UNIVERSITI PUTRA MALAYSIA

THE INFLUENCE OF THE SCHOOL ENVIRONMENT ON LUNG FUNCTION AND RESPIRATORY SYMPTOMS AMONG SECONDARY SCHOOL STUDENTS IN KOTA KINABALU, SABAH

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BY

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ABSTRACT

THE INFLUENCE OF THE SCHOOL ENVIRONMENT ON LUNG FUNCTION AND RESPIRATORY SYMPTOMS AMONG SECONDARY SCHOOL STUDENTS IN KOTA KINABALU, SABAH

NUR SHAHIRA FADZIL

Introduction: Kota Kinabalu is a location of rapid and dynamic change with the increase of industrial activities, construction, and transportation. Air pollutants released from these activities is a health concern especially in school children. **Objective:** This study was conducted to determine the relationship between indoor air pollutants (PM_{10}, $PM_{2.5}$, TVOC, NO_2, CO_2, and formaldehyde) in schools with lung function and respiratory symptoms of the students. **Methodology**: A cross-sectional study was conducted on 346 Form Two students from six secondary schools in Kota Kinabalu, Sabah. There were three types of data collection used in this study. ISAAC questionnaire was used to obtain the reported respiratory symptom and air pollutants level were measured by using the calibrated equipment such as DustTrak for $PM_{2.5}$ and PM_{10}, MultiRAE for formaldehyde, Air Velocity meter for TVOC, CO_2, temperature and relative humidity and IVL passive sampler for NO_2. Meanwhile, Lung function test was carried out using the portable spirometer. The data obtained were analysed using SPSS version 22. **Results:** The findings showed that there was significant relationship between $PM_{2.5}$, PM_{10}, and NO_2 with the lung function (FVC% predicted and FEV_1/FVC% predicted) of the students. Besides, $PM_{2.5}$, PM_{10}, TVOC, and formaldehyde were found to have significant association with the reported respiratory symptoms such as irritating cough, wheezing, and respiratory infections. The findings also showed that $PM_{2.5}$ and PM_{10} were the predictors which significantly reduced children's lung function while the total volatile organic compound and formaldehyde were found to increase the risk of getting respiratory infection. **Conclusion:** The findings concluded that exposure to the air pollutants reduced children's lung function and caused reported respiratory symptoms among the students.

Keywords: Air pollutants, lung function and respiratory symptoms.

ABSTRAK

PENGARUH KUALITI UDARA DI PERSEKITARAN SEKOLAH TERHADAP FUNGSI PARU-PARU DAN SIMPTOM PERNAFASAN DI KALANGAN PELAJAR SEKOLAH DI KOTA KINABALU, SABAH.

NUR SHAHIRA FADZIL

Pengenalan: Kota Kinabalu merupakan lokasi perubahan pesat dan dinamik dengan peningkatan aktiviti perindustrian, pembinaan, dan pengangkutan. Pencemar udara yang dilepaskan daripada aktiviti ini adalah membimbangkan terutama pada kesihatan pelajar-pelajar sekolah. **Objektif:** Kajian ini dijalankan untuk menentukan hubungan antara bahan pencemar udara (PM10, PM2.5, TVOC, NO2, CO2, dan formaldehid) di sekolah dengan fungsi paru-paru dan simptom pernafasan para pelajar. **Metodologi:** Satu kajian rentas telah dijalankan ke atas 346 pelajar Tingkatan Dua dari enam buah sekolah menengah di Kota Kinabalu, Sabah. Terdapat tiga jenis pengumpulan data yang digunakan dalam kajian ini. Soal selidik ISAAC digunakan untuk mendapatkan simptom pernafasan yang dilaporkan. Seterusnya, paras bahan pencemar udara diukur dengan menggunakan peralatan yang dikalibrasi seperti DustTrak untuk $PM_{2.5}$ dan PM_{10}, MultiRAE untuk formaldehid, Air Velocity Meter untuk TVOC, CO_2, suhu dan kelembapan relatif dan akhir sekali, IVL pasif sampler untuk NO_2. Sementara itu, ujian fungsi paru-paru dilakukan dengan menggunakan spirometer mudah alih. Data yang diperoleh dianalisa dengan menggunakan SPSS versi 22. **Keputusan:** Hasil kajian menunjukkan bahawa terdapat hubungan yang signifikan antara $PM_{2.5}$, PM_{10}, dan NO_2 dengan fungsi paru-paru (FVC% ramalan dan FEV_1/FVC% ramalan). Selain itu, $PM_{2.5}$, PM_{10}, TVOC, dan formaldehid didapati mempunyai hubungan yang signifikan dengan simptom pernafasan yang dilaporkan seperti batuk, berdehit, dan jangkitan pernafasan. Penemuan juga menunjukkan bahawa $PM_{2.5}$ dan PM_{10} adalah peramal yang melemahkan fungsi paru-paru kanak-kanak manakala jumlah kompaun organik dan formaldehid didapati meningkatkan risiko jangkitan pernafasan. **Kesimpulan:** Hasil kajian menyimpulkan bahawa pendedahan kepada pencemaran udara melemahkan fungsi paru-paru kanak-kanak dan menyebabkan gejala pernafasan yang dilaporkan dalam kalangan pelajar.

Keywords: Pencemar udara, fungsi paru-paru dan simptom-simptom pernafasan

CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

$PM_{2.5}$	Particulate matter with up to 2.5 micrometres aerodynamic diameter
PM_{10}	Particulate matter with up to 10 micrometres aerodynamic diameter
TVOC	Total volatile organic compound
NO_2	Nitrogen dioxide
CO_2	Carbon dioxide
FVC	Forced Vital Capacity
FEV_1	Forced Expiratory Volume in 1 seconds
$\mu g/m^3$	Microgram per meter cube
ppm	Parts per million
IAQ	Indoor air quality
ISAAC	International Study of Asthma and Allergies in Childhood
WHO	World Health Organization
USEPA	United States Environmental Protection Agency
DOSH	Department of Occupational Safety Health
IQR	Interquartile range
OR	Odd ratio
CI	Confidence Interval
β	Regression Coefficient
SE	Standard error
<	More than
>	Less than

CHAPTER 1

INTRODUCTION

1.1. BACKGROUND

Globally, out of 10 people, there were 9 who inhaled polluted air containing high level of contaminants (World Health Organization, 2018). Air pollution is a matter of life and death. This invisible killer lessens the level of fresh air and make people sick especially children. Children were facing greatest danger because yearly 600,000 children lost their live from breathing polluted air (WHO, 2016). Recently, school children spend most of their time indoors (about 80%) including school and home places where this population may be exposed to the pollutants and poor indoor air quality (Choo et al., 2014). School environment is crucial for children to ensure their health in school.

High quality of indoor air is important to create a positive environment for children and providing a healthy school environment is a most important consideration for child health. However, school environment can be polluted by numerous pollutants such as allergens and chemical (Daisey et al., 2003). Besides, in schools, children may engage in the physical activity that can increase breathing rates and dose of the pollutants (Eurostat, 2011). Children are our next future. They should have access to clean air in order to grow healthy

and live comfortably. If they remain surrounded in this situation, how will they continue to breathe?

More concern were given to children because they are high vulnerable to air pollution due to some factors such as pattern of breathing and physical constitution (Choo & Jalaludin, 2015). World Health Organisation define children as a person who is 19 years old or younger except if national law defines a person to be an adult at an earlier age. Children were included in the susceptible group to the effects of air pollution as their body equipped with the larger lung surface area per kilogram of body weight than adults and they breathe 50% more air per kilogram of body weight compared to adults.

WHO define air pollution as a contamination of the environment by physical, chemical or biological agent that change the natural characteristics of the atmosphere. Recently, high concern were given on the effect of anthropogenic activities such as traffic, construction and industrial activities to urban air quality. Ministry of Transport Malaysia (2017) reported a dramatic increase of the inland transportation in 2015 specifically in the urban and developing area. Burning of fossil fuels released a primary pollutants in the atmosphere such as carbon monoxide, nitrogen oxides, hydrocarbons and particulate matters (Finkelstein et al., 2004)

Ministry of Natural Resources and Environment reported that the main sources of air pollution in Malaysia are land clearing activities, power generation, open burning and forest fires, development activities, industries and

motor vehicles. Department of Environment highlighted that cars were the main contributor to the pollutants suspended in the air. It contribute about 75% of total carbon monoxide and suspended particulate matter also 76-79% of the oxides of nitrogen and sulphur (DOE, 1991). A study in Malaysia showed that outdoor air pollutants resulted from the man activities such as construction activities, urbanisation and industrialisation have established poor indoor environment through the openings and natural ventilated classrooms (Salleh et al., 2013).

Natural ventilation is a ventilation that mainly occurs through the opening of the windows, doors and the walls. The ventilation is driven by the temperature differences in inside and outside buildings and/or driven by the wind or pressure The group of the European scientist (EUROVEAN) agreed that ventilation is strongly associated with the comfort (perceived air quality) and health including Sick Building Syndrome, asthma, allergy, inflammation and infections (Choo et al., 2014).

Indoor air quality in the school environment plays an important factor in affecting children's health. Poor air quality contribute to short-term and long-term health complications (Annesi-Maesano et al., 2012). Health effect that associated with indoor air pollutants are vary from eye, nose and throat irritation, headaches, dizziness, fatigue to respiratory disease, heart disease and cancer (Choo& Jalaludin, 2015; Suhaimi& Jalaludin, 2015). The most common chronic disease among children is asthma (WHO, 2017). Zhao et al (2013) stated that, there is a global increment of asthma and allergies particularly in children. Global Burden of Disease report in 2015 claimed that the estimated prevalence

of asthma is 358 million cases (GG Collaborators, 2017). Asthma is define as attack of breathlessness and wheezing which may vary in frequency and severity from one to others. Asthma is now considered a worldwide public health issue and the diagnosis of asthma increase parallel with the increase of the urbanization and industrialization in the urban area.

Besides, greater concerned were given on lung-function growth because it demonstrates how well the lung works. Lung volumes of the individual are related to the body size and standing height. Height is the crucial correlating variable to the lung volume. Most reference equations for children are derived from the Caucasian population however differences due to ethnicity are not well defined (Pellegrino et al., 2005). Exposure to polluted environment during childhood can change the development of the lung and affect the pulmonary function of the children (Silva et al., 2015). A study conducted in Taiwan in school children aged of 6-15 years old found that sub-chronic exposure to ambient $PM_{2.5}$ and Ozone reduced the lung capacity of the student (Chen et al., 2015).

Lung function test also known as spirometry is a screening test of general respiratory health that measures how an individual inhales or exhales volumes of air as a function of time (Miller et al., 2005). According to Mayo Clinic Staff (2014), spirometry is used to diagnose some respiratory disease such as asthma, chronic obstructive pulmonary disease (COPD) and other conditions which affect the breathing. In school-aged, children measurement of lung function can give an assessment of airflow limitation and aid to confirm the diagnosis (Carroll

et al., 2014). In this study, the important parameters of the spirometry are the forced vital capacity (FVC) and forced expiratory volume in one second. Ratio of FEV_1 to FVC are also addressed.

1.2. PROBLEM STATEMENT

Day by day, the world is changing. As a developing country, air pollution in Malaysia tends to be worse due to the population growth and urbanization process. Recently, Science Advisory Board of USEPA (United State Environmental Protection Agency) have consistently ranked outdoor air pollution in the top 5 environmental risk to public health. Previously, a report from State of the Environment in Sabah (2000), stated that the air quality standards in Sabah is good except for the periods of forest fires outbreak that releases high level of hazardous pollutants in the atmosphere. However Eric et al (2000) stated that the urbanisation processes is predicted to be higher in the coming decades.

Kota Kinabalu, the state of Sabah is a location of rapid and dynamic change with increase of manufacturing, industrial activities and transportation. Among of all these sources, emission from motor vehicles is the main contributors to the deterioration of air quality in that city (Eric et al., 2000). To date, there is relatively scarce evidence on epidemiological studies on lung function and respiratory symptom among children in urban area in Sabah, Malaysia.

In addition, most of the stationary sources of air pollution in Malaysia were reported to reside in Selangor, Sarawak, Johor, Sabah, Perak and Pahang (Afroz & Ibrahim, 2003). In Sabah, Kota Kinabalu is the most targeted place to run all the activities. Stationary sources means the pollutants is released from fix emitter of air pollutants such as from industry, power stations, and domestic fuel burning processes. From the observation, small and mid-sized industries usually not equipped with pollution control equipment and this activities increases the pollutants level at that area (Afroz & Ibrahim, 2003). Industrial areas were often high in pollutants which may lead to increase morbidity and mortality depending on the type of the pollutant and concentration of the pollutants in that area (Martuzzi et al., 2014)

Changes in the environment could harm the earthling especially the children as they have higher minute ventilation to their lung volume (Chen et al., 2015). Good indoor air quality (IAQ) inside home and school is an important determinant for children's well-being and healthy life (WHO, 2010). However, more than half of school-aged children are exposed to inadequate environment and poor indoor air quality during their times spent in house or classrooms (Yahaya & Jalaludin, 2014). Poor IAQ is resulted from inadequate ventilation and air contaminants, those of which, if not meet the standards, may cause adverse health effects to the children (Choo& Jalaludin, 2015).

Besides, major concern were given to the school children due to the global increase of asthma and allergies among children (Zhao et al., 2013). Besides, international study on asthma and allergies in childhood (ISAAC)

showed an increase of asthma cases in middle-income countries especially in Asia (Asher et al., 2006). Many studies had shown that exposure to air pollutants among school children could give an adverse effect to their health. According to Rice et al (2016), long-term exposure to air pollution could have adverse effects to the lung development of the children.

1.3. RESEARCH JUSTIFICATION

Children crave clean air to thrive and shine. Safe environment is one of the condition where the air pollutants level is below the limits or in the range of the standards. In Malaysia, there are guidelines and standards for indoor air quality (Industrial Code of Practice on Indoor Air Quality) to protect workers at the workplace. However, there is no guidelines that have been developed specifically to the school environment with the susceptible children. Thus this study can be used as a baseline data that can be used by the related agencies.

To our knowledge, many studies have been conducted in peninsular Malaysia such as schools in Penang (Norback et al, 2017), Selangor (Jalaludin et al., 2017), Johor (Norback et al, 2017) but lack in east Malaysia especially study that focussed air quality in school with lung function status of the students. Besides, limited data is available on the present indoor air quality in Malaysia especially for school buildings (Afroz, R. et al., 2003). Thus, this study was conducted to provide the information and data on air quality in the school environment in Kota Kinabalu, Sabah. With the availability of the data, to some extent it can contribute to the policy makers to prescribe clean air for children in

order to save lives and protect them from long-term effects of air pollution exposure.

Air pollution is incurable and the only way to cope with the situation is to prevent it. Top mortality cases in Malaysia were non-communicable disease and one of it is chronic respiratory disease. In Ninth Malaysia Plan, Malaysia has emphasised in reducing the prevalence of the diseases especially asthma, chronic obstructive pulmonary disease (COPD) and its related risk factors. Health screening for children-aged is vital to detect problems and early stage to go for treatment to help the children to be healthy and live longer. Thus, this study was conducted to provide the information and data about their respiratory health status.

Records on children's health can be used by the government sectors to monitor and create a strategies to reduce the cases in order to generate healthier future generations. Data on school environment and children health can be used as a reference to develop and practice appropriate control strategies in order to limit exposures that may cause or contribute to allergy, asthma, and other respiratory symptoms in children and minimize the adverse health effects. In addition, result from this study could be useful for policy makers in providing crucial information on how to ensure safe school environment for school children in Malaysia. Last but not least, this research is conducted to highlight the primary prevention specifically in promoting awareness of community involved on the risk of air pollution on children's health.

The respondents were benefit from this study as this study can provide a health data regarding their lung function status. This research provide a free spirometry test that act as a screening test on their lung. The result of this study could be useful for the students to further check with the medical doctors to confirm the diagnosis. Next, it would benefit the students indirectly to keep the lung healthy, limit exposure to the environmental tobacco smoke and all.

1.4 CONCEPTUAL FRAMEWORK

In the conceptual framework (Figure 1), the studied air pollutants were PM_{10}, $PM_{2.5}$, TVOC, NO_2, CO_2 and formaldehyde. The main sources of the pollutants are mainly generated from the human activities such as transportation, domestic and industrial activities. It also comes from the natural sources such as forest fires, volcanic eruption and evaporation of organic compound.

The pollutants released then accumulated in the atmosphere and affect the indoor air quality of the school environment. There are three route of exposure by which the substances can enter the body which are ingestion, inhalation and dermal contact. This study focused on the exposure from the inhalation as the major route of entry for most of the chemicals in the forms of particulates, vapours and gases is through breathing. Short-term and long-term exposure to air pollutants can give adverse effect to children's health especially their respiratory system.

This study focused on the lung function and respiratory symptoms of the students. Reported respiratory symptoms were obtained by using the validated questionnaire adopted from ISAAC and lung function status of the students were determined through the lung function test (spirometry) using the portable spirometer. The confounding factors in this study were gender, ethnicity, smoking behaviour, parental smoke and household income.

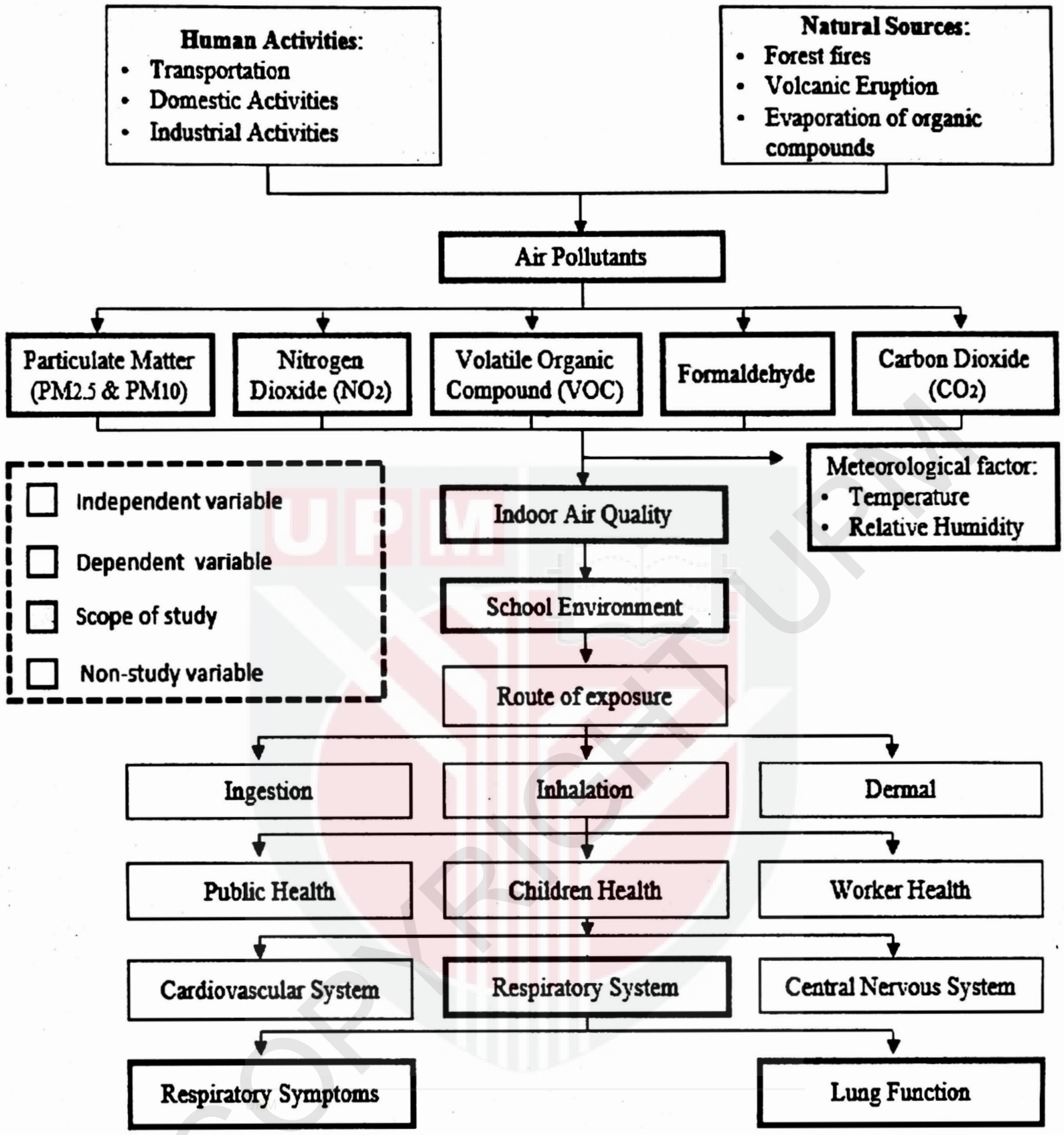

Figure 1: Conceptual framework of the research

1.5 STUDY OBJECTIVES

1.5.1 GENERAL OBJECTIVE

To study the association between different types of indoor air pollutants (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2 and formaldehyde) in schools with lung function and respiratory symptoms of secondary school students in Kota Kinabalu, Sabah.

1.5.2 SPECIFIC OBJECTIVES

1. To determine the socio-demographic characteristics of the respondents.
2. To measure the air quality parameters (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2 formaldehyde, temperature and relative humidity) in indoor and outdoor of the schools environment in Kota Kinabalu, Sabah.
3. To determine the lung function measurement of the students in Kota Kinabalu, Sabah.
4. To determine the prevalence of respiratory symptoms among students in Kota Kinabalu, Sabah.
5. To determine the association between air pollutants (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2, formaldehyde) and lung function of the students.
6. To determine the association between air pollutants (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2, formaldehyde) and respiratory symptoms of the students.
7. To determine the predictors that influenced the reported lung function and respiratory symptoms.

1.6 HYPOTHESIS

1. There is a significant difference between indoor and outdoor air quality parameter.
2. There is a significant association between air pollutants (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2, formaldehyde) and lung function of the students in Kota Kinabalu, Sabah.
3. There is a significant association between air pollutants (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2, formaldehyde) and respiratory symptoms of the students in Kota Kinabalu, Sabah.
4. PM_{10} level is significantly associated with the lung function and reported respiratory symptoms.

1.7 STUDY VARIABLES

1.7.1 INDEPENDENT VARIABLE

The independent variable were particulate matters ($PM_{2.5}$ and PM_{10}), total volatile organic compound, nitrogen dioxide, carbon dioxide, formaldehyde, temperature and relative humidity.

1.7.2 DEPENDENT VARIABLE

The dependent variable is lung function and respiratory symptoms.

1.8 DEFINITION OF TERMS

1.8.1 CONCEPTUAL DEFINITION

a) Indoor Air Quality

Indoor air quality is defined as mixture of various pollutants originated from a wide spectrum of pollution sources, with all of them having specificities associated to the place, climate and the culture: the local ambient air, the building characteristic and the indoor activities (Oliveira Fernandes et al., 2008).

b) Air pollutants

Air pollutants is defined as substances that is released as waste and can cause air pollution. In Malaysia, there are five major pollutants which are particulate matter, sulphur dioxide, nitrogen dioxide, ozone and carbon monoxide (Rasidi et al., 2016).

c) Children

WHO (2013) define children as a person who is 19 years old or younger except if national law defines a person to be an adult at an earlier age.

d) Particulate Matter (PM_{10})

PM_{10} is inhalable particles with a diameter of 10 micrometres or less ($\leq$10 μm). PM_{10} is a complex mixture of small particles and liquid droplets that suspend in the atmosphere. Particulate matter can penetrate the lung and lodge deep inside the lungs (Kampa& Castanas, 2008)

e) Particulate Matter ($PM_{2.5}$)

$PM_{2.5}$ is fine inhalable particles with a diameter of 2.5 micrometres or less (≤2.5 μm). $PM_{2.5}$ is the most concern as this fine particulates can travel deeply in the lung and enter the blood stream (Kampa& Castanas, 2008).

f) Volatile Organic Compound (VOC)

US Environmental Protection Agency define VOC as any compound of carbon excluding carbon monoxide, carbonic acid, ammonium carbonate and metallic carbides that engage in atmospheric photochemical reactions.

g) Nitrogen Dioxide (NO_2)

In atmosphere, nitrogen oxides (NO) was emitted in the air and react with ozone or radicals to produced nitrogen dioxide. Nitrogen dioxide mainly released from mobile and stationary combustion sources (Kampa& Castanas, 2008).

h) Carbon Dioxide (CO_2)

CO_2 is a primary greenhouse gases that emitted through man activities and naturally present in the atmosphere as part of the Earth's carbon cycle (USEPA, 2018). CO_2 is released in the atmosphere from the activities such as combustion of fossil fuels for energy and transportation, industrial processes and land-use.

i) Formaldehyde

Formaldehyde is one of the most common VOCs. Formaldehyde is a colourless gas with a pungent odour that is released from particle board, plywood, household product such as paints and coating also from various combustion processes (Gupta et al., 1982).

j) Temperature and Relative Humidity

Temperature and relative humidity are parameters of indoor air that commonly used for indoor air quality.

k) Respiratory Symptoms

American Lung Association (2016) define respiratory system as a group of organs and tissue that includes the muscles and bones, lung and blood vessels which function together for the breathing process. Respiratory health symptoms are usually include headache, nasal congestion, cough, sore throat, runny nose, facial pressure and sneezing. The onset begins 1 to 3 days after exposure and last to 7 to 10 days (Eccles et al., 2007).

l) Lung Function

European Environment Agency describes the main function of the lungs is the process of gas exchange called respiration (or breathing). In respiration, oxygen from incoming air enters the blood, and carbon dioxide, a waste gas from the metabolism, leaves the blood. A reduced lung function means that the ability of lungs to exchange gases is reduced

m) Forced Vital Capacity, FVC

FVC is defined as the maximal volume of air breathe out with a great forced effort from a maximal inhalation, expressed in litres at BPTS (ATS, 2005)

n) Forced Expiratory Volume in the first second, FEV_1

FEV_1 is the maximal volume of air breathe out in the first second of a forced exhalation from a position of full inhalation, expressed in litres at BPTS (ATS, 2005).

1.8.2 OPERATIONAL DEFINITION

a) Particulate Matter (PM_{10} & $PM_{2.5}$)

Level of PM_{10} and $PM_{2.5}$ were measured using TSI DustTrak. Unit measurement for particulate matters is microgram per cubic meter ($\mu g/m^3$).

b) Total Volatile Organic Compound (TVOC)

TVOC were measured by using TSI Air Velocity Meter. Unit measurement for TVOC is parts per million (ppm).

c) Nitrogen Dioxide (NO_2)

NO_2 was sampled by a diffusion sampler that obtained from and analysed by IVL Swedish Environmental Research Institute Laboratory.

d) Carbon Dioxide (CO_2)

CO_2 were measured by TSI Air Velocity Meter. Unit measurement for CO_2 is parts per million (ppm).

e) Formaldehyde

Formaldehyde were measured by using MultiRAE 6 Gas Monitor –Multi Gas Detector. Unit measurement for formaldehyde is parts per million (ppm).

f) Temperature and Relative Humidity

Both parameters were measured using TSI Air Velocity Meter. Indoor air temperature were measured in degree of Celsius (°C) and percentage (%) for relative humidity.

g) Respiratory Symptoms

Data on respiratory symptoms were obtained by using standardized questionnaire from the International Study of Asthma and Allergies in Childhood (ISAAC) based on symptoms that appear and experienced by the students for the past 12 month history.

h) Lung Function

Lung function of the student were measured through lung function test using the portable EasyOne Spirometer.

i) **FVC**

FVC was measured by using the EasyOne Spirometer and expressed in litres. FVC% predicted were calculate as below:-

Expected value of FVC% predicted:

FVC (spirometer) / FVC (expected value) X 100

ii) **FEV_1**

FEV_1 is measured by using the EasyOne Spirometer and expressed in litres. FEV_1% predicted were calculate as below:-

Expected value of FEV_1% predicted:

FEV_1 (spirometer) / FEV_1 (expected value) X 100

CHAPTER 2

LITERATURE REVIEW

2.1 Children

Children are the future builders of this country. By investing in children's needs to provide clean air and healthy environment, we are contributing to create a literate and self-sufficient generations also help in the development of the country. Children have been shown to be at the particular risk for the effect of air pollution. In Malaysia, there a numbers of studies that underlined the effect of the indoor air pollution towards the respiratory health especially among the school-aged children. (Choo and Juliana, 2015). This is a health concern due to the development and urbanization process in Malaysia for the past decades that have contribute to the increase of the air pollutants in both indoor and outdoor environment.

Indoor air pollutants can cause short-term and long-term health problems in the children (Annesi-Maesano et al., 2013). Morever, it can provoke discomfort and reduce children's productivity also the attendance rate. The most prevalent diseases among children are asthma and allergy (Pearce, 2000). Even though death from asthma during childhood is rare, it still happen. There were 1143 death from asthma in the UK in 2010 and 16 of these were children aged 14 and under (Asthma UK). Thus, school-children age of 14 years old were also at risk to be affected due to the exposure to the air pollutants around the school environment in Sabah.

2.2 Indoor air quality in the school environment

Good indoor air quality is an important element of a healthy indoor environment also can assist schools in achieving their primary goal of educating children (USEPA, 2017). The indoor air quality in schools generically identified by a combination of numerous pollutants including volatile organic compound, particulate matter, bacteria and moulds (Madureira, 2009). Department of Occupational and Safety Health (DOSH) stated that indoor air quality describes how indoor air can affect the individual's health, comfort and ability to perform the task. The parameters include temperature, humidity, mould, bacteria, poor ventilation and chemicals.

In the schools, cooking and tobacco smoke were prohibited to minimize the combustion exposure to the students in the classrooms (Phipatanakul et al., 2017). However combustion related pollutants from outdoor sources can enter the school buildings through doors, windows, and structural imperfections of the buildings. Therefore, exposure encountered in this environment can have a substantial health effect to the occupants. Classrooms that composed of furnishings, wood desk and chairs and other manufacturing materials may contribute to the poor indoor air quality of the buildings (Yang et al., 2009). Special concern were given on indoor air quality in classrooms because the students spend most of their time indoor which 6 to 10 hours per day. Several studies had catalogued indoor air quality in schools with the association with the respiratory health. However, the sources and type of the pollutants may vary based on the geographic region (Mazaheri et al., 2016)

2.3 Air Pollution

Air pollution is a worldwide public health crisis. It was a ladder to the distortion of human health. However, one questions that remains important is to what extent the air pollution affect the life expectancies. Data released by WHO showed that 93% of all children worldwide live in the environment where the level of air pollution exceeds the WHO guidelines (WHO, 2016). Indoor air pollution is caused by the combination effect of factors from physical, chemical, biological and the adequacy of the ventilation in the environment (Lee & Chang, 2000).

Although the natural sources also contribute to the pollutants in the environment, such as the volcanoes and fire, the anthropogenic activities are the main cause to the environmental air pollution. Increase of pollutants level by anthropogenic sources is thoughtful to be more likely in the dense populated urban area (Jamal et al., 2004). Kota Kinabalu, the state capital in Sabah is one of such area. The city is high in traffic and population density. Department of Statistic Malaysia reported that the number of population in Sabah increased every year and by 2018, the estimated number of people is 3.9 million.

All type of air pollution can affect the respiratory symptoms at the high concentration (Kampa and Castanas, 2008). Health impact of the air pollution were studied more in the developing and developed countries in order to reduce the effect of the human pollutant exposure. By the year of 2020, Malaysia aim to become and industrialized nation, thus according to the determination, air quality in Malaysia is a major health concern days by days.

2.4 Air pollutants

Air pollutants is any substances or matter including physical, chemical, biological and r adioactive agent that is emitted in the air and can harm humans. Ambient air pollutants are commonly generated from the traffic, construction, combustion and industrial activities (Wark & Warner, 1981) while sources for indoor air pollutants are coming from outdoors, building equipment, furniture and human activities. Gaseous pollutants such as nitrogen dioxide and volatile organic compound are mainly produced by the combustion of fossil fuels and greatly release to the atmosphere (Katsouyanni, 2003). Particulate matters were mainly released by industries, fires, power plant, construction activities and motor vehicles (Kampa & Castanas, 2008).

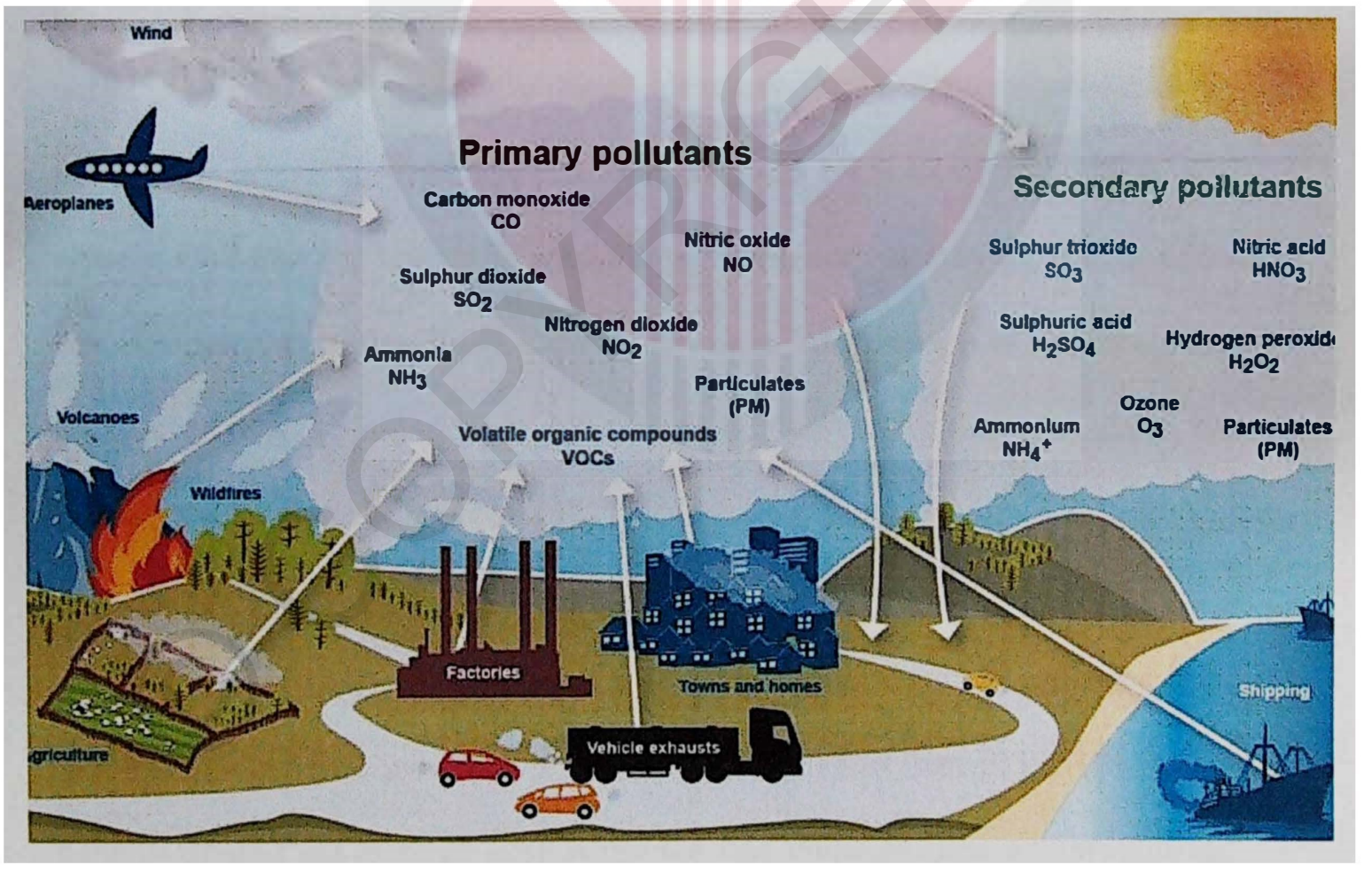

Figure 2.1: Sources of atmospheric pollutants

Source: http://facts.net/air-pollution

Air pollutants were categorised based on their chemical composition, reaction properties, persistence in the atmosphere, distribution/dispersion, and their eventual impacts on human health (Kampa & Castanas, 2008). Many studies found that indoor pollutants level is greater than outdoor levels (Montgomery & Kalman, 1989). US EPA (2017) claim that level of pollutants indoors can be two to five times, occasionally more than 100 times higher than level of pollutants outdoors.

2.5 Mechanism of air pollutants in the body

Children have special susceptibility and vulnerability to the exposure of air pollution. Air Pollutants can enter someone body through ingestion, inhalation and dermal contact. For ingestion, the pollutants can settled on the surfaces in home or class where the children can ingest them. Inhalation is the main route of exposure for pollutants to enter the body through the lungs and alveoli. Children are known to inhale more pollutants as they breathe at twice rate compared to adults (Etzel, 2007). Growth of lung during the childhood and adolescent may be exposed to many airborne pollutants that may harm the growth and function (Calogero &Sly, 2010).

Size of particle will determines how far the pollutants travel in the body and where it is deposited. Particle with the diameter less than 10 μm (PM_{10}) are usually filtered out through nose while for fine particles such as $PM_{2.5}$, it can travel and penetrate deeper until reached the lower airways (WHO, 2016). Exposure to hazardous pollutants such as $N0_2$, $PM_{2.5}$ and PM_{10} is associated with

the development of asthma in children (Gehring et al. 2015; Nishimura et al., 2013· Khreis et al. 2017).

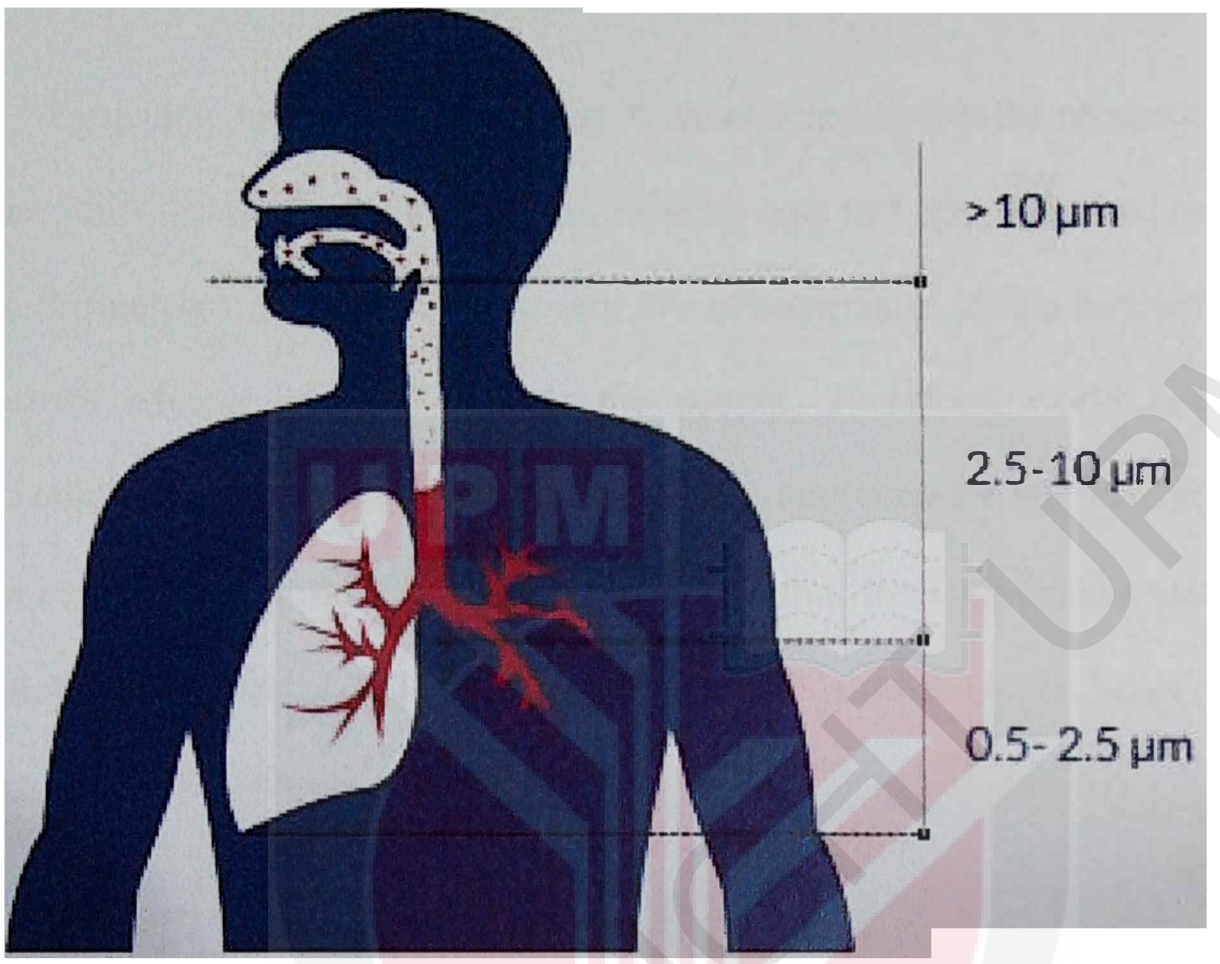

Figure 2.2: Size of particles and site deposition

Source from:
https://www.afro.who.int/sites/default/files/201706/9789241565233_eng.pdf

2.6 Air pollutants and its health effects

2.6.1 Particulate matters ($PM_{2.5}$ & PM_{10})

Particulate matter is a common indicator used in air pollution. It comprise of complex mixture of particles of inorganic and organic substances that suspended in the atmosphere. The sources is primarily from the mechanical processes such as construction activities and road dust whereas the latter mainly originated from the combustion sources. In urban environment, both $PM_{2.5}$ and

PM_{10} are present but the proportion of this two different size of particles is likely to vary between cities around the world depending on the local geography, meteorological and specific source of the particulate matter (WHO, 2005)

Particulate matter (PM_{10}) existed in the classroom with the presence of curtains, dust from fans and blackboard, flooring type and age of the buildings (Choo & Jalaludin, 2015). Even at a very low concentration of fine particles it can cause adverse impacts towards the people. Therefore, world health organization has targeted to achieve the lowest concentration of particulate matter in the World Health Organization 2005 guideline limit. Particulate matter ($PM_{2.5}$) is one of the dangerous pollutants as it can be drawn into the lungs and damage respiratory tissue.

There are few studies that found a significant relationship of particulate matters with the health effect towards the children. Study by Zhao et al (2008) stated that exposure to indoor levels of particulate matter ($PM_{2.5}$) enhanced the risk of getting abnormal lung function and it is associated with the respiratory symptoms such as wheezing. Besides, high levels of $PM_{2.5}$ in the classrooms showed an increase of the prevalence of past year asthma (Isabella et al., 2013). In another study carried out by Madureira et al (2015), they reported a significant association between high levels of $PM_{2.5}$ and PM_{10} with higher odds of wheezing in children.

2.6.2 Total Volatile Organic Compound (TVOC)

Total volatile organic compound means the amount of VOC in indoor air. Indoor sources of VOC may be originated from the solvents, cleaning product, floor adhesive, paint and room fresheners. VOCs are released by a broad range of products and many product able to release organic compounds when people used it. Level of VOCs indoors can be 2-5 times higher compared to outdoor (Cometto-Muniz & Abraham, 2015).

Indoor air that contained volatile organic compounds can be harmful to the respiratory health of the school children (Choo et al., 2014). Volatile chemicals used in the schools has been linked to the building-related illnesses. A study conducted by Sahlberg et al. (2010) found an association between poor ventilation and volatile organic compounds with the symptoms included in the Sick Building Syndrome (SBS). There are studies that was conducted in the newly constructed home and the findings showed an associations between indoor level of Benzene and SBS (Takigawa et al., 2009).

Besides, according to Norback et al (1990), there found a relationship between sick building syndrome symptoms such as eye irritation and headache with concentration of hydrocarbons (VOC). Based on a study conducted by Lu et al. (2015), the result showed the positive association between total volatile organic compounds with dry throat and mucosal irritation. A study done by Madureira et al (2015) showed that high levels of TVOC in indoor air was associated with higher odds of wheezing.

2.6.3 Nitrogen Dioxide

Nitrogen dioxide is one of the major concern as these gases can cause harm to human health. It is commonly used as the indicator for the nitrogen oxides. NO_2 is a gaseous substances that resulted from the combustion process and the common sources of the pollutant are automobile exhaust, refineries, and power plants activities (Cibella et al., 2015). In indoor environment, NO_2 were mainly emitted from the tobacco smoke, vented appliances with defective installations and unvented combustion appliances such as gas stoves. Indoor level of nitrogen dioxide were depend on both outdoor and indoor emissions (Breysse et al., 2010) as well as air exchange rate.

Exposure to low levels of NO_2 in indoor air is associated with increased of reported respiratory symptoms (Van Strien et al., 2004) and higher level of NO_2 significantly increase asthma symptoms and reduced expiratory peak flows in children (Kattan et al., 2007) while USEPA (2016) stated that exposure to high level of NO_2 can irritate the airways in the respiratory system. Based on study by Nazariah et al. (2013), the results showed that there was a significant association between levels of NO_2 and lung function. Nitrogen dioxide in schools environment could be a risk factor for fatigue and throat symptoms in form two students in Malaysia (Norback et al., 2017). In another study conducted among children aged of 10-17 years in the Mediterranean area, the result showed that children that exposed to highest level of NO_2 had increased the frequency of current asthma, chronic phlegm, rhinoconjunctivitis and wheezing in the past 12 months (Cibella et al., 2015).

2.6.4 Carbon dioxide

Carbon dioxide is the main greenhouse gases that released by anthropogenic activities during the usage of the fossil fuels (USEPA, 2018). The main sources of CO_2 emission are electricity, transportation and industrial activities. According to Salleh et al. (2013), level of CO_2 indoor were significantly affected by occupant density and the ventilation system in the building. Apte et al. (2000) stated that, level of carbon dioxide that less than 1000 ppm (<1000 ppm) not necessarily represent that the ventilation rate is sufficient to remove air pollutants that coming from the other sources.

A cross-sectional study that was conducted in five European countries showed that schoolchildren that exposed to carbon dioxide level more than 1000 ppm showed a significantly higher risk for dry cough and rhinitis (Simoni et al., 2010). In another study by Fox et al. (2003), the results showed that symptoms of upper airway irritation was significantly related with carbon dioxide level in the classrooms.

2.6.5 Formaldehyde

Formaldehyde is a common type of VOCs and widely used in construction, wood processing and furniture. The environmental protection agency has classified formaldehyde as a probable human carcinogen as it can cause leukemia and nasopharyngeal cancer (IARC, 2006). Acute effects of exposure to formaldehyde are mainly irritation of eye, nose and throat and common symptom experienced to high concentration of formaldehyde were cough, wheeze and chest pains (USEPA, 1988; WHO, 1989). A study conducted

in secondary schools in Johor Bahru by Norback et al. (2017) concluded that formaldehyde was associated with fatigue and throat symptom in form two students. Based on Takigawa et al. (2010), formaldehyde was significantly associated with sick building syndrome (SBS) in Japan.

2.6.6 Temperature and Relative Humidity

A study by California School Boards Association (2008) stated that poor indoor air quality including poor ventilation, air pollutants and temperature either it is too high or too low can contribute to the absenteeism and reduced the person's performance. Natural ventilation is a ventilation coming from open windows and doors also by infiltration though crack of the buildings such as wall, windows.

Based on Salleh et al. (2013), they concluded that sore throat and fatigue were related to the classroom's ventilation strategies. Besides, Meyer (1983) stated that low and high relative humidity in buildings may contribute to physical discomfort as it is directly affect the perception of the temperature. A study conducted by McIntyre (1978) and Eng (1979) showed that low relative humidity (<20%) can cause irritation of eye and moderate to high level of relative humidity were reported to reduce the severity of asthma (Strauss et al., 1978).

2.7 Respiratory symptoms

Respiratory symptoms are the common symptoms experienced by the person that relate to the respiratory system. The system is a series of organs that responsible for oxygen intake and carbon dioxide removal. Respiratory symptom can be divided into lower and upper respiratory tract infection. Headaches, fatigue, irritation in nose, throat, eyes, hands and skin may be resulted due to poor indoor air quality in the classrooms (Choo et al., 2014). The symptoms may occurred due to the exposure to the pollutants and poor ventilated classrooms. The symptoms are varied depends on the frequency, duration and the pollutant's characteristics.

A study by Salleh et al. (2013) stated that high prevalence of symptoms such as runny nose, sore throat and coughing were reported in natural ventilated classrooms. Besides, a cross-sectional study conducted by Simoni et al. (2010) stated that all respiratory problems were high among children in the classrooms that have poor ventilation system. Children's with low immune system may easily get the symptoms as their body may had low activity of the immune system or decrease in the ability to fight the substances.

2.8 Lung Function

Lung is one of the important organ that keep the person breathing and keep all the organs functioning. It is crucial to protect and keep the lung healthy. Spirometry has become common lung function test that has been done in industry and outpatient setting. Spiro means "to breathe" and metron is to "measure". Pellegrino et al (2005) stated that lung function is an objective marker to assess the severity and the type of the respiratory health problems and it is extensively used as an effect marker to assess effects to health due to air pollution (Chen et al., 2015).

In school level, measurement of lung function can provide an assessment of airway inflammation, and assisting to confirm diagnosis (Carroll & Ruggins, 2014). The American Thoracic Society (2005) define spirometry as a physiological test that estimates how much air is inhaled and out of the lungs and how fast the air moves. The crucial aspects of spirometry are the forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and ratio of FEV_1/ FVC.

Predicted normal values of lung function can be affected with height, weight, gender and ethnicity and the range of normal is considerably varied (Sewa & Ong, 2014). Blockage in the airways may affect children's lung function and there are many others contributor that can influence the lung function abnormality in children (Choo & Jalaludin, 2015).

A study by Sowa (2002) found that nitrogen dioxide and particulate matter (PM_{10}) was associated with the lung function reduction in children on a daily scale. In another study by Nazariah et al. (2013) , the lung function outcome were categorized into normal and abnormal lung function and the result showed that, level of PM_{10} and NO_2 were significantly associated with the lung function. Based on a study by Chen et al. (2015), they found that $PM_{2.5}$ reduced parameters of lung capacity in children aged of 6-15 years old. In another study conducted by Ierodiakonou (2016) the result showed increases in the average of long-term concentrations of NO_2 was associated with reductions in lung function consistent with airflow obstruction and with some decreased in vital capacity represented by a decrease in forced vital capacity (FVC).

In Malaysia, a study carried out by Yahaya & Jalaludin (2014) showed that increase level of PM_{10} in urban area associated with reduced lung function and increase reported respiratory symptoms experienced by the children. This study also supported by a study conducted by Schwartz et al (1994) where the exposure to $PM_{2.5}$ not only reduced lung function in children health but also have significantly associated with various respiratory symptoms such as bronchitis and emphysema. However, there a review article finalized that adverse effects on children's lung function is cause by the long-term exposure to ambient air-pollutions (Gotschi et al., 2008). This also supported by Nyberg and Pershahgen (2000) that the decline in lung function is more strongly associated to exposure levels of longer period compared to those in shorter period.

CHAPTER 3

METHODOLOGY

3.1 STUDY DESIGN

This is a cross-sectional study that has been conducted from January to February at Sabah, Malaysia. The study objective is to study the association between different types of indoor air pollutants (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2, formaldehyde) in schools with respiratory health and lung function of secondary school students in Kota Kinabalu, Sabah.

3.2 STUDY LOCATION

This study was conducted at secondary schools in Kota Kinabalu, Sabah. Kota Kinabalu is purposively selected as this is an urban area where the traffic and population density is high.

3.3 SAMPLING

3.3.1 STUDY POPULATION

Secondary school children from secondary schools in Kota Kinabalu area were selected as the study population. Student age of 14 years old from both gender involved in this study. These children were selected randomly to avoid the selection bias.

3.3.2 SAMPLING FRAME

The list of the students were obtained from the school management. The sampling frame were Form Two students from the selected classes of six schools in Kota Kinabalu, Sabah.

3.3.3 SAMPLING UNIT

The study unit is secondary school children aged of 14 years old. Only Malaysian students that were in the same school for at least one years were included in this study. Students with chronic medical diseases such as congenital physical chest abnormality, heart disease and other severe diseases related to the respiratory and cardiovascular system were excluded from this study.

3.3.4 SAMPLE SIZE ESTIMATION

A study conducted by Leung & Ho (1994) compared the prevalence of asthma and allergic disease among secondary school students in three south-east Asian populations including Hong Kong, Kota Kinabalu in Malaysia, and San Bu in China. The findings reported that prevalence of hay fever, eczema, and wheeze or asthma were 8.2 %, 5.5%, 10.9% respectively in Kota Kinabalu, Malaysia. The sample size calculation is based on formula from Lemeshow et al., (1990) of cross-sectional (one group) study.

Formula: $n = z^2_{1-\alpha/2} P (1-P) / d^2$

Where,

$Z^2_{1-\alpha/2}$ =Confidence level at 95% (standard value of 1.96)

P= estimated prevalence or proportion

D= desired precision

Calculation: $n = 1.96^2 \times 0.109 (1-0.109) / 0.05^2$

$n = 0.373/0.05^2$

$n = 149$

Lemeshow et al., (1990)

Based on the formula, 149 student were needed in this study. The number is increased by 20% to take account for non-responsive respondents, missing data and errors. Thus, the minimum number of the respondents needed were 178.

3.3.5 SAMPLING METHOD

In Kota Kinabalu district, six secondary schools were randomly selected and from each of the schools, four classes of Form Two student were randomly selected. Form two classes were selected as these classes are non-examination class and these children were old enough to fill up the questionnaire and participate in the health assessment with the guidance from the researchers. The classes were randomly selected using simple random sampling. In the selected classes, consent forms were distributed to all students and only those with the written permission were included. In addition, the respondents had to fulfil the inclusive and exclusive criteria stated.

3.4 STUDY INSTRUMENTATION

3.4.1 Questionnaire

This study used the standardized questionnaire obtained from the International Study of Asthma and Allergies in Childhood (ISAAC) study. The questionnaire were divided into six parts which were (A) the respondent's background information, (B) asthma and allergies, (C) health status, (D) allergies among family members, (E) childhood medical history and (F) reported respiratory symptoms.

3.4.1 Air Velocity Meter TSI 9565-P

Air velocity meter were used to monitor the air temperature, relative air humidity, carbon dioxide and total volatile organic compound (TVOC). The VelociCalc Model 9565 have an optional "smart" plug-in probes including VOC and CO_2. The equipment display all the four measurement simultaneously.

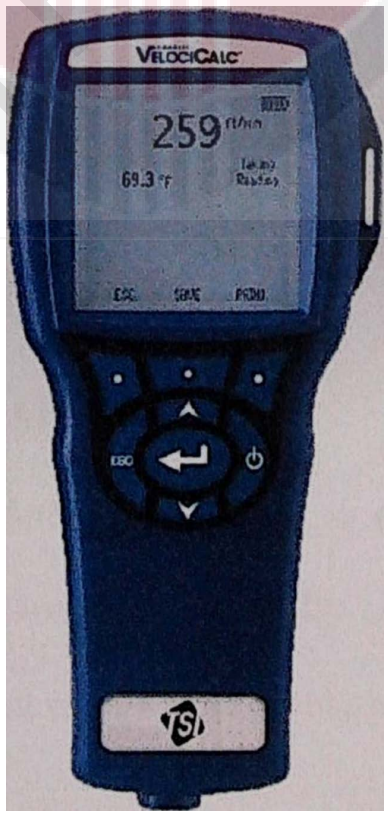

Figure 3.1: Air Velocity Meter TSI 9565-P

Adapted from TSI Website

3.4.2 Aerosol Monitor TSI 8534 DustTrak DRX

DustTrak DRX were used to measure particulate matters (PM_{10} and $PM_{2.5}$). This equipment simultaneously measured both mass and size fraction. Sheath air systems were used in this equipment to isolates the aerosol in the optic chamber in order to keep the optics clean for improved reliability. The detection limit for this equipment range from 0.001 to 150 mg/m^3.

Figure 3.2: TSI 8532 DustTrak II

Adapted from TSI Website

3.4.3 MultiRAE LITE PGM-6208

This is a multi-gas detector was used to measure formaldehyde. It s equipped with man down alarm and have fully automatic bump testing and calibration. The detection limit of this equipment range from 0 to 10 ppm.

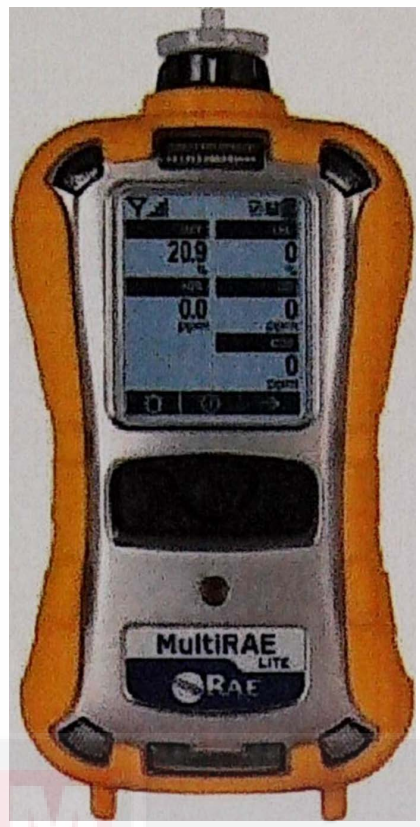

Figure 3.3: MultiRAE LITE PGM-6208

Adapted from ANHVU Corporation Website

3.4.4 EasyOne Diagnostic Spirometer (Model 2001)

EasyOne Spirometer is portable spirometer that able to provide reliable results without need a calibration test and remains consistently accurate over years. However, calibration checked has been done prior to data collection with a syringe using the calibration check function. Also it is not influenced by humidity, barometric pressure and contamination. This equipment used the spirette (mouthpiece) to conduct the test. This spirometer can store and display the best or the best three trial test with the curve. This procedure and method used in this spirometer was in accordance with the American Thoracic Society (ATS) and European Respiratory Society (ERS). The test measure important parameters such as FVC (liter), FEV1 (liter), and FEV1/FVC.

Figure 3.4: EasyOne Spirometer (Model 2001)

Adapted from NDD Medical Technologies Website

3.5 DATA COLLECTION

There were three types of data collection used in this study which were questionnaire, environmental measurement and health assessment. Information on children's background and respiratory symptoms were obtained from the questionnaire. Air pollutants level were assessed by using the calibrated equipment that is specified to each pollutants. Meanwhile, data on children's health were obtained through the lung function test.

3.5.1 Questionnaire form

The questionnaire is translated into Malay language. Set of questionnaire were given and distributed to the children in schools prior the health assessment. The researcher went through the questionnaire together with a group of students with the assistance from the researchers. The questionnaire were collected after all information is completed. Meanwhile, for incomplete details, the parents were called to obtain the information.

Figure 3.5: Questionnaire filling

3.5.2 Environmental measurement of the pollutants

Environmental measurements were conducted during their classes. Particulate matter ($PM_{2.5}$ & PM_{10}) were measured simultaneously using DustTrak DRX (TSI 8534). Besides, formaldehyde was measured using the Multi-gas

detector (MultiRAE LITE PGM-6208). For TVOC, CO_2, temperature and relative humidity, Air Velocity Meter (TSI 9565-P) was used to measure these pollutants simultaneously. The pollutants were measured for 45 minutes with 1 minute log interval by using this equipment near the student's breathing zone. The sampling location was located in the middle of the classroom which was no closer than 1m to the wall, window and door also as far as possible from the whiteboard.

For NO_2, IVL passive sampler was used and analyzed by IVL Swedish Environmental Research Institute Laboratory. Spectrophotometry method was used to analyze this sample. The analysis method and procedure were accordance with the ISO 15923-1:2013 in the determination of selected parameters by discrete analysis system with photometric detection also the standard of ISO 13395: 1996 for spectrometric detection. The limit of detection for this sampler is 0.4 µg $NO2/m^3$ for one week sampling. The sampler were was attached at the wall of the classroom for one week at the higher places (approximately 2 meter above the floor) to avoid any disturbance along the sampling process. The environmental measurement was conducted in the four selected classrooms and outdoor location of each school.

Figure 3.6: Measuring air pollutants

Figure 3.7: NO_2 Passive Sampler

3.5.2 Health assessment (Spirometry)

Spirometry were performed at school by the trained researcher. Lung function measurement by spirometer allow the discrimination of the respondents with respiratory symptoms and is extremely useful as a screening test for general respiratory health (Miller et al., 2005). Lung function of the students were measured by using portable spirometer (EasyOne Model 2001). Spirometry were performed according European Respiratory Society Guidelines & American Thoracic Society Standards.

The procedure of the lung function test started with the anthropometric measurement. The height and body weight of the students were measured using the height scale model and electronic weighing scale respectively. Demonstration to the children of the procedure were performed prior the test. In brief, students were required to be in a standing position while performed the test. The procedure started with the students inhaled completely and seals his/her lips tightly around the mouthpiece. This is to prevent any leakage of air during the test conducted. Next, the respondents need to blast the air out as fast as possible until the lungs are absolutely empty (approximately 6 seconds exhalation period).

To obtain the best results, students were asked to perform the test for 3 times (minimum) to give an accurate reading of the test. The data collected were saved automatically in the spirometer and were transferred in the computers through the Spirometry Software. Waste bin were provided during the sample collection for proper waste management.

Evaluation of Lung Function Test

From the test, parameter value of FVC (liter), FEV1 (liter) and ratio FEV1/FVC of the best result were obtained. After that, predicted value of this parameters were calculated using the predicted equation to calculate the predicted value for FVC and FEV_1 for children proposed by Azizi and Henry (1994) Percentage predicted (%) for FEV1, FVC and FEV1/FVC were then calculated using the formula stated in the operational definition of FEV_1 and FVC. Evaluation of lung function was done based on the American Thoracic Society (2005) classification as stated in Table 3.2 to identify whether the lung function were normal or abnormal.

Table 3.1: Equation for predicted FVC and FEV_1 among children in Malaysia

Lung Function	Boy	Girl
FVC	$4.1120 \times 10^{-6} H^{2.6421}$	$6.0777 \times 10^{-7} H^{3.0112}$
FEV_1	$6.2523 \times 10^{-6} H^{2.5388}$	$5.7588 \times 10^{-7} H^{3.0067}$

H=Height
FVC= Forced Vital Capacity
FEV_1=Forced Expiratory Capacity in 1 second

Source: Azizi and Henry (1994)

Table 3.2: Evaluation of lung function (Classification of lung function)

Obstructive Disease	% predicted FEV1
Normal	≥80
Mild	70-79
Severe	60-69
Very severe	<60
Restrictive disease	**% predicted FVC**
Normal	≥80
Mild	70-79
Severe	60-69
Very severe	<60

Source: American Thoracic Society (2005)

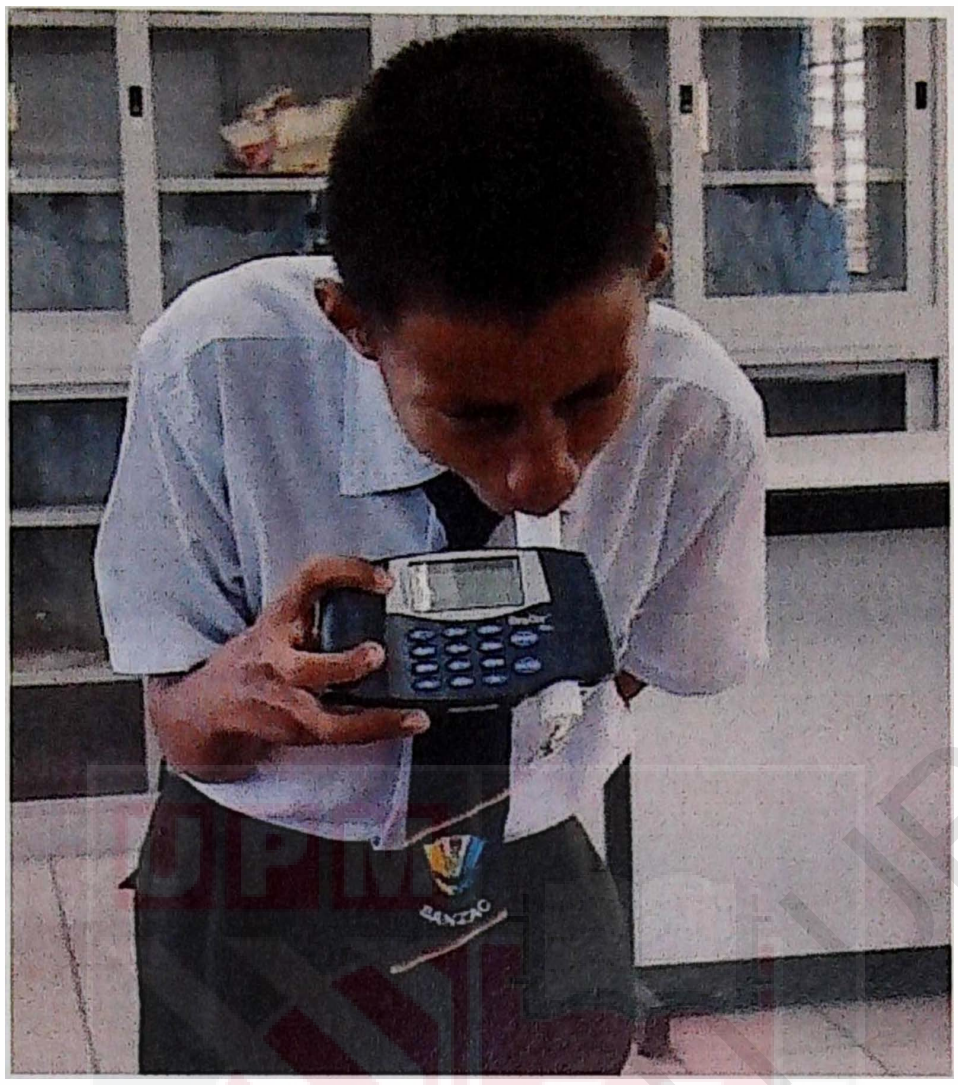

Figure 3.8: Lung function Test

3.6 DATA ANALYSIS

Statistical analysis were run by using Statistical Package for Social Science (SPSS) version 22.0. Kolmogorov Smirnov test and Shapiro Wilk test were used to determine the normality of the data. Besides, descriptive test were used to calculate the mean, median, standard deviation and interquartile range. All of the test were important to determine the correct test to be used in further data analysis. The tests used to analyse the objectives of the study were:-

Objective 1: To determine the socio-demographic characteristics of the respondents.

Statistical analysis: Descriptive Analysis (Frequency and percentage)

Objective 2: To measure the air quality parameters (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2 formaldehyde, temperature and relative humidity) in indoor and outdoor of the school environment in Kota Kinabalu, Sabah

Statistical analysis: Non- parametric (Mann-Whitney U Test)

Objective 3: To determine the lung function measurement of the students in Kota Kinabalu, Sabah.

Statistical analysis: Descriptive Analysis (Median and Interquartile range)

Objective 4: To determine the prevalence of respiratory symptoms among students in Kota Kinabalu, Sabah.

Statistical analysis: Descriptive Analysis (Frequency and percentage)

Objective 5: To determine the association between air pollutants (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2, formaldehyde) and lung function of the students.

Statistical analysis: Non-parametric (Spearman-Rho Correlation Test)

Objective 6: To determine the association between air pollutants (PM_{10}, $PM_{2.5}$, VOC, NO_2, CO_2, formaldehyde) and respiratory symptoms of the students.

Statistical analysis: Chi-Square Test

Objective 7: To determine the predictors that influenced the reported lung function and respiratory symptoms.

Statistical analysis:

a) Multiple Linear Regression (Lung Function)
b) Multiple Logistic Regression (Respiratory symptom)

3.7 QUALITY CONTROL

To ensure the reliability and validity of the data collections, quality control on the instruments and procedures were taken as followed:

3.7.1 Questionnaire

The questionnaire was translated in Malay language to ensure the better understanding of the students. Besides, the Questionnaire were pre-tested prior the data collection at SMK in peninsular Malaysia. A total of 20 students that fulfilled the inclusive criteria were selected to pre-test the questionnaire. The clearness of the instructions and understanding of the questions were evaluated during the session. Subsequently, any problems encountered by the respondents while answering the questionnaire were identified and corrected. Cronbach's alpha test were used to determine the validity, consistency and reliability of the questionnaire and the result obtained was 0.76.

3.7.2 Environmental assessment

Instruments used in this study were send to the supplier for calibration check prior to the data collection using standard and recommended procedure. The calibration certification were provided in the Appendix. During the data collection, the instrument were zero calibrated for 60 second and leaved for about 10 minutes to stabilize the instrument before the data collection were made. This is to ensure the instruments in a good condition and most important to give an accurate result and eliminate any bias or error.

Besides, the equipment were kept in the specific brief case for each equipment and store in the room temperature all the time to maintain the sensitivity of the equipment. In addition, samples collected for passive sampling (NO_2) were sealed tightly and kept in the zip lock to prevent cross contamination of the samples.

3.7.3 Lung function test (Spirometry)

Spirometry test were conducted three times and above to give an accurate reading of the respondents. The respondents were required to repeat the test until the spirometer get the best reading of the estimated value. Prior to the test, clear instruction of the procedure and video of spirometry test were given to the respondents to give a better understanding on lung function test. Besides, the spirometer were sterilized using alcohol swab for every student before conducted the test.

3.8 ETHICAL APPROVAL

Ethical approval of this study was obtained from Research Ethic Committee of Universiti Putra Malaysia. The approval to conduct the study in the secondary school was obtained from the related bodies which were Ministry of Education, Sabah State Education Department and management of the secondary schools. The written consent form were distributed to the parents/guardians prior to the data collection to obtain their permission on approving their children to be the respondents in this study. All data collected were served as confidential between the researcher and the institution.

CHAPTER 4

RESULT

4.1 Socio-demographic data of the secondary school students

Table 4.1 shows the socio-demographic data of the secondary school students in Kota Kinabalu, Sabah. There were six secondary schools involved in this research. A total of 346 school children participated in this study. Both genders were involved in this study with 142 (41%) male and 204 (59%) female respondents respectively. The major ethnicity in this study were Bajau followed with Melayu, Kadazan-dusun, Bugis and others. 'Others' ethnicity were comprised of 15 different ethnics that range from two to six numbers of people. The reported groups were from Rungus, Dusun, Murut, Bisaya, Kedayan, Sino-Nativ, Banjar, Cina, Jawa, Sungai, Irranun, Idahan, Suluk, Sigh and Eurasian.

The median for height and weight were 153(10) and 46 (13.7) respectively. From the data collected, almost half of the father who smoked (51.7%). Majority of the students have a household income less than RM 1500 (43.6%) and one third of the populations (33.5%) with household income of more than RM 3000.

Table 4.1: Socio-demographic data of the respondents

Characteristics	School, N (%)						
	A	B	C	D	E	F	Total
Gender							
Male	16 (37.2)	14 (24.1)	18 (41.9)	27(35.5)	42 (73.7)	25(35.3)	142 (41.0)
Female	27 (62.8)	44 (75.9)	25 (58.1)	49(64.5)	15 (26.3)	44(64.7)	204 (59.0)
Ethnicity							
Kadazan-Dusun	14 (32.6)	13 (22.4)	3 (7.0)	7(9.2)	3 (5.3)	12(17.6)	52 (15.0)
Bajau	7 (16.3)	26(44.8)	19 (44.2)	21(27.6)	23(40.4)	28(40.6)	125 (36.1)
Melayu	7 (16.3)	4 (12.2)	11(19.1)	33(43.4)	11(19.3)	7(10.1)	73 (21.1)
Bugis	2 (4.7)	1 (1.7)	0 (0.0)	7 (9.2)	9 (15.8)	5 (7.2)	24 (6.9)
Others	13(30.2)	14(24.1)	9 (20.9)	8 (10.5)	11(19.3)	17(10.1)	72 (20.8)
Weight, median (IQR)	46.9(13.0)	43.8(15.5)	47.0(11.7)	49.0(14.5)	44.4(17.4)	44.0(13.7)	46.0(13.7)
Height, median (IQR)	154(7.70)	149(10.7)	153(8.5)	154(9.07)	153(14)	154(9.0)	153(10)
Smoking behaviour							
Yes	0 (0)	4 (6.9)	5 (11.6)	0 (0)	14 (24.6)	4(4.4)	27 (7.8)
No	43 (100)	54 (93.1)	38 (88.4)	76 (100)	43(75.4)	65(94.2)	319 (92.2)
Family smoking							
Father	18 (41.9)	33 (56.9)	26(60.5)	29(38.2)	33(57.9)	40(58.0)	179(51.7)
Mother	0 (0)	0 (0)	4 (9.3)	1(1.3)	2(3.5)	2(2.9)	9 (2.6)
Siblings	14 (32.6)	20 (34.5)	9 (20.9)	23(30.3)	33(57.9)	28(41.2)	139(40.2)
Family Asthma							
Father	3 (7.0)	2 (3.4)	1 (2.3)	2 (2.6)	4(7.0)	2(2.9)	14 (4.0)
Mother	2 (4.7)	5 (8.6)	4 (9.3)	3(3.9)	5(8.8)	10(14.5)	29 (8.4)
Siblings	7 (16.3)	8 (13.8)	9 (20.9)	13(17.1)	9 (15.8)	21(30.4)	67 (19.4)
Income							
<RM 1500	14 (32.6)	40 (69.0)	21(48.8)	5(6.6)	33(57.9)	38(55.1)	151(43.6)
RM 1500-RM3000	7 (16.3)	14 (24.1)	12 (27.9)	9(11.8)	18(31.6)	19(27.5)	79 (22.8)
>RM 3000	22 (51.2)	4 (6.9)	10 (23.3)	62(81.6)	6(10.5)	12(17.4)	116(33.5)

N=346

4.2 Air pollutants level around the school environment in Kota Kinabalu, Sabah

The level of the air quality parameters were not normally distributed ($p<0.05$) hence non-parametric test (Mann-Whitney U Test) were used to determine the significant difference of air pollutants level in indoor and outdoor of the schools. From the median, all the pollutants were higher in indoor except for formaldehyde and temperature. There were significant difference for PM_{10} ($p=0.026$) and carbon dioxide ($p<0.001$) level in indoor and outdoor of the schools.

Table 4.2: Concentration of air pollutants in indoor and outdoor

Variables	Indoor (N=24)	Outdoor (N=6)	Z-score	p	I/O ratio
	Median (IQR)				
$PM_{2.5}$ ($\mu g/m^3$)	22.0(8.0)	20.5(8.0)	-1.862	0.063	1.07
PM_{10} ($\mu g/m^3$)	30.79(8.98)	26.0(12)	-2.233	0.026*	1.18
Total VOC (ppm)	0.56(0.22)	0.55(5.67)	-0.083	0.934	1.01
CO_2 (ppm)	464(85)	401(16)	-4.304	<0.001***	1.16
Formaldehyde (ppm)	0.007(0.024)	0.008	-0.625	0.532	0.88
NO_2 ($\mu g/m^3$)	18.0 (6.0)	15.0(9.0)	-1.032	0.302	1.19
Temperature (°C)	26.3(4.9)	26.5(6.40)	-0.851	0.393	0.99
Relative Humidity (%)	66.4 (6.4)	64.4(9.4)	-1.237	0.216	1.03

Z= Mann-Whitney U Test

* *Significant at p<0.05*

*** *Significant at p<0.001*

4.3 Prevalence of lung function outcome among students in Kota Kinabalu, Sabah

The normality test shows that the outcome were not normally distributed ($p>0.05$) for FVC (liter), FEV_1 (liter), FVC% predicted, FEV_1% predicted and FEV_1/FVC % predicted. Data on FVC (liter) and FEV_1 (liter) were obtained during the health assessment of the lung function test. FVC% predicted and FEV_1% predicted were calculated based on the measured lung function with the predicted value calculated from the equation proposed by Azizi and Henry (1994) for children lung function in Malaysia. Table 4.3 represents the median value for each of the lung function parameter.

Table 4.3: Lung Function outcome of the students in Kota Kinabalu, Sabah

Variables	Median (IQR)
FVC (liter)	2.56 (0.83)
FEV1 (liter)	2.24 (0.68)
FEV1/FVC (ratio)	0.90(0.13)
FVC% predicted	108.5 (23.38)
FEV1% predicted	105.4 (21.63)
FEV1/FVC predicted%	98.02 (13.44)

N=346

4.4 Prevalence of Lung Function Abnormality of the Students

In Table 4.4, descriptive statistics were used to report the prevalence of the lung function abnormalities among students in Kota Kinabalu, Sabah. The value of FVC% predicted, FEV_1% predicted and FEV_1/FVC% predicted of the student was categorized into normal and abnormal based on American Thoracic Society (2005) classification to determine the lung function abnormalities of the students. The normal value for FVC and FEV_1 % predicted was 80% and above (≥80) while the normal value for FEV_1/FVC % predicted was more than 70% (>70). Majority have normal FVC% predicted value (94.2%) while only 5.8% were categorized as abnormal. For FEV_1% predicted, 9% were abnormal and the rest were normal. Besides, 11% had abnormal FEV_1/FVC% predicted.

Table 4.4: Lung Function abnormality among the students

Lung Function	N (%)
FVC% predicted	
Abnormal	20 (5.8)
Normal	326 (94.2)
FEV1% predicted	
Abnormal	31 (9.0)
Normal	315 (91.0)
FEV1/FVC% predicted	
Abnormal	38 (11.0)
Normal	308(89.0)

N=346

4.5 Prevalence of respiratory health and symptoms of the students

The variables selected for respiratory symptoms include diagnosed asthma, headache, respiratory infections, sore throat, fatigue, irritating cough, breathing difficulty, wheezing, and chest tightness. From the results, 11.3% had doctor's diagnosed asthma. Majority of the students experienced headache and almost half of the students had respiratory symptoms such as sore throat (51.2%), fatigue (50%), and respiratory infections (52.9%). There were more than 20% of the students who had irritating cough and breathing difficulty followed with wheezing and chest tightness.

Table 4.5: Respiratory health and symptoms of the students

Respiratory health and symptoms	N	%
Diagnosed asthma	39	11.3
Headache	272	78.6
Respiratory infections	183	52.9
Sore throat	177	51.2
Fatigue	173	50.0
Irritating cough	96	27.7
Breathing difficulty	81	23.4
Wheezing	46	13.3
Chest Tightness	19	5.5

N=346

4.6 Association between the concentrations of air pollutants (PM_{10}, $PM_{2.5}$, Total TVOC, NO_2, CO_2, formaldehyde) and lung function outcome of the students.

Table 4.6 shows the result based on the fifth study objective. Since the data were not normally distributed, Spearman-Rho test was used to correlate the air pollutants level and lung function. There were six pollutants included in this correlation which were PM_{10}, $PM_{2.5}$, TVOC, NO_2, CO_2, and formaldehyde. The FVC% predicted was found to have a significant correlation with NO_2 ($p=0.037$). Besides, measured ratio of FEV_1/FVC showed an association with PM_{10} ($p=0.009$), $PM_{2.5}$ ($p=0.020$), and NO_2 ($p=0.032$). Among the total number of the respondents ($N=346$), there were significant correlation between FEV_1/FVC% predicted with $PM_{2.5}$ ($p=0.009$), PM_{10} ($P=0.004$) and NO_2 ($p=0.023$)

Table 4.6 Association between air pollutants level (PM_{10}, $PM_{2.5}$, TVOC, NO_2, CO_2, formaldehyde) and lung function

Variables	Air Pollutants											
	PM_{10}		$PM_{2.5}$		TVOC		NO_2		CO_2		Formaldehyde	
	r	p	r	p	r	p	r	p	r	p	r	p
FVC(liter)	-0.104	0.054	-0.001	0.988	-0.042	0.431	-0.053	0.365	0.049	0.364	0.020	0.717
FEV1(liter)	-0.002	0.976	-0.093	0.085	-0.034	0.524	0.019	0.742	0.066	0.219	0.034	0.528
FEV1/FVC (ratio)	-0.141	0.009**	-0.125	0.020*	0.051	0.348	0.125	0.032*	0.009	0.864	0.017	0.755
FVC% predicted	0.081	0.135	0.060	0.264	-0.070	0.195	-0.121	0.037*	0.044	0.419	0.071	0.189
FEV1% predicted	-0.041	0.445	-0.055	0.305	-0.066	0.222	-0.032	0.582	0.041	0.447	0.047	0.387
FEV1/FVC% predicted	-0.155	0.004**	-0.140	0.009**	0.064	0.234	0.132	0.023*	0.001	0.979	-0.008	0.887

N=346
r = Spearman Correlation
* *Significant at p<0.05*
** *Significant p<0.01*

4.7 Association between air pollutants and respiratory symptoms of the students in Kota Kinabalu, Sabah.

Table 4.7 to Table 4.12 shows the association between air pollutants level (PM_{10}, $PM_{2.5}$, Total VOC, NO_2, CO_2, and formaldehyde) and respiratory symptoms of the student. There were nine respiratory health and symptoms reported which were diagnosed with asthma, headache, respiratory infections, sore throat, fatigue, irritating cough, breathing difficulty, wheezing and chest tightness. Air pollutants level were categorized into high and low levels of the pollutants based on the median value for each of the pollutant. Chi-Square test was used to determine the association between the variables.

From six different type of pollutants assessed, there were four pollutants (PM_{10}, $PM_{2.5}$, Total VOC, formaldehyde) related to the reported respiratory symptoms. Firstly, PM_{10} level was found to have a significant association with wheezing ($p= 0.026$). The low level of PM_{10} was set to be $<31\mu g/m^3$ while the high level of PM_{10} was set as $\geq 31\mu g/m^3$. Next, exposure to $PM_{2.5}$ at schools was associated with irritating cough of the students ($p= 0.012$). Besides, there were significant association between TVOC ($p=0.024$) and formaldehyde ($p<0.001$) with the reported respiratory infections of the students. However, no significant association were found between NO_2 and CO_2 with any reported respiratory symptoms.

Table 4.7: Association between PM_{10} levels and respiratory symptoms among the students

Variables	PM_{10} levels		χ^2	p	OR	95% CI
	Low ($<31\mu g/m^3$)	High ($\geq 31\mu g/m^3$)				
Diagnosed Asthma						
Yes	14(35.0)	25(64.1)	1.690	0.194	1.578	0.790-3.150
No	144(46.9)	163(53.1)				
Headache						
Yes	129(47.4)	143(52.6)	1.591	0.207	0.714	0.423-1.206
No	29(39.2)	45(60.8)				
Respiratory infections						
Yes	83(45.4)	100(54.6)	0.015	0.903	1.027	0.672-1.569
No	74(46.0)	88(54.0)				
Sore throat						
Yes	81(45.8)	96(54.2)	0.001	0.970	0.992	0.650-1.515
No	77(45.6)	92(54.4)				
Fatigue						
Yes	79(45.7)	94(54.3)	0.000	1.000	1.000	0.655-1.527
No	79(45.7)	94(54.3)				
Irritating Cough						
Yes	49(51)	47(49)	1.548	0.213	0.741	0.463-1.189
No	109(43.6)	141(56.4)				
Breathing Difficulty						
Yes	36(44.4)	45(55.6)	0.063	0.801	1.066	0.647-1.759
No	122(46)	143954.0)				
Wheezing						
Yes	28(60.9)	18(39.1)	4.943	0.026*	0.492	0.261-0.927
No	130(43.3)	170(56.7)				
Chest Tightness						
Yes	11(57.9)	8(42.1)	1.212	0.271	0.594	0.233-1.515
No	147(45.0)	180(55)				

N =346

χ^2 = Chi-Square Test

**Significant at $p<0.05$*

Table 4.8: Association between $PM_{2.5}$ levels and respiratory symptoms among the students

Variables	$PM_{2.5}$ levels		χ^2	p	OR	95% CI
	Low (<22µg/m³)	High (≥22µg/m³)				
Diagnosed Asthma						
Yes	15(43.4)	24(61.5)	0.428	0.513	1.256	0.634-2.487
No	135(44.0)	172(56.0)				
Headache						
Yes	121(44.5)	151(55.5)	0.664	0.415	0.804	0.476-1.359
No	29(39.2)	45(60.8)				
Respiratory infections						
Yes	83(45.4)	100(54.6)	0.634	0.426	0.841	0.549-1.288
No	67(41.4)	96(58.9)				
Sore throat						
Yes	80(45.2)	97(54.8)	0.502	0.478	0.857	0.560-1.312
No	70(41.4)	99(58.6)				
Fatigue						
Yes	75(43.4)	98(56.6)	0.000	1.000	1.000	0.654-1.530
No	75(43.4)	98(56.6)				
Irritating Cough						
Yes	52(54.2)	44(45.8)	6.327	0.012*	0.546	0.339-0.877
No	98(39.2)	152(60.8)				
Breathing Difficulty						
Yes	35(43.2)	46(45.9)	0.001	0.976	1.008	0.610-1.165
No	115(43.4)	150(56.6)				
Wheezing						
Yes	26(56.5)	20(43.5)	3.747	0.053	0.542	0.290-1.014
No	124(41.3)	176(58.7)				
Chest Tightness						
Yes	9(47.4)	10(56.6)	0.132	0.716	0.842	0.333-2.128
No	141(43.1)	186(56.9)				

N =346

χ^2 = Chi-Square Test

**Significant at p<0.05*

Table 4.9: Association between Total VOC levels and respiratory symptoms among the students

Variables	Total VOC levels		χ^2	p	OR	95% CI
	Low (<0.56 ppm)	High (≥0.56 ppm)				
Diagnosed Asthma						
Yes	13(14.9)	26(66.7)	0.432	0.511	1.266	2.560
No	119(38.8)	188(61.2)				
Headache						
Yes	103(37.9)	169(62.1)	0.43	0.836	1.057	0.624-1.791
No	29(39.2)	45(60.8)				
Respiratory infections						
Yes	80(43.7)	103(56.3)	5.099	0.024*	0.603	0.388-0.937
No	52(31.9)	111(68.1)				
Sore throat						
Yes	65(36.7)	112(63.3)	0.313	0.576	1.132	0.733-1.747
No	67(39.6)	102(60.4)				
Fatigue						
Yes	64(37.0)	109(63.0)	1.96	0.658	1.103	0.715-1.702
No	68(39.3)	105(60.7)				
Irritating Cough						
Yes	40(41.7)	56(58.3)	0.696	0.404	0.815	0.504-1.318
No	92(36.8)	158(63.2)				
Breathing Difficulty						
Yes	30(37.0)	41(63.0)	0.056	0.814	1.064	0.636-1.779
No	102(38.5)	163(61.5)				
Wheezing						
Yes	21(45.7)	25(54.3)	1.265	0.261	0.699	0.374-1.307
No	111(37.0)	189(63.0)				
Chest Tightness						
Yes	7(36.8)	12(63.2)	0.015	0.904	1.061	0.407-2.766
No	125(38.2)	202(61.8)				

N =346

χ^2 = Chi-Square Test

**Significant at p<0.05*

Table 4.10: Association between NO_2 levels and respiratory symptoms among the students

Variables	NO_2 levels		χ^2	p	OR	95% CI
	Low (<18µg/m3)	High (≥18µg/m3)				
Diagnosed Asthma						
Yes	17(43.6)	22(56.4)	0.434	0.510	1.253	0.640-2.451
No	151(49.2)	156(50.8)				
Headache						
Yes	132(48.5)	140(51.5)	0.000	0.985	1.005	0.601-1.680
No	36(48.6)	38(51.4)				
Respiratory infections						
Yes	91(49.7)	92(50.3)	0.214	0.644	0.905	0.593-1.381
No	77(47.2)	86(52.8)				
Sore throat						
Yes	84(47.5)	93(52.5)	0.175	0.676	1.094	0.715-1.668
No	84(49.7)	85(50.3)				
Fatigue						
Yes	78(45.1)	95(54.9)	1.666	0.197	1.321	0.865
No	90(52.0)	83(48.0)				
Irritating Cough						
Yes	45(46.9)	51(53.1)	0.150	0.698	1.098	0.685-1.759
No	123(49.2)	127(50.8)				
Breathing Difficulty						
Yes	39(48.1)	42(51.9)	0.007	0.933	1.021	0.621-1.681
No	129(48.7)	136(51.3)				
Wheezing						
Yes	28(60.9)	18(39.1)	3.221	0.073	0.563	0.298-1.060
No	140(46.7)	160(53.3)				
Chest Tightness						
Yes	13(68.4)	6(31.6)	3.176	0.075	0.416	0.154-1.121
No	155(47.4)	172(52.6)				

N =346

χ^2 = Chi-Square Test

Table 4.11: Association between CO_2 levels and respiratory symptoms among the students

Variables	CO_2 levels		χ^2	p	OR	95% CI
	Low (<464 ppm)	High (≥464 ppm)				
Diagnosed Asthma						
Yes	19(48.7)	20(51.3)	0.816	0.366	1.359	0.697-2.648
No	173(56.4)	134(43.6)				
Headache						
Yes	152(55.9)	120(44.1)	0.079	0.779	0.929	0.554-1.556
No	120(44.1)	34(45.9)				
Respiratory infections						
Yes	110(60.1)	73(39.9)	3.354	0.067	0.672	0.439-1.029
No	82(50.3)	81(49.7)				
Sore throat						
Yes	99(55.9)	78(44.1)	0.029	0.865	0.964	0.631-1.473
No	93(55.0)	76(45.0)				
Fatigue						
Yes	102(59.0)	71(41.0)	1.685	0.194	0.755	0.493-1.255
No	90(52.0)	83(48.0)				
Irritating Cough						
Yes	56(58.3)	40(41.7)	0.434	0.510	0.852	0.529-1.372
No	135(54.4)	114(45.				
Breathing Difficulty						
Yes	48(59.3)	33(40.7)	0.608	0.436	0.818	0.494-1.355
No	144(54.3)	121(45.7)				
Wheezing						
Yes	28(60.9)	18(39.1)	0.621	0.431	0.775	0.411-1.462
No	164(54.7)	136(45.3)				
Chest Tightness						
Yes	11(57.9)	8(42.1)	0.047	0.828	0.902	0.353-2.300
No	181(55.4)	146(44.6)				

N =346

χ^2 = Chi-Square Test

Table 4.12: Association between Formaldehyde levels and respiratory symptoms

Variables	Formaldehyde levels		χ^2	p	OR	95% CI
	Low (<0.007ppm)	High (≥0.007ppm)				
Diagnosed Asthma						
Yes	16(41.0)	23(59.0)	3.572	0.059	1.906	0.969-3.750
No	175(57.0)	132(43.0)				
Headache						
Yes	154(56.6)	118(43.4)	1.030	0.310	0.766	0.458-1.282
No	37(50.0)	37(50.0)				
Respiratory infections						
Yes	120(65.6)	63(34.4)	16.897	<0.001***	0.405	0.262-0.626
No	71(43.6)	92(56.4)				
Sore throat						
Yes	100(56.5)	77(43.5)	0.246	0.620	0.898	0.588-1.373
No	91(53.8)	78(46.2)				
Fatigue						
Yes	98(56.6)	75(43.4)	0.292	0.589	0.890	0.582-1.359
No	90(53.8)	80(46.2)				
Irritating Cough					0.661	0.408-1.070
Yes	60(62.5)	36(37.5)	2.861	0.091		
No	131(52.4)	119(47.6)				
Breathing Difficulty						
Yes	41(50.6)	40(49.4)	0.899	0.343	1.273	0.773-2.095
No	150(56.6)	115(43.4)				
Wheezing						
Yes	24(52.2)	22(47.8)	0.197	0.657	1.151	0.618-2.143
No	167(55.7)	133(44.3)				
Chest Tightness						
Yes	9(47.4)	10(52.6)	0.499	0.480	1.395	0.552-3.523
No	182(55.7)	145(44.3)				

N =346

χ^2 = Chi-Square Test

****Significant at p<0.001*

4.8 Factors that influenced lung function among students in Kota Kinabalu, Sabah

Multiple linear regression was used to determine the most selected variables that influenced the FEV_1/FVC % predicted of the students which include PM_{10}, $PM_{2.5}$ and NO_2. All possible variables were included simultaneously into the regression. The analysis were performed after controlling the cofounders in this study. Table 4.13 showed that $PM_{2.5}$ (p=0.048) and PM_{10} (p=0.008) were significantly influenced FEV_1/FVC% predicted among the students.

Table 4.13 Risk factors that influenced FEV_1/FVC% predicted among the students

Independent Variables	β	S.E	p	95% CI
Constant	107.719	4.600	<0.001	98.666-116.772
$PM_{2.5}$	1.413	0.712	0.048*	0.012-2.813
PM_{10}	-1.484	0.553	0.008*	-2.572-(-0.395)
NO_2	-0.033	0.186	0.860	-0.399-0.333

N=346

β= Standardized Coefficient

S.E= Standard Error

Negelkerke R^2 value= 0.053

**Significant at p<0.05*

***Significant at p<0.001*

4.9 Factors that influenced the reported respiratory symptom

In this analysis, multiple logistic regression were used to determine the selected variables that influenced the reported respiratory infection among students after controlling all the cofounder which include TVOC and formaldehyde. Based on Table 4.14, the result shows that there were significant regressions between Total VOC (p=0.04) and formaldehyde (p=<0.001) with respiratory infections.

Table 4.14 Risk factors which contributed to the reported respiratory infection

Independent Variables	B	S.E	p	OR	95% CI
Constant	-0.547	0.185	0.003	0.578	-
Total VOC	0.473	0.230	0.04*	1.604	1.022-2.517
Formaldehyde	0.887	0.223	<0.001***	2.427	1.567-3.758

N=346

B= Regression Coefficient

S.E= Standard Error

Negelkerke R^2 value= 0.08

**Significant at p<0.05*

****Significant at p<0.001*

CHAPTER 5

DISCUSSION

5.1 Socio-demographic data of the secondary school students

In this study, 346 students participated with the majority from the female respondents (59%). Sabahan was constructed in multi-ethnicity. Regis et al (2016) stated that three major groups in Sabah were Kadazan-Dusun, Bajau, Murut followed with Brunien Malay, Suluk meanwhile in this study, the main respondents have consisted of Bajau (36.1%). From the questionnaire, the prevalence of smoking behavior among students in Kota Kinabalu was 7.8 %. In another state which is Negeri Sembilan, the prevalence of smoking status among secondary school students was 14% (Lee et al., 2014). Smoking history was highly reported among father (51.7%) and siblings (40.2%) meanwhile 19.4% of the siblings reported to have asthmatic problems. Willemsan et al (2008) suggested that genetics is one of the risk factors that important in the development of the allergy and asthma in the person.

Majority of the parent has an income of less than RM 1500 (43.6%). These group mainly self-employed person that runs a small business in the agriculture sector. Household income was considered in this study as this factor can cause a range of children's health effect even when other factors of socioeconomic status taken into concern (Emerson et al., 2011). This factor can influence the risk of respiratory problems due to inadequate medical treatment and access especially in children from the low level of household income.

5.2 Descriptive data on the school environment and air pollutants level around schools in Kota Kinabalu, Sabah

The mean age of the buildings was 34 years old with the newest school constructed in 2002 and the oldest in 1967. The schools building were 3-4 storey concrete buildings with the painted walls and ceilings and most of the schools consist of concrete floor surface without any floor covering or paint. The buildings were primarily furnished with plastic/wood chairs and desks and some school have bookshelves without any carpet on the floor. All classes equipped with electric fan in the ceiling and none of the rooms installed air conditioned or mechanical ventilation. In the classrooms, there is efficient natural ventilation where there are two doors with windows on each side of the room that allows the ambient air to enter the spaces and egress through the other side. During the class, the front door and windows were usually opened except for the back door.

Based on Table 4.2, levels of pollutants in indoor class is higher compared to outdoor. This is in accordance with the USEPA (2017) where the level of pollutants indoors can be higher than the level of pollutants outdoors. The sources of the pollutants may be originated both from the indoor and outdoor. In indoor environment, building materials and furniture may be the sources to the high pollutants in the classroom. Besides, use of marker during the learning session may release organic compounds in the indoor air. Teachers in the classrooms tends to use markers all the day during the session to write on the whiteboard. Plus, the students in the classroom also use the markers at least once a week for their presentation on the mahjong paper.

Moreover, there are few schools that still use woody chairs, desk, and bookshelf. Plus, the condition of the furniture quite old and defected. Other sources might be released from the paint wall. This findings is supported by Zhang and Smith (2003), where the researcher stated that furniture in the classrooms can contribute to the indoor air pollutants in the classroom.

On the other side, the pollutants was higher in indoor due to outdoor activities that released numbers of pollutants including traffic around the schools. Most of the schools were located beside the roads where the traffic density quite high especially early in the morning and afternoon. Traffic may release traffic-related air pollutants such as particulate matters and nitrogen oxides that can travel in a long distance and get into the classroom. The pollutants that is light than air can travel up into the buildings and reside in the classroom through the openings of the windows during the day. According to Choo et al (2014), the sources of indoor air contaminant were mainly released by transportation, industrial process and construction activities.

In this study the Industrial Code of Practice on Indoor Air Quality (ICOP IAQ) 2010 and Malaysian Ambient Air Quality Standard (MAAQS) 2013 were used as the reference value for the air pollutants level. However, the averaging time for the pollutants in the standard provided were 24 hours. Thus, this study cannot compared directly with the standards, but the standard can be used as the reference only to see whether the pollutants is too higher or too low in that area. By comparing to the 24 hours averaging time, the obtained measurement in this study may slightly higher to

the standards. However, from the results, most of the pollutants were below than the standard.

Industrial Code of Practice on Indoor Air Quality have set an acceptable range for the indoor parameter of temperature, relative humidity, and carbon dioxide. The range of the parameters were 23-26°C, 40-70% and 1000 ppm for temperature, relative humidity, and carbon dioxide respectively. From the measurement, temperature in the classroom was slightly higher than the standards provided while relative humidity and carbon dioxide were in a safe limit. Choo et al (2014) stated that the origins of the indoor carbon dioxide level in schools were usually generated from the human respiration (occupant density). The classes mainly consisted of 20 to 30 student with the small space area occupied with the student and the furniture. Besides, the acceptable limits for indoor air contaminants of formaldehyde and TVOC were 0.1 ppm and 3 ppm respectively. The averaging time of the pollutants were set for 8 hour exposure. From the table, formaldehyde and TVOC did not exceed the acceptable limits set by the DOSH.

In addition, MAAQS (2013) was referred in this study as a baseline for the level of PM_{10}, $PM_{2.5}$, and NO_2. The limit for $PM_{2.5}$ and PM_{10} of averaging time of 24 hours were 150 $\mu g/m^3$ and 75 $\mu g/m^3$ respectively. From the results, $PM_{2.5}$ and PM_{10} levels in the school environment were below the air quality standards. In addition, the level of NO_2 in the school environment was 18 $\mu g/m^3$. The MAAQS 2013 stated that the limit for NO_2 averaging time of 24 hours is 75 $\mu g/m^3$. Thus NO_2 level did not exceed the limit provided.

5.3 Lung Function Outcome of the students

Height was included in the predicted equation as it can influence the air volume. The taller the students, the bigger the size of the lungs (Moore, 2012). The normal value for FVC and FEV_1% predicted are within 80% of the reference value while the normal value for the ratio of FEV_1/FVC% predicted is 70% (ATS, 2005). Table 4.3 shows that median of FVC%, FEV_1 % and FEV_1/FVC % predicted were higher than the reference value. FVC% predicted and FEV_1% predicted that are equal to or greater than 80% are considered normal. However, the data in Table 4.3 only represent the result of the total number of the respondent (average).

Exposure to the air pollutants may cause adverse effect towards the children's lung function. However, the exposure to the air pollutants not necessarily cause the lung function abnormality in the children. Plus, the occurrence of the lung function abnormality in the respondents might be not only cause by the single factor of the air pollutants around the school environment. Other factors that can contribute to the reduced children's lung function were environmental tobacco smoke and home environment. In this study, the cofounder were controlled statistically using the multivariate analysis technique.

Table 4.4 shows the prevalence of lung function abnormality. The normality of the lung was characterized as normal when the value of FEV_1 and FVC % predicted are higher than 80% and the ratio FEV_1/FVC% predicted higher than 70%. According to the results, there were 5.8%, 9% and 11% had abnormal FVC%, FEV_1 % and ratio FEV_1/FVC predicted respectively. According to Pellegrino et al (2005), FVC that is less than 80% for person age of 5 to 18 years old indicate a restrictive pattern.

Interpretative strategies for lung function test stated that the presence of a restrictive ventilatory defect may be suspected when VC is reduced and increased of FEV_1/FVC ratio. A restrictive lung disease prevents the lung from fully inhale the air and this restriction makes breathing difficult. Common causes of decreased lung function were pneumonia, pulmonary fibrosis, and pulmonary oedema. Besides, FEV_1 is a common parameter used to measure the mechanical properties of the lungs (Sewa & Ong, 2014). The measurement of the FEV_1 are usually decreased in obstructive and restrictive lung diseases. Chronic Obstructive Pulmonary Disease (COPD) is one of the example of the obstructive disease. The common parameters obtained was usually percentage predicted of FEV_1 rather than absolute value of the FEV_1.

Reduce of FEV_1/FVC (<70%) can be interpreted as an obstructive disease. In obstructive lung disease, the FEV_1 is reduced due to the obstruction of air escaping from the lung thus the ratio of FEV_1/FVC reduced. During rapid breathing, greater pressure is needed to overcome the resistance to flow. Common obstructive diseases were asthma, bronchitis, COPD, and emphysema. According to the findings from Ariffudin et al (2019), they concluded that exposure to traffic-related air pollutants specifically $PM_{2.5}$ and PM_{10} in an urban area could increase the risk of getting lung function abnormality and respiratory symptom of the students. Construction activities and traffic around the schools in Kota Kinabalu could be the sources that triggered the lung function abnormality of the students. Besides, a similar study conducted by Choo and Juliana (2005) stated that exposure to indoor $PM_{2.5}$ increased the risk of getting lung function abnormality.

5.4 Prevalence of respiratory and health and symptoms

The prevalence of diagnosed asthma in this study is 11.3%. Table 4.5 shows the reported respiratory symptoms experienced by the student in the past 12 months. The highest reported symptom among the students was headache. A study conducted in Johor Bharu, Malaysia by Dorback et al (2017) suggested that headache, fatigue and throat symptoms were often reported by the students and correlate with the indoor air pollutants. This is also supported by the study conducted by Choo and Juliana (2015) and Suhaimi and Jalaludin (2015) that found an association between indoor air pollutants and health effects such as headache, dizziness, and fatigue.

The symptoms experienced by the students may varies in different person. Immuno-compromised students may experience frequent respiratory symptoms due to poor ventilated classroom (Simoni et al., 2010) and acute exposure to the pollutants in the classroom. The reported respiratory symptoms among the students also may not necessarily caused by the exposure to the air pollutants in the classroom. Viral and bacterial infection may also cause this symptoms to occur such as flu, cough, headache and throat symptoms.

From the table, there are 52.9% of the students who had respiratory infections followed with 51.2% of sore throat symptom. A study conducted by Norback et al (2017) in schools in Penang found a significant association between dampness in the classrooms with respiratory infections (OR=3.70, 95% CI=1.14-12.1). From the building checklist, it shows that most of the classes has the visible mould that might be the sign of dampness in the classrooms. However, in this study, mould were not

included as the study variable and future study was recommended to take it in a consideration. As the classes were on the top level, water tank may be the sources of the occurrence of the mould in the classroom.

Besides, half of the students experienced an irritating cough for the past 12 months. Symptoms such as cough are one of the indicators of the airway irritant stimuli towards the air pollutants and the symptom usually occurred to increase the secretion of mucus in the airway due to the damage of mucociliary system that cannot effectively clear the airways mucus (David and Foster, 1999). A cough that is acute will last for less than three weeks, while chronic cough will extend to the period that can worsen the airways and throat of the individual.

A study from Norway shows that higher prevalence on upper airway irritation is significantly associated with CO_2 level in the school's room (Fox et al., 2003). Meanwhile, the reported wheezing among children in the schools were 13.3% of the total of 346 students. According to Madureira et al (2015), high exposure to $PM_{2.5}$ and PM_{10} increase the odds of wheezing among the school children. Wheezing is a condition where the airways were constricted and inflammed by the pollutants. Wheezing symptom is one of the common symptoms for asthma patient where the person have difficulties to exhale air from the lungs.

5.5 Association between air pollutants level and lung function among the students.

The correlation between air pollutants level of $PM_{2.5}$, PM_{10}, Total VOC, NO_2, CO_2, and formaldehyde were presented in Table 4.6. The findings show that there was a significant association between FEV_1/FVC (ratio) and FEV_1/FVC % predicted with PM_{10}, $PM_{2.5}$, and NO_2. Besides, FVC% predicted was found to have a significant association with NO_2 level. The hypothesis was failed to be rejected since there was a significant correlation between air pollutant level and lung function of the students in Kota Kinabalu, Sabah. From the results, $PM_{2.5}$ and PM_{10} were inversely correlated with the ratio of FEV_1/FVC % predicted. Significant value for FEV_1/FVC% predicted showed that, there was airway obstruction for the lung function of the student. Airway obstruction was defined as a blockage of respiration in the airway and may influence the children's lung function (Choo & Jalaludin, 2015).

Sources of the particulate matters in the school environment mainly released from the combustion of the fossil fuels. Traffic-related air pollution released the particulate matters in the atmosphere and this pollutants from the outdoor enter the indoor environment of the classrooms through the opening windows and doors. Most of the classes opened the front door and all the windows during the learning session. Srimuruganandam and Nagendra (2012) claimed that these fine particles can go up to 1000 kilometers and the lifetimes of this pollutants took days to weeks. The pollutants may also reside in the classroom and settled on the desk, floor and any surfaces. Thus the concentration of the pollutants in indoor air is sufficient to reduce children's lung function.

Inhaled of the particulate matters in the classroom draw the pollutants deeper in the lung. $PM_{2.5}$ are known to be more hazardous as this ultrafine particles able to deposit in the alveoli sacs and at worst can get into the bloodstream and can cause cardiovascular disease. Once the pollutants reached the targeted places in the lung, the pollutants irritate and inflame the lining and cells of the lung. Long-term exposure to the pollutants will alter the lung development, function and elasticity of the lung (Braver et al., 2012). Thus the students will have difficulties to breathe in air or out from the lungs.

Besides, there is an association between NO_2 and $FEV_1/FVC\%$ predicted. NO_2 is one of the harmful pollutants that can cause acute and chronic effect to the school-children. In Malaysia, there are more studied that found a relationship between NO_2 with lung function in school-aged children (Nurul Anis Sofiah & Juliana (2013); Azwani & Juliana (2015)). Moreover, Kattan et al. (2007) stated that high level of NO_2 not only decreased the expiratory peak flow in children but also increase the reported asthma symptoms among the children. In this study, the prevalence of the doctor's diagnosed asthma was 11.3%. According to Gillespie-Bennett et al. (2011), exposure to NO_2 levels is associated with increased of reported respiratory symptoms and reduced the respiratory function especially in an asthmatic children.

5.6 Association between air pollutants level and reported respiratory symptom among secondary school students.

Table 4.7 to Table 4.12 shows the association between air pollutants level (PM_{10}, $PM_{2.5}$, Total VOC, NO_2, CO_2 and formaldehyde) and reported respiratory symptoms. From the result obtained, there was a significant relationship between PM_{10} level and wheezing (p= 0.026). Besides, $PM_{2.5}$ was found to have significant correlation with irritating cough (p= 0.012) and respiratory infections were associated with TVOC (p=0.024) and formaldehyde (p<0.001).Hypothesis two in this study was failed to be rejected since there is a significant association between air pollutants and reported respiratory symptoms among students in Kota Kinabalu, Sabah.

Even though the pollutants level is below the standards, the children still at risk to get the symptoms of the respiratory problem. From the result, wheezing symptoms was related with the PM_{10}. Wheezing is a condition where the person breathe with a high-pitched whistling sound. Obstructive disease such as COPD and asthma were the common causes to the wheezing. Narrowed and inflamed airway make the breathing difficult for the person. PM_{10} is a pollutant that can travel into the upper airways and inflamed the lung. Once the pollutants get into the deeper area in the lung there is no way to flush the pollutants. This result was supported by Rawi & Jalaludin (2015) which found a significant association between PM_{10} and wheezing among respondents.

Next, $PM_{2.5}$ was related with the coughing. Davenport (2012) suggested that cough is an important defensive reflex in order to remove foreign matter from the airway passage. $PM_{2.5}$ was considered as dangerous as this can travel deep in the lung and caused an acute and chronic effect on the persons. A study conducted by Qian et al (2004) on particulate matter ($PM_{2.5}$) exposure among 5-16 years of age showed the odds ratio for cough and the pollutant of 1.90.

In this study, TVOC and formaldehyde were found to have a significant association with respiratory infections. Stellrecht (2017) stated that respiratory tract infections (upper and lower) were a spectrum of diseases include the common cold, influenza-like illness, bronchiolitis, and pneumonia. A cross-sectional study in Taiwan and China among student age of 11-15 years old reported that Environmental Tobacco Smoke (ETS) and new furniture in the rooms were risk factor for developing respiratory infections. Formaldehyde is a common volatile organic compound that is produced commercially in the manufacturer of buildings material and household product.

The sources of the pollutants may be originated indoor. Old woody furniture in the classroom might be one of the contributor to the organic compounds. To date, there is limited studies that study directly the effect of the organic compounds with the respiratory infections. Organic compounds were usually related with the sick building syndrome such as headache, flu, itchy and all. Respiratory infections include common cold, sinusitis, influenza and more. This infections were mainly occurred with the symptoms that almost exactly like sick building syndrome such as flu, influenza, cough

and more. The respiratory infections were mostly know to be caused by the viral and bacterial infections. The school environment with the existence of mold and dampness might be the other factors that cause the respiratory infection. Future study is recommended to fill in the gap of this study.

5.7 Predictors that influenced the lung function and the reported respiratory symptom

Based on Table 4.13, $PM_{2.5}$ and PM_{10} levels have a significant relationship with the FEV_1/FVC % predicted with the adjusted R^2 of 5.3%. This study suggested that the exposure to particulate matters were the predictor to the reduction of lung function. This is similar to Gemenetzis et al (2006) where they found an association with an increase of particulate matter with the reduction of lung function and lung disorder.

The sources of the $PM_{2.5}$ and PM_{10} were mainly release from the mobile sources and construction activities around the school environment. From the observation, most of the schools were located near the heavy traffic. The traffic were mostly busy in the morning as there is a limited way/road for people to go to work and send their children to the schools. Moreover, the construction activities were located near to the schools. There are more than one construction site operated in Kota Kinabalu, Sabah. The pollutants released from this activities were mainly consist of fine and ultrafine particle that can affect the children's health.

$PM_{2.5}$ and PM_{10} were smaller enough to reach the lower airways of the students especially $PM_{2.5}$ as this fine inhalable particle can go deeper in the lung and some may get into the bloodstream (US EPA, 2018). Long-term exposure to this pollutants caused lung irritation and increase the permeability in lung tissue. Thus it reduces the lung function of the students. Sin (2009) stated that reduced FEV_1/FVC ratio is a more specific indicator of airways disease than is reduced FEV_1 alone in the general population.

The ratio of FEV_1/FVC is important to indicate the specific type of lung disease. According to Pellegrino et al (2005) ratio of FEV_1/FVC that is less than 70% showed that the obstructive lung disease is likely to present. Long term exposure to these pollutants around the school environment will worsen the lung function and increase the risk to get lung function abnormality. Particulate matters released in the school environment in Sabah were found to be released from the construction activities and mobile sources.

Table 4.14 shows a significant contribution to the model with the adjusted R^2 of 8%. In this study, statistical evidence demonstrated that secondary school children who exposed to formaldehyde and TVOC were over 1.6 and 2.2 times more likely to have respiratory infections. This study suggested that exposure to the TVOC and formaldehyde were the predictor for the respiratory infection of the student.

Organic compound comprised of a variety of chemicals and this concentration is consistently higher indoors than outdoor (US EPA, 2017). This is similar to this study and the sources could be from the indoor such as the wood furniture used for chair and desk in most of the schools, painted wall, cleaning agent and permanent marker. Besides, mold that showed the presence of bacteria could contribute to the organic compound in the class. Upper respiratory infections were common illness resulting in school. The symptoms of upper respiratory infection include coughing, sneezing, runny nose, and nasal discharge. However, there was a limited study on VOCs and respiratory infection in schools.

5.8 STUDY LIMITATION

There were some limitations in this study need to be acknowledged. Firstly, the study design was a cross-sectional study thus it has some limitation which the findings do not allow causal relationships between health outcomes and the pollutants. Besides, due to time limitation and geographical area, this study in Kota Kinabalu, Sabah did not do the comparative study among the urban and rural area. This is important to see whether there is a significant difference between air pollutants level and respiratory health in an urban and rural area. Moreover, this study may encounter with recall bias during the questionnaire filling. As this study is based on self-reported of respiratory symptoms, without verifying with clinical reports, the bias might occur. The respondents also might have difficulties to remember details during the questionnaire filling. However, in order to minimize bias, the questionnaire used close-response format instead of open-ended format.

Besides, the air pollutants were not measured in their home places. The exposure to air pollutants at home is important to see the effect on the children's respiratory health when exposed in both school and home. Due to time limitation provided by the school management, the air pollutants was carried out for 45 minutes with one minute log interval. Therefore, the Malaysian Ambient Air Quality Standard may not be suitable for comparing the exposure as most of it was based on 8-hour or 24-hour exposure. As there are still no standards established yet for building in non-occupational settings such as the school to compare with this study findings. Therefore, it is also not suitable to use as the setting at occupational workplaces is different with school setting.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

Level of air pollutants around the school environment and respiratory health were explored among students in Kota Kinabalu, Sabah. Level of air pollutants were mostly higher in indoor air compared to outdoor. The findings concluded that exposure to air pollutants around the school environment increase the risk of lung function abnormality and respiratory health symptoms of the students. A significant relationship was found between $PM_{2.5}$, PM_{10} and NO_2 with the student's lung function. Besides, wheezing, coughing and respiratory infection were associated with the exposure to the air pollutants in the school environment (PM_{10}, $PM_{2.5}$, formaldehyde and TVOC). This study concluded that $PM_{2.5}$ and PM_{10} were the risk factors for lung function reduction while TVOC and formaldehyde were risk factors for the respiratory infections in the students. The findings of this study should, therefore, be taken into account by the policy maker and school administration in formulating policies and control measures to mitigate air pollution around the schools in the city.

6.2 RECOMMENDATION

Exposure to the air pollutants can be a serious problem either acute or chronic health effect towards the student's health. In an urban area such as Kota Kinabalu, the

air pollution able to reach the levels that can threaten student's health depends on the human activities and traffic density around the school area.

6.2.1 Regulatory body

Ministry of Education is recommended to monitor the ventilation in the classroom to ensure adequate ventilation provided. This can be done at least every 12 months to ensure the school is not polluted and the environment is safe for children to stay in the buildings. The researcher would like to suggest the regulatory bodies to establish air quality guidelines for schools to reduce the impact of air pollution from human activities.

6.2.2 The School

In the school setting, the schools' administration is recommended to ensure and prioritize the classroom cleanliness in the school. This can be done by educating the students to practice and maintain good housekeeping and periodically clean the classroom. Mopping and vacuum are suggested to remove the dust effectively. This is not only to reduce the respirable dust but to improve the indoor air quality for everyone comfort and health. Besides, it is recommended to do health promotion program on "Stop SMOKING" among students to increase the awareness on bad of smoking and to reduce smoking rate under school-aged children.

6.2.3 Parents

The parents are advice to concern more on their children's health. Children with abnormal lung function should seek further medical consultations to determine their respiratory health status. Besides, parents need to encourage the children to not smoking and monitor their activities. It is also advised for parents that smoked to limit the exposure of the environmental tobacco smoke to children in home places. Smoking should be outside home and far from the children.

6.2.4 Future Study Research

In addition, few recommendations to note for future studies would be to assess the rural area in Kota Kinabalu, Sabah as well. By doing that, it will be effective to represent Sabah in a wide range for the air quality and respiratory health of the students. It is also recommended to do more studies to determine lung function of the students with the considerations of vary ages from the primary school till the secondary school and to take in consideration of vary study locations as there are still lack of local studies.

Besides, the environmental measurement could be conducted for whole day exposure in the schools. The data collected will be more accurate to represent the exposure of the pollutants to the children. In addition, the exposure of the pollutants at home should be measured to determine the synergistic effects on the exposure of the pollutants at home and schools.

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APPENDIX

APPENDIX 1:

MINISTRY OF EDUCATION APPROVAL

KEMENTERIAN PENDIDIKAN MALAYSIA
BAHAGIAN PERANCANGAN DAN PENYELIDIKAN DASAR PENDIDIKAN
ARAS 1-4, BLOK E8
KOMPLEKS KERAJAAN PARCEL E
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62604 PUTRAJAYA

TEL : 0388846591
FAKS : 0388846579

Ruj. Kami : KPM.600-3/2/3-eras(2632)
Tarikh : 17 Disember 2018

NUR SHAHIRA BINTI MOHAMAD FADZIL
NO. KP : 961022025800

112, JALAN BANGGOL SEDANG,
KAMPUNG SUNGAI LIMAU 9100 BALING
KEDAH

Tuan,

KELULUSAN UNTUK MENJALANKAN KAJIAN DI SEKOLAH, INSTITUT PENDIDIKAN GURU, JABATAN PENDIDIKAN NEGERI DAN BAHAGIAN DI BAWAH KEMENTERIAN PENDIDIKAN MALAYSIA

Perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan bahawa permohonan tuan untuk menjalankan kajian seperti di bawah telah diluluskan.

" PENGARUH KUALITI UDARA DI PERSEKITARAN SEKOLAH TERHADAP FUNGSI PARU-PARU DAN SIMPTOM PERNAFASAN DI KALANGAN PELAJAR SEKOLAH DI KOTA KINABALU, SABAH. "

3. Kelulusan adalah berdasarkan kepada kertas cadangan penyelidikan dan instrumen kajian yang dikemukakan oleh tuan kepada bahagian ini. Walau bagaimanapun kelulusan ini bergantung kepada kebenaran Jabatan Pendidikan Negeri dan Pengetua / Guru Besar yang berkenaan.

4. Surat kelulusan ini sah digunakan bermula dari **10 Januari 2019** hingga **13 Februari 2019** .

5. Tuan dikehendaki menyerahkan senaskhah laporan akhir kajian dalam bentuk *hardcopy* bersama salinan *softcopy* berformat pdf dalam CD kepada Bahagian ini.Tuan juga diingatkan supaya mendapat kebenaran terlebih dahulu daripada Bahagian ini sekiranya sebahagian atau sepenuhnya dapatan kajian tersebut hendak diterbitkan di mana-mana forum, seminar atau diumumkan kepada media massa.

Sekian untuk makluman dan tindakan tuan selanjutnya. Terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Ketua Sektor
Sektor Penyelidikan dan Penilaian
b.p. Pengarah
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pendidikan Malaysia

salinan kepada:-

JABATAN PENDIDIKAN SABAH

* SURAT INI DIJANA OLEH KOMPUTER DAN TIADA TANDATANGAN DIPERLUKAN *

APPENDIX 2:

SABAH STATE EDUCATION DEPARTMENT APPROVAL

APPENDIX 3:

UPM ETHICS APPROVAL

APPENDIX 4:

EQUIPMENT CALIBRATION CERTIFICATION

APPENDIX 5:

CONSENT FORM (RESPONDENT)

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

BORANG 2.4: PENERANGAN DAN PERSETUJUAN RESPONDEN

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

1.TAJUK KAJIAN

Pengaruh kualiti udara di persekitaran sekolah terhadap fungsi paru-paru dan simptom pernafasan di kalangan pelajar sekolah di Kota Kinabalu, Sabah.

2. PENGENALAN

Persekitaran sekolah mempunyai potensi dalam memberi kesan terhadap gejala-gejala asma, alahan dan pernafasan di kalangan pelajar sekolah menengah di Kota Kinabalu, Sabah. Kajian ini dilakukan dengan menggunakan borang soal selidik dan pemeriksaan kesihatan terhadap fungsi paru-paru.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Kajian ini dilakukan untuk mendapatkan maklumat mengenai kadar prevalens asma, alahan dan gejala pernafasan di kalangan pelajar sekolah ini, dan hubungannya dengan persekitaran sekolah dan rumah.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

- Pelajar yang mempunyai masalah kesihatan yang kronik seperti sakit jantung, tekanan darah tinggi dan lain-lain.
- Bukan pelajar
- Pelajar yang tidak mendapat persetujuan ibu bapa/ penjaga

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a)KEPADA ANDA SEBAGAI PESERTA?

- Peserta dapat mengetahui tahap kesihatan semasa terutamanya kesihatan pernafasan.
- Peserta akan diberikan cenderahati sebagai tanda penghargaan

b) KEPADA PENYELIDIK?

Maklumat-maklumat yang diperolehi dapat memberikan manfaat bagi perancangan program-program kesihatan di sekolah-sekolah di Malaysia pada masa hadapan.

6. ADAKAH IA BERISIKO?

Tidak. Kajian ini hanya menggunakan borang soal-selidik dan pemeriksaan kesihatan yang tidak invasif terhadap peserta.

7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?
Semua maklumat yang diberikan dalam soalselidik ini akan dirahsiakan dari segi identiti pemberi maklumat, dan hanya akan digunakan untuk tujuan penyelidikan sahaja

8. SIAPA YANG SAYA PERLU HUBUNGI SEKIRANYA SAYA MEMPUNYAI SOALAN TAMBAHAN SEMASA MENGIKUTI PENYELIDIKAN INI?
Jika terdapat sebarang kemushkilan atau soalan mengenai kajian atau soalselidik ini, sila bertanya kepada para penyelidik yang mengendalikan kajian ini di sekolah anda.

011-40685226
NUR SHAHIRA BINTI MOHAMAD FADZIL
JABATAN KESIHATAN PERSEKITARAN DAN PEKERJAAN,
FAKULTI PERUBATAN DAN SAINS KESIHATAN ,
UNIVERSITI PUTRA MALAYSIA,
43400, UPM SERDANG,
SELANGOR MALAYSIA

017-6361367
PROF. DR. ZAILINA HASHIM
JABATAN KESIHATAN PERSEKITARAN DAN PEKERJAAN,
FAKULTI PERUBATAN DAN SAINS KESIHATAN ,
UNIVERSITI PUTRA MALAYSIA,
43400, UPM SERDANG,
SELANGOR MALAYSIA

Kerjasama anda adalah amat penting bagi menjamin kejayaan kajian ini. Penglibatan dalam kajian ini adalah voluntari dan adalah diharapkan bahawa anda boleh menjawab soalselidik ini dengan benar dan jawapannya perlu diisi dengan tepat. Peserta berhak untuk tidak meneruskan penglibatan dalam kajian ini tanpa soalan daripada pihak penyelidik. Adalah dimaklumkan bahawa peserta mempunyai hak untuk mengetahui data dan rekod yang diperoleh hasil daripada kajian yang dilakukan.

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

9.PERSETUJUAN

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

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

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

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

*potong yang tidak berkenaan

Tandatangan .....
(*Responden*)

Tarikh :.....

Tandatangan .....
(*Saksi*)

Nama :.....

No. K/P: .....

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

Tarikh .....

Tandatangan .....
(*Penyelidik*)

APPENDIX 6:

CONSENT FORM (PARENTS/GUARDIAN)

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

BORANG 2.5: PENERANGAN DAN PERSETUJUAN IBUBAPA/PENJAGA

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

1.TAJUK KAJIAN

Pengaruh kualiti udara di persekitaran sekolah terhadap fungsi paru-paru dan simptom pernafasan di kalangan pelajar sekolah di Kota Kinabalu, Sabah.

2. PENGENALAN

Persekitaran sekolah mempunyai potensi dalam memberi kesan terhadap gejala-gejala asma, alahan dan pernafasan di kalangan pelajar sekolah menengah di Kota Kinabalu, Sabah. Kajian ini dilakukan dengan menggunakan borang soal selidik dan pemeriksaan kesihatan terhadap fungsi paru-paru.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Untuk mendapatkan maklumat mengenai kadar prevalens asma, alahan dan gejala pernafasan di kalangan pelajar sekolah ini, dan hubungannya dengan persekitaran sekolah dan rumah

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Pelajar yang mempunyai masalah kesihatan yang kronik seperti sakit jantung, tekanan darah tinggi dan lain-lain.

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANAK/JAGAAN SAYA SEBAGAI PESERTA?

- Dapat memperolehi maklumat mengenai kesihatan fungsi paru-paru anak/jagaan tuan/puan.
- Peserta akan diberikan cenderahati sebagai tanda penghargaan.

b) **KEPADA PENYELIDIK?**
Maklumat-maklumat yang diperolehi dapat memberikan manfaat bagi perancangan program-program kesihatan di sekolah-sekolah di Malaysia pada masa hadapan.

6. ADAKAH IA BERISIKO?

Tidak. Kajian ini hanya menggunakan borang soal-selidik dan pemeriksaan kesihatan yang tidak invasif terhadap peserta.

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

Semua maklumat yang diberikan dalam soalselidik ini akan dirahsiakan dari segi identiti pemberi maklumat, dan hanya akan digunakan untuk tujuan penyelidikan sahaja

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

Jika terdapat sebarang kemushkilan atau soalan mengenai kajian atau soalselidik ini, sila bertanya kepada para penyelidik yang mengendalikan kajian ini di sekolah anak/jagaan anda.

011-40685226
NUR SHAHIRA BINTI MOHAMAD FADZIL
JABATAN KESIHATAN PERSEKITARAN DAN PEKERJAAN,
FAKULTI PERUBATAN DAN SAINS KESIHATAN ,
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43400, UPM SERDANG,
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017-6361367
PROF. DR. ZAILINA HASHIM
JABATAN KESIHATAN PERSEKITARAN DAN PEKERJAAN,
FAKULTI PERUBATAN DAN SAINS KESIHATAN ,
UNIVERSITI PUTRA MALAYSIA,
43400, UPM SERDANG,
SELANGOR MALAYSIA

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

9. PERSETUJUAN

Saya..... No Kad Pengenalan. .....
beralamat.....
.....dengan ini secara sukarela bersetuju membenarkan *anak / jagaan saya ..... menyertai **penyelidikan tersebut di atas *(klinikal/percubaan ubat-ubatan/rakaman video/kumpulan sasaran/temuduga/ soal selidik).**

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

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

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

*potong yang tidak berkenaan

Tandatangan ..... Tandatangan .....
(*Ibubapa/ Penjaga*) (*Saksi*)

Tarikh :..... Nama :.....

No. K/P: .....

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

Tarikh ..... Tandatangan .....
(*Penyelidik*)

APPENDIX 7:
QUESTIONNAIRE FORM

FAKULTI PERUBATAN DAN SAINS KESIHATAN
FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG
SELANGOR, MALAYSIA

NO	
NAME	
CLASS	

BORANG SOAL SELIDIK KAJIAN

TAJUK: PENGARUH KUALITI UDARA DI PERSEKITARAN SEKOLAH TERHADAP FUNGSI PARU-PARU DAN SIMPTOM PERNAFASAN DALAM KALANGAN PELAJAR SEKOLAH DI KOTA KINABALU, SABAH.

ADALAH DIMAKLUMKAN BAHAWA ANDA TELAH TERPILIH UNTUK MENYERTAI KAJIAN INI SILA JAWAB SEMUA SOALAN DENGAN TEPAT DAN LENGKAP

TERIMA KASIH DI ATAS KERJASAMA ANDA

MAKLUMAT KEPADA PESERTA KAJIAN

Pengenalan

Assalamualaikum dan salam sejahtera. Persekitaran sekolah adalah persekitaran yang penting untuk pelajar, dan terdapat keperluan untuk mengetahui bagaimana persekitaran tersebut dapat memberi kesan kesihatan terhadap pelajar sekolah di Kota Kinabalu, Sabah. Penyelidikan ini dijalankan untuk mengkaji hubungan di antara pendedahan terhadap pencemaran udara dengan fungsi paru-paru dan simptom pernafasan dalam kalangan pelajar sekolah menengah.

Hak Responden

Penyertaan dalam kajian ini adalah secara sukarela dan tidak akan ada sebarang pembayaran dikenakan. Persetujuan dari ibu bapa atau penjaga amatlah diperlukan bagi setiap peserta sebelum menyertai kajian ini. Peserta bebas untuk tidak mengambil bahagian, untuk menamatkan penyertaan pada bila-bila masa atas sebarang sebab atau enggan menjawab sebarang pertanyaan tanpa penalti atau kehilangan cenderamata.

Semua peserta akan menerima satu cenderamata sebagai tanda penghargaan menyertai sesi penyelidikan ini. Tiada pampasan tambahan akan diberikan.

Adalah diharapkan bahawa kajian ini dapat memberi manfaat bagi perancangan program-program kesihatan di sekolah-sekolah di Malaysia pada masa hadapan.

Maklumat Rahsia

Semua jawapan peserta adalah rahsia. Hanya penyelidik yang terlibat dalam kajian ini dan mereka yang bertanggungjawab untuk penyelidikan akan mempunyai akses kepada maklumat yang anda berikan. Keputusan umumnya akan diterbitkan sebagai ringkasan perbincangan.

Jika terdapat sebarang kemusykilan atau soalan mengenai kajian atau soal selidik ini, sila bertanya kepada para penyelidik yang mengendalikan kajian ini di sekolah anda.
Sekian, terima kasih.

Penyelidik
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BAHAGIAN A : MAKLUMAT LATAR BELAKANG

Arahan: Sila isi maklumat dan tandakan (✓) untuk setiap jawapan yang berkenaan.

	MAKLUMAT LATAR BELAKANG RESPONDEN
1	Nama Penuh:
2	Jantina: ☐ Lelaki ☐ Perempuan
3	Bangsa: ☐ Kadazan-Dusun ☐ Bajau ☐ Murut ☐ Melayu ☐ Lain-lain, nyatakan:_____
4	Tarikh Lahir:
5	Alamat Rumah: _____ _____ _____
6	No. Telefon: Diri Sendiri _____ Ibu/Bapa _____
7	Nama Sekolah: _____ Nama Kelas: _____
	MAKLUMAT LATAR BELAKANG IBUBAPA/PENJAGA
8	Tahap pendidikan tertinggi **bapa/penjaga** anda: ☐ Tiada pendidikan formal ☐ Sijil/A Level/Diploma ☐ Sekolah Rendah ☐ Universiti (Sarjana Muda/Master/PhD) ☐ Sekolah Menengah
9	Status pekerjaan **bapa/penjaga** anda sekarang: ☐ Tidak bekerja ☐ Bekerja separuh masa ☐ Bekerja sepenuh masa Jika **bekerja**, sila nyatakan maklumat dibawah: a) Nama pekerjaan: _____ b) Tempat kerja: _____
10	Pendapatan semasa **bapa/penjaga** anda dalam sebulan: **RM**_____
11	Tahap pendidikan tertinggi **ibu** anda: ☐ Tiada pendidikan formal ☐ Sijil/A Level/Diploma ☐ Sekolah Rendah ☐ Universiti (Sarjana Muda/Master/PhD) ☐ Sekolah Menengah

12	Status pekerjaan **ibu/penjaga** anda sekarang: ☐ Tidak bekerja ☐ Bekerja separuh masa ☐ Bekerja sepenuh masa Jika **bekerja**, sila nyatakan maklumat dibawah: a) Nama pekerjaan: _____ b) Tempat kerja: _____
13	Pendapatan **isirumah** anda dalam sebulan (jumlah pendapatan ibu dan bapa sebulan):_____

BAHAGIAN B : ASMA DAN ALAHAN (ALERGI)

Dada Berbunyi & Bersiul Arahan: Sila tanda (✓) untuk setiap jawapan		Ya	Tidak
14	Pernahkah anda mengalami dada berbunyi dan bersiul dalam tempoh **tahun 2018**? **Jika "TIDAK", teruskan ke SOALAN 18, jika "YA" jawab soalan di bawah (SOALAN 15-17):**		
15	Pernahkah anda mengalami sesak nafas apabila dada anda berbunyi?		
16	Pernahkah anda mengalami dada berbunyi tanpa menghidap selsema?		
17	Pernahkah anda mengalami kesempitan dada apabila anda bangun dari tidur pada **tahun 2018?**		

Kesukaran bernafas Arahan: Sila tanda (✓) untuk setiap jawapan		Ya	Tidak
18	Pernahkah anda mengalami sesak nafas di siang hari ketika anda berehat pada bila-bila masa pada **tahun 2018**?		
19	Pernahkah anda mengalami sesak nafas setelah anda melakukan aktiviti lasak pada bila-bila masa pada **tahun 2018**?		
20	Pernahkah anda terjaga dari tidur akibat sesak nafas **tahun 2018**?		

Dada Berbunyi & Bersiul Arahan: Sila isi maklumat dan tandakan (✓) untuk setiap jawapan yang berkenaan.		Ya	Tidak
21	Pernahkah anda menghidapi asma? **Jika "Tidak", teruskan ke SOALAN 28, jika "Ya" jawab soalan di bawah (22-27):**		
22	Jika **YA**, adakah penyakit asma itu telah didiagnosis oleh doktor?		
23	Jika **YA**, berapakah umur anda apabila anda didiagnosis oleh doktor?	_____tahun	
24	Jika **YA**, berapakah umur anda pada kali **pertama** anda diserang asma?	_____tahun	

25	Jika **YA**, pada umur berapakah anda diserang asma yang terkini?	_____tahun	
26	Pernahkah anda mengalami serangan asma pada **tahun 2018**?		
27	Adakah anda kini mengambil ubatan asma? (semburan, ubat pil, serbuk sedutan) Jika **YA**, sila nyatakan nama ubat :_____		

Alahan (Alergi) Hidung Arahan: Sila tanda (✓) untuk setiap jawapan yang berkenaan.		Ya	Tidak
28	Pernahkah anda mengalami masalah bersin, hidung berair atau hidung tersumbat dalam keadaan anda tidak selsema pada **tahun 2018**? **Jika "Tidak", teruskan ke SOALAN 30, jika "Ya" jawab soalan di bawah (29):**		
29	Jika **YA**, adakah masalah ini berlaku disertai dengan mata berair atau gatal?		

Ekzema atau Alahan (Alergi) Kulit Arahan: Sila tanda (✓) untuk setiap jawapan yang berkenaan.		Ya	Tidak
30	Pernahkah anda mengalami ruam-ruam gatal yang wujud dan sembuh dalam tempoh masa **sekurang-kurangnya 6 bulan mulai Jun 2018 – Januari 2019**? **Jika "Tidak", teruskan ke SOALAN 33, jika "Ya" jawab soalan di bawah (31-32):**		
31	Jika **YA**, pernahkah anda mengalami ruam gatal ini **sepanjang tahun 2018**?		
32	Jika **YA**, pernahkah ruam gatal ini berlaku **pada bila-bila masa** di kawasan seperti di lipatan siku, lipatan lutut, di buku lali, di bawah punggung atau di sekitar leher, telinga dan mata?		

BAHAGIAN C : KESIHATAN DAN ALAHAN (ALERGI) YANG DIALAMI SEKARANG

Arahan: Sila isi maklumat dan tandakan (✓) untuk setiap jawapan yang berkenaan.

33	Berapa kalikah anda mengalami jangkitan saluran pernafasan dalam tempoh **3 bulan yang lepas mulai September – Disember 2018**?		_____kali	
34	Pernahkah anda menghidapi penyakit yang memerlukan anda berjumpa dengan doktor pada **tahun 2018**? Jika **YA**, apakah penyakit tersebut? Sila nyatakan: _____	Ya, lebih dari sekali	Ya, sekali	Tidak pernah
35	Pernahkah anda mengambil antibiotik (contoh penicillin) untuk masalah jangkitan saluran pernafasan pada **tahun 2018**?	Ya, lebih dari sekali	Ya, sekali	Tidak pernah
36	Adakah anda seorang perokok?		Ya	Tidak

BAHAGIAN D : MASALAH ALAHAN (ALERGI) DI KALANGAN AHLI KELUARGA LAIN

Arahan: Sila isi maklumat dan tandakan (✓) untuk setiap jawapan yang berkenaan.

37	Bilangan adik beradik yang lebih tua daripada anda	_____ orang
38	Bilangan adik beradik yang lebih tua yang menetap di rumah bersama anda sekarang	_____ orang
39	Bilangan adik beradik yang lebih muda daripada anda	_____orang
40	Bilangan adik beradik yang lebih muda yang menetap di rumah bersama anda sekarang	_____ orang

41 Adakah di antara ahli keluarga anda yang mengalami masalah alahan?
Tandakan (√)pada ruangan yang berkenaan, sama ada mereka pernah atau tidak mengalami masalah alahan.

Alahan	Bapa		Ibu		Adik beradik	
	Ya	Tidak	Ya	Tidak	Ya	Tidak
Asma						
Simptom alahan hidung						
Ekzema						

BAHAGIAN E : ZAMAN KANAK-KANAK

Arahan: Sila isi maklumat dan tandakan (✓) untuk setiap jawapan yang berkenaan.

42 Adakah ahli keluarga anda yang merokok sejak anda dilahirkan sehingga anda berusia satu tahun?
Tandakan (√) pada ruangan yang berkenaan, sama ada mereka pernah atau tidak merokok ketika itu.

Keluarga	Ya	Tidak
Ayah merokok		
Emak merokok		
Ahli keluarga lain merokok		

43 Pernahkah anda ditempatkan di rumah asuhan kanak-kanak?

☐ Tidak pernah ☐ Ya, 1-3 tahun

☐ Ya, kurang dari 1 tahun ☐ Ya, lebih dari 3 tahun

Jika **YA**, pada umur berapakah anda mula ditempatkan di rumah asuhan tersebut?

☐ Kurang dari 1 tahun ☐ 1-2 tahun ☐ Lebih dari 2 tahun

BAHAGIAN F : SIMPTOM SEMASA

Arahan: Sila tanda (✓) untuk setiap jawapan yang berkenaan.

44 Adakah anda mengalami simptom-simptom berikut dalam tempoh **tiga (3) bulan** yang lepas **mulai Oktober –Disember 2018**?

	Simptom	Ya, setiap hari	Ya, selalu (1-4 kali/minggu)	Ya, Selalu (1-3 kali/bulan)	Tidak Pernah
A	Ruam pada tangan atau lengan				
B	Ruam pada muka atau leher				
C	Kemerahan kulit, Jika **YA**, dimana? Sila nyatakan:_____				
D	Gatal pada muka atau leher				
E	Gatal pada tangan atau lengan				
F	Iritasi mata (kemerahan, kering, gatal)				
G	Kelopak mata bengkak				
H	Pening kepala				
I	Rasa loya/mual				
J	Hidung berair/hidung berhingus				
K	Hidung tersumbat				
L	Tekak kering				
M	Terasa akan menghidapi selsema				
N	Sakit tekak				
O	Batuk yang beriritasi				
P	Susah bernafas				
Q	Berasa letih dan tidak bermaya				

Arahan: Sila isi maklumat dan tandakan (✓) untuk setiap jawapan yang berkenaan.

45 Adakah simptom-simptom di atas (Soalan 44) terdapat peningkatan?

Apabila anda **berada di sekolah**

- ☐ Ya
- ☐ Tidak
- ☐ Tidak Pasti

Jika **YA**, simptom yang mana satu? (tuliskan huruf bagi simptom berkenaan, Sila rujuk **SOALAN 44**:

_____

Apabila anda **berada di rumah**

- ☐ Ya
- ☐ Tidak
- ☐ Tidak Pasti

Jika **YA**, simptom yang mana satu? (tuliskan huruf bagi simptom berkenaan, Sila rujuk **SOALAN 44**:

_____