | 11 | 27 | | | | |
| **$PM_{10}$** | | | | | | |
| High (>116$\mu g/m^3$) | 16 | 8 | **8.868** | **0.003*** | 3.553 | 1.979-16.693 |
| Low (<116$\mu g/m^3$) | 10 | 26 | | | | |
| **VOCs** | | | | | | |
| High(>0.04ppm) | 12 | 13 | 0.380 | 0.538 | 1.385 | 0.491-3.901 |
| Low (<0.04ppm) | 14 | 21 | | | | |
| **Mold** | | | | | | |
| High (>275CFU/$m^3$) | 10 | 12 | 0.064 | 0.801 | 1.146 | 0.398-3.300 |
| Low (>275CFU/$m^3$) | 16 | 22 | | | | |
| **Bacteria** | | | | | | |
| High (>142CFU/$m^3$) | 15 | 12 | 2.986 | 0.084 | 2.500 | 0.876-7.136 |
| Low (>142CFU/$m^3$) | 11 | 22 | | | | |
| **Gram-negative Bacteria** | | | | | | |
| High (>18CFU/$m^3$) | 14 | 8 | **5.831** | **0.016*** | 3.792 | 1.255-11.455 |
| Low (>18CFU/$m^3$) | 12 | 26 | | | | |

N=60

***Significant at p<0.05**

## 4.7 Associations between Exposures of Indoor Air Pollutants in Preschools and Residential with Respiratory Health Symptoms among Respondents

Further analysis was done to determine an association between pollutants exposure in schools and houses with respiratory health symptoms among the preschool children by using the median value. The results were tabulated in Table 12(a) to Table 12(h) for exposure in preschools and Table 13(a) to Table 13(h) for exposure in houses for every respective pollutant.

From Table 12(a) and 12(b), there is a significant association between high level of $PM_{2.5}$ and $PM_{10}$ in schools with four respiratory health symptoms which are cough (p= 0.006, PR= 2.27, 95% CI= 1.12-11.26), phlegm (p= 0.001, PR= 2.07, 95%= 0.82-12.03), runny nose (p= 0.017, PR= 2.30, 95% CI= 1.15-9.44) and blocked nose (p= 0.020, PR= 2.06, 95% CI= 1.28-10.58). It is suggested that, odds of preschool children who exposed to high level of $PM_{2.5}$ and $PM_{10}$ to get cough, phlegm, runny nose and blocked nose were 2 times higher than those who exposed to the low level.

For VOCs (Table 12(c)), there is a significant association between high level of VOCs with only one respiratory health symptoms which is blocked nose (p= 0.026, PR= 2.46, 95% CI= 1.10-5.48). It is suggested that, odds of preschool children who exposed to high level of VOCs to get blocked nose was 2.46 times higher than those who exposed with low level of VOCs.

From Table 12(d), there is a significant association between high level of mold with three respiratory health symptoms which are cough (p= 0.001, PR= 4.00, 95% CI= 1.67-9.61), runny nose (p= <0.001, PR= 4.75, 95% CI= 1.98-11.42) and blocked nose (p= 0.003, PR= 3.53, 95% CI= 1.49-8.38). It is suggested that, odds of preschool children who exposed to high level of mould to get cough, runny nose and blocked nose were 3 to 4 times higher than those who exposed to low level of mold.

There is no significant association between levels of bacteria with any respiratory health symptoms that can be seen (Table 12(e)). However, from Table 12(f), there is a significant association between high level of Gram-negative bacteria with four respiratory health symptoms which are cough (p= 0.005, PR= 3.29, 95% CI= 1.39-7.77), phlegm (p= 0.035, PR= 2.51, 95% CI= 1.05-6.01), runny nose (p= 0.021, PR= 2.67, 95% CI= 1.14-6.22) and blocked nose (p= 0.003, PR= 3.53, 95% CI= 1.49-8.38). It is suggested that, odds of preschool children who exposed to high level of Gram-negative bacteria to get cough, phlegm, runny nose and blocked nose were approximately 2 to 3 times higher than those who exposed to low level of Gram-negative bacteria.

For exposure of pollutants inside the house (Table 13(a) – Table 13(f)), $PM_{2.5}$ and $PM_{10}$ shows a significant association with cough, runny nose and blocked nose among the respondents. Gram-negative bacteria show significant association with cough and runny nose. Meanwhile, bacteria show significant association with phlegm only. Last but not least, there was no significant association between exposures of

VOCs and mold inside the house with any reported respiratory symptoms among the respondents.

From the result above, it can be simplified that the symptoms of cough, phlegm, runny nose and blocked nose were significantly associated with high level of most of the pollutants that being studied. This result was supported by Norback et al, (2000) study where they found a significant relationship between various types of indoor gaseous and particulate pollutants with nasal effects. International study by Madureira et al,. (2015) stated that some indoor air pollutants, even at low exposure levels, were related to the development of respiratory symptoms.

The result from this study also supported by a local study by Andrew and Juliana (2014) where $PM_{10}$, VOCs, mold and bacteria have significant association with parental reported respiratory symptoms such as cough, phlegm, runny nose, blocked nose and sneezing. It is suggested that, all of these symptoms were actually a natural defense mechanism to cope up with the exposure of high level of pollutants in our respiratory system.

**Table 12(a):** The association between exposure of $PM_{2.5}$ in preschools and respiratory health symptoms among preschool children.

| Variables | $PM_{2.5}$ (High) | $PM_{2.5}$ (Low) | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Number | | | | | |
| **Cough** | | | | | | |
| Yes | 34 | 20 | **7.447** | **0.006*** | 2.267 | 1.122-11.258 |
| No | 25 | 41 | | | | |
| **Phlegm** | | | | | | |
| Yes | 37 | 27 | **10.356** | **0.001*** | 2.066 | 0.815-12.030 |
| No | 16 | 40 | | | | |
| **Wheezing** | | | | | | |
| Yes | 3 | 10 | - | 0.540** | - | - |
| No | 37 | 70 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 2 | 4 | - | 1.000** | - | - |
| No | 38 | 76 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 33 | 20 | **5.711** | **0.017*** | 2.300 | 1.153-9.438 |
| No | 27 | 40 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 31 | 21 | **5.401** | **0.020*** | 2.059 | 1.279-10.577 |
| No | 26 | 42 | | | | |
| **Sneezing** | | | | | | |
| Yes | 3 | 12 | 1.371 | 0.242 | 0.459 | 0.122-1.732 |
| No | 37 | 68 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 16 | 30 | 0.071 | 0.791 | 1.111 | 0.510-2.419 |
| No | 24 | 50 | | | | |

N=120

***Significant at $p<0.05$,** **Fisher Exact Test

**Table 12(b):** The association between exposure of $PM_{10}$ in preschools and respiratory health symptoms among preschool children.

| Variables | $PM_{10}$ (High) | $PM_{10}$ (Low) | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Number | | | | | |
| **Cough** | | | | | | |
| Yes | 34 | 20 | **7.447** | **0.006*** | 2.267 | 1.122-11.258 |
| No | 25 | 41 | | | | |
| **Phlegm** | | | | | | |
| Yes | 37 | 27 | **10.356** | **0.001*** | 2.066 | 0.815-12.030 |
| No | 16 | 40 | | | | |
| **Wheezing** | | | | | | |
| Yes | 3 | 10 | - | 0.540** | - | - |
| No | 37 | 70 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 2 | 4 | - | 1.000** | - | - |
| No | 38 | 76 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 33 | 20 | **5.711** | **0.017*** | 2.300 | 1.153-9.438 |
| No | 27 | 40 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 31 | 21 | **5.401** | **0.020*** | 2.059 | 1.279-10.577 |
| No | 26 | 42 | | | | |
| **Sneezing** | | | | | | |
| Yes | 3 | 12 | 1.371 | 0.242 | 0.459 | 0.122-1.732 |
| No | 37 | 68 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 16 | 30 | 0.071 | 0.791 | 1.111 | 0.510-2.419 |
| No | 24 | 50 | | | | |

N=120

***Significant at p<0.05**, **Fisher Exact Test

**Table 12(c):** The association between exposure of VOCs in preschools and respiratory health symptoms among preschool children.

| Variables | VOCs (High) | VOCs (Low) | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Number | | | | | |
| **Cough** | | | | | | |
| Yes | 21 | 29 | 2.897 | 0.089 | 1.944 | 0.900-4.198 |
| No | 19 | 51 | | | | |
| **Phlegm** | | | | | | |
| Yes | 13 | 21 | 0.513 | 0.474 | 1.353 | 0.591-3.096 |
| No | 27 | 59 | | | | |
| **Wheezing** | | | | | | |
| Yes | 6 | 7 | 1.078 | 0.299 | 1.840 | 0.575-5.893 |
| No | 34 | 73 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 3 | 3 | - | 0.399** | - | - |
| No | 37 | 77 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 17 | 26 | 1.160 | 0.282 | 1.535 | 0.702-3.356 |
| No | 23 | 54 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 18 | 20 | **4.929** | **0.026*** | 2.455 | 1.100-5.477 |
| No | 22 | 60 | | | | |
| **Sneezing** | | | | | | |
| Yes | 3 | 12 | 1.371 | 0.242 | 0.459 | 0.122-1.732 |
| No | 37 | 68 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 19 | 27 | 2.133 | 0.144 | 0.144 | 0.819-3.853 |
| No | 21 | 53 | | | | |

N=120

***Significant at** $p<0.05$, **Fisher Exact Test

**Table 12(d):** The association between exposure of Mold in preschools and respiratory health symptoms among preschool children.

| Variables | Mold (High) | Mold (Low) | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Number | | | | | |
| **Cough** | | | | | | |
| Yes | 20 | 30 | **10.286** | **0.001*** | 4.000 | 1.665-9.610 |
| No | 10 | 60 | | | | |
| **Phlegm** | | | | | | |
| Yes | 12 | 22 | 2.681 | 0.102 | 2.061 | 0.859-4.940 |
| No | 18 | 68 | | | | |
| **Wheezing** | | | | | | |
| Yes | 4 | 9 | - | 0.735** | - | - |
| No | 26 | 81 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 3 | 3 | - | 0.164** | - | - |
| No | 27 | 87 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 19 | 24 | **13.156** | **<0.001*** | 4.750 | 1.976-11.421 |
| No | 11 | 66 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 16 | 22 | **8.678** | **0.003*** | 3.532 | 1.490-8.377 |
| No | 14 | 68 | | | | |
| **Sneezing** | | | | | | |
| Yes | 4 | 11 | - | 1.000** | - | - |
| No | 26 | 79 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 12 | 34 | 0.047 | 0.828 | 1.098 | 0.471-2.558 |
| No | 18 | 56 | | | | |

N=120

*__Significant at p<0.05__, **Fisher Exact Test

**Table 12(e):** The association between exposure of Bacteria in schools and respiratory health symptoms among preschool children.

| Variables | Bacteria (High) | Bacteria (Low) | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Number | | | | | |
| **Cough** | | | | | | |
| Yes | 10 | 40 | 1.143 | 0.285 | 0.625 | 0.263-1.485 |
| No | 20 | 50 | | | | |
| **Phlegm** | | | | | | |
| Yes | 7 | 27 | 0.492 | 0.483 | 0.710 | 0.272-1.852 |
| No | 23 | 63 | | | | |
| **Wheezing** | | | | | | |
| Yes | 5 | 8 | - | 0.307** | - | - |
| No | 25 | 82 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 3 | 3 | - | 0.164** | - | - |
| No | 27 | 87 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 11 | 32 | 0.012 | 0.912 | 1.049 | 0.445-2.477 |
| No | 19 | 58 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 11 | 27 | 0.462 | 0.497 | 1.351 | 0.567-3.220 |
| No | 19 | 63 | | | | |
| **Sneezing** | | | | | | |
| Yes | 4 | 11 | - | 1.000** | - | - |
| No | 26 | 79 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 15 | 31 | 2.303 | 0.129 | 1.903 | 0.824-4.397 |
| No | 15 | 59 | | | | |

N=120

***Significant at $p<0.05$,** **Fisher Exact Test

**Table 12(f):** The association between exposure of Gram-negative Bacteria in preschools and respiratory health symptoms among preschool children.

| Variables | G-ve Bac (High) | G-ve Bac (Low) | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Number | | | | | |
| **Cough** | | | | | | |
| Yes | 19 | 31 | **7.726** | **0.005*** | 3.287 | 1.390-7.772 |
| No | 11 | 59 | | | | |
| **Phlegm** | | | | | | |
| Yes | 13 | 21 | **4.432** | **0.035*** | 2.513 | 1.051-6.008 |
| No | 17 | 69 | | | | |
| **Wheezing** | | | | | | |
| Yes | 3 | 10 | - | 1.000** | - | - |
| No | 27 | 80 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 3 | 3 | - | 0.164** | - | - |
| No | 27 | 87 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 16 | 27 | **5.328** | **0.021*** | 2.667 | 1.143-6.222 |
| No | 14 | 63 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 16 | 22 | **8.678** | **0.003*** | 3.532 | 1.490-8.377 |
| No | 14 | 68 | | | | |
| **Sneezing** | | | | | | |
| Yes | 2 | 13 | - | 0.352** | - | - |
| No | 28 | 77 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 14 | 32 | 1.175 | 0.278 | 1.586 | 0.687-3.663 |
| No | 16 | 58 | | | | |

N=120

*Significant at $p<0.05$, **Fisher Exact Test

**Table 13(a):** The association between exposure of $PM_{2.5}$ in houses and respiratory health symptoms among preschool children.

| **Variables** | **$PM_{2.5}$ (High)** | **$PM_{2.5}$ (Low)** | **$\chi^2$ value** | **p value** | **PR** | **95% CI** |
|---|---|---|---|---|---|---|
| | **Number** | | | | | |
| **Cough** | | | | | | |
| Yes | 16 | 14 | **13.017** | **<0.001*** | 10.286 | 2.557-41.372 |
| No | 3 | 27 | | | | |
| **Phlegm** | | | | | | |
| Yes | 11 | 14 | 3.013 | 0.083 | 2.652 | 0.868-8.097 |
| No | 8 | 27 | | | | |
| **Wheezing** | | | | | | |
| Yes | 2 | 4 | 0.009 | 1.000 | 1.088 | 0.181-6.530 |
| No | 17 | 37 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 1 | 0 | - | 0.317** | - | - |
| No | 18 | 41 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 13 | 15 | **5.287** | **0.021*** | 3.756 | 1.180-11.949 |
| No | 6 | 26 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 12 | 14 | **4.450** | **0.035*** | 3.306 | 1.064-10.274 |
| No | 7 | 27 | | | | |
| **Sneezing** | | | | | | |
| Yes | 2 | 8 | - | 0.480** | - | - |
| No | 17 | 33 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 11 | 13 | 3.710 | 0.054 | 2.962 | 0.963-9.108 |
| No | 8 | 28 | | | | |

N=60

***Significant at p<0.05,** **Fisher Exact Test

**Table 13(b):** The association between exposure of $PM_{10}$ in houses and respiratory health symptoms among preschool children.

| **Variables** | **$PM_{10}$ (High)** | **$PM_{10}$ (Low)** | **$\chi^2$ value** | **p value** | **PR** | **95% CI** |
|---|---|---|---|---|---|---|
| | **Number** | | | | | |
| **Cough** | | | | | | |
| Yes | 17 | 13 | **17.330** | **<0.001*** | 18.308 | 3.674-91.229 |
| No | 2 | 28 | | | | |
| **Phlegm** | | | | | | |
| Yes | 11 | 14 | 3.013 | 0.083 | 2.652 | 0.868-8.097 |
| No | 8 | 27 | | | | |
| **Wheezing** | | | | | | |
| Yes | 2 | 4 | - | 1.000** | - | - |
| No | 17 | 37 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 1 | 0 | - | 0.317** | - | - |
| No | 18 | 41 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 14 | 14 | **8.155** | **0.004*** | 5.400 | 1.613-18.073 |
| No | 5 | 27 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 13 | 13 | **7.127** | **0.008*** | 4.667 | 1.449-15.033 |
| No | 6 | 28 | | | | |
| **Sneezing** | | | | | | |
| Yes | 2 | 8 | - | 0.480** | - | - |
| No | 17 | 33 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 10 | 14 | 1.849 | 0.174 | 2.143 | 0.708-6.486 |
| No | 9 | 27 | | | | |

N=60

***Significant at $p<0.05$,** **Fisher Exact Test

**Table 13(c):** The association between exposure of VOCs in houses and respiratory health symptoms among preschool children.

| Variables | VOCs (High) | VOCs (Low) | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Number | | | | | |
| **Cough** | | | | | | |
| Yes | 12 | 18 | 0.069 | 0.793 | 0.872 | 0.312-2.435 |
| No | 13 | 17 | | | | |
| **Phlegm** | | | | | | |
| Yes | 11 | 14 | 0.096 | 0.757 | 1.179 | 0.417-3.333 |
| No | 14 | 21 | | | | |
| **Wheezing** | | | | | | |
| Yes | 2 | 4 | - | 1.000** | - | - |
| No | 23 | 31 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 1 | 0 | - | 0.417** | - | - |
| No | 24 | 35 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 13 | 15 | 0.490 | 0.484 | 1.444 | 0.515-4.052 |
| No | 12 | 20 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 11 | 15 | 0.008 | 0.930 | 1.048 | 0.372-2.950 |
| No | 14 | 20 | | | | |
| **Sneezing** | | | | | | |
| Yes | 5 | 5 | - | 0.728** | - | - |
| No | 20 | 30 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 12 | 12 | 1.143 | 0.285 | 1.769 | 0.619-5.056 |
| No | 13 | 23 | | | | |

N=60

***Significant at p<0.05,** **Fisher Exact Test

**Table 13(d):** The association between exposure of Mold in houses and respiratory health symptoms among preschool children.

| Variables | Mold (High) | Mold (Low) | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Number | | | | | |
| **Cough** | | | | | | |
| Yes | 10 | 20 | 0.287 | 0.592 | 0.750 | 0.262-2.151 |
| No | 12 | 18 | | | | |
| **Phlegm** | | | | | | |
| Yes | 11 | 14 | 0.992 | 0.319 | 1.714 | 0.591-4.970 |
| No | 11 | 24 | | | | |
| **Wheezing** | | | | | | |
| Yes | 0 | 6 | - | 0.077** | - | - |
| No | 22 | 32 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 0 | 1 | - | 1.000** | - | - |
| No | 22 | 37 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 11 | 17 | 0.155 | 0.694 | 1.235 | 0.431-3.538 |
| No | 11 | 21 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 10 | 16 | 0.064 | 0.801 | 1.146 | 0.398-3.300 |
| No | 12 | 22 | | | | |
| **Sneezing** | | | | | | |
| Yes | 4 | 6 | - | 1.000** | - | - |
| No | 18 | 32 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 9 | 15 | 0.012 | 0.913 | 1.062 | 0.364-3.096 |
| No | 13 | 23 | | | | |

N=60

*Significant at $p<0.05$, **Fisher Exact Test

**Table 13(e):** The association between exposure of Bacteria in houses and respiratory health symptoms among preschool children.

| Variables | Bacteria (High) | Bacteria (Low) | $\chi^2$ value | p value | PR | 95% CI |
|---|---|---|---|---|---|---|
| | Number | | | | | |
| **Cough** | | | | | | |
| Yes | 17 | 13 | 3.300 | 0.069 | 2.615 | 0.917-7.457 |
| No | 10 | 20 | | | | |
| **Phlegm** | | | | | | |
| Yes | 15 | 10 | **3.896** | **0.048*** | 2.875 | 0.994-8.313 |
| No | 12 | 23 | | | | |
| **Wheezing** | | | | | | |
| Yes | 2 | 4 | - | 0.681** | - | - |
| No | 25 | 29 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 0 | 1 | - | 1.000** | - | - |
| No | 27 | 32 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 16 | 12 | 3.128 | 0.077 | 2.545 | 0.895-7.239 |
| No | 11 | 21 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 12 | 14 | 0.025 | 0.875 | 1.086 | 0.389-3.029 |
| No | 15 | 19 | | | | |
| **Sneezing** | | | | | | |
| Yes | 2 | 8 | - | 0.162** | - | - |
| No | 25 | 25 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 12 | 12 | 0.404 | 0.525 | 1.400 | 0.495-3.956 |
| No | 15 | 21 | | | | |

N=60

***Significant at p<0.05**, **Fisher Exact Test

**Table 13(f):** The association between exposure of Gram-negative Bacteria in houses and respiratory health symptoms among preschool children.

| **Variables** | **G-ve Bac (High)** | **G-ve Bac (Low)** | **$\chi^2$ value** | **p value** | **PR** | **95% CI** |
|---|---|---|---|---|---|---|
| | **Number** | | | | | |
| **Cough** | | | | | | |
| Yes | 16 | 14 | **7.177** | **0.007*** | 4.571 | 1.452-14.389 |
| No | 6 | 24 | | | | |
| **Phlegm** | | | | | | |
| Yes | 11 | 14 | 0.992 | 0.319 | 1.714 | 0.591-4.970 |
| No | 11 | 24 | | | | |
| **Wheezing** | | | | | | |
| Yes | 2 | 4 | - | 1.000** | - | - |
| No | 20 | 34 | | | | |
| **Chest Tightness** | | | | | | |
| Yes | 1 | 0 | - | 0.367** | - | - |
| No | 21 | 38 | | | | |
| **Runny Nose** | | | | | | |
| Yes | 15 | 13 | **6.461** | **0.011*** | 4.121 | 1.345-12.628 |
| No | 7 | 25 | | | | |
| **Blocked Nose** | | | | | | |
| Yes | 10 | 16 | 0.064 | 0.801 | 1.146 | 0.398-3.300 |
| No | 12 | 22 | | | | |
| **Sneezing** | | | | | | |
| Yes | 4 | 6 | - | 1.000** | - | - |
| No | 18 | 32 | | | | |
| **Sore Throat** | | | | | | |
| Yes | 12 | 12 | 3.062 | 0.080 | 2.600 | 0.881-7.677 |
| No | 10 | 26 | | | | |

N=60

***Significant at p<0.05**, **Fisher Exact Test

## 4.8 Factors Influenced the Abnormality of Lung Function among Study Respondents

Logistic regression was performed to determine the main factor that influenced the abnormality of FVC% and $FEV_1$% among the preschool children in study areas. From Table 14 and Table 15, exposure of preschool children toward $PM_{2.5}$ was significantly associated with both abnormalities of FVC% ($\beta$=1.403, p= 0.013, PR= 4.07, 95% CI= 1.34-12.33) and $FEV_1$% ($\beta$=1.858, p= 0.025, PR= 6.41, 95% CI= 1.27-12.39)

Based on the result, respondents that significantly exposed with $PM_{2.5}$ is four times more likely to have lung function (FVC %) abnormalities compared to those who did not expose. On the other hand, respondents that exposed with $PM_{2.5}$ is also getting six times more likely to have lung function ($FEV_1$ %) abnormalities compared to those who did not expose.

Gemenetzis et al., (2006) reported that, increase in particulate matter concentration had significant with related lung disorder and with reduction in lung function, while $PM_{2.5}$ were strongly associated with cardiopulmonary diseases and lung cancer. It is suggested that, these problems could be due to reaction of polycyclic aromatic hydrocarbon contained in particulate matter on human body tissues (Madureira et al., 2015).

**Table 14:** Factors Influenced the Lung Function (FVC%) Abnormality among Respondents.

| Variables | *β* | S.E | P value | PR | 95% CI |
|---|---|---|---|---|---|
| Constant | -1.698 | 0.570 | 0.003 | | |
| $PM_{2.5}$ | 1.403 | 0.566 | **0.013*** | 4.07 | 1.34-12.33 |
| $PM_{10}$ | 0.634 | 0.730 | 0.386 | 1.88 | 0.45-7.89 |
| VOCs | -0.949 | 1.277 | 0.457 | 0.38 | 0.03-4.73 |
| Mould | -0.431 | 0.660 | 0.513 | 0.65 | 0.17-2.37 |
| Bacteria | 0.109 | 0.878 | 0.901 | 1.12 | 0.20-6.24 |
| Gram-negative Bacteria | 1.792 | 1.300 | 0.168 | 6.00 | 0.47-76.70 |

N=120

***Significant at $p<0.05$**

95% CI= 95% Confidence Interval, *β*= Regression Coefficient, S.E= Standard Error
Nagelkerke R Square= 0.284

**Table 15:** Factors Influenced the Lung Function ($FEV_1$%) Abnormality among Respondents.

| Variables | *β* | S.E | P value | PR | 95% CI |
|---|---|---|---|---|---|
| Constant | -1.533 | 0.557 | 0.006 | | |
| $PM_{2.5}$ | 1.858 | 0.827 | **0.025*** | 6.41 | 1.27-12.39 |
| $PM_{10}$ | 0.799 | 0.736 | 0.277 | 2.22 | 0.53-9.41 |
| VOCs | 0.067 | 1.302 | 0.959 | 1.07 | 0.08-13.74 |
| Mould | -0.422 | 0.652 | 0.518 | 0.66 | 0.18-2.36 |
| Bacteria | 0.802 | 0.919 | 0.383 | 2.23 | 0.37-13.51 |
| Gram-negative Bacteria | 0.758 | 1.316 | 0.565 | 2.13 | 0.16-28.16 |

N=120

***Significant at $p<0.05$**

95% CI= 95% Confidence Interval, *β*= Regression Coefficient, S.E= Standard Error

Nagelkerke R Square= 0.289

**Study Limitation**

There were few limitations found during conducted this study. First of all, from the study design itself. In a cross-sectional study, the exposure and outcome were assessed concurrently. Even the data in this study show certain relationships were established between the exposure and the outcome, there were insufficient evidences to prove them. The true measure of association can only be determined if the entire population participate in this study. Besides that, the study population was in between 5 to 6 years old children and only specific to Malay ethnicity, thus the result cannot be generalized for other ethnicities in Malaysia because the characteristics of the population were different.

Besides that, for indoor air assessment, there are still no standards established for building in non-occupational settings such as homes or schools in Malaysia. In this study, the indoor air assessment was done for 4 hours exposure in preschools. Therefore, Recommended Malaysian Air Quality Guideline (RMAQG) or other reference standard may not be suitable for comparing the exposure as most of it was based on 8-hour or 24-hour exposure.

Furthermore, there could be a possibility for information bias in this study as the respondents' parents might have difficulties to remember details when answering the given questionnaires. However, in order to minimize this bias, the questions from the constructed questionnaire were mostly using close-response format instead of open-ended format where the parents supplied with list of answer option (e,g.Yes/No) instead of writing down all the answer details.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

Finding from this study indicated that the exposures to poor indoor air quality or high level indoor pollutants might increase the risk of getting respiratory symptoms and reduction in lung function among the study respondents.

All indoor air pollutants in preschools were significantly associated with lung function abnormalities among preschool children. Only $PM_{2.5}$, $PM_{10}$ and Gram-negative bacteria in houses were significantly associated with lung function abnormalities among preschool children. $PM_{2.5}$ was found to be the most significant air pollutant in predicting the lung function abnormalities among the respondents. Meanwhile, the most reported respiratory symptoms were cough, phlegm, runny nose and blocked nose. Even though very limited study had been done on airborne Gram-negative bacteria towards human, this study proved that; there was also a significant association between exposures of Gram-negative bacteria with lung function abnormalities and higher reported respiratory symptoms among the respondents.

The hypothesis set in the early stage of this study had been tested statistically and those proven to be true are as follows:

1. There is a significant difference between the level of air pollutants ($PM_{2.5}$, $PM_{10}$, VOC, mold, bacteria and Gram-negative bacteria) for both studied and comparative areas.
2. There is a significant difference between the reported respiratory symptoms among the preschool children in the study and comparative areas.
3. There is a significant difference between the lung function among the preschool children in the study and comparative areas.
4. There is a significant association between the level of air pollutants ($PM_{2.5}$, $PM_{10}$, VOC, mold, bacteria and Gram-negative bacteria) and respiratory symptoms among the preschool children.
5. There is a significant association between the level of air pollutants ($PM_{2.5}$, $PM_{10}$, VOC, mold, bacteria and Gram-negative bacteria) and lung function among the preschool children.

## 5.2 Recommendations

First of all, educating the preschool teachers, parents and communities on the environmental risks they are facing is a good action to be taken. Health Promotion Unit in District Health Office or Ministry of Health can collaborate with the preschools management and communities to hold a campaign related to the awareness of air pollutants, their health risks and action to take. By educating the whole communities, strong awareness can be shaped, pollutants exposure may be controlled and health risk can be minimized.

Moreover, Department of Environment may introduce standards for IAQ in preschools and houses, as this may help the preschool management and parents to maintain the environment in preschools and houses with specific limit. As government being the highest in administration hierarchy ranking, it is time to come out with such idea to improve our school environment not only in indoor air quality but also with the standard of the building criteria, construction material, design and furniture used in a classroom. Until now, there has been start a lot of research and attention given related to the impact of indoor pollutants towards school children's health in Malaysia. For a long term perspective, in establishing a specific guideline or standard, the health problem will be prevented or at least minimized from threatening our children.

Besides that, based on the result of this study, it is recommended for preschools management to implement housekeeping program such that the ventilation in the classroom is well-maintained and cleaned regularly. As $PM_{2.5}$ is the most significant in predicting the lung function abnormalities among preschool children, it is advisable to clean the classroom by using wet vacuum cleaner as it proves more effective in eliminating small particulate instead of disperse them as compared to regular floor sweeping. The kitchen or cooking activities also should be separated from the classroom as it is the primary sources of pollutants in the preschools.

Moreover, parents and guardian should clean their houses regularly and it is advisable to be done without the presence of children in homes. Parents also need to give more attention and need to be very sensitive to their children's health status. Children that have frequently respiratory symptoms or problem should seek for further medical checkup and consultation. As learning starts from home, good hygiene practices should be taught early in children life so that it becomes a good habit as they grew older.

Malaysia is a tropical country with a hot and humid weather throughout the year. This is the most favorable condition for the microbiological organism to grow. Therefore, research on biological pollutants such as mold and bacteria need to be taken into consideration as they also possess health risks in human. As Gram-negative bacteria show association with lung function abnormalities in this study, further research need to be done to understand the mechanism of these bacteria by taking consideration on the level of endotoxin that can be produced.

Last but not least, this study also could be improved with certain modifications. It is recommended for future study to determine the association of respiratory health among preschool children, with an increased sample size and take into account of varied age range and races in order for the findings to be more generalizes to the Malaysian population and to explore the very complex relationship between indoor air pollutants with respiratory health.

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# APPENDICES

# APPENDIX 1:
# Gantt Chart

| | 2015 | | | | 2016 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Project Activities | September | October | November | December | January | February | March | April | May | June |
| Determine Research/Title | | | | | | | | | | |
| Proposal Writing | | | | | | | | | | |
| Proposal Submission | | | | | | | | | | |
| Proposal Presentation | | | | | | | | | | |
| Order/Book for Equipment & Materials | | | | | | | | | | |
| Data Collection | | | | | | | | | | |
| Data Analysis | | | | | | | | | | |
| Thesis Writing | | | | | | | | | | |
| Thesis Submission & VIVA | | | | | | | | | | |

# APPENDIX 2:

# Ethical Approval

**JKEUPM Ref No.** : **FPSK(EXP15-OSH)U017**

a) Members of the JKEUPM who reviewed the documents:
   Prof Dr Lim Thiam Aun

b) Date of approval: 17/12/2015

Endorsed at JKEUPM Meeting on **30/12/2015**, attended by:

| NAME | DESIGNATION | GENDER | TICK IF PRESENT |
|---|---|---|---|
| Prof. Dato' Dr. Abdul Jalil Nordin | Nuclear Radiologist & Dean, Faculty of Medicine and Health Sciences | Male | |
| Prof. Dr Zamberi Sekawi | Medical Microbiologist & Deputy Dean of Research and Internationalization, Faculty of Medicine and Health Sciences | Male | √ |
| Prof. Dato' Dr. Lye Munn Sann | Medical Statistician, Dept of Community Health, Faculty of Medicine and Health Sciences | Male | √ |
| Prof. Dr. Tengku Aizan Abd Hamid | Gerontologist & Director, Institute of Gerontology | Female | |
| Prof. Dr. Lekhraj Rampal | Medical Statistician, Dept of Community Health, Faculty of Medicine and Health Sciences | Male | |
| Prof. Dr. Lim Thiam Aun | Anesthesiologist, Dept of Surgery, Faculty of Medicine and Health Sciences | Male | |
| Prof. Dr. Patimah Ismail | Professor of Biomedicine, Dept of Biomedical Sciences, Faculty of Medicine and Health Sciences | Female | √ |
| Prof. Dr. Johnson Stanslas | Pharmacologist, Dept of Medicine, Faculty of Medicine and Health Sciences | Male | |
| Prof. Dr. Sherina Mohd.Sidik | Professor of Medical, Department of Psychiatry, Faculty of Medicine and Health Sciences | Female | |
| Prof Dr. M. Iqbal Saripan | Professor of Department of Computer and Communication Systems Engineeering | Male | |
| Assoc. Prof. Dr. Mansor Abu Talib | Assoc. Professor of Guidance and Counselling, Dept of Human Development and Family Studies, Faculty of Human Ecology | Male | |
| Assoc. Prof. Dr. Hejar Abd.Rahman | Assoc. Professor of Public Health / Head Of Unit, Department of Community Health, Faculty of Medicine and Health Sciences | Female | √ |
| Assoc. Prof. Dr. Normala Ibrahim | Assoc. Professor of Psychiatry, Department of Psychiatry, Faculty of Medicine and Health Sciences | Female | √ |

| | | | |
|---|---|---|---|
| Assoc Prof Dr Sharmala Paramasivam | Assoc Prof of Department English, Faculty of Modern Languages and Communication | Female | √ |
| Assoc Prof Dr Arshad Abdul Samad | Assoc Prof of Department Language and Humanities Education, Faculty of Educational Studies | Male | |
| Assoc Prof Dr Muhamamd Najib Mohamad Alwi (Independent Member) | Psychiatric Consultant, Cyberjaya University College of Medical Sciences ( CUCMS) | Male | √ |
| Dr. Salmiah Md. Said | Lecturer of Epidemiology, Medical Statistics, Department of Community Health, Faculty of Medicine and Health Sciences | Female | √ |
| Assoc. Prof. Dr. Noritah Omar (Lay Person) | Assoc. Professor of English Language, Dept of English Language, Faculty of Communication and Modern Languages | Female | |
| Dr. Rojanah Kahar (Lay Person) | Senior Lecturer of Dept of Human Development and Family Studies, Faculty of Human Ecology | Female | |
| Tan Sri Dato' Napsiah Omar (Independent Member) | Chairman, National Population and Family Development Board | Female | |
| En John Posko Anthony (Lay Person) | Headmaster of Sekolah Jenis Kebangsaan (Tamil) Kajang | Male | √ |

# APPENDIX 3:

# Information Sheet and Consent Form

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

## BORANG B2: PENERANGAN DAN PERSETUJUAN IBUBAPA/PENJAGA

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

### 1.TAJUK KAJIAN

Kualiti udara dalaman serta hubungkait dengan kesihatan respiratori dalam kalangan kanak-kanak prasekolah di kawasan bandar dan pinggir bandar.

### 2. PENGENALAN

Kanak-kanak berumur sekitar 4 hingga 6 tahun dipercayai banyak menghabiskan masa mereka di dalam bangunan, rumah atau sekolah. Hal ini menunjukkan kadar pendedahan kepada pencemar udara dalaman bagi kanak-kanak tersebut adalah tinggi. Kualiti udara dalaman yang teruk akan mendedahkan seseorang kepada risiko kesihatan akibat pencemaran zarah-zarah, pencemar biologi seperti kulat dan bakteria, komia organik yang meruap (VOCs) dan juga formaldehid ( Yoon et al., 2010 & Lignell et al., 2005). Sejajar dengan teori ini, kajian beberapa dekad ini telah menunjukkan peningkatan gejala-gejala masalah kesihatan pernafasan terutamanya di kalangan kanak-kanak berumur lingkungan prasekolah. Kajian ini akan menilai kualiti udara dalaman bangunan tadika untuk mewujudkan perkaitan antara pendedahan kepada pencemar udara dan bakteria Gram-negatif dengan masalah respiratori di kalangan kanak-kanak prasekolah.

### 3. APAKAH YANG PERLU ANDA LAKUKAN?

Anda sebagai ibu/bapa/penjaga kepada anak anda dikehendaki menandatangani borang penyertaan responden dan menyatakan minat anda untuk menyertai kajian ini. Ianya boleh dilakukan setelah anda membaca dan memahami isi kandungan penerangan ini. Borang penyertaan responden harus dikembalikan kepada pengkaji sebelum temubual dan ujian yang akan dijalankan. Selain itu, kebenaran daripada pihak anda juga diperlukan bagi membenarkan anak di bawah jagaan anda untuk menjalankan ujian fungsi paru-paru *(Spirometry test)* ketika kajian ini dijalankan. Ujian ini langsung tidak akan membahayakan anak anda dan **tiada** sebarang sampel biologi akan diambil seperti darah, air liur dan lain-lain. Ujian fungsi paru-paru hanya memerlukan anak anda untuk melakukan hembusan melalui corong *(mouthpiece)* daripada alat yang dipanggil Spirometer. Corong yang digunakan adalah selamat, boleh dibuang *(disposable)* dan disediakan 1 bagi setiap responden.

### 4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Pelajar atau kanak-kanak yang berumur di bawah 5 tahun atau berumur melebihi 6 tahun dan bukan berbangsa Melayu tidak dibenarkan menyertai kajian ini. Pelajar atau kanak-kanak yang mempunyai masalah alahan rhinitis atau resdung, pernah mengalami kecederaan teruk pada hidung dan mempunyai sejarah alergi dan asma yang disahkan oleh pihak perubatan/doktor juga tidak dibenarkan untuk menjadi responden.

## 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 .....................................
(*Ibubapa/ Penjaga*)

Tarikh :............................................

Tandatangan .....................................
(*Saksi*)

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 Form

ID Responden (diisi oleh penyelidik)

| | | | | |
|---|---|---|---|---|
| | | | | |

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

# BORANG SOAL SELIDIK

**TAJUK:**

KUALITI UDARA DALAMAN SERTA HUBINGKAIT KEPADA KESIHATAN RESPIRATORI DALAM KALANGAN KANAK-KANAK PRASEKOLAH DI KAWASAN BANDAR DAN PINGGIR BANDAR

INDOOR AIR QUALITY AND ITS ASSOCIATION WITH RESPIRATORY HEALTH AMONG PRESCHOOL CHILDREN IN URBAN AND SUBURBAN AREA

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.**

## BAHAGIAN A: BUTIRAN DIRI

1. Nama : ____________________

2. Jantina : 1. Lelaki [ ] 2. Perempuan [ ]

3. Tarikh Lahir : ____________ (Hari/Bulan/Tahun)

4. Alamat : ____________________

   Poskod : Bandar: ____________

   Negeri: ____________

5. Sudah berapa lama tinggal di alamat sekarang : [ | ] tahun [ | ] bulan

6. Bangsa : 1. Melayu [ ] 2. India [ ]
   2. Cina [ ] 4. Lain-lain [ ] Nyatakan: ____________

7. Tahun berdaftar di sekolah ini : [2|0| | ]

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 [ ]
    2. Sekolah rendah [ ]
    3. Tingkatan 3 [ ]
    4. Tingkatan 5 [ ]
    5. STPM/Diploma [ ]
    6. Ijazah [ ]
    7. Pasca siswazah [ ]

12. Pendidikan Ibu :
    1. Tidak bersekolah [ ]
    2. Sekolah rendah [ ]
    3. Tingkatan 3 [ ]
    4. Tingkatan 5 [ ]
    5. STPM/Diploma [ ]
    6. Ijazah [ ]
    7. Pasca siswazah [ ]

13. Pendapatan bapa/penjaga lelaki : RM ____________

14. Pendapatan ibu/penjaga perempuan : RM ____________

## 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. 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? | | |

## B4. KESAKITAN DADA/CHEST PAIN

| | | 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? | | |

## B5. PENYAKIT-PENYAKIT LAIN/ OTHER DISEASES

| | | | | YA | TIDAK |
|---|---|---|---|---|---|
| 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 | | | | |
| | c) Emfisema | | | | |
| | d) Asma (lelah) | | | | |
| | e) Pneumonia (jangkitan paru-paru) | | | | |
| | f) Lain-lain | | | | |

## B6. 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? | | |

## B7. SEJARAH KESIHATAN KELUARGA

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

| | | YA | TIDAK |
|---|---|---|---|
| 1 | Bronkitis kronik | | |
| 2 | Emfisema | | |
| 3 | Asma | | |
| 4 | Barah paru-paru | | |
| 5 | 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? | | |
| | • Bapa | | |
| | • 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

1. Apakah jenis rumah yang didiami sekarang?
   - Teres ☐
   - Banglo ☐
   - Apartmen ☐
   - Flat ☐
   - Kampung/Felda ☐
   - Jenis-jenis Lain ☐

2. Jenis kawasan rumah:
   - Bandar ☐
   - Sub-bandar ☐
   - Luar Bandar ☐

3. Adakah anda tinggal di kediaman yang sama sejak anak anda lahir? Ya ☐ Tidak ☐
   **Jika TIDAK,** pada tahun berapakah anda pindah ke kediaman sekarang? ____________

4. Berapakah anggaran keluasan tempat kediaman anda? ____________

5. Bahan apakah yang digunakan dalam pembinaan rumah anda?
    - Batu ☐
    - 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? Ya ☐ Tidak ☐
   **Jika YA**, apakah binatang itu? ____________________

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 ☐ Tidak ☐
    - Buih atau luntur kuning pada pelapik plastik lantai atau luntur hitam pada lantai yang berkarpet Ya ☐ Tidak ☐
    - Kulat tumbuh di dinding, lantai atau siling Ya ☐ Tidak ☐
    - Bau kulat di mana-mana bilik (kecuali di bilik bawah tanah) Ya ☐ Tidak ☐
    - Bau-bau lain di dalam rumah. Ya ☐ Tidak ☐
      **Jika YA**, nyatakan bau itu: ____________________

10. Adakah masalah kelembapan/kerosakan air berlaku di tempat kediaman anda dalam tempoh 5 tahun yang lepas? Ya ☐ Tidak ☐

11. Adakah terdapat asap rokok di dalam rumah? Ya
    - Ya, setiap hari ☐
    - 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 ☐
    - berkongsi dengan 2 orang ☐
    - berkongsi dengan 3 orang ☐
    - berkongsi dengan ≥ 4 orang ☐

15. Apakah bahan api yang digunakan untuk memasak di dalam rumah anda?
    - Elektrik ☐
    - 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 ☐

18. Apakah alat yang digunakan untuk menyejukkan udara di dalam rumah? ____ ____
    - Penyaman udara ☐
    - Kipas ☐
    - Lain-lain. Sila nyatakan ______________________ ☐

19. Adakah anda menggunkan 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? ______________

24. Berapa kerapkah anda membersihkan rumah anda dalam seminggu? kali

25. Adakah anda menggunkan 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? | ☐ | ☐ | ☐ | ☐ |
| 2. | Ruam di muka/tekak? | ☐ | ☐ | ☐ | ☐ |
| 3. | Sakit kulit<br>**Jika YA**, di mana? ____________ | ☐ | ☐ | ☐ | ☐ |
| 4. | Gatal-gatal di muka/tekak? | ☐ | ☐ | ☐ | ☐ |
| 5. | Gatal-gatal di tangan? | ☐ | ☐ | ☐ | ☐ |
| 6. | Radang mata (merah, kering, gatal) | ☐ | ☐ | ☐ | ☐ |
| 7. | Bengkak kelopak mata | ☐ | ☐ | ☐ | ☐ |
| 8. | Sakit kepala | ☐ | ☐ | ☐ | ☐ |
| 9. | Loya | ☐ | ☐ | ☐ | ☐ |
| 10. | Hidung berair/selesema | ☐ | ☐ | ☐ | ☐ |
| 11. | Hidung tersekat/tersumbat | ☐ | ☐ | ☐ | ☐ |
| 12. | Tekak kering | ☐ | ☐ | ☐ | ☐ |
| 13. | Sakit tekak | ☐ | ☐ | ☐ | ☐ |
| 14. | Radang batuk | ☐ | ☐ | ☐ | ☐ |
| 15. | Susah bernafas | ☐ | ☐ | ☐ | ☐ |
| 16. | Penat dan tak berdaya | ☐ | ☐ | ☐ | ☐ |

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 MENGISI BORANG SOAL SELIDIK INI**