

UNIVERSITI PUTRA MALAYSIA

ASSOCIATION BETWEEN TRAFFIC-RELATED AIR POLLUTION, LUNG FUNCTION AND RESPIRATORY SYMPTOMS AMONG PRIMARY SCHOOL CHILDREN IN KLANG VALLEY, MALAYSIA

MUHAMMAD AFIF MOHD JUHARI

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BY

MUHAMMAD AFIF MOHD JUHARI

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

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ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful.

One of the great pleasures of writing this thesis is acknowledging the efforts of many people whose help a lot by contributing their suggestion, ideas and opinions in making this project come to success stage. I would, therefore, like to offer my sincere thanks to all of them.

I would like to take this opportunity to extend my utmost gratitude and appreciation to my supervisor, Associate Prof. Dr. Juliana Jalaludin for the trust, advice, support and knowledge that she is indeed a great coach with endless encouragement, support, advice and time she willing to spend in supervising me throughout many stages of this project. Without her guidance, this research would not have been possible.

Special thanks to Dr Ho Yu Bin for great assistance in coordinating final year project for Bachelor of Environmental and Occupational Health and as my academic advisor throughout my studies. Special thanks also to my internal examiner, Dr Suhaili Abu Bakar @ Jamaludin for her guidance in making this project become successful at the end of this journey. Not to forget, my mentor; Khairul Amalin Abd Rahman who have taught me to always strive to be the best in everything.

My deepest appreciation to all dearest respondents, their parents or guardians, teachers and school management for their time and effort in willingness to participate with this project. Furthermore, my sincere gratitude goes to my research team who have been making my journey much easier with their helping hands and endless support; Faris Syahmi Shahidin, Syidatul Farhana, Nur Faseeha and Nur Hazirah.

Last but not least, all credit goes to my beloved family members who have been very supportive, endless encouragement and providing every financial support that I need; my father Mr Juhari Ab Kadir, my mother Mrs Norhayati Yahaya and my siblings; N. Iffah Juhari and N. Fahira Juhari and not to forget my endless supporter, my team member and comrade who have been there with unlimited support and encouragement for not settle for less; Aina N. Yusof. Lastly, a million thanks to those individuals who have contributed either directly or indirectly in my research, may Allah shower all of you with eternal blessings. Thank you.

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ABSTRACT

ASSOCIATION BETWEEN TRAFFIC-RELATED AIR POLLUTION, LUNG FUNCTION AND RESPIRATORY SYMPTOMS AMONG PRIMARY SCHOOL CHILDREN IN KLANG VALLEY, MALAYSIA

MUHAMMAD AFIF MOHD JUHARI

Introduction: An increasing range of vehicles on traffic roads in the urban area leads to traffic-related air pollution (TRAP) due to the emission of air pollutants from the vehicles and is currently becoming the main concern for health especially among children. Air pollution at current levels is accountable for morbidity, hospital admissions and exacerbations of symptoms. Therefore, it is a good chance for Malaysia to establish an environmental framework for the management and mitigation of emerging health impacts. **Objective:** The objective of this study was to determine the association between TRAP with lung function and respiratory health as well as determining the main factors them after controlling all confounders. **Methodology:** This cross-sectional comparative study was conducted at six schools which consisted of three schools in Klang Valley for the exposed group (N= 76) and three schools for the comparative group (N= 76) in Hulu Langat. Respondents' parents or guardians were asked to answer the modified questionnaire adapted from American Thoracic Society (ATS) and International Study of Asthma and Allergies in Childhood (ISAAC). Lung function test was conducted among the respondents using an electronic spirometer (Chestgraph HI-105 Spirometer). Air quality assessment was conducted to monitor PM_{10}, $PM_{2.5}$, TVOC, NO_2, SO_2 and CO using TSI DustTrak DRX Aerosol Monitor 8534, ppbRAE-3000, LaMotte's Model BD Air Sampling Pump and TSI Q-TRAK 7565 respectively. Data collected were analyzed using the SPSS v.22. **Result:** The concentration of TRAP in primary schools was significantly higher at heavy traffic density area. The respiratory symptoms among primary school children at primary schools in heavy traffic density area were significantly higher compared to the children at primary schools in low traffic density area. The lung abnormality (FEV_1%) among children in heavy traffic density area was significantly higher compared to the children in low traffic density area. There is an association between TRAP [NO_2 (p=0.003, PR=2.699, 95% CI=1.387-5.252), SO_2 (p=0.003, PR=2.699, 95% CI=1.387-5.252), CO (p=0.003, PR=2.699, 95% CI=1.387-5.252), TVOC (p=0.003, PR=2.699, 95% CI=1.387-5.252), $PM_{2.5}$ (p=0.003, PR=2.699, 95% CI=1.387-5.252) and PM_{10} (p=0.003, PR=2.699, 95% CI=1.387-5.252)] with lung abnormality (FEV_1%) among respondents. The most significant respiratory symptom caused by TRAP was chest tightness, while NO_2 was the main predictor for both chest tightness and FEV_1% abnormalities among the study group. **Conclusion:** This study demonstrated that children in schools near heavy traffic roads have an increased risk for respiratory symptoms such as chest tightness and lung abnormality (FEV_1%) due to higher exposure to TRAP. The long-term effects from exposure to TRAP remain mostly unknown, but the current study could support future in associations documented between TRAP and respiratory health among children, especially in Malaysia.

Keywords: TRAP, lung function, school children

ABSTRAK

HUBUNGANKAIT ANTARA PENCEMARAN UDARA BERKAITAN DENGAN TRAFIK, FUNGSI PARU-PARU DAN SIMPTOM PERNAFASAN DALAM KALANGAN KANAK-KANAK SEKOLAH RENDAH DI LEMBAH KLANG, MALAYSIA.

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Pengenalan: Peningkatan kenderaan di jalan raya membawa kepada bahan pencemar udara berkaitan trafik (TRAP) akibat pelepasan bahan pencemar udara dari kenderaan dan kini menjadi perhatian utama kesihatan terutama dalam kalangan kanak-kanak. Kajian ini merupakan peluang yang baik untuk Malaysia mewujudkan rangka kerja alam sekitar untuk pengurusan dan mengurangkan kesan kesihatan. **Objektif:** Kajian ini adalah untuk menentukan hubungan antara TRAP dengan fungsi paru-paru dan kesihatan pernafasan serta menentukan faktor-faktor utama selepas mengawal semua pembauran. **Metodologi:** Kajian perbandingan keratan rentas ini dijalankan di enam buah sekolah yang terdiri daripada sekolah di Lembah Klang untuk kumpulan terdedah (N = 76) dan sekolah kumpulan perbandingan (N = 76) di Hulu Langat. Ibu bapa responden diminta menjawab soal selidik yang diubah suai dari American Thoracic Society (ATS) dan International Study of Asthma and Allergies in Childhood (ISAAC). Ujian fungsi paru-paru dilakukan kepada responden menggunakan spirometer elektronik (Chestgraph HI-105 Spirometer). Penilaian kualiti udara telah dijalankan untuk memantau PM_{10}, $PM_{2.5}$, TVOC, NO_2, SO_2 dan CO menggunakan TSI DustTrak DRX Aerosol Monitor 8534, ppbRAE-3000, Pam Air Sampling Model BD LaMotte dan TSI Q-TRAK 7565. Data yang dikumpul dianalisis menggunakan SPSS v.22. **Keputusan:** Simptom pernafasan dalam kalangan kanak-kanak di kawasan kepadatan lalu lintas yang tinggi secara signifikan lebih tinggi berbanding dengan kawasan kepadatan lalu lintas yang rendah. Keabnormalan paru-paru (FEV_1%) dalam kalangan kanak-kanak di kawasan kepadatan lalu lintas yang tinggi adalah secara signifikan lebih tinggi berbanding dengan kawasan kepadatan lalu lintas yang rendah. Terdapat hubungkait antara TRAP [NO_2 (PR = 2.699, 95% CI = 1.387-5.252), SO_2 (PR = 2.699, 95% CI = 1.387-5.252) , PR = 2.699, 95% CI = 1.387-5.252), TVOC (PR = 2.699, 95% CI = 1.387-5.252), $PM_{2.5}$ (PR = 2.699, 95% -5.252) dan PM_{10} (PR = 2.699, 95% CI = 1.387-5.252)] dengan keabnormalan paru-paru (FEV_1%) dalam kalangan responden. Simptom pernafasan yang paling utama yang disebabkan oleh TRAP adalah sesak dada, manakala NO_2 pula merupakan faktor utama bagi sesak dada dan keabnormalan FEV_1% di kalangan kumpulan kajian. **Kesimpulan:** Kajian ini menunjukkan bahawa kanak-kanak yang bersekolah berdekatan dengan jalan raya yang sibuk mempunyai risiko yang lebih tinggi untuk mendapat simptom pernafasan seperti sesak dada dan keabnormalan paru-paru (FEV_1%) disebabkan pendedahan yang lebih tinggi kepada TRAP. Kesan jangka panjang daripada pendedahan kepada TRAP masih tidak diketahui, namun begitu kajian ini boleh menyokong kajian masa hadapan tentang mendokumentasikan hubungkait antara TRAP dan simptom pernafasan dalam kalangan kanak-kanak terutamanya di Malaysia.

Kata Kunci: TRAP, Fungsi Paru-Paru, Kanak-Kanak Sekolah

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LIST OF ABBREVATIONS

$\mu g/m^3$	Microgram per metre cube
ATS	American Thoracic Society
CI	Confidence Interval
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COPD	Chronic Obstructive Pulmonary Disease
FEV_1	Forced Expiratory Volume in 1 Second
FVC	Force Vital Capacity
IQR	Interquartile Range
ISAAC	International Study of Asthma and Allergies in Childhood
MOE	Ministry of Education
MOT	Ministry of Transport
NO_2	Nitrogen Dioxide
OR	Odd Ratio
$PM_{2.5}$	Particulates matter with up to 2.5 micrometres aerodynamic diameter
PM_{10}	Particulates matter with up to 10 micrometres aerodynamic diameter
ppm	Parts per million
PR	Prevalence Rate
R^2	Regression coefficient
SD	Standard Deviation
SE	Standard Error
SO_2	Sulphur Dioxide

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SPSS	**Statistical Package for Social Science**
TVOC	**Total Volatile Organic Compounds**
TRAP	**Traffic-related Air Pollutants**
UPM	**Universiti Putra Malaysia**
USEPA	**United States Environmental Protection Agency**
WHO	**World Health Organization**

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CHAPTER 1

INTRODUCTION

1.1 Study Background

Degrading air quality has become a worldwide concern since most of the population reside in areas with high pollution levels, and over six million deaths had been significantly related to exposure to indoor and outdoor air pollution (World Health Organization, 2014). Additionally, research has shown that air pollution at current levels is accountable for a major burden of death, hospital admissions and exacerbations of symptoms (World Health Organization, 2016). Transportation is one of the main human activities around the world (Al-Mofleh *et al.*, 2010). The increase in urbanization and urban population have increases in dependence on motorized vehicles and traffic jam, additionally changed land use patterns especially more individuals are close to traffic sources of pollution. The increasing range of vehicles in traffic road in the urban area can lead to TRAP due to the emission of air pollutants from the vehicles. This has continued to be the main concern for health due to most of the world's population lives in urban areas roughly 55% of the population, and this proportion is expected to extend to 68% by 2050 (United Nations, 2018).

As results of speedy urbanization, unsustainable economic growth, rural-urban migration and industrial growth, the environment is presently facing great pressure especially for air pollution issue in most urban areas. According to the World Health Organization (2017), air pollution can be defined as contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. There is an associate evidence which shows that air pollution at current levels is accountable for a significant burden of death, hospital admissions and exacerbations of symptoms (WHO, 2018). This is due to deterioration of air quality might contribute to respiratory and cardiovascular diseases, neurological and physiological disorders.

Therefore, it is a good chance for Malaysia to establish the environmental framework that includes management and mitigation of the emerging health impacts from the environmental hazards. It was proven in few previous published studies that traffic exposure may cause adverse respiratory health outcomes including wheezing (Gauderman *et al.* 2005; Nordling *et al.* 2008), increased prevalence of asthma (McConnell *et al.* 2006; Nicolai *et al.* 2003), decreased lung function (Balmes *et al.* 2009; Brunekreef *et al.* 1997; Kan *et al.* 2007), recurrent respiratory illnesses (Kim *et al.* 2004), increased lung inflammation markers (Dales *et al.* 2008; Holguin *et al.* 2007), and increased medical visits and hospital admissions for asthma (Chang *et al.* 2008; English *et al.* 1999).

Traffic-related air pollution is generated by gasoline-powered cars, diesel-fueled buses and lorries. Thus, the increasing number of vehicles remains the most significant source of air pollution is many Malaysian urban areas (Suhaili *et al.*, 2017). A study conducted by Fadzil and Jalaludin (2013) shows a significant association between TRAP and health problem for children who live near busy road compare to the comparative group which children who live near less busy road. The exposed group were showing the respiratory symptoms including chronic cough without cold, congestion and/or phlegm without cold, wheezing without cold and chest illness.

According to Oravisjarvi *et al.* (2011) and Rodes *et al.* (2012), children tend to be more vulnerable to air pollutants because their developmental state suggests greater susceptibility than adults at the same ambient concentration. This was also supported by a study conducted by Schultz *et al.* (2017) which stated that children may also be more exposed to air pollution compared to adults relative to their size which is smaller than an adult. An additional consideration is the smaller lung surface area/kg in the early stages of development; thus, the higher amounts of inspired air will affect a relatively smaller area of lung tissue (Moya *et al.*, 2004). Furthermore, due to higher ventilation per minute, they tend to be more exposed to air pollution. In addition, the immune system of infants and young children is not fully developed, which may contribute to an increased vulnerability to the effects of exposure to air pollution. Lastly, a study conducted by Ierodiakonou *et al.* (2016) shows that reductions in lung function were consistent with airflow obstruction and with some decrement in vital capacity represented by a decrease

in forced vital capacity (FVC) associated with increased concentrations of ozone, CO, and NO_2.

1.2 Problem Statement

Malaysia is now on the track to achieve a title of developing the country by 2020 while balancing social wellbeing and nation development to maintain and fulfil the demand by people. The objective of 2020 Vision is to make Malaysia as a country with sustainable economy status by improving the economic system by 2020. Therefore, in complementing a developed country by 2020, vehicle is a requirement for every family. Therefore, increment of population will lead to increment of traffic density in Malaysia. This is proven by a report from Road Transport Department Malaysia (2017) which shows that by the end of 2015, there were 26.3 million vehicles registered compared to 20.1 million in 2010, an increase of almost 6.2 million vehicles (Road Transport Department Malaysia, 2017). This traffic congestion may increase vehicle emission that contributes to urban air pollution (Health Effects Institute, 2010). However, little attention has been paid for the underlying issue which was proven in the previous study to cause many health implications from chronic exposure.

Exposure to TRAP is a public health concern particularly in children, who are the most susceptible group of the population. Children are more vulnerable because they spend more time outside than adults, particularly in the summer and in the late afternoon

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(Salvi, 2007). Carbon monoxide (CO), carbon dioxide (CO_2), particulate matter (PM), nitrogen oxides (NO_2), and Total Volatile Organic Compounds (TVOC) such as benzene and formaldehyde are the example of products from TRAP. Huang *et al.* (2015) in his study states that diesel exhaust engines and gas exhaust engines produced multiple of pollutants such as PM, CO, hydrocarbons, NO_2 and mobile source air toxins such as benzene, formaldehyde, acetaldehyde. The adverse effects of TRAP among children are well recognized worldwide and in Malaysia. Therefore, it is very important to carry out this study to explore traffic-related air quality perception among children in order to prevent this susceptible group to develop chronic diseases associated to air pollution such as bronchitis, markers of atherosclerosis, lung cancer and mortality during their adulthood (Gotschi *et al.*, 2008).

In 2016, diseases of the respiratory system are one of the leading causes of hospitalization with the percentage of 12.8% and the second leading cause of death in hospital, which is by 21.65% according to Health Facts 2017 by Ministry of Health Malaysia (MoH) (MoH, 2017). In Malaysia, the multi-centered Third National and Health Morbidity Survey had shown that 32.1% of children had visited emergency departments due to acute asthma exacerbations and 81.7% had unscheduled visits to the doctors for asthma exacerbations (MoH, 2006). Based on a study conducted by Ahad and Khoo (2017), a total of 6441 primary school children were first screened for parent-reported physician-diagnosed asthma and 448 (8.9%) children were reported to have asthma. This is due to the consequence of declining urban air quality due to TRAP. Other than that, non-communicable diseases such as heart disease, lung cancer, stroke, chronic and acute

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respiratory diseases also currently emerging primarily in an urban area which have a high density of traffic such as Klang Valley.

1.3 Research Question

i. How is the concentration of TRAP (TVOC, PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO) at schools nearby heavy traffic density area and low traffic density area?

ii. What are the risk factors that contribute to the respiratory problem among school children in Klang Valley?

iii. Is there any difference between the respiratory symptoms among primary school children in heavy traffic density area and in low traffic density area?

iv. Is there any difference in lung function status between the children in the exposed group and in the comparative group?

v. Is there any association between traffic-related air pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) with respiratory symptoms among study respondents?

vi. Is there any association between traffic-related air pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) with lung function among study respondents?

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1.4 Research Objective

1.4.1 General Objective

To determine the association between urban traffic-related air pollution with lung function and respiratory health among primary school children in Klang Valley, Selangor.

1.4.2 Specific Objectives

i. To determine the sociodemographic status and exposure to air pollution among primary school children.

ii. To compare the concentration of traffic-related air pollutant (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) in primary school at heavy traffic density area and in a primary school in low traffic density area.

iii. To compare the respiratory symptoms among primary school children in heavy traffic density area and low traffic density area.

iv. To compare lung function status between the children in heavy traffic density area and primary school in low traffic density area.

v. To determine the association between traffic-related air pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) with respiratory symptoms between exposed and comparative group

vi. To determine the association between traffic-related air pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) with lung function among study respondents.

vii. To identify the main factor that influence respiratory symptoms among study respondents after controlling the confounders.

viii. To identify the main factor that influence lung function among study respondents after controlling the confounders.

1.5 Research Hypothesis

i. There is a significant difference between concentration of TRAP between primary schools at heavy traffic density area and primary schools in low traffic density area.

ii. There is a significant difference between respiratory symptoms between primary school children in heavy traffic density area and primary school children in low traffic density area.

iii. There is a significant difference in lung function status between children in heavy traffic density area and children in low traffic density area.

iv. There is an association between TRAP and lung function among the exposed and comparative group.

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v. There is a significant difference in reported respiratory symptoms between primary school children in heavy traffic density area (exposed group) and primary school children in low traffic density area (comparative group).

vi. Exposure to TRAP is the main factor that influence respiratory symptoms among study respondents affected by the density of traffic after controlling the confounders.

vii. Exposure to TRAP is the main factor that influence lung function among study respondents affected by the density of traffic after controlling the confounders.

1.6 Study Justification

The population in Klang Valley is now showing a growing trend which is estimated to reach 7.8 million by 2020. One of the cities in Klang Valley is Kuala Lumpur which is now ranked as an alpha world city, the economic, financial and cultural city of the country has become the attraction for youngsters to grow in this city. The city also has a high Human Development Index. However, there is a price to be paid due to the unbalance urbanization process which has contributed badly to the existing air quality problem according to a study conducted by Peng (2012). Thus, for a better evaluation of existing urban development pattern towards a healthy environment, the level of air environment health of Klang Valley needs to be studied and evaluated.

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Therefore, this study is important in order to reveal and evaluate the exposure of particulate matter (PM_{10}, $PM_{2.5}$), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), Carbon Monoxide (CO) and total Volatile Organic Compound (TVOC) level and traffic-related air quality understanding. This study was able to provide data on the traffic-related air pollutants among school children. This benefits to widen and diverse the air quality understanding. The information from this study is essential to provide data for further action plan and strategies which will assist to enhance environmental quality, enhancement of public health and make sure the health of future generation in the region in accordance with the National Environmental Health Action Plan (NEHAP) for children environmental health. Therefore, it is a good chance for Malaysia to establish the environmental framework that includes management and mitigation of the emerging health impacts from the environmental hazards.

1.7 Variable Definition

1.7.1 Conceptual Definition

i. Fine Particles ($PM_{2.5}$)

$PM_{2.5}$ is also known as fine inhalable particles, with an aerodynamic diameter of 2.5 microns or less. This particle is emitted directly from a

source such as construction sites, unpaved, smokestacks or fires. Most particles form in the atmosphere resulting in complex reactions of chemicals which emitted from power plants, industries and transportation. These particulate matters are the main problem of haze which causing reduction of vision. (EPA, 2018)

ii. Inhalable Particles (PM_{10})

According to the United States Environment Protection Agency (2016), PM_{10} is an inhalable particle, with a diameter of 10 microns or less. Most particles form in the atmosphere resulting in complex reactions of chemicals which emitted from power plants, industries and transportation. This particle is emitted directly from a source such as construction sites, unpaved, smokestacks or fires. The particulate matters such as PM_{10} contain microscopic solid or small liquid droplets that can be inhaled and cause serious health problems.

iii. Traffic-Related Air pollutant (TRAP)

Traffic-related air pollutant is defined as pollutant emitted from the process of fossil fuel combustion as the source of energy for motor vehicles. TRAP include large quantities of particulate matter, carbon monoxides, volatile organic compounds and nitrogen oxides (Huang *et al.*, 2012). TRAP

contributes significantly to ambient air pollution especially in urban settings.

iv. Carbon monoxide (CO)

Carbon monoxide (CO) is a colourless, odourless gas that can be harmful when inhaled in large amounts. Carbon monoxide (CO) is released when something is burned (USEPA 2016). This pollutant usually produced by incomplete combustion of fossil fuels and may affect air quality.

v. Nitrogen dioxide (NO_2)

According to EPA (2017), this gas is primarily emitted in the air from the burning of fuels and forms from the emission of vehicles, power plants and off-road equipment. Respiratory airway inflammation and respiratory symptoms such as coughing, wheezing or difficulty in breathing are the acute effects of NO_2. In the other hand, development of asthma and increase the susceptibility to respiratory infection are the chronic effects of NO_2.

vi. Sulphur Dioxide (SO_2)

Sulphur Dioxide (SO_2) is derived from the combustion of sulphur-containing fossil fuel and it is a major air pollutant in many parts of the world. Oxidation of SO_2 especially at the surface of particles in the

presence of metallic catalysts leads to the formation of sulphurous and sulphuric acids. Neutralization by ammonia leads to the production of bisulphate and sulphates. SO_2 is a colourless gas that is readily soluble in water (EPA, 2017)

vii. Total Volatile Organic Compound (TVOC)

TVOC is a grouping of a wide range of organic chemical compounds to simplify reporting when these are present in ambient air or emissions. Many substances, such as natural gas, could be classified as volatile organic compounds (VOCs). VOC are organic chemicals that have a high vapour pressure at ordinary room temperature result from a low boiling point which causes large numbers of molecules to evaporate or sublimate from the liquid or solid form of the compounds and enter the surrounding air (USGS, 2017). Emission of traffic due to the combustion of fossil fuel is a common source which may emit VOCs (Stojić et al., 2015)

viii. Low Traffic Density Area

A neighbourhood with minor roads, characterized by low traffic volume with an average of 2800 vehicles/day (Elhadi *et al.*, 2017)

ix. Heavy Traffic Density Area

Area located 500m from highways. This area has an average daily traffic volume of more than or equal to 18000 vehicles or 100m of major roads with an average daily traffic volume of more than or equal to 15000 vehicles (Brauer *et al.*, 2013).

x. Respiratory Health Symptoms

According to the United States Environment Protection Agency (2016), the respiratory symptom can be defined as a condition that resulted from disturbance of the respiratory system. There are many factors that contributed to this condition which are either internally or externally such as cough, phlegm, wheezing, shortness of breath and chest tightness.

xi. Relative Humidity (RH)

The relative humidity is one of the indoor air quality physical parameter. According to DOSH, the acceptable range for indoor relative humidity is between 40 – 70%. This was measured using LaMotte's Model BD Air Sampling Pump.

xii. Ventilation

According to ASHRAE (2016), the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity or temperature within the space. The indicator for ventilation is air velocity. According to DOSH, the acceptable range for indoor air velocity is between 0.15 – 0.50 m/s.

xiii. Forced Expiratory Volume in 1 Second (FEV_1)

Forced expiratory volume in 1 second (FEV_1) is the forced expiratory volume (FEV) in one second, which is the volume of air exhaled in the first second of an FVC manoeuvre.

xiv. Forced Vital Capacity (FVC)

Forced vital capacity (FVC) is the maximum volume of air exhaled during an expiration made as forcefully and maximum as possible starting from full inspiration.

1.7.2 Operational Definition

i. Traffic-Related Air Pollutant

PM_{10}, $PM_{2.5}$, nitrogen dioxide, carbon monoxide and total Volatile Organic Compound are included as the parameters involved in measuring TRAP. Measurement of TRAP was conducted using air quality monitoring equipment. This equipment is DustTrak, La Motte Air Sampling Pump, Q-Trak Indoor Air Quality Monitor 7565 and PPBRAE 3000. All equipment was calibrated to increase sensitivity to get the best accurate data and to prevent data error during the operation. before the measurement is taken. The measurement taken also indicates real-time exposure to air pollutants.

ii. Inhalable Particles (PM_{10})

The exposure of PM_{10} was measured using TSI Dust-TRAK DRX Aerosol Monitor 8534. A photometric principle which measures the mass concentration of particles floating in the air by the strength of scattered light is the principle used for this equipment. The unit for PM_{10} measurement is microgram per cubic metre ($\mu g/m^3$). The range of detection was from 0.001-100 mg/m^3. The unit measurement can be either part per million (PPM) or part per billion (PPB).

iii. Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2)

Nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) exposure was measured using LaMotte's Model BD Air Sampling Pump which is using the calorimetric principle. The unit for measurement of NO_2 and SO_2 is parts per million (ppm) which was translated from quantitative value.

iv. Carbon Monoxide (CO)

Carbon monoxide (CO) was measured in the unit of parts of million (ppm). The range of detection was from 0 – 500 ppm. This measurement was conducted twice for per assessment session by using the TSI Q-TRAK 7565 Indoor Air Quality Monitor. This equipment is using the electrochemical sensor to detect the concentration of CO.

v. Total Volatile Organic Compound (TVOC)

The presence of VOCs indoor and outdoor air was assessed using PbbRAE Portable VOC Monitor (PbbRAE 3000). Its Photoionization Detector (PID) provides true parts-per-billion (ppb) detection for air quality assessment, ranging from 1 pbb up to 10 000 ppm.

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vi. Air Temperature

Air temperature measurement was conducted twice for per assessment session by using The TSI Q-TRAK 7565 Indoor Air Quality Monitor. This equipment is using a thermistor sensor to measure the air temperature. The range of detection was from 0 – 50°C. The air temperature was measured in the degree of Celsius (°C).

vii. Ventilation

Type of ventilation rate in selected primary school was identified and observed through a site visit. Air velocity in the ventilation system of selected schools was measured using TSI's Model 8386 VelociCalc Plus. This equipment is using the thermal sensor of the pitot tube. The range of detection was from 0 – 50 m/s. It simultaneously measures and data log of several ventilation parameters including temperature, velocity and pressure. The air velocity was measured in metre per second (m/s).

viii. Respiratory Health Symptoms

Respiratory health will present with respiratory SBS symptoms, health symptoms and lung function. The data was taken by using modified questionnaire from The International Study of Asthma and Allergies in

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Childhood (ISAAC) based on symptoms that appear among the study samples for the past two weeks history and by using lung function test (spirometry).

ix. Forced Expiratory Volume in 1 Second (FEV_1%)

The value of FEV_1% is calculated by dividing the measured FEV_1 value which obtained from spirogram with its normal value derived from the standard equation and then multiplies it with 100. The value of FEV_1% was obtained from spirogram that printed by spirometer after spirometry test. The FEV_1% was expressed in percentage (%).

x. Forced Vital Capacity (FVC %)

From spirogram, the value of FVC% is calculated by dividing the measured FVC value with its normal value derived from standard equation and then multiplies it with 100. The value of FVC was obtained from spirogram that printed by spirometer after spirometry test. The FVC% was expressed in percentage (%). The value of FVC% is calculated by dividing the measured FVC value which obtained from spirogram with its normal value derived from the standard equation and then multiplies it with 100. The value of FVC was obtained from spirogram that printed by spirometer after spirometry test. The FVC% was expressed in percentage (%).

1.8 Conceptual Framework

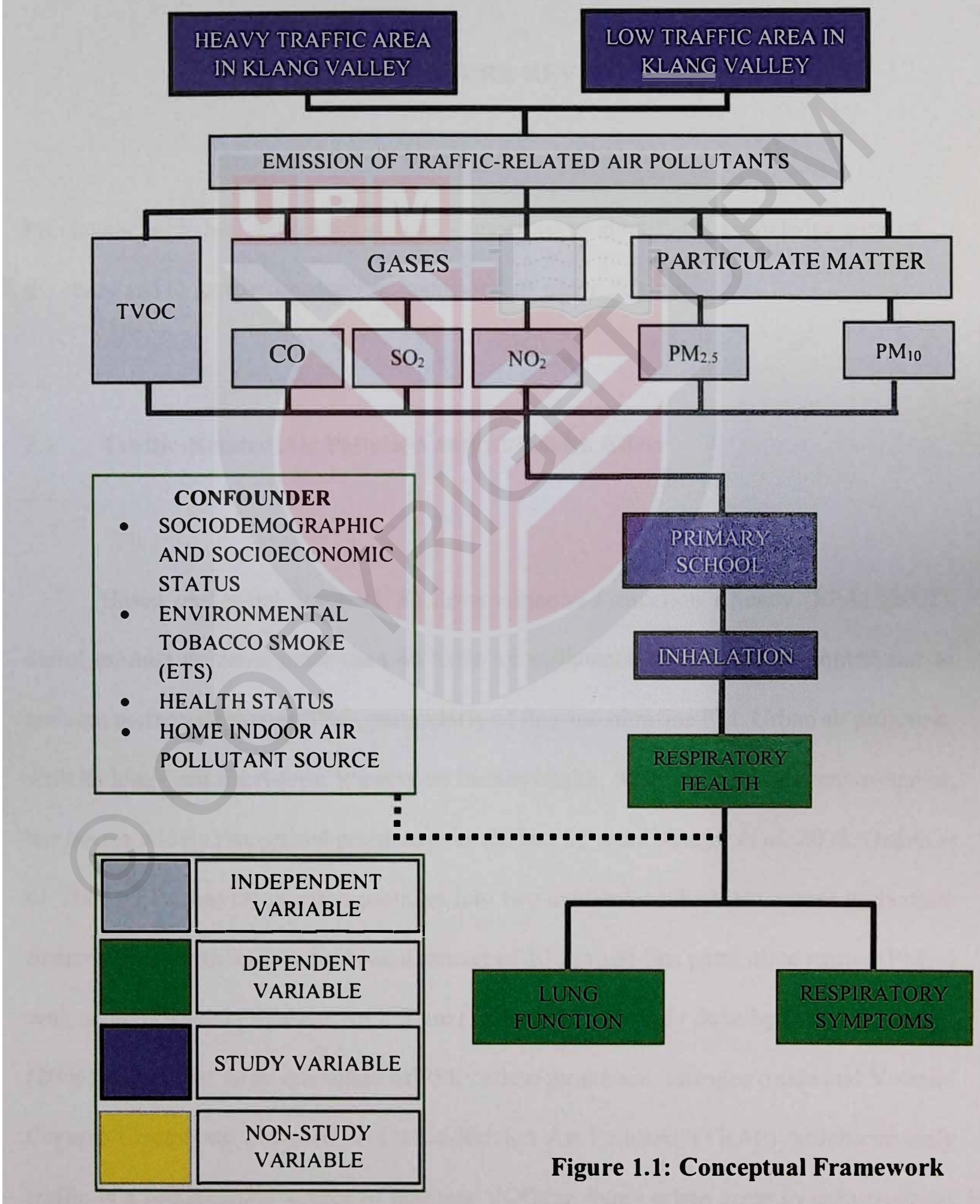


Figure 1.1: Conceptual Framework

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CHAPTER 2

LITERATURE REVIEW

Previously published studies are critically reviewed to identify the knowledge gaps of the study and to justify the study rationale and its methodology.

2.1 Traffic-Related Air Pollution and Its Health Effect

Based on United States (U.S) Environmental Protection Agency (EPA) (2002), diesel exhaust contains more than 40 toxic air pollutants and is a major contributor to ambient particulate matter (PM), particularly of fine and ultrafine PM. Urban air pollution, with its long- and short-term impacts on human health, well-being and the environment, has been a widely recognised problem over the last 50 years (Gurjar *et al.* 2008; Ozden *et al.* 2008). EPA has categorized particles into two categories which are coarse particulate matter (PM_{10}) with an aerodynamic diameter of 10 μm and fine particulate matter ($PM_{2.5}$) with an aerodynamic diameter of 2.5 μm (EPA, 2016). A study done by Han and Naeher (2006) shows that large quantities of PM, carbon monoxide, nitrogen oxide and Volatile Organic Compound included in Traffic-Related Air Pollutant (TRAP) which currently traffic is a predominant source of ambient VOCs in many urban areas in industrialized

countries. Traffic is an increasingly important source of PM especially fine PM with an aerodynamic diameter less than 2.5 μm ($PM_{2.5}$), $PM_{2.5}$ can penetrate easily into the respiratory tract and reach circulatory system and be more toxic than coarse particles. Kim *et al.* (2014), mentioned in his study that the size of particles precisely linked to be a major cause of adverse health effects. Therefore, the smaller the size, the deeper particles will penetrate to be deposited on the respiratory tract at an increasing rate. In Malaysia, a study conducted by Yahaya & Jalaludin (2014) reported that a high level of urban PM_{10} is associated with the reduction of lung function of children as well as increased respiratory symptoms. This study is supported by Rawi et al. (2014) which stated that exposures to particulate matters (PM) including PM_{10} are associated with wheezing. Furthermore, 24.4% and 19% of urban children are having wheezing and chest tightness respectively when exposed to PM_{10} (Choo *et al.*, 2015).

Numerous epidemiological studies reviews evidence of exposure to PMs has been identified as the cause of diverse health problems (Kim *et al.*, 2015; Kim *et al.*, 2013). In a study by Kim *et al.* (2013), demonstrated the health effects of PM exposure have been summarized in Table 2.1.

Table 2.1: Health Effects Exposure to Airborne Particulate Matter

Concentration (μg/m^{-3})	Health Effects
Increases of 10 μg/m-3 of PM in same day	1.9% and 3.3% respective increases in respiratory
Increases of 20 μg/m-3 of PM in same day	8% increase of lower respiratory illness among children

120	Increase in hospital admissions of children with respiratory disease
150	Increase the likelihood of respiratory symptoms and aggravation of lung disease
200	Increase in respiratory diseases such as pneumonia, chronic obstructive pulmonary disease, and asthma
400 to 600	Alveolar macrophages, neutrophils and Tlymphocytes in bronchoalveolar lavage fluid

(Source: Kim *et al.*, 2013)

There are few studies that are relevant to prove the association between TRAP exposure and acute respiratory health effects among children. It was identified that short term TRAP exposure may increase respiratory symptoms, allergic diseases, the incidence of asthma and reduces lung function especially for those who live within 100m from heavy traffic area.

A study conducted by Gauderman *et al.*, (2015) and Korten *et al.*, (2017) highlighted that the exposure to air pollution during infancy and early childhood stage may cause non-communicable diseases (NCD) such as impairs lung growth, lung damage and can increase subsequent risk for asthma, pneumonia and chronic obstructive pulmonary disease. This finding also supported by Bateson & Schwartz (2008) which proves that air pollutants certainly seem to affect pulmonary development and development of bronchitic symptoms. There is also increasing evidence for atopic sensitization, development of asthma and chronic cough which also associated with air

pollution in several studies (Van Vliet *et al.*, 1997; Tiittanen *et al.*, 1999; Mar *et al.*, 2004). Pollution exposures in early life may also increase risk across the lifespan for a range of NCDs including chronic obstructive pulmonary disease, cardiovascular disease, stroke and cancer (Barker, 2004). In other study conducted by Sunyer *et al.*, (2015) and supported by Pujol *et al.*, (2016) proves that there are a significant association between slow brain maturation and delayed cognitive development with exposure of school-aged children to traffic-related air pollution (TRAP).

Another study has shown that exposure to vehicular traffic increases the prevalence of respiratory symptoms among children. Foetuses, infants and young children are exquisitely sensitive to environmental pollution, especially during windows of vulnerability in early development (Suk *et al.*, 2016; Vrijheid *et al.*,2016). The Harvard 24-Cities Study collected data from over 13,000 children 8–12 years old related to lung function and collected data from air monitors in all communities, which were selected to reflect areas with high air pollution of various kinds (Dockery *et al.*, 1996). The study found that as $PM_{2.5}$ concentration increased, the percentage of children with abnormal lung function also increased. This is a serious concern because damage to the lung during periods of susceptibility in childhood may result in airway remodelling that might increase vulnerability in the future. (Bateson & Schwartz 2008). Children are considered as the most susceptible population because of their physical behaviour. Children have different patterns of breathing than adults that may alter the deposition of inhaled pollutants. The nose partially filters toxic particles and gases, making the mode of breathing, oral versus nasal, an important determinant of toxicant dose to the lungs (Bennett *et al.*, 2003;

Nikasinovic *et al.*, 2003). Apart from that, children are known to have a larger lung surface area per unit of body weight than adults, and under normal breathing, breathe considerably more air per unit of body weight than adults—with the highest rates in the youngest children (Iliff & Lee, 1952; Poets *et al.*, 1993; Arcus-Arth & Blaisdell, 2007).

There is also a study demonstrating that exposure to TRAP contributes to potential risk factors for allergic disease by Jung *et al.*, (2015). The study was conducted as cross-sectional study to assess the relationship of living near to main roads with allergic diseases among 5443 Korean children aged 6-14 years old. There is a considerable evidence in the study that exposure to TRAP is associated with childhood asthma symptoms and exacerbations and recent evidence suggests that TRAP is also associated with reduced lung growth and the development of asthma (Jung *et al.*, 2015). Questionnaire survey completed by children's parents was used in that study. The TRAP exposure includes the distance from busy roads, the length of main roads and main road density in the home area were assessed using Geographical Information System (GIS). In that study, it was mentioned that particulate matter (PM) derived from traffic sources are primarily ultrafine in dimension (< 100 nm), can be deposited in the nasal and peripheral airways, and have been proven to cause oxidative stress and airway hyperresponsiveness, elevate allergic responses and airway inflammation. Based on the data, children living less than 75 m from the main road was significantly associated with lifetime allergic rhinitis (AR), past-year AR symptoms, diagnosed AR and treated AR. Thus, it is crystal clear that there was a positive association between living alongside busy roads and allergic sensitization.

A Health Effects Institute (2010) reports that large quantities of nitrogen dioxide (NO_2), particulate matter (PM) and ozone (O_3) emit by motor vehicles. Health Effects Institute (2010) reports the epidemiologic associations between exposure to pollutants from traffic and health outcomes like cardiovascular morbidity and mortality, asthma and respiratory symptom and allergy. A review studies by Brunekreef and T Holgate (2002), found that Austria, France and Switzerland (population about 74.5 million), 40 000 million deaths per year are estimated to be attributable air pollution about half to air pollution from traffic. In addition, a study in the former German Democratic Republic, estimates are based on three major assumptions which are a causality of the epidemiological associations, the linearity of exposure-response relations and threshold is absent or has a very low value, this is consistent with the review studies by Kim *et al.*, (2015).

There is also study conducted in Malaysia by Yahaya and Jalaludin (2014) which reported that a high level of urban PM_{10} is associated with the reduction of lung function of children as well as increased respiratory symptoms. This study is supported by Rawi *et al.* (2014) study stated that exposures to particulate matters (PM) including PM_{10} are associated with wheezing. Furthermore, 24.4% and 19% of urban children are having wheezing and chest tightness respectively when exposed to PM_{10} (Choo *et al.*, 2015).

A cohort study done by Rice *et al.*, (2016) found that there is an association between lower lung function in Boston student with an estimation of long-term exposure

to ambient pollution, including proximity to a major roadway, $PM_{2.5}$ and black carbon. Statistical analysis showed that distances greater than or equal to 400 m from a major roadway was associated with lower FVC (-98.6 ml; -176.3 to -21.0). The study indicated that residential proximity to roadway and prior-year and lifetime $PM_{2.5}$ and black carbon exposure were all associated with lower FVC.

Based on a study titled Chronic respiratory symptoms in children and adults living along streets with heavy traffic density conducted by Oosterlee *et al.*, (1996), it can be concluded that chronic respiratory disease in school children was related to annual mean air pollution levels. These respiratory symptoms include wheezing, asthma and self-reported respiratory symptoms. International Study of Asthma and Allergies in Childhood (ISAAC) also have listed symptoms associated with respiratory symptoms in childhood including asthma, eczema and rhinitis.

2.1.1 Nitrogen Dioxide (NO_2)

According to EPA (2016), NO_2 is one of a group of gases known as nitrogen oxides (NO_x) which include nitrous acid and nitric acid. This gas is principally emitted in the air from the burning of fuels and additionally forms from emission from cars, lorries and buses, power plants and off-road equipment. Nitrogen dioxide is a precursor of photochemical smog that can be found all around in both indoor and outdoor air (Kim *et al.*, 2013).

Exposure to nitrogen dioxide can irritate airways in the human respiratory system. Exposure to short periods can aggravate respiratory diseases, including asthma that will lead to respiratory symptoms such as coughing, wheezing or difficulty breathing, hospital admissions and visits to emergency rooms. Ierodiakonou *et al.* (2016) in her study showed the increases in the average long-term (4-month) concentrations of NO_2 were all associated with reductions in lung function consistent with airflow obstruction and with some decrease in vital capacity represented by a decrease in FVC which contradicted with Neas *et al.*, (1991) study.

Exposure to nitrogen dioxide can irritate airways in the human respiratory system. Exposure to short periods can aggravate respiratory diseases, including asthma that will lead to respiratory symptoms such as coughing, wheezing or difficulty breathing, hospital admissions and visits to emergency rooms. Meanwhile, exposure to a longer period of time may contribute to the development of asthma and potentially increase susceptibility to respiratory infections (EPA, 2016).

2.1.2 Carbon Monoxide (CO)

The product of incomplete combustion for organic compounds such as petrol and diesel are CO. According to EPA (2017), CO is a colourless and odourless gas that can be harmful when inhaled in large amounts that released when something is burned. cars, lorries and other automobiles or machinery that burn fossil fuels are the greatest sources of CO to outdoor air. The oxidation of the carbon monoxide (CO) contained in the fuel does not proceed to the final product (CO_2) due to a lack of combustion air.

A study conducted by Ierodiakonou *et al.* (2016) stated that concentrations of CO are associated with reductions in lung function consistent with airflow obstruction and with some decrease in vital capacity represented by a decrease in FVC. This is supported by a study conducted by Rawi *et al.* (2014) in Malaysia reported that exposure of CO among children showed an association with wheezing and a study by Kamaruddin *et al.* (2014) reported children that exposed to high concentration of CO are 3 times more likely to get cough, 2 times more like to get chest tightness.

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2.1.3 Sulphur Dioxide (SO_2)

According to U.S EPA (2019), The largest source of SO_2 in the atmosphere is the burning of fossil fuels by power plants, other industrial facilities and vehicles emission. Smaller sources of SO_2 emissions include industrial processes such as extracting metal from ore, natural sources such as volcanoes and locomotives such as ships and other vehicles and heavy equipment that burn fuel with a high sulphur content. Short-term exposures to SO_2 can harm the human respiratory system and make breathing difficult. Susceptible individuals particularly children diagnosed with asthma are sensitive to these effects of SO_2. High concentrations of SO_2 in the air generally also lead to the formation of other sulphur oxides (SO_x). SO_x that can react with other compounds in the atmosphere to form small particles. These particles contribute to particulate matter (PM) pollution. Small particles may penetrate deeply into the lungs and in sufficient quantity can contribute to health problems.

2.1.4 Fine Particles ($PM_{2.5}$)

According to U.S EPA (2019), $PM_{2.5}$ is diameters that are 2.5 micrometres and smaller. $PM_{2.5}$ has linked to various serious respiratory and cardiovascular health problem. $PM_{2.5}$ comprised of metals, nitrates, allergens, sulphates, organic chemicals, soil and dust that are emitted from combustions,

soot from fireplaces and dust from construction sites and agricultural activities. $PM_{2.5}$ levels are higher during the winter months due to weather, temperature and inversions (U.S EPA, 2019). Primary annual $PM_{2.5}$ was revised by U.S EPA to improve nation's air quality standard for fine particle pollution to improve public health protection. The annual $PM_{2.5}$ standard was amended to 12 micrograms per cubic meter (µg/m3) and retaining the 24-hour fine particle standard of 35 $\mu g/m^3$. The National Ambient Air Quality Standard (NAAQS) is 12 $\mu g/m^3$ and 15 $\mu g/m^3$ for primary and secondary standard respectively and 35 $\mu g/m^3$ (U.S EPA, 2015). According to New Malaysia Ambient Air Quality Standard (2015), the air pollutants concentration limit will be strengthened in few stages until 2020. There are three interim targets set which include interim target 1 (IT-1) in 2015, interim target 2 (IT-2) in 2018 and the full implementation of the standard in 2020. The New Malaysia Ambient Air Quality Standard for $PM_{2.5}$ in 2018 was 25 $\mu g/m^3$ (1-year exposure) and 50 $\mu g/m^3$ (24 hours exposure).

2.1.5 Inhalable Coarse Particles (PM_{10})

Inhalable coarse particle or also known as PM_{10} is particles with diameter larger than 2.5 micrometres and smaller than 10 micrometres (U.S EPA, 2019). Major concerns for human health due to exposure to PM_{10} include effects on respiratory systems, damage to lung tissue, cancer and premature death (U.S EPA, 2012). The sources of PM_{10} includes from combustion of fossil fuels, waste

incineration and other industrial process. Some particulates are released naturally from forest fires, volcanoes and from dust storms. Outdoor source of air pollution such as haze can cause increment in the reading of PM_{10} measured and eventually will increase the exposure of PM_{10} on human. U.S EPA (2015) strengthened the nation's air quality standard at 150 $\mu g/m^3$. According to New Malaysia Ambient Air Quality Standard (2015), the air pollutants concentration limit will be strengthened in few stages until 2020. There are three interim targets set which include interim target 1 (IT-1) in 2015, interim target 2 (IT-2) in 2018 and the full implementation of the standard in 2020. Based on New Malaysia Ambient Air Quality Standard (2015), Health Canada (1995) and WHO Air Quality Guidelines (2005), the standard recommended threshold level for $PM_{2.5}$ was set at 150 $\mu g/m^3$ for 24 hours exposure.

2.2 TRAP Exposure on Children as Susceptible Group

Children are more susceptible than adults to environmental risks especially air pollution due to their rapidly growing, under developing body system, their behaviour and lastly, they have little control over their environment (WHO, 2018). The efficiency of detoxification systems exhibits a time-dependent pattern during prenatal and postnatal lung development that in part accounts for the increased susceptibility of young children to pollutants at critical points in time. Exposure to the highly polluted environment during childhood can alter the development of lung and affect pulmonary function in children

(Silva *et al.*, 2015). According to Ortega-Garcia *et al.*, (2018), one percent of the deaths associated with acute respiratory tract infections in children can be attributed to air pollution

Children may be a particularly vulnerable population because they spend more time outdoors, are generally more active, and have higher ventilation rates than adults (Wiley *et al.*, 1993). Based on Bateson & Schwartz (2007), adult tends to breath more using nasal which able to reduce some pollution concentration especially larger particles but children in the other hand typically mouth-breathers which able to pull air pollutant deeper through the respiratory tract, lung and goes to the bloodstream. Therefore, a larger dose of air pollutant will be inhaled as compared to an adult.

2.3 Lung Function as an Indicator to Determine Obstructive or Restrictive of Airways

Lung function can be used to identify the types of pulmonary condition such as obstruction, restriction, a normal or mixed combination of them through a test called spirometry test. Lung function test or 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). This test will help to identify the respiratory health and the severity of respiratory health symptoms such as wheezing and cough.

A Dutch study based on land use regression and dispersion exposure modelling approaches conducted by Wang *et al*. (2015) stated that NO_2 and $PM_{2.5}$ soot is associated with the reduction of lung function. Lung function is playing an essential role in diagnosis and the management of respiratory health symptoms such as chronic obstructive pulmonary disease (COPD). Monitoring of lung function can suggest the therapy of respiratory health symptoms such as COPD, enable monitoring of disease progression, help determine the prognosis and estimate the long-term survival (Bailey, 2012).

A study conducted in North Eastern United States showed that long term exposure to traffic-related air pollutants and low levels of $PM_{2.5}$ are associated with an accelerated rate of reduction of lung function and lower FEV_1 and FVC (Rice *et al*., 2015). A study conducted by Ierodiakonou *et al*. (2016) proved that community living near to major roadway is associated with lower FEV_1 and accelerated the rate of FEV_1 reduction support that lung function can act as an indicator to identify respiratory health symptoms. On the other hand, there is also a study that took place in North America conducted by Ierodiakonou *et al*. (2016) that proved there is an association between increasing of reduction in lung function consistent with airflow obstruction and a decrease in forced vital capacity (FVC) with chronic exposure of traffic-related air pollutants (CO and NO_2).

On the other hand, a study conducted among preschool children from urban and rural areas in Selangor by Yahaya and Jalaludin (2014) proves that TRAP pollutants have an association with risk of getting abnormal lung function as well as respiratory

symptoms. Children attend school in urban areas are at greater risk of getting abnormal lung function as well as increased respiratory symptoms than children in rural areas. On other local research conducted by Ayuni and Juliana (2014) concluded that children may have lung function impairment due to chronic exposure of pollutants such as PM_{10} and NO_2 concentrations.

2.4 Mechanism of How Particulate Matter Deposited in Human Body

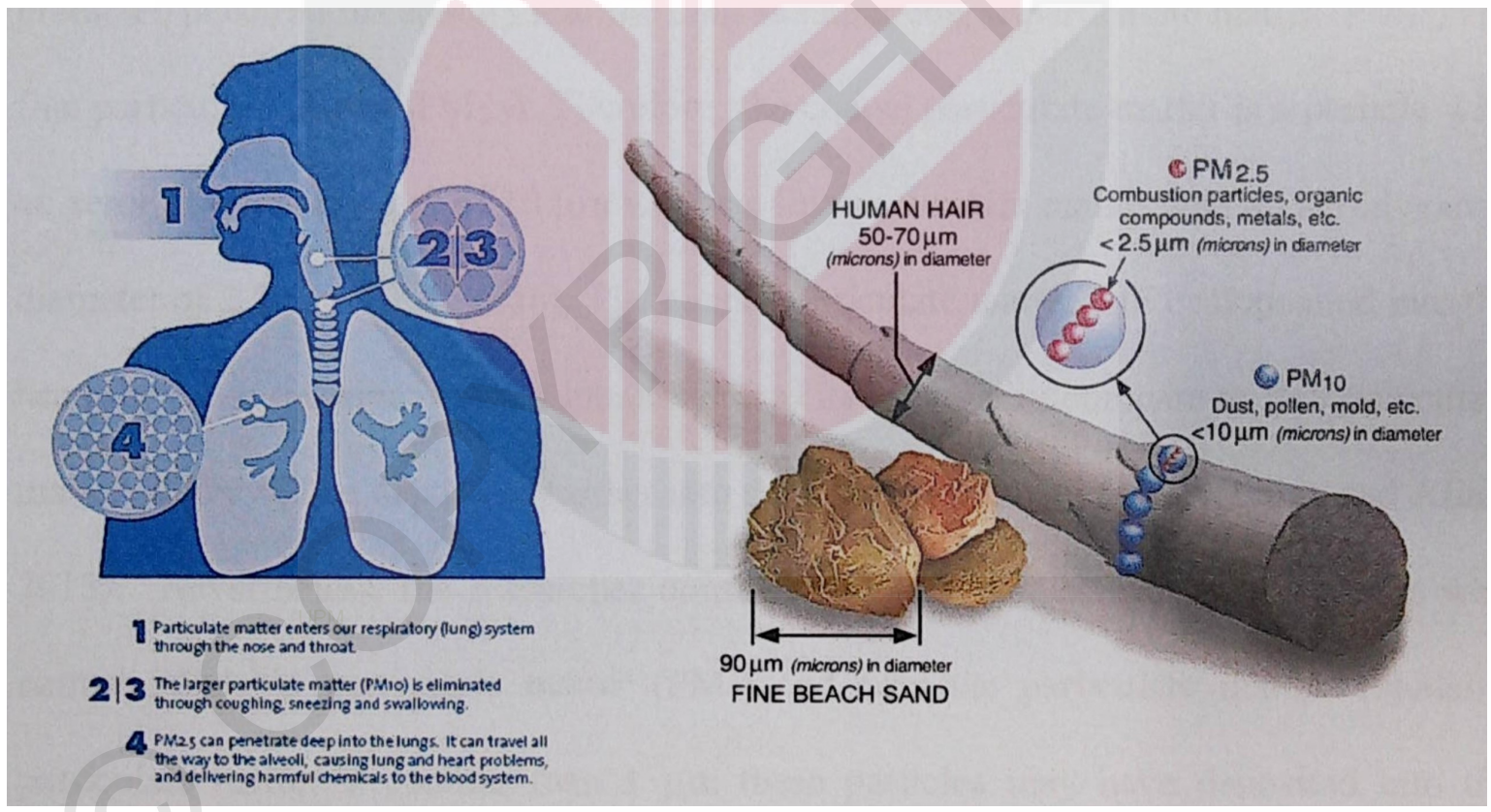


Figure 2.1: Simple Pathways of Particulate in Respiratory System (Source: British Columbia Website)

EPA defines particulate matter as a mixture of solid particles and liquid found in the air. Particles such as dust, dirt, soot, or smoke are visible enough to be seen with the naked eye. Some particles are so small they can only be detected using an electron microscope (EPA, 2016). Exposure to particulate material may affect human heart and

lungs, especially the fine particles which contained microscopic solids or liquid droplets which small in size that may penetrate deeper into the lungs and cause harm to human health (EPA, 2002). EPA is concerned about particles than 10 micrometres in diameter or smaller (PM_{10}). This is because those particles can pass easily through the human throat and nose. Once it passes through, these particles affect the heart and lungs and may harm human health.

EPA classified particle pollution mainly into two size categories based on their predicted penetration capacity into the lung as either coarse particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$). Therefore, the coarse particulate matter is a particle with an aerodynamic diameter of 10 μm whereas fine particulate matter with an aerodynamic diameter of 2.5 μm (EPA, 2016). The coarse particulate matter will be deposited into the head region of the airway when inhaled due to its bigger size compare to fine particulate matter which will be deposited further into the tracheobronchial region (Lilian and Aline, 2013). Nevertheless, the researcher considers another two categories of PMs as well named inhalable particulate matter (PM_1) and ultrafine particulate matter. Inhalable particulate matter is smaller than 1 μm these particles may have deposited into the pulmonary alveoli. Ultrafine particulate matter is 100 nm in diameter and smaller. They comprise a high concentration of organic compounds in their composition and may deposit in the alveolar region and enter the bloodstream (Lilian and Aline, 2013). These PMs primarily comes from the traffic due to the wear of vehicle components like brakes and tire as well as suspension of road dust in urban areas (Kim *et al.*, 2015).

In a review study by Kim *et al.* (2015), the health effects of PM_{10} and $PM_{2.5}$ are well documented. Numerous studies proved that exposure to PMs is related to respiratory problems and cardiovascular health effects. Evidence of the size of the particle is related to the most harmful effects of PMs. Though, there are still insufficient studies or evidence yet able to determine a safe level of exposure to PMs. Therefore, in 2013, PM as a human carcinogenic from group 1 has been declared by the International Agency for Research on Cancer (IARC) from World Health Organization (WHO) (IARC, 2013).

2.5 Traffic-Related Air Pollutant (TRAP) in Klang Valley

Traffic congestion is one of the major effects of using land transport as the main transportation. Traffic congestion can be classified into 2 types which are heavy traffic and low traffic. According to Road Traffic Volume Malaysia (RTVM), classification of traffic congestion can be based on the level of service (LOS). There are several characteristics in LOS should be considered to classify the traffic congestion.

A study conducted in North America showed that the increases in the average long-term (4-month) concentrations of CO and NO_2 were all associated with reductions in lung function consistent with airflow obstruction and with some decrease in vital capacity represented by a decrease in FVC (Ierodiakonou *et. al.*, 2016). This study was supported by a study conducted in the Netherlands that stated exposure to traffic-related air pollution, in particular, diesel exhaust particles, may lead to reduced lung function in children living

near major motorways (Brunekreef *et. al.*, 2016). A local study conducted in Cheras also showed children that living near a busy road which exposed to a high concentration of $PM_{2.5}$ have a significant reduction in lung function (Fadzil & Jalaludin, 2013).

Other than a few events largely influenced by the periodic haze episodes in the Southeast Asian region, the air quality in Malaysia is generally within the recommended level or guideline, except for certain times of the year and at very few industrial sites or at certain places within the highly urbanized area, namely the Klang Valley in the state of Selangor, as well as Federal Territory and capital city of Malaysia, Kuala Lumpur (Awang *et al.*, 2001). A study showed that emission from vehicle accounted for about 30% of the total $PM_{2.5}$ emissions in the urban area of Klang Valley (Rahman *et al.*, 2011). Moreover, the trans-boundary haze episode in 2007 and 2009 also had significantly contributed to the number of unhealthy days and deteriorating air quality in this region (Sahani *et al.*, 1997; Afroz *et al.*, 2003; Abdullah *et al.*, 2012; Rahman *et al.*, 2017).

Table 2.2: Classification of traffic congestion based on Level of Service (LOS)

Level of Service (LOS)	Description
LOS – A	• No congestion • Free flow with low traffic volumes and high speeds
LOS – B	• No congestion • Reasonably free flow, but speed depends on traffic flow.
LOS – E	• Severe congestion

	• Very unstable flow • Possible short stoppages
LOS – F	• Extreme congestion • Unacceptable congestion • Stop-and-go congestion • Forced flow

Source: Road Traffic Volume Malaysia 2014

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CHAPTER 3

Methodology

3.1 Study Design

This is a cross-sectional comparative study which aimed to determine the association between traffic-related air pollutants and respiratory health symptoms. The study groups were chosen among primary school children in heavy traffic area for exposed group and primary school children in low traffic area. This study focused on the respiratory effects of TRAP which are inhalable particles (PM_{10}), fine particle ($PM_{2.5}$), Nitrogen Dioxide (NO_2), carbon monoxide (CO), Sulphur Dioxide (SO_2) and Volatile Organic Compound (TVOC). The selection of air pollutant parameters is corresponding to four (PM_{10}, NO_2, SO_2, CO) criteria air pollutants in the Air Pollutant Index (API) which has been used since 1989 in Malaysia with the addition of another two parameters which is TVOC and $PM_{2.5}$. The primary schools were selected clustered by location of primary school based on the type of traffic road nearby reported traffic census stations. Permission was obtained from the Ministry of Education before the study was conducted.

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3.2 Study Location

Klang Valley was selected as the location for this study. Klang Valley is known as a fast-growing area where it put a high population; the number of vehicles is increasing yearly, traffic density and the increasingly large number of industries. For this study, the sampling sites were located at 500 m of highways with an average daily traffic volume of ≥ 18, 000 vehicles (Brauer *et al.*, 2013). Low traffic density areas refer to schools located around the neighbourhood with minor roads, characterized by low traffic volume with an average of 2800 vehicles/day (Elhadi *et al.*, 2017). List of selected schools according to heavy and low traffic density areas in Klang Valley were shown in Figure 3.1.

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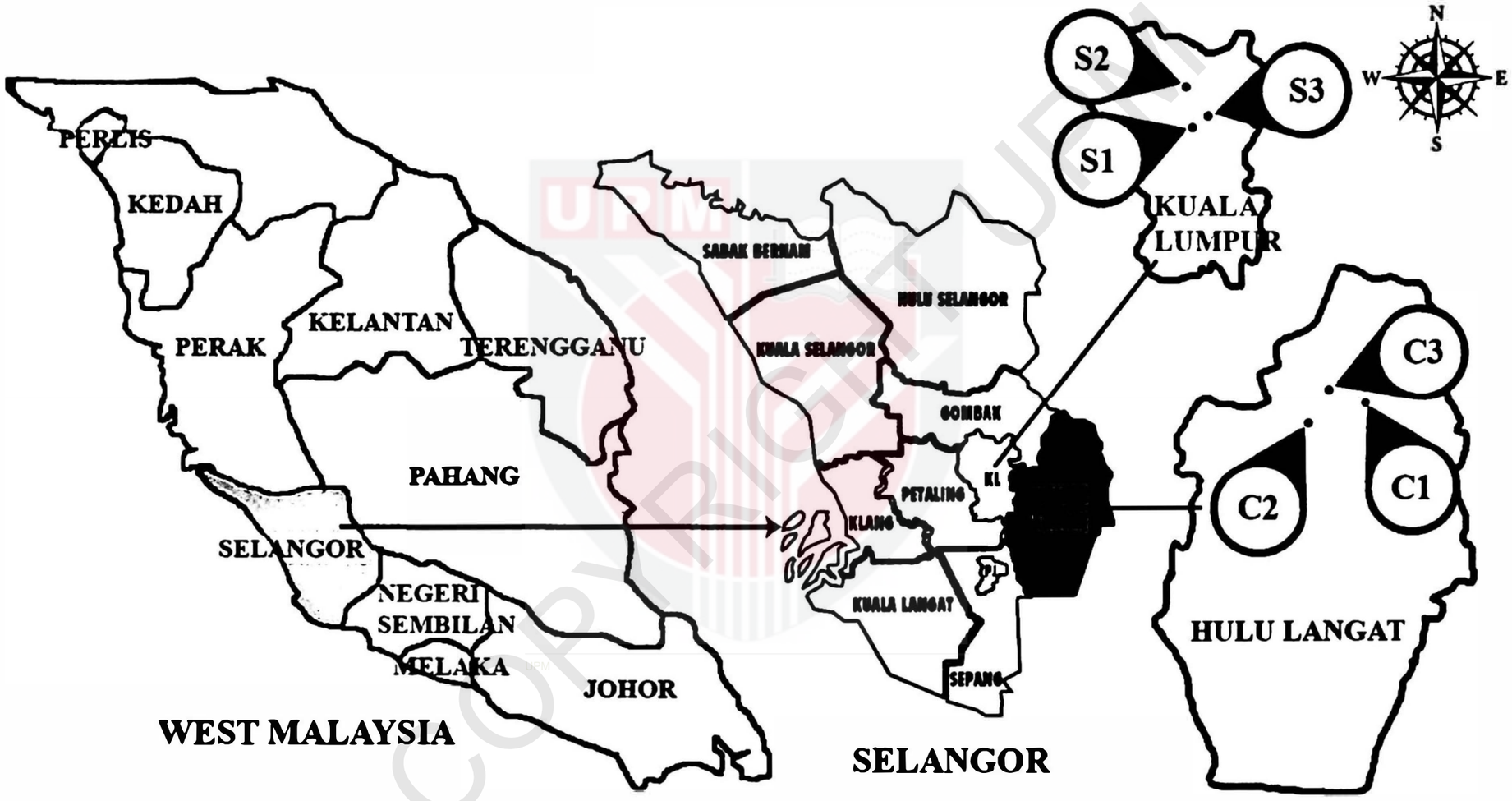


Figure 3.1: Study Location

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3.3 Study Duration

The sampling was conducted from February 2019 until March 2019. During data collection, the important thing that was considered is climate as it should be in a good term since rain will influence data obtained. Therefore, the time frame for this research to be conducted is suitable for data collection.

3.4 Study Sampling

3.4.1 Study Population

The primary school children aged 9 to 11 years old who attend school in the area of interest were randomly selected as the study population. This group may be exposed to traffic air pollutants from heavy traffic density area. On the other hand, the same aged primary school children who attend school near low traffic density road in Klang Valley district were selected randomly as a comparative group. Both groups shall match the inclusive criteria that have been decided. These children were also selected randomly to avoid selection bias.

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3.4.2 Sampling Frame

This study includes school children in primary school aged between 9 to 11 years old at selected schools in Klang Valley. The schools that were involved include primary schools in heavy traffic area (exposed group) and schools in low traffic area (comparative group). They need to fulfil the inclusion criteria. Name list of primary school children was obtained from school administration from each school. These children need to have parental permission from their parents before the study is being conducted. About 5-6 classes were involved considering there were around 30 students per class for this data collection.

3.4.3 Inclusion Criteria

- Primary school children aged between 9 to 11 years old who are registered under the Ministry of Education and attending the selected schools.
- Only Malaysian citizen primary school student was recruited as respondent.

3.4.4 Exclusion Criteria

- Primary school children without parental consent did not participate in this study.
- Primary school children with a history of diagnosed respiratory illnesses or with a known history of medical problems. This criterion has been decided because it can affect the physiological function of children and may increase their susceptibility to exposure to any pollutants (Ruchirawat *et al*., 2007)
- Respondents must free from a history of doctor-diagnosed chronic diseases such as free from respiratory illnesses to ensure the validity of result is not interfered by medical history status and to make sure the results are based on the exposure of traffic-related air pollutants.

3.4.5 Sampling Method

The selection of school and respondent were based on proximity to high and low traffic area. This study applied a stratified sampling method which was chosen based on the location of primary school based on the type of traffic road nearby reported traffic census stations in order to comply research characteristics which require a density of traffic at the particular school. Meanwhile, the respondent was stratified based on their year of schooling or age and level of

severity (LOS). The selection of the respondent was conducted through simple random sampling with the willingness to be a part of this study. A parental or guardian permission letter was required upon obtaining students' name list from the school's management and distributing questionnaires. Permission from the parent was mandatory for children to involve in this study. Therefore, not all children in the class can be selected for this study. The children also need to fulfil the inclusion criteria before being selected as participants of the study.

3.4.6 Size Calculation

Objective : To compare the respiratory symptoms (cough, phlegm, chest tightness, and wheezing) among primary school children between primary school in heavy traffic area (exposed group) and primary school in low traffic area (comparative group).

$$n = \frac{2 \times 2\,\sigma^2[\,Z_{1-\alpha/2} + Z_{1-\beta}]^2}{(\mu 1 - \mu 2)^2}$$

Where,

n	=	Sample size
σ^2	=	Estimated pooled standard deviation (assumed to be equal to each group)
μ_1	=	Prevalence value of primary school children with cough, phlegm, chest tightness, and wheezing among exposed group

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μ_2 = Prevalence value of primary school children with cough, phlegm, chest tightness, and wheezing among comparative group

$Z_{1-\beta}$ = Standard error associated with confidential interval, 95% C1= 1.96

$Z_{1-\alpha/2}$ = Standard error associated with power, 80% of power = 0.84

Therefore,

Where,

n = Sample size

σ^2 = Estimated pooled standard deviation (assumed to be equal to each group)

μ_1 = Prevalence value of primary school children with cough, phlegm, chest tightness, and wheezing among exposed group (Ayuni *et al*,. 2014).

μ_2 = Prevalence value of primary school children with cough, phlegm, chest tightness, and wheezing among comparative group (Ayuni *et al*,. 2014).

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

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

$$n = \frac{4(0.56)^2 (1.96 + 0.84)^2}{(0.53 - 0.18)^2}$$

= 80.28 ≈ 80 respondents (Wesley & Jalaludin, 2015)

Based on the formula, 80 respondents were needed for both exposed and comparative group. The number of respondents was increased by 20 % for the strength of analysis of the study and to take into account on non-

responsive respondents, missing data and errors. Therefore, the total number of samples that included in this study is 96 respondents which include 48 respondents for the exposed group and comparative group respectively.

Objective : To compare lung function status between child in heavy traffic area (exposed group) and primary school in low traffic area (comparative group).

The sample size of this study was calculated based on (Lwanga & Lemeshow, 1991) formula for group comparison study using the combined (or pooled) standard deviation (σ^2) for the two groups as follows:

Formula:

$$n = \frac{2 \times 2\,\sigma^2 (Z_{1-\alpha/2} + Z_{1-\beta})^2}{(\mu 1 - \mu 2)^2}$$

Where;

n = Sample size

σ^2 = Estimated pooled standard deviation (assumed to be equal to each group)

μ_1 = Estimated prevalence (larger)

μ_2 = Estimated mean (smaller)

$Z_{1-\beta}$ = Standard error associated with confidential interval, 95% C1= 1.96

$Z_{1-\alpha/2}$ = Standard error associated with power, 80% of power = 0.84

Therefore,

$$n = \frac{2 \times 2\sigma^2 (Z_{1-\alpha/2} + Z_{1-\beta})^2}{(\mu_1 - \mu_2)^2}$$

Where;

n = Sample size

σ^2 = Estimated pooled standard deviation (assumed to be equal to each group)

μ_1 = mean of measured FEV_1/FVC among exposed group

μ_2 = mean of measured FEV_1/FVC among comparative group

$Z_{1-\beta}$ = Standard error associated with confidential interval, 95% C1= 1.96

$Z_{1-\alpha/2}$ = Standard error associated with power, 80% of power = 0.84

$$n = \frac{4(0.02)^2 (0.84 + 1.96)^2}{(1.00 - 0.99)^2}$$

= 125.44 ≈ 126 respondents (Fadzil & Jalaludin, 2013)

Based on the formula, 126 respondents were needed for both exposed and comparative group. The number of respondents was increased by 20 % for the strength of analysis of the study and to consider on non-responsive respondents, missing data and errors. Therefore, the total number of samples that included in this study is 152 respondents which include 76 respondents for both exposed group and comparative group respectively.

3.5 Research Tools/Instruments and Data Collection

3.5.1 Briefing

During the first meeting with the school management, researchers explained the nature of this study especially on the involvement of school management, teachers, children/student and parents/guardians. They were briefed that this research will not interfere with the educational process between teachers and students and complied with ethical guidelines. At Universiti Putra Malaysia, Ethics Review Panel (JKEUPM) supervised the quality assurance of research which also include progress monitoring of the project.

The school management or Ministry of Education is not responsible to researchers for any loss, damage or failure to perform is occasioned by fire, flood, explosion, windstorm, riot, war or any other cause beyond the reasonable control of the school management or Ministry of Education. Any data that the researchers generate that was determined as personal needs to be protected and the release of

any information needs to go through a strict informed consent process. Any data collected is anonymized so that it is not personally identifiable by establishing anonymization keys which are only accessible to the researchers only. The researchers also stated the period of samples or data will be retained, accessibility of data and destruction of data upon completion of the research.

3.5.2 Questionnaire

This study was done using a modified questionnaire based on two standardised and recognised international questionnaires which were set by the American Thoracic Society (Questionnaire ATS-DLD-78-C) for data on sociodemographic background and school and home environment data and questionnaire about asthma, allergies and respiratory symptoms from the International Study of Asthma and Allergies in Childhood (ISAAC). This questionnaire consists of five parts which are:

- Part A for sociodemographic background
- Part B for health history
- Part C for children preschool history
- Part D for home environment
- Part E for current symptoms

The parental permission form was attached to the questionnaires to explain the methodology used in the study to children's parent, so the study can be done on their children with permission to avoid any problems or issues in the future. Most of the questions were constructed as a close-response format using "yes" and "no" as an answer. This type of question can easily be answered by parent or guardian and takes approximately about or less than 10 minutes to complete. The questionnaires were given to the respective teachers from selected primary school and collected a week after the date of distributing the questionnaires to the students. The researcher did a quick interview with the children after collecting the questionnaires to make sure the questionnaires were fully completed by the parents as a representative for their children. The flow of the questionnaire from distribution until collection from the respondent is shown in Diagram 3.1

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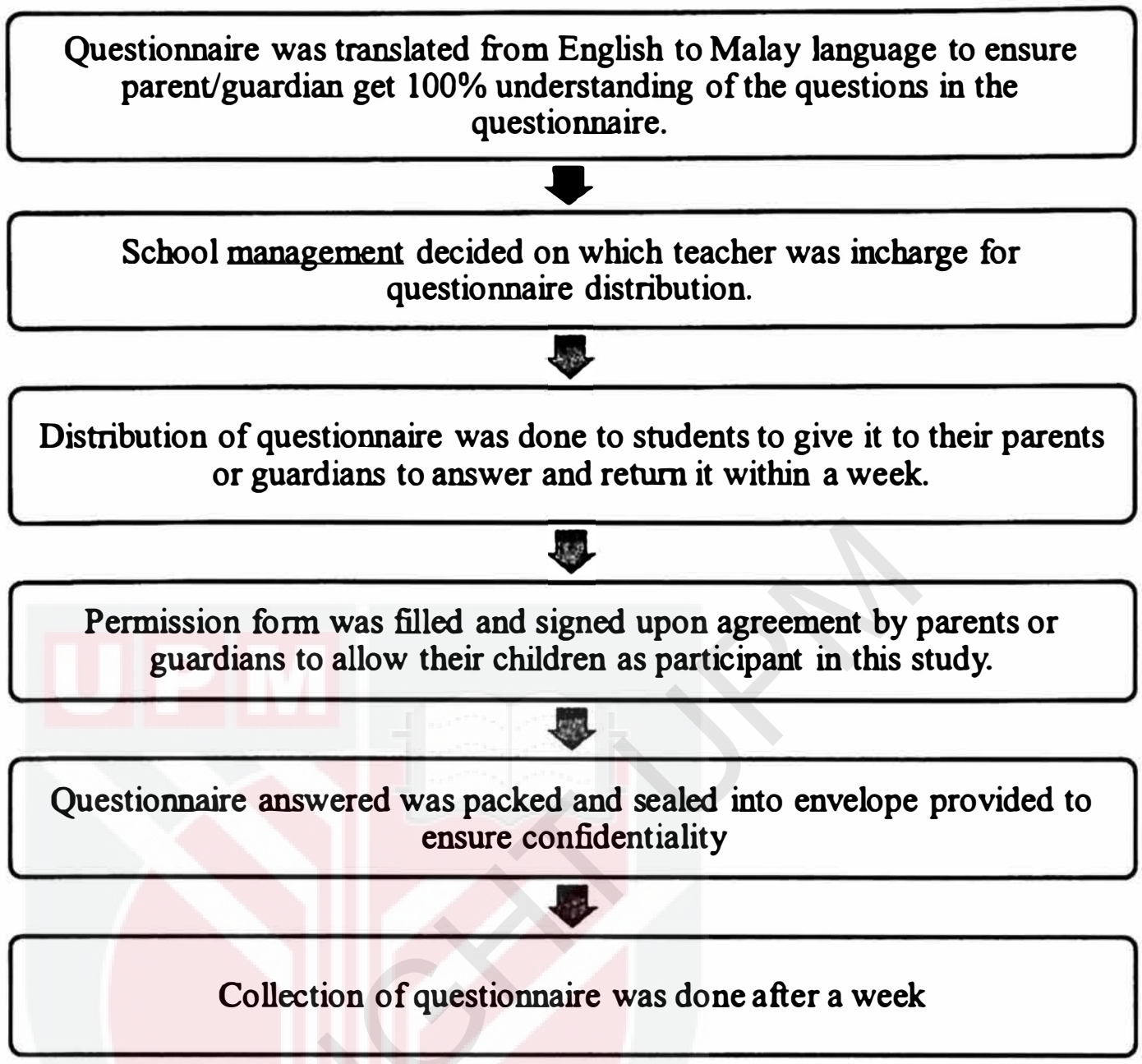


Diagram 3.1: Distribution of questionnaire

3.5.3 Measurements of Inhalable Particles (PM_{10}) and Fine Particle ($PM_{2.5}$)

TSI DustTrak™ DRX Aerosol Monitor 8534 was used to measure $PM_{2.5}$ and PM_{10}. This equipment also has been used in numerous studies in order to measure PM_{10}, $PM_{2.5}$ (Ramos *et al.*, 2016; Hankey & Marshall, 2015; Hsien *et al.*, 2017). This device is a handheld battery-operated, data-logging, light scattering laser photometer that gives real-time aerosol mass readings. It uses a sheath air system that isolates the aerosols in the optics clean for improved reliability and low maintenance. It is suitable for clean office settings as well as harsh industrial

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workplaces, construction and environmental sites, and other outdoor applications. The DustTrak™ DRX Aerosol Monitor 8534 measures aerosol contaminants such as dust, smoke, fumes and mists corresponding to $PM_{1.0}$, $PM_{2.5}$, respirable or PM_{10} size fraction with a concentration range from 0.001 to 150 mg/m^3.

The equipment was calibrated before the monitoring and the calibration was recorded. The instrument was placed at 1.0 m above the floor which indicates children breathing zone at the back of the classroom and 1.5 m away from the windows. PM_{10} and $PM_{2.5}$ concentration levels were measured for 6 hours which is from 7 am to 1 pm to represent time spent by the student at school during school hours inside the selected primary school buildings during class sessions, and outside of the school buildings to get the reading of $PM_{2.5}$ and PM_{10} from an outside source. This device was monitored by a researcher from time to time to make sure no disturbance on the measurement either due to technical reason or due to disturbance from children. Then, TRAKPRO™ data analysis software was used for analysis.

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Figure 3.2: TSI Dust-TRAK DRX Aerosol Monitor 8534
(Source: TSI Website)

3.5.4 Measurements of Nitrogen Dioxide (NO_2)

Nitrogen dioxide (NO_2) was measured using LaMotte's Model BD Air Sampling Pump, based on the colourimetric method. The diaphragm vacuum pump draws the air sample through absorbing reagent in an impinger at a constant rate between 0 and 2.0 litres per minute. The measurement was conducted for 1-hour sampling for indoor environment and outdoor sampling. In order to minimize other sources that could contribute to the detection of these indoor air pollutions, all of these measurements were placed away from any source of heat, school children, windows and also doors. The instrument was placed at 1.0 m above the floor on a table at the back of the classroom and 1.5 m away from the windows. This device was monitored by a researcher from time to time to make sure no disturbance on the measurement either due to technical reason or due to disturbance from children. The colourimetric test was conducted after 1-hour

sampling and the colour change was observed. The colour obtained was compared with the visual comparator to get the results.



Figure 3.3: LaMotte's Model BD Air Sampling Pump (Source: LaMotte Website)

3.5.5 Measurement of CO, CO_2, Temperature and Relative Humidity

Indoor Air Quality (IAQ) assessment was done in selected schools with permission obtained prior to assessment. The indoor air parameters include temperature, relative humidity, carbon dioxide (CO_2) and carbon monoxide (CO) was measured in 6 hours (0700 to 1300) during the school hour session in real-time at each sample location. This measurement was conducted by using the TSI Q-TRAK 7565 Indoor Air Quality Monitor. This device was placed on the table at 1.0m from the ground which indicates children breathing zone. This device was monitored by a researcher from time to time to make sure no disturbance on the measurement either due to technical reason or due to disturbance from children. Other characteristics that were also included are the type of ventilation used, the

layout of the classroom, building materials, age of school buildings, and the number of occupants per classroom.



Figure 3.4: TSI Q-TRAK 7565 Indoor Air Quality Monitor (Source: TSI Website)

3.5.6 Measurement of Air Velocity

Air velocity in selected schools was measured using TSI's Model 9565 VelociCalc Plus. It simultaneously measures and data log several ventilation parameters including temperature, velocity and pressure. Besides, the automatic calculation of flow rate and automatic conversion between actual and standard velocity readings can also be done. It measures a wide velocity range of 0 – 10 000 ft/min (0 – 50 m/s) using a thermal sensor of a pilot tube. The wind probe was used in the air velocity measurement in which the measurement was taken thrice to get average results. The air velocity was measured in 6 hours which is from 7 am until 1 pm during school hours. This instrument was held by the researcher during the measurement. For air movements, the researcher set up the monitor at the shoulder

level of a seated person or measure at the level of air supply at the height of the seated person.



Figure 3.5: TSI's Model 9565 VelociCalc Plus
(Source: TSI Website)

3.5.7 Measurement of Volatile Organic Compound (TVOC)

Measurement of TVOC was done using ppbRAE-3000 which using PID (Photoionization detector) to measure VOC. Rae Systems' ppbRae 3000 is a VOC gas detector for monitoring at the parts per billion (ppb) level. A real-time monitoring method was used for this monitoring. Point for measurement was calculated as per guided in Indoor Air Quality (IAQ) Industrial Code of Practice (ICOP) by the Department of Occupational Safety and Health (DOSH). This instrument was mounted on a tripod on the height of 1.0m which indicates a

breathing zone for children inside and outside the classroom and was monitored by the researcher to ensure no disturbance during the measurement.



Figure 3.6: Rae Systems' ppbRae 3000
(Source: Rae Systems' Website)

3.5.8 Lung Function Test (Spirometry)

Lung function was measured by using Chestgraph HI-101 Spirometer. This is the most common and simplest pulmonary function tests to determine how well the lungs receive, hold and utilize air, to monitor lung disease, to determine the severity of lung disease and determine whether the lung disease is restrictive or obstructive. Therefore, the lung function of randomly selected primary school children with parental permission was evaluated by using a spirometer.

A total of 152 respondent was selected based on random sampling from all respondents that qualified inclusive criteria and with parental permission. Parental permission was necessary for this study thus children without parental permission was not selected for this test.

The height of selected respondents was measured by using a height scale model "SECA 208 Body Meter". The respondents need to stand in a straight position and barefooted. The body weight of all selected respondent was measured by using an electronic weighing scale which was placed on a flat surface during measurements.

The selected respondents were asked to breathe through a mouthpiece attached to the spirometer during the spirometry test. Then, all selected respondents performed the test thrice to get the best results. The results were printed out on a chart called spirogram. The evaluation of the spirometry test was performed by comparing the obtained value with a standard value. Each respondent was given a one-time mouthpiece. The designated clinical waste bin was available during sampling for proper waste management. This test was accompanied by a medical assistant at the field.

Evaluation of lung function was done based on the American Thoracic Society (1991) classification to identify whether the lung function of selected respondents is normal or abnormal. Prediction equation for the normal value of

lung function parameters among children in Malaysia by Azizi and Henry (1994) was used to obtain predicted FVC% predicted and FEV1% predicted.



Figure 3.7: Chestgraph HI-101 Spirometer
(Source: Prometheus Healthcare Website)

Table 3.1: Formula for Normal Value of Lung Function Parameters among Children in Malaysia

Lung Function Test	Boys	Girls
FVC	4.1120×10^{-6} (Height)$^{2.6421}$	6.0777×10^{-7} (Height)$^{3.0112}$
FEV_1	6.2523×10^{-6} (Height)$^{2.5388}$	5.7588×10^{-7} (Height)$^{3.0067}$

Source: Azizi and Henry (1994)

Table 3.2: Evaluation of Lung Function

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

Mild	**70-79**
Severe	**60-69**
Very Severe	**< 60**

Source: American Thoracic Society (1991)

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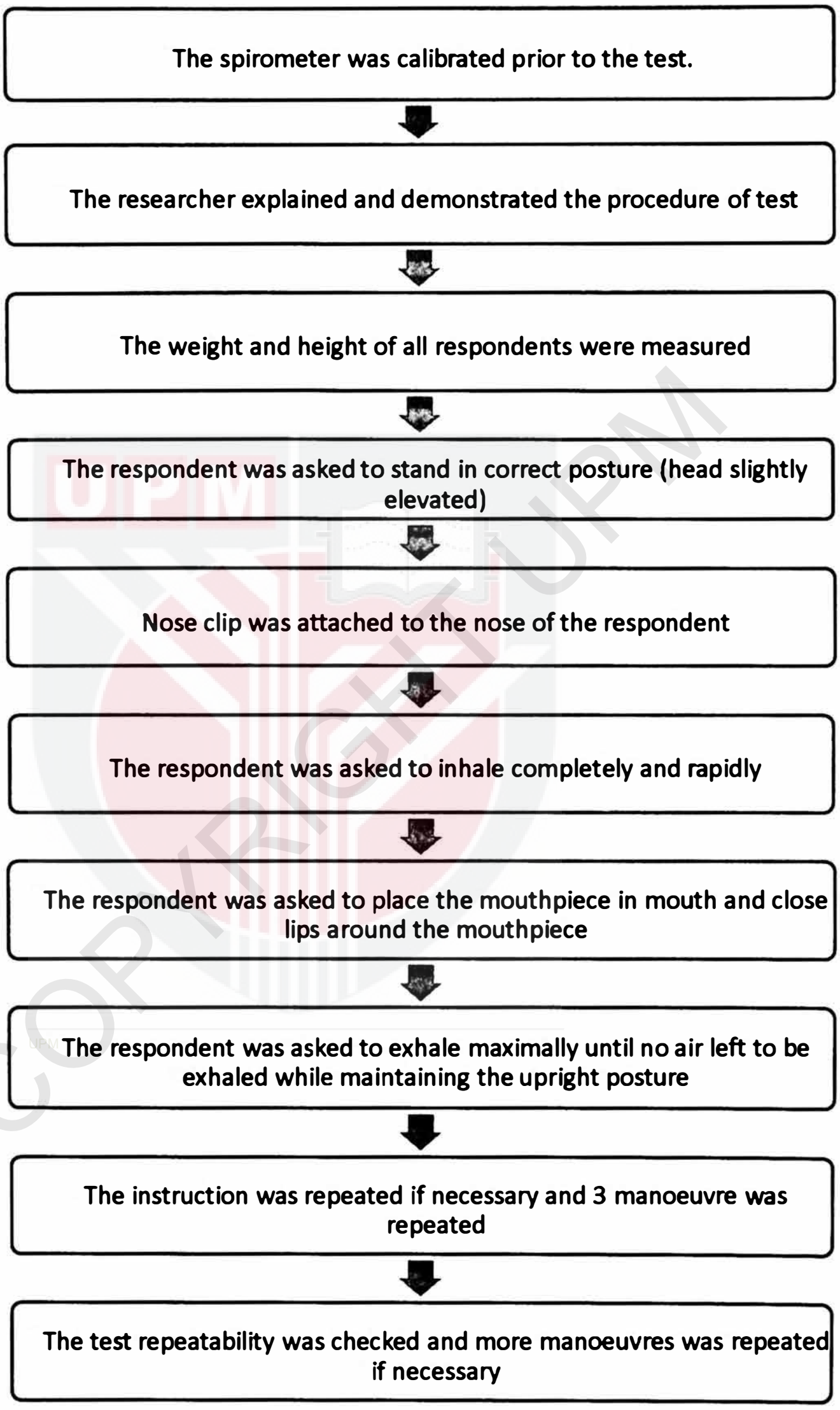


Diagram 3.1: Lung Function Test Procedure
(Source: American Thoracic Society)

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3.5.9 Flowchart of Progress

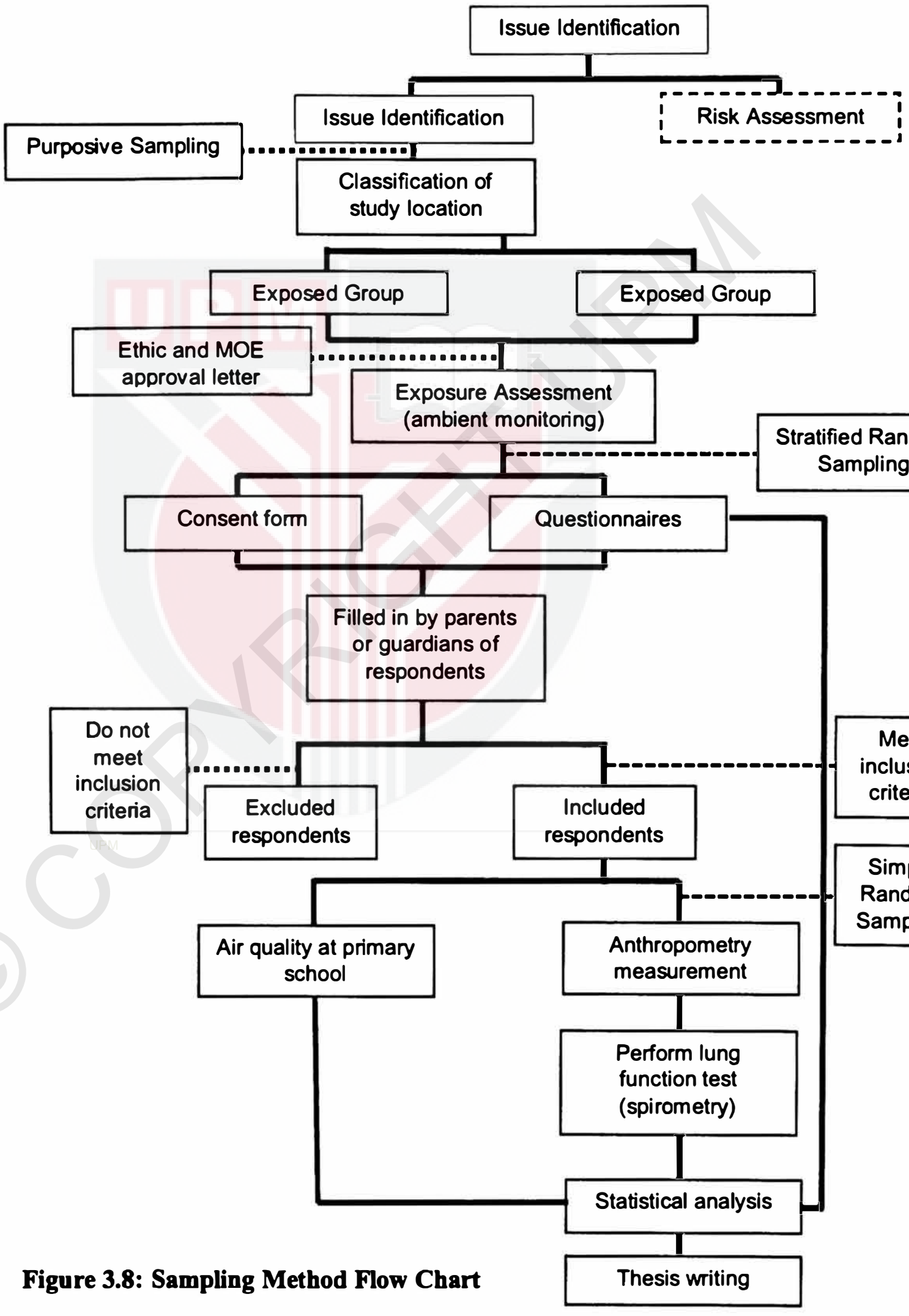


Figure 3.8: Sampling Method Flow Chart

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3.6 Data Analysis

Questionnaire response tabulation and graphical summarizes was completed with Microsoft Excel 2016, while statistical analysis was analysed by using Statistical Package for Social Science (SPSS) v.22. The descriptive test was used to calculate mean, median, mode and standard deviation. Meanwhile, the Kolmogorov Smirnov test and skewness were used to determine the normality of the data. Data is normally distributed when the p-value of Kolmogorov-Smirnov is more than 0.05 and the skewness, as well as kurtosis values, are in the range of -2 to 2 respectively. Then, data that are normally distributed were analysed using parametric tests while the non-parametric test was used for data that are not normally distributed. Finally, the univariate, bivariate and multivariate testing were used to analyse each of the objectives in this study.

3.6.1 To determine the sociodemographic status and exposure of air pollution among the study respondents.

Statistical analysis:

Descriptive data : Mean and Standard Deviation (SD),
Median and Interquartile range (IQR)

Categorical data : Frequency and percentage (%)

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3.6.2 To compare the concentration of traffic pollutant in primary school at heavy traffic area and in primary school in low traffic area.

Statistical analysis:

Parametric	:	Independent t-test
Non-Parametric	:	Mann-Whitney U test

3.6.3 To compare the respiratory symptoms among primary school children between primary school in heavy traffic area (exposed group) and primary school children in low traffic area (comparative group).

Statistical analysis:

Parametric	:	Independent t-test
Non-Parametric	:	Mann-Whitney U test
Categorical	:	Chi-square

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3.6.4 To compare lung function status between child in heavy traffic area (exposed group) and primary school in low traffic area (comparative group).

Statistical analysis:

Parametric	:	Independent t-test
Non-Parametric	:	Mann-Whitney U test
Categorical	:	Chi-square

3.6.5 To determine the association between traffic-related air pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, VOC) and respiratory symptoms among study respondents.

Statistical analysis:

Parametric	:	Pearson Correlation test
Non-Parametric	:	Spearman Rho's test
Categorical	:	Chi square: Test of association

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3.6.6 To determine the association between traffic-related air pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) and lung function among study respondents.

Statistical analysis:

Categorical : Chi square: Test of association

3.6.7 To identify the main factor influencing the lung function among study respondents among study respondents after controlling the confounders.

Statistical analysis:

Categorical data : Multiple Logistic Regression

3.6.8 To identify the main factor influencing the respiratory symptoms among study respondents among study respondents after controlling the confounders.

Statistical analysis:

Categorical data : Multiple Logistic Regression

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3.7 Study Ethics

There are some aspects of ethics that need to be addressed before carrying out the research:

3.7.1 Ethics Approval

Ethical approvals of this study were obtained from the Research Ethics Committee of Universiti Putra Malaysia (JKEUPM-2018-381). Approval to conduct the study in primary school was obtained from a related department which is the Ministry of Education (KPM.600-3/2/3-eras (2626) and management of the primary school. A written consent form was given to all respondents' parents or guardians along with the objective of the research to obtain their permission on approving the children as the respondents of this study. All data collected and information of all respondents were served as confidential between the researcher and the institution and only used for research and scientific publication.

3.7.2 Permission Letter

Permission to conduct the study was obtained from the Ministry of Education (MOE). A written proposal and application form were submitted to MOE prior via their website.

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3.7.3 Parental Permission Form

Parent or guardian of respondents was required to fill up the parental permission. The procedure of data collection and the benefit of the study were briefed prior to sampling. Any information obtained from this study is confidential and solely for the purpose of scientific study.

3.8 Declaration of Conflict of Interest

There is no potential conflict of interest in this study.

3.9 Quality Control

3.9.1 Questionnaire

The modified questionnaire was tested first on 10% of the total respondents to ensure its validity and reliability. The results were calculated by using Cronbach's Alpha test which value of 0.7 and above shows acceptable reliability and validity. For this study, the result obtained were 0.8.

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3.9.2 Air Pollution Monitoring

All equipment used in this study were calibrated prior sampling according to the manufacturer's standard to avoid any bias or error.

3.9.3 Air Monitoring Equipment

All equipment was calibrated and checked before operating to maintain its sensitivity and to prevent the error from occurring during measurement. Zero calibration is needed to prevent zero error during operating the equipment. The operational procedure of the devices was followed based on the manual downloaded on the internet for each instrument used.

3.9.4 Lung Function Test (Spirometry)

Different mouthpieces for spirometer were used for each respondent to avoid any transmission of communicable diseases and for hygienic purposes. The spirometer was calibrated prior data collection according to the manufacturer's standard to avoid any bias or error.

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CHAPTER 4

RESULTS

4.1 Sociodemographic status and exposure of air pollution among the study respondents.

This study was conducted to determine the association of TRAP ($PM_{2.5}$, PM10, CO, CO_2, NO_2, SO_2, TVOC) exposure with lung function status and health symptoms among primary school children attending school located at high-density traffic (n=76) and low-density traffic (n=76) in Klang Valley.

There are 152 consent form and questionnaires that have been distributed to primary school children's parents/ guardians evenly for heavy traffic density areas and low traffic density area. Based on the questionnaire, there were significantly lower in number for male compared to the female which were 36 (47.4%) to 40 (52.6%) respectively in high traffic density. Same goes to low traffic density area, there were significantly lower in number for male compared to the female which is 37 (48.7%) to 39 (51.3%) respectively. The total respondent for both groups was proportional which were 76 respondents respectively. The response rate for both study and comparative groups

were 100% respectively. All respondents selected were Malays to homogenize respondents. Furthermore, all students that were selected as respondent are all studies at selected school with the majority of Malays.

Table 4.1: Total of Study Population in Respective to Gender

Variables	Exposed Group (n=76)	Comparative Group (n=76)
	Number (%)	Number (%)
Gender		
Male	36(47.4)	37(48.7)
Female	40(52.6)	39(51.3)

Descriptive analysis
N=152

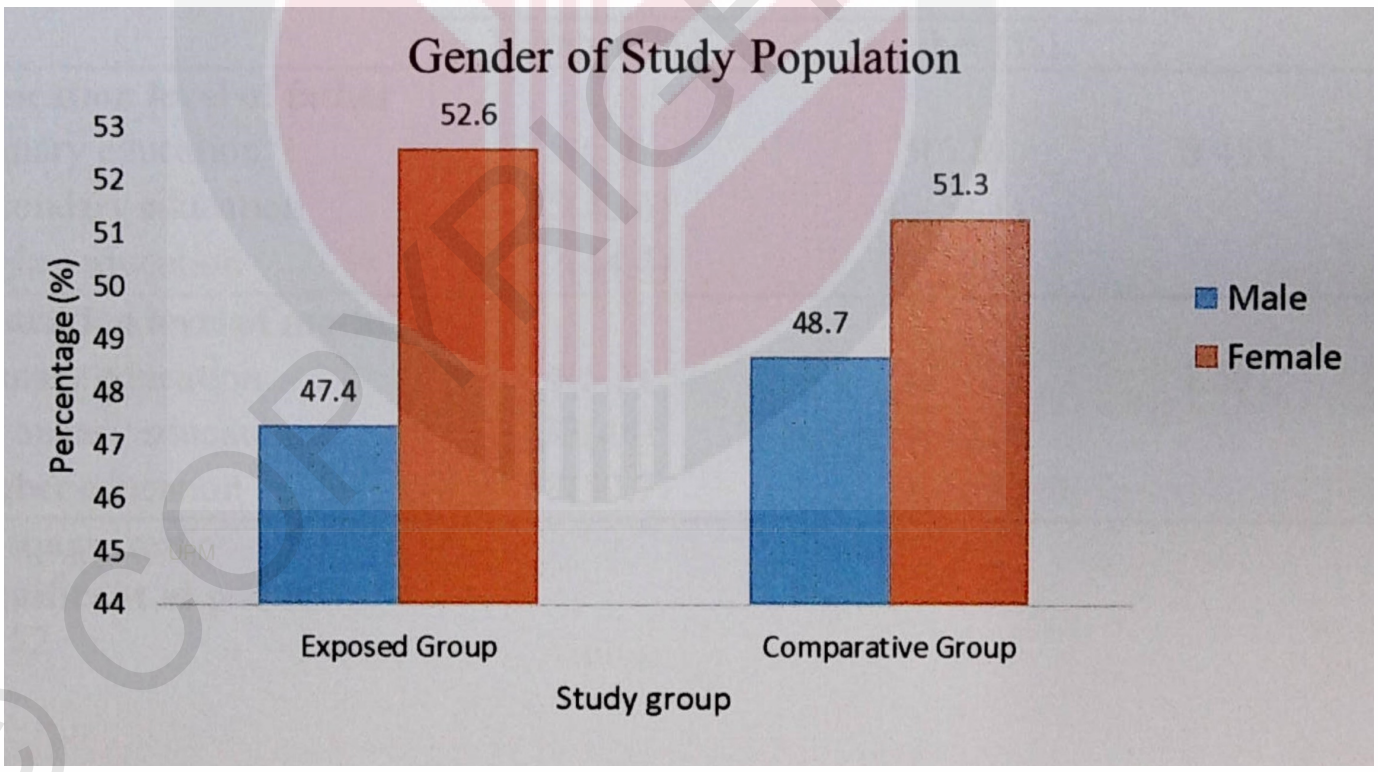


Figure 4.1: Comparison of Respiratory Health Symptoms among Primary School Children from Exposed and Comparative Group

Table 4.2 reflects the comparison of parental education level between study groups. It was categorized as primary education, secondary education and higher education. For those who finished their primary school or lower, they were categorized as

primary education. For those who finished their study until secondary school, they were categorized as secondary education. Lastly higher education was for those who finished STPM or diploma to postgraduate level. The highest level of education among these group was PhD whereas the lowest education obtained by respondent's parent was UPSR. Majority of the father in both groups' education level was secondary education meanwhile the majority of mother in both groups obtain education until higher education level. There were no significant differences observed for the respondent's father and mother education level between the exposed and comparative group which at p=0.797 and p=0.451.

Table 4.2: Comparison of Parental Education Level between Study Groups

Variables	Exposed Group (n=76) Number (%)	Comparative Group (n=76) Number (%)	χ^2-value	p-value
Education level of father				
Primary education	5(6.9)	5(6.8)	0.454	0.797
Secondary education	35(48.6)	40(54.1)		
Higher education	32(44.4)	29(39.2)		
Education level of mother				
Primary education	4(5.3)	8(11)	1.591	0.451
Secondary education	33(44)	31(42.5)		
Higher education	38(50.7)	34(46.6)		

Chi-square test
***Significant at p<0.05**
N=152

Table 4.3 shows the comparison of parental occupation between high traffic density area with low traffic density area. it was categorized into the employer, government employee, private sectors employee, self-employed and unemployed. Majority of the respondents' father and mother in exposed group work in the private sector and unemployed respectively while the majority of respondents' father and mother in the comparative group are self-employed and unemployed respectively. There were no

significant differences for respondents' father (p=0.690) and mother occupation (p=0.451).

Table 4.3: Comparison of Parental Occupation between Study Groups

Variables	Exposed Group (n=76) Number (%)	Comparative Group (n=76) Number (%)	χ^2-value	p-value
Occupation of father				
Government	14(20)	12(16.9)	3.062	0.690
Private sector	32(45.7)	26(36.6)		
Self-employed	22(31.4)	30(42.2)		
Unemployed	1(1.4)	1(1.4)		
Retirees	1(1.4)	2(2.8)		
Occupation of mother				
Government	15(21.1)	21(29.6)	5.724	0.451
Private sector	22(31)	13(18.3)		
Self-employed	6(8.5)	4(5.6)		
Unemployed	28(39.4)	33(46.5)		
Retirees	0(0)	0(0)		

Chi-square test
***Significant at p<0.05**
N=152

Table 4.4 shows the distribution of respondent's outdoor residential background among respondents for both high and low-density traffic area. Most of the respondent for exposed group lives in the urban area (82.2%) while most of the respondent for comparative group lives in the rural area (82.4%). It clearly shows that the majority of respondents for both groups live within both comparative and exposed vicinity. Statistical analysis showed a highly significant difference between study groups (x^2=115.129, p<0.001). Comparison distance between the distance of respondents' house from the highway between study groups also showed a highly significant difference (x^2 = 21.83,

p<0.001). Majority of the respondent's house for both exposed and comparative group is more than 5000 meters away from the factory which is 92.1% and 97.4% for exposed and comparative group respectively. Lastly, the majority of the home environment at both study groups is moderately dusty which is 63.2% for the exposed group and 51.3% for the comparative group.

Table 4.4: Distribution of Respondent's Outdoor Residential Background among Study Group

Variables	Exposed Group (n=76)	Comparative Group (n=76)	χ^2-value	p-value
	Number (%)	Number (%)		
Housing area				
Urban	60(82.2)	1(1.4)	115.129	**<0.001***
Sub-urban	12(16.2)	12(16.2)		
Rural	1(1.4)	61(82.4)		
Distance of house from highways				
<100 meters	13 (17.1)	9 (11.8)		
100-299	5 (6.6)	5 (6.6)	21.83	**<0.001***
300-499	9 (11.8)	9 (11.8)		
>500 meters	28 (36.8)	53 (69.7)		
Distance of house from factory				
<2.5 km	0 (0.0)	0 (0.0)	2.111	0.146
2.5-4.9 km	6 (7.9)	2 (2.6)		
>500 meters	70 (92.1)	74 (97.4)		
Distance of house from power station				
2.5-4.9 km	11 (14.5)	9 (11.8)	0.230	0.631
>500 meters	65 (85.5)	67 (88.2)		
Home environment				
Very Dusty	15 (19.7)	12 (15.8)	5.054	0.080
Moderately Dusty	48 (63.2)	39 (51.3)		
Not Dusty	13 (17.1)	25 (32.9)		

Chi-square test
***Significant at p<0.05**
N=152

4.2 Comparison of Concentration of Traffic-related Air Pollutant in Primary School at Heavy Traffic Area and in Primary School in Low Traffic Area.

Table 4.5 shows the comparison of TRAP, which is PM_{10}, $PM_{2.5}$, which was measured into $\mu g/m^3$ while NO_2, SO_2, CO and TVOC measured was converted into part per million (ppm) at both study groups. Normality testing was performed prior to any statistical analysis to test the independent variable. Upon normality testing, $PM_{2.5}$, NO_2 and SO_2 were identified distributed normally within primary schools thus independent T-test was performed for these variables. However, PM_{10}, CO and TVOC were identified otherwise. Therefore, non-parametric was performed which is Mann-Whitney U test to compare the variables within groups. The concentration of the TRAP measured was averaged from two readings which from indoor and outdoor measurement. The indoor reading was obtained from classroom measurement and the outdoor reading was obtained from ambient air which was measured by placing the equipment at the guard house. Every guard house at the studied school sited less than 3 meter from the main road.

Statistical analysis showed the median concentration of PM_{10} at primary school in the exposed group [246.67 (11.55)] was higher compared to the median concentration of PM_{10} at comparative group [66.67 (5.77)]. Mann-Whitney U result showed that there was a significant difference between the concentration of PM_{10} in heavy and low traffic density area (Z^{-}-2.023, p=0.043).

Statistical analysis showed that mean concentration of $PM_{2.5}$ at primary school in heavy traffic density area [193.33 (11.55)] was higher than the mean concentration of $PM_{2.5}$ at primary school in low traffic density area [40.00 (20.00)]. Independent T-test result showed that there was a significant difference between the concentration of $PM_{2.5}$ in heavy and low traffic density area (t=-11.500, p=<0.001).

Statistical analysis showed the mean concentration of NO_2 at primary school in the exposed group [0.24 (0.10)] was lower compared to the mean concentration of NO_2 at comparative group [0.03 (0)]. Independent T-test result showed that there was a significant difference between the concentration of NO_2 in heavy and low traffic density area (t=-3.623, p=0.022).

Statistical analysis showed that mean concentration of SO_2 at primary school in heavy traffic density area [0.09 (0.01)] was higher than the mean concentration of SO_2 at primary school in low traffic density area [0.02 (0.01)]. Independent t-test result showed that there was a significant difference between the concentration of SO_2 in heavy and low traffic density area (t=-6.709, p=0.003).

Statistical analysis showed that median concentration of CO at primary school in heavy traffic density area [23.32 (9.11)]. was higher than the median concentration of CO at primary school in low traffic density area [0 (0)] Mann-Whitney U test result showed

that there was a significant difference between the concentration of CO in heavy and low traffic density area (Z=-3.931, p=0.017).

Statistical analysis showed that median concentration of TVOC at primary school in heavy traffic density area [5.14 (10.91)] was higher than the median concentration of TVOC at primary school in low traffic density area [0.01 (0)]. Mann-Whitney U test result showed that there was a significant difference between the concentration of TVOC in heavy and low traffic density area (Z=-2.087, p=0.037).

Table 4.5: Comparison of TRAP among Study Groups

Variables	Exposed Group (n=9)	Comparative Group (n=9)	t-value/Z-value	p-value
	Mean (SD)/Median (IQR)			
PM_{10} ($\mu g/m^3$) [b]	246.67 (11.55)	66.67 (5.77)	**-2.023**	**0.043***
$PM_{2.5}$ ($\mu g/m^3$) [a]	193.33 (11.55)	40.00 (20.00)	**-11.500**	**<0.001***
NO_2 (ppm)[a]	0.24 (0.10)	0.03 (0)	**-3.623**	**0.022***
SO_2 (ppm)[a]	0.09 (0.01)	0.02 (0.01)	**-6.709**	**0.003***
CO (ppm)[b]	23.32 (9.11)	0 (0)	**-3.931**	**0.017***
TVOC (ppm)[b]	5.14 (10.91)	0.01 (0)	**-2.087**	**0.037***

[a]T-test, [b]Mann-Whitney U Test
***Significant at p<0.05**
N=18

Table 4.6 shows the comparison of TRAP, which is PM_{10} and $PM_{2.5}$, which was measured in $\mu g/m^3$ while NO_2, SO_2, CO and TVOC was converted into part per million (ppm). It was measured in the classroom and ambient air in the studied primary schools. Normality testing was performed prior to any statistical analysis to test the independent

variable. Upon normality testing, SO_2 and CO were identified distributed normally. However, $PM_{2.5}$, PM_{10}, NO_2 and TVOC were identified otherwise. Therefore, independent T-test was performed for normally distributed variables and non-parametric which is Mann-Whitney U test was performed for variables that were not distributed normally. Overall, the concentration of indoor and outdoor air pollutants of the exposed group was higher compared to the comparative group except for SO_2 which was otherwise. The statistical test showed that the comparison of the indoor and outdoor pollutant among studied schools were not significantly different where PM_{10} (z=-0.647, p=0.517), $PM_{2.5}$ (z=-0.321, p=0.748), NO_2 (z=-1.299, p=0.194), SO_2 (t=-0.314, p=0.760), CO (t=-0.256, p=0.818) and TVOC (z=-0.598, p=0.550). From this analysis, most of the particulates measured in ambient air were higher compare to particulates measure in indoor air except for $PM_{2.5}$.

Table 4.6: Comparison of TRAP between Indoor and Outdoor

Variables	Indoor (n=9)	Outdoor (n=9)	t-value/Z-value	p-value
	Mean (SD)/Median (IQR)			
PM_{10} ($\mu g/m^3$) [b]	170.00 (132.50)	250.00 (467.50)	-0.647	0.517
$PM_{2.5}$ ($\mu g/m^3$) [b]	165.00 (267.50)	160.00 (225.00)	-0.321	0.748
NO_2 (ppm) [b]	0.06 (0.16)	0.16 (0.30)	-1.299	0.194
SO_2 (ppm) [a]	0.05 (0.04)	0.05 (0.03)	-0.314	0.760
CO (ppm) [a]	6.10 (24.04)	6.17 (25.04)	-0.256	0.818
TVOC (ppm) [b]	0.01 (1.50)	2.31 (10.99)	-0.598	0.550

[a]T-test, [b]Mann-Whitney U Test
***Significant at p<0.05**
N=18

Table 4.7 shows the summary of air pollutants concentration between the exposed and comparative group. Letter S indicates schools in high traffic density area while letter

C is for schools in low traffic density area. The numbering was organized in descending order according to the level of exposure to TRAP. S1 indicates exposed primary school which was exposed to the highest TRAP concentration followed by S2 for and S3 which was the intermediate and the lowest TRAP exposure for exposed group respectively. On the other hand, for comparative school, C1 is for the primary school which was exposed to highest TRAP concentration among the comparative group, C2 for intermediate exposure and C3 which is the lowest TRAP exposure among the comparative group.

Table 4.7: Summary of Air Pollutants Concentration between Exposed and Comparative Group

		Exposed School			Comparative School		
		S1	S2	S3	C1	C2	C3
PM_{10} ($\mu g/m^3$)	Avg	240.00	260.00	240.00	60.00	70.00	70.00
$PM_{2.5}$ ($\mu g/m^3$)	Avg	200.00	180.00	200.00	20.00	40.00	60.00
TVOC (ppm)	Avg	9.01	5.28	2.36	0.01	0.01	0.01
CO (ppm)	Avg	28.18	10.54	23.32	0.00	0.00	0.00
SO_2 (ppm)	Avg	0.10	0.07	0.07	0.02	0.01	0.02
NO_2 (ppm)	Avg	0.32	0.13	0.13	0.03	0.03	0.03

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4.3 Comparison of Respiratory Symptoms among Primary School Children in Heavy Traffic Area and Low Traffic Area

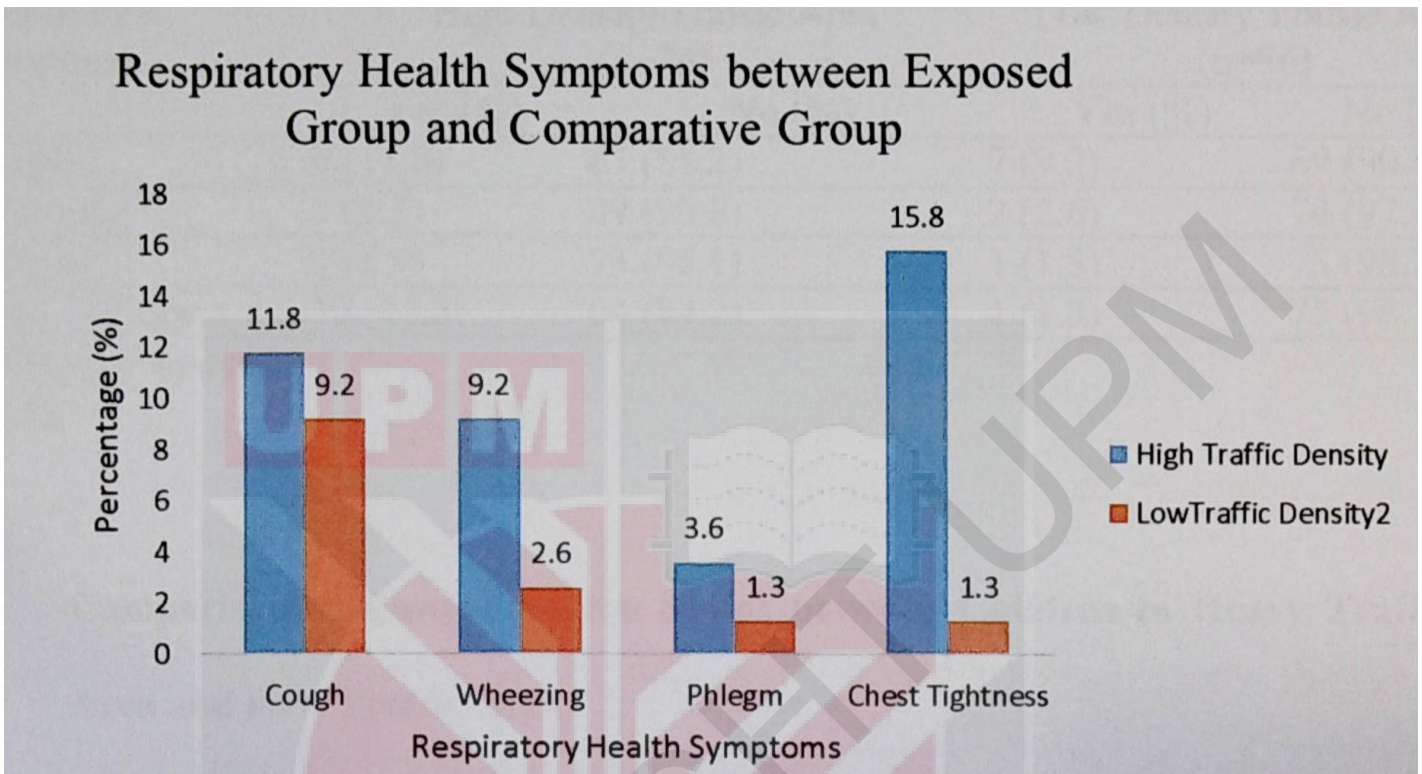


Figure 4.2: Comparison of The Respiratory Health Symptoms among Primary School Children from Exposed and Comparative Group

There were four parameters of respiratory health symptoms that have been studied which included cough, wheezing, phlegm and chest tightness. As shown in Figure 4.2, 9 (11.8%) from the exposed group and 7 (9.2%) from comparative group experienced cough. Next, 7 (9.2%) from the exposed group and 2 (2.6%) from comparative group reported experienced wheezing. Symptoms such as phlegm are not common among studied groups which reported only 3 (3.9%) for the exposed group and only 1 (1.3%) for the comparative group. Next reported symptoms were chest tightness which reported 12 (15.8%) report for the exposed group while 1 (1.3%) for the comparative group.

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Table 4.8: Comparison between Reported Respiratory Health Symptoms among Respondent from Exposed and Comparative Group

Respiratory Symptoms	High Density Traffic Area (n=76)		Low Density Traffic Area (n=76)	
	Yes (%)	No (%)	Yes (%)	No (%)
Cough	9 (11.8)	67 (88.2)	7 (9.2)	69 (90.8)
Wheezing	7 (9.2)	69 (90.8)	2 (2.6)	74 (97.4)
Phlegm	3 (3.9)	73 (96.1)	1 (1.3)	75 (98.7)
Chest Tightness	12 (15.8)	64 (84.2)	1 (1.3)	75 (98.7)

Descriptive analysis
N=152

4.4 Comparison of Lung Function Status between Children in Heavy Traffic Area and Low Traffic Area

Table 4.9 shows the comparison of lung function among primary school children in high and low-density traffic area. Based on normality testing, some of the data including FEV_1%/FVC (%), FVC % predicted and FEV_1/FVC% predicted were distributed normally while other variables were not distributed normally which required non-parametric testing. Upon Man-Whitney U Test for non-parametric testing, Kolmogorov Smirnov was used to determine the p-value due to large sample size. There was significant difference in value of FVC% predicted (z=-4.002, p=<0.001), FEV1% predicted (t=-2.544, p=0.012) and FEV1%/FVC% predicted (z=-2.675, p=0.007) among primary school in high density and low density traffic area.

The mean of FVC values among primary school children in high-density traffic area [1.17(0.39)] was lower compared to mean of FVC value among primary school

children in low-density traffic area [1.28 (0.44)]. Next, mean of FEV_1 values among primary school children in high-density traffic area [1.06 (0.37)] was lower compared to mean of FEV_1 value among primary school children in low-density traffic area [1.08 (0.39)]. The median of FEV_1 %/FVC (%) values among the exposed group [95.72 (13.97)] was lower compared to the median of the comparative group [97.33 (24.99)]. However, the median of FVC (%) predicted values among the exposed group [78.77 (32.44)] was higher compared to the median of the comparative group [96.82 (31.40)]. Same goes to mean of FEV_1 % Predicted values among primary school children. The value in high-density traffic area [97.88 (13.39)] was lower compared to mean of FEV_1 value among primary school children in low-density traffic area [91.41 (17.67)]. Lastly, the median of FEV_1 %/FVC (%) predicted values among the exposed group [102.73 (11.20)] was higher compared to the median of the comparative group [97.54 (22.81)].

Table 4.9: Comparison of the Lung Function among Primary School Children in High Traffic Density and Low Traffic Density Area

Variables	High Density Traffic Area (n=76)	Low Density Traffic Area (n=76)	Z/t-value	p-value
	Mean (SD) / Median (IQR)			
FVC (Litre) [a]	1.17 (0.39)	1.28 (0.44)	1.633	0.105
FEV_1 (Litre) [a]	1.06 (0.37)	1.08 (0.39)	0.265	0.791
FEV_1 %/FVC (%) [b]	95.72 (13.97)	97.33 (24.99)	-0.602	0.547
FVC % pred [b]	78.77 (32.44)	96.82 (31.40)	-4.002	**<0.001***
FEV_1 % pred [a]	97.88 (13.39)	91.41 (17.67)	-2.544	**0.012***
FEV_1/FVC % pred [b]	102.73 (11.20)	97.54 (22.81)	-2.675	**0.007***

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

***Significant at p<0.05**

N=152

FVC %, FEV_1% and FEV_1%/FVC% values were categorized into two categories which were normal and abnormal status. It is based on the American Thoracic Society (2005) and reflected in Table 4.10 for comparison of the lung function abnormalities among primary school children in high traffic density and low traffic density area. Chi-square test was carried out to compare lung function abnormalities among the studied group. FEV_1% showed a significant difference at p=0.002 between high and low-density traffic area. For FVC% in the high-density traffic area, 20 (26.7%) was identified having abnormal status and 15 (19%) in contrast with respondents in low traffic density area who was identified to be abnormal which was lower compared to exposed group. For FEV_1%, respondents among the exposed group were identified to have a higher abnormal status which is 41 (54.7%) compared to the comparative group which is 23 (29.9%). Lastly, for FEV_1%/FVC % a total of 34 (44.7%) for abnormal status was identified among respondents from the exposed group was slightly higher from the comparative group which was a total of 31 (40.8%).

Table 4.10: Comparison of the Lung Function Abnormalities Among Primary School Children in High Traffic Density and Low Traffic Density Area

Lung Function	High Density Traffic Area (n=76)		Low Density Traffic Area (n=76)		χ^2-value	p-value	PR	95% CI
	Normal (%)	Abnormal (%)	Normal (%)	Abnormal (%)				
FVC %	55 (73.3)	20 (26.7)	62 (80.5)	15 (19)	1.107	0.293	1.503	0.702-3.219
FEV_1 %	34 (45.3)	41 (54.7)	54 (70.1)	23 (29.9)	9.583	**0.002***	**2.831**	**1.453-5.516**
FEV_1 %/FVC %	42 (55.3)	34 (44.7)	45 (59.2)	31 (40.8)	0.242	0.623	1.175	0.618-2.236

Chi-square test

***Significant at p<0.05**

****PR significant at 95% CI>1**

Yates correction was not performed due to no value less than 5

N=152

4.5 Association between Traffic-related Air Pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) and Respiratory Symptoms between Exposed Group and Comparative Group.

As shown in Table 4.11, 9 (11.8%) from the exposed group and 7 (9.2%) from comparative group experienced cough. Next, 7 (9.2%) from the exposed group and 2 (2.6%) from comparative group reported experienced wheezing. Symptoms such as phlegm are not common among studied groups which reported only 3 (3.9%) for the exposed group and only 1 (1.3%) for the comparative group. Next reported symptoms were chest tightness which reported 12 (15.8%) report for the exposed group while 1 (1.3%) for the comparative group. The result from the Chi-square test revealed that the reported respiratory symptoms were significantly higher among primary school children in exposed group for chest tightness (p=0.001, PR=0.071, 95% CI= 0.009-0.562)

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Table 4.11: Comparison between Reported Respiratory Health Symptoms among Respondent from Exposed and Comparative Group

Variables	TRAP***		⊔2-value	p-value	PR	95% CI
	Exposed (n=76)	Comparative (n=76)				
	Number (%)					
Chest Tightness			**10.178**	**0.001***	0.071	0.009-0.562
Yes	12 (15.8)	1 (1.3)				
No	64 (84.2)	75 (98.7)				
Wheezing						
Yes	7 (9.2)	2 (2.6)	2.953	0.086	0.266	0.054-1.327
No	69 (90.8)	74 (97.4)				
Cough						
Yes	9 (11.8)	7 (9.2)	0.279	0.597	0.755	0.266-2.144
No	67 (88.2)	69 (90.8)				
Phlegm						
Yes	3 (3.9)	1 (1.3)	1.027	0.311	0.324	0.033-3.191
No	73 (96.1)	75 (98.7)				

Chi-square test
***Significant at p<0.05**
****PR significant at 95% CI>1**
*****TRAP = PM_{10}, $PM_{2.5}$, NO_2, SO_2, TVOC, CO**
N=152

4.6 Association between Traffic-related Air Pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2 CO, VOC) and Lung Function among Study Respondents.

Table 4.12 and 4.13 shows the association between traffic-related air pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, VOC) and lung function among study respondents. Selected TRAP was categorized based on their median value of both study areas. A value that was

higher than median was categorized as high meanwhile the value that was lower than median was categorized as low. The value of FVC% predicted, FEV_1% predicted and FEV_1/FVC% predicted among primary school children was then determined by categorizing them into whether they are normal or abnormal based on American Thoracic Society (2005) to determine the lung abnormalities of respondents from both groups. Chi-square test was performed to find an association between two qualitative variables which were categorized based on standard and median rating.

Upon the test, the result shows that there were significant association between NO_2 (p=0.003, 95% CI=1.387-5.252), SO_2 (p=0.003, 95% CI=1.387-5.252), CO (p=0.003, 95% CI=1.387-5.252), TVOC (p=0.003, 95% CI=1.387-5.252), $PM_{2.5}$ (p=0.003, 95% CI=1.387-5.252) and PM_{10} (p=0.003, 95% CI=1.387-5.252) with abnormality of FEV_1%.

Table 4.12: Association Between Lung Function Abnormalities (FEV_1%) Among Study Respondents

Variables	FEV_1%		χ^2-value	p-value	PR	95% CI
	Abnormal	Normal				
	Number (%)					
NO_2						
High (≥0.64 ppm)	41 (64.1)	35 (39.8)	**8.744**	**0.003***	**2.699****	**1.387-5.252**
Low (<0.64 ppm)	23 (35.9)	53 (60.2)				
SO_2						
High (≥0.04 ppm)	41 (64.1)	35 (39.8)	**8.744**	**0.003***	**2.699****	**1.387-5.252**
Low (<0.04 ppm)	23 (35.9)	53 (60.2)				
CO						

High (≥0.05 ppm)	**41 (64.1)**	**35 (39.8)**	**8.744**	**0.003***	**2.699****	**1.387-5.252**
Low (<0.05 ppm)	**23 (35.9)**	**53 (60.2)**				
TVOC						
High (≥0.97 ppm)	**41 (64.1)**	**35 (39.8)**	**8.744**	**0.003***	**2.699****	**1.387-5.252**
Low (<0.97 ppm)	**23 (35.9)**	**53 (60.2)**				
$PM_{2.5}$						
High (≥120 µg/m³)	**41 (64.1)**	**35 (39.8)**	**8.744**	**0.003***	**2.699****	**1.387-5.252**
Low (<120 µg/m³)	**23 (35.9)**	**53 (60.2)**				
PM_{10}						
High (≥155 µg/m³)	**41 (64.1)**	**35 (39.8)**	**8.744**	**0.003***	**2.699****	**1.387-5.252**
Low (<155 µg/m³)	**23 (35.9)**	**53 (60.2)**				

Chi-square test
***Significant at p<0.05**
****PR significant at 95% CI>1**
N=152

Statistical data shows that there were no significant association between NO_2 (p=0.335, 95% CI=0.678-3.110), SO_2 (p=0.335, 95% CI=0.678-3.110), CO (p=0.335, 95% CI=0.678-3.110), TVOC (p=0.335, 95% CI=0.678-3.110), $PM_{2.5}$ (p=0.335, 95% CI=0.678-3.110) and PM_{10} (p=0.335, 95% CI=0.678-3.110) with abnormality of FVC%.

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Table 4.13: Association Between Lung Function Abnormalities (FVC%) Among Study Respondents

Variables	FVC%		χ^2 -value	p-value	PR	95% CI
	Abnormal	Normal				
	Number (%)					
NO_2						
High (≥0.64 ppm)	20 (57.1)	56 (47.9)	0.928	0.335	1.452	0.678-3.110
Low (<0.64 ppm)	15 (42.9)	61 (52.1)				
SO_2						
High (≥0.04 ppm)	20 (57.1)	56 (47.9)	0.928	0.335	1.452	0.678-3.110
Low (<0.04 ppm)	15 (42.9)	61 (52.1)				
CO						
High (≥0.05 ppm)	20 (57.1)	56 (47.9)	0.928	0.335	1.452	0.678-3.110
Low (<0.05 ppm)	15 (42.9)	61 (52.1)				
TVOC						
High (≥0.97 ppm)	20 (57.1)	56 (47.9)	0.928	0.335	1.452	0.678-3.110
Low (<0.97 ppm)	15 (42.9)	61 (52.1)				
$PM_{2.5}$						
High (≥120 µg/m^3)	20 (57.1)	56 (47.9)	0.928	0.335	1.452	0.678-3.110
Low (<120 µg/m^3)	15 (42.9)	61 (52.1)				
PM_{10}						
High (≥155 µg/m^3)	20 (57.1)	56 (47.9)	0.928	0.335	1.452	0.678-3.110
Low (<155 µg/m^3)	15 (42.9)	61 (52.1)				

Chi-square test
***Significant at p<0.05**
****PR significant at 95% CI>1**
N=152

4.7 Main Factor Influencing the Lung Function among Study Respondents after Controlling the Confounders.

In order to estimate the probability of factor that influenced the abnormality of lung function for $FEV_1\%$ the most, a binary logistic regression analysis was conducted. The abnormality of lung function for $FEV_1\%$ was estimated using an existing questionnaire. The model was 57.9% accurate in its prediction on the main factor that influencing the lung function among study respondents. As demonstrated in Table 4.14, NO_2 was the only predictor which significantly improved the model's predictive capability. The odds ratio for NO_2 indicated that if NO_2 increased by one unit, then the $FEV_1\%$ decrease by 0.9 and the prevalence rate by 1.1 times of getting $FEV_1\%$ abnormality due to exposure of NO_2.

Table 4.14: Factor Influencing the Lung Function Abnormality ($FEV_1\%$) among Study Respondents after Controlling the Confounders.

Variables	β	SE	p-value	PR	95% CI
Constant	0.158	0.230	0.492	1.171	
NO_2	-0.993	0.340	**0.003***	0.370	0.190-0.721

N= 152
95% CI=95% Confidence Interval
B=Regression coefficient
SE=Standard Error
Nagelkerke R Square=0.076
***Significant at p<0.05**
****PR significant at 95% CI>1**
(Adjusted for distance house from roads and industry, indoor smoking, ventilation system, carpets, open burning)

4.8 Main Factor Influencing Respiratory Symptoms among Study Respondents after Controlling the Confounders.

In order to estimate the probability of factor that influenced the respiratory symptoms (chest tightness) the most, a binary logistic regression analysis was conducted. The respiratory symptoms (chest tightness) was estimated using an existing questionnaire. The model was 91.4% accurate in its prediction on the main factor that influencing the chest tightness among study respondents. As demonstrated in Table 4.15, NO_2 was the only predictor which significantly improved the model's predictive capability. The odds ratio for NO_2 indicated that if NO_2 increased by one unit, then the respiratory symptoms (chest tightness) increased by 2.6 and the prevalence rate by 14.1 times of getting respiratory symptoms (chest tightness) due to exposure of NO_2.

Table 4.15: Factor influencing the respiratory symptom (chest tightness) among study respondents among study respondents after controlling the confounders.

Variables	β	SE	p-value	PR	95% CI
Constant	1.674	0.315	<0.001	5.330	
NO_2	2.644	1.055	**0.012***	14.062	1.780-111.118

N= 152
95% CI=95% Confidence Interval
B=Regression coefficient
SE=Standard Error
Nagelkerke R Square=0.169
***Significant at p<0.05**
****PR significant at 95% CI>1**

(Adjusted for distance house from roads and industry, indoor smoking, ventilation system, carpets, open burning)

CHAPTER 5

DISCUSSION

The main aim of this analysis was to determine the association of TRAP ($PM_{2.5}$, PM_{10}, CO, NO_2, SO_2, TVOC) exposure with lung function status and health symptoms among primary school children attending school located at high-density traffic (n=76) and low-density traffic (n=76) in Klang Valley.

5.1 Sociodemographic Status and Exposure of Air Pollution among the Study Respondents.

Confounder was the most significant aspect need to be identified before any research was carried out. This is to eliminate any underlying factors that may cause disruption to any outcome. Therefore, in this study, only primary school children aged 9-11 years old was selected in compliance with their literacy and understanding level with the addition of avoidance from disrupting primary school children on exam year. Furthermore, only Malays respondents were taken into this study to homogenized them in compliance with Azizi and Henry (1994) formula for calculation of lung function which focused only on Malay children. Based on questionnaire analysed, there were significantly

lower in number for male compared to female in high traffic density area which was 36 (47.4%) and 40 (52.6%) respectively. Same goes to low traffic density area, there were significantly lower in number for male compared to the female which by 37 (47.4%) and 40 (52.6%) respectively. According to Sheldon (2000), factors such as gender, age, height and weight are the important factors that can influence the outcomes of lung function test among respondents.

Questionnaires were one of the tools used to assess the respondent's background. Some of the key element assessed by questionnaires was parental education level, parental occupation and respondent's outdoor residential background. For this study specifically, parental education levels were compared between the studied group. It was categorized into three categories which were primary education, secondary education and higher education. The highest education among these two groups is PhD level and on the other hand, for the lowest education was UPSR. Majority of fathers in both groups' education level was secondary education at 35 (48.6%) for the exposed group and 40 (54.1%) for the comparative group. Meanwhile, majority of mothers in both groups obtained education until higher education level which at 33 (44%) for the exposed group and 31 (42.5%) for the comparative group. However, the result of analysis from this study shows that there was no significant difference between the respondent's education among these two groups. This clearly shows that the education level for residents in the less developed area currently is now in the same par with residents in a developed area. Same goes to parental occupation between study group. There was no significant difference between these two studied groups. From the analysed questionnaire, majority of the respondents' father [32

(45.7%)] and mother [28 (39.4%)] in exposed group work in private sector and unemployed respectively while majority of respondents' father [29 (40.8%)] and mother [33 (46.5%)] in comparative group are self-employed and unemployed respectively.

This study found that most of the respondent for exposed group lives in the urban area (82.2%) while most of the respondent for comparative group lives in the rural area (82.4%). It clearly shows that most respondents for both groups live within both comparative and exposed vicinity. Based on the previous study conducted in 2015 by Choo and Juliana, it states that respiratory illness was prone to children living or studying in schools in urban areas compared to the rural area. Combining both studies result from previous study and this study, it clearly shows that those primary school children in the exposed group were more likely to have respiratory health symptoms in compared to primary school children in the comparative group. Majority of children in both study groups which is 28 (36.8) and 53 (69.7) for exposed and comparative group respectively live more than 500 meters from highways. Therefore, exposure to traffic at home has not influenced by the result of this study. This is because as stated in a study conducted by Venn *et al*., (2001) where it stated that living near to the main road are associated with increased risk of wheezing.

The study also found that majority of the respondent's house for both groups were located more than 500 meters from the factory and power station. Lastly, majority of the

respondent's house environment were considered their home environment moderately dusty at 48 (63.2%) for the exposed group and 39 (51.3%) for the comparative group.

5.2 Comparison of Concentration of Traffic-related Air Pollutant in Primary School at Heavy Traffic Area and Low Traffic Area.

There was a significant difference between the concentration of traffic pollutant in primary schools in a heavy traffic area and in primary schools in a low traffic area. By definition, heavy traffic area is the area that has an average daily traffic volume of more than or equal to 18000 vehicles or 100 m of major roads with an average daily traffic volume of more than or equal to 15000 vehicles (Brauer *et al.*, 2013). This is on the contrary with the comparative group which their schools were located away from heavy traffic congestion or, this area has low traffic volume with an average of 2800 vehicles/day (Elhadi *et al.*, 2017). The finding was reflected on a study done by Fadzil & Jalaludin (2013) which stated that there was a significant difference between the concentration of TRAP in a residential area near busy roads compared to those who lived near a less busy road. This is because high traffic density may contribute to high TRAP emission and exposure to residents. In comparison with a previous study conducted by Choo *et al.* (2015) on preschool children, the value of PM_{10} measured was lower in comparison to this study. However, for other variables such as CO and TVOC, the value measured in this study was higher in comparison to their study. However, the values are about the same and the similarities between these studies are the location of the study areas have the same

characteristics which are both studies located near high traffic density area for the exposed group. In addition, in their discussion, they did highlight that heavy traffic and vehicle fossil fuel combustion might contribute to high levels of particulate matters in studied areas. Based on the traffic count survey conducted, the medium sized vehicle has the highest number counted in the exposed area. In contrast, the highest vehicle type counted for the comparative group was small size vehicle. The motorcycle was classified as small size vehicle while car and van were classified as medium size vehicle and lastly, lorry, trailer and bigger vehicles were classified as large size vehicles. A high number of medium sizes contributed to high emission of TRAP compared to a low number of large size vehicles (Zuurbier *et al.*, 2010). This clearly shows that children in the exposed group are prone to be exposed to high TRAP emission compared to the comparative group. Furthermore, based on observation during the traffic-count survey, there was a lot of medium size vehicles idling nearby school compound during the afternoon. It was believed that those vehicles belong to primary school children's parent or guardian waiting for their child at the end of the school session. The air measurement for this study was conducted at two point and these points was then being averaged to generalize the value. these points were done at classroom for indoor measurement and at guard house for ambient air measurement. The location of the guard house which very close to the road causes the reading such as the reading of the CO turns out to be tremendously high. However, the exposure to the children in the classroom may be differ from the value measured. Next, this study also proved that there was no significant difference between indoor TRAP concentration and outdoor TRAP concentration. However, by using the formula of indoor and outdoor ratio (Deng *et al.*, 2016), it shows that most of the particulates came from outdoor except for $PM_{2.5}$ which is equilibrium. Generally, the I

(Indoor)/O (Outdoor) ratio was used to evaluate the I/O relationships of air pollutants. I/O > 1.2 means indoor concentration is higher than the outdoors and could be due to indoor sources. 0.8 < I/O ≤1.2 means indoor concentration is equilibrating with outdoor concentration and lastly, I/O ≤ 0.8 means indoor concentration is lower than the outdoors which illustrating possible outdoor influence. This was supported by a study conducted by Amato *et al.*, (2014) which stated that $PM_{2.5}$ measured indoor commonly sources from the continuous suspension of soil particles, mixed sources (skin flakes, clothes fibres and possible condensation) and Ca-rich particles (chalk and building deterioration). The poor indoor environment may result from outdoor urban sources and proximity to road traffic. This was suggested by a study conducted by Chua *et al.*, (2015) which stated that poor ventilation and good opening will cause a further negative impact on indoor air environment where these TRAP may easily penetrate and deposited into the indoor environment.

Indoor and outdoor ratio formula:

$$\frac{\text{Indoor concentration (I)}}{\text{Outdoor concentration (O)}}$$

If the value > 1.2 (I>O)

If 0.8 <I/O≤ 1.2 (I is equilibrating with O)

If the value < 0.8 (I<O)

Based on data in Table 4.5, the highest TRAP concentration for 6 hours of measurement was NO_2 concentration for both study group at 0.24 $\mu g/m^3$ and 0.03 $\mu g/m^3$

for exposed and comparative group respectively. Although the concentration of NO_2 for both study groups are higher from other TRAPs concentration, the concentration of NO_2 for the exposed group was far higher from the comparative group. This is due to other nitrogen-containing compounds such as the existence of Nitric Acid or PAN (Atmospheric peroxyacetyl nitrate) converted to NO. The measurement of NO_2 was based on using the chemiluminescence technique where it works from the conversion of NO_2 to NO. High NO_2 concentration was significantly associated with high traffic density as per proven in a study conducted by Rijnders *et al.*, (2001). In his study, it was proven that school located near to the busiest traffic measured the highest concentration of NO_2 in comparison to the school located at very less urban area. It also suggested that concentration of NO_2 have the association with open terrain downwind of a highway where in that particular study proven that it was proven that open terrain downwind of a highway found a decline in NO_2 with distance. The same goes to other pollutants where most of the TRAP concentration in the exposed group was identified higher compare to TRAP concentration in the comparative group was due to the relationship with the distance from highways.

5.3 Comparison of Respiratory Symptoms among Primary School Children in Heavy Traffic Area and Low Traffic Area

Generally, the prevalence of reported respiratory symptoms (cough, wheezing, phlegm and chest tightness) was higher in the exposed group in comparison to the comparative group. The reported respiratory syndrome was identified by using a modified

questionnaire from ATS which coded ATS-DLD-78-C and questionnaire from ISAAC. From these answered questionnaires, the prevalence of respiratory symptoms was identified and assessed. This finding was supported by Chen *et al.*, (1998) which reported that children living in the urban area had consistently higher rates of respiratory symptoms and diseases than did those living in the rural community. This was also supported by a study conducted in Istanbul by Gül *et al.*, (2011) which found that there was a significant difference between a student attending school in an urban area in comparison with a student attending school in a rural area. A possible interpretation for our study may be the presence of higher contrasts in pollution levels in high traffic density areas than in low traffic density area. A study conducted by Migliore *et al.*, (2009) also proves that their findings support a causal effect of exposure to traffic road pollution on respiratory illnesses in childhood. Children attend their school in high traffic density area was found to be more prone to exposure of TRAP. Therefore, this may be the culprit for the existence of respiratory symptom among the school children similar to a finding found by Arifuddin *et al.*, (2019).

5.4 Comparison of Lung Function Status between Children in Heavy Traffic Area (Exposed Group) and Low Traffic Area (Comparative Group)

This study has found that there was a significant difference between FVC % predicted, FEV_1 % predicted and FEV_1/FVC % predicted among the study group. It shows that primary school children in high traffic density area have a lower FVC %, FEV_1 %

and FEV_1/FVC % in comparison to primary school in low traffic density area. This study also proved that children in high traffic density are more prone to have abnormal FEV_1% at 54.7% of respondent in the exposed group compared to 29.9% of the total respondent in the comparative group. It was also proved by statistical analysis by Chi-square test that there was a significant difference between abnormal FEV_1% among the exposed group and comparative group. This was supported by a study conducted by lerodiakonou *et al.*, (2016) where it proves that children living near the major road were associated with lower FEV_1% and accelerated rate of FEV_1% reduction. Children schooled in the area of high traffic density are more prone to get a reduction in lung function. This statement was supported by a study conducted by Arifuddin *et al.*, (2019), Chen *et al.*, (2015), Schultz *et al.*, (2017) and Migliore *et al.*, (2009) where the finding in their study proves that there is a significant association between reduction of lung function with exposure to high concentration of TRAP. The exposure of children on TRAP will cause inflammatory changes in small airways which will reflect in the reduction of lung function. This may have a relationship with loss of lung elastic recoil which will cause bronchial spasm, increased intraluminal secretions, airway inflammation and/or reduction in parenchyma support of the airways.

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5.5 Association between Traffic-related Air Pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) and Respiratory Symptoms between Exposed and Comparative Group

Statistically, there was a significant association between traffic-related air pollutants which is PM_{10}, $PM_{2.5}$, TVOC, CO, SO_2 and NO_2 with respiratory symptoms among study respondents for chest tightness. However, based on statistical analysis from Chi-square proved a significant difference only on the reported chest tightness [(x^2=10.178), (p=0.001), (PR=0.071), (95% CI=0.009-0.562)]. This finding was supported by a study conducted by Petel *et al.*, (2010) that suggested there is a significant relationship between exposure of TRAP with chest tightness among children. Thus, from the result, it was concluded that the primary school children in the exposed group were 0.07 times more susceptible to get chest tightness as compared to primary school children in the comparative group. Therefore, there was an association between reported respiratory symptoms occurrence in primary school children with the location of primary school they attended due to traffic exposure.

5.6 Association between Traffic-related Air Pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, VOC) and Lung Function among Study Respondents.

Lung function status was categorized into whether normal or abnormal based on the American Thoracic Society (2005) to determine the lung abnormalities of respondents

from both groups. The median value for recorded lung function values was used as the reference value. This study shows that there were a significant association between TRAP (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) and FEV_1% abnormalities among study respondents. However, from this statistical analysis, it showed that there was no significant association between TRAP (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) and FVC% abnormalities among study respondents. Putri et al. (2018) proved in their study that those who were exposed to TRAP were more susceptible to get abnormalities of FEV_1% in compare to abnormalities of FVC% due to exposure to the more polluted area. This was supported by a study conducted at Dhaka by Shahriar *et al.*, (2016) which stated that inhaled noxious particles and gases cause an inflammatory response in the lungs which assist in the activation of proteinase and inactivation of anti-proteinase. Inactivation of anti-proteinase and activation of proteinases may lead to the destruction of the lung parenchyma, hypersecretion of mucus and hyperplasia of epithelial cells. Thus, this caused the abnormalities of lung function among the studied group.

5.7 Main Factor that Influenced Lung Function among Study Respondents after Controlling the Confounders.

In order to estimate the probability of factor that influenced the abnormality of lung function for FEV_1% the most, a binary logistic regression analysis was conducted. The abnormality of lung function for FEV_1% was estimated using an existing questionnaire. The confounders of the study were also included and run simultaneously

including housing area, home environment, the distance of the house from highway and factory. Generally, this model was explained by 7.6% of Nagelkerke R Square from the variance of lung function among studied groups. Based on statistical analysis, only NO_2 shows that there are unique signatures that contribute to the model. Therefore, this showed that NO_2 was the strongest predictor of lung function (FEV_1%) abnormalities with a prevalence ratio of 0.37. The odds ratio for NO_2 indicated that if NO_2 increased by one-unit $\mu g/m^3$, then the FEV_1% decrease by 0.9 and the prevalence rate by 1.1 times of getting FEV_1% abnormality due to exposure of NO_2. A study conducted in Germany by Cyrys *et al.,* (2000) proves that NO_2 was the main indicator for TRAP. This aligns with this study that suggested exposure to NO_2 was the main factor that influenced the reduction of lung function. This finding was supported by a study conducted by Castro *et al.*, (2009) which stated that there was an association between NO_2 with a decrease in lung function in children. A study conducted by Ayuni *et al.*, (2014) also suggests that NO_2 exposure may lead to airway responsiveness and lung function injury. This finding was also supported by a study conducted in Kuopio, Finland by Timonen *et al.,* (2002) that high exposure to NO_2 concentration was consistently associated with impairment of lung function among children.

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5.8 Main Factor that Influenced Respiratory Symptoms among Study Respondents after Controlling the Confounders

In order to estimate the probability of factor that the respiratory symptoms (chest tightness) the most, a binary logistic regression analysis was conducted. The respiratory symptoms were estimated using an existing questionnaire. The confounders of the study were also included and run simultaneously including housing area, home environment, the distance of the house from highway and factory. Generally, this model was explained by 0.169% of Nagelkerke R Square from the variance of lung function among studied groups. Based on statistical analysis, only NO_2 shows that there is a unique significance that contributed to the model. Therefore, this showed that NO_2 was the strongest predictor of chest tightness with a prevalence ratio of 14.06. The odds ratio for NO_2 indicated that if NO_2 increased by one-unit $\mu g/m^3$, then the respiratory symptoms (chest tightness) increased by 2.6 and the prevalence rate by 14.1 times of getting respiratory symptoms (chest tightness) due to exposure of NO_2. This study suggested that exposure to NO_2 was the main predictor for chest tightness. This study suggested that exposure to NO_2 was the main predictor for chest tightness. This was supported by a study conducted by Belanger *et al.*, (2006) that proves that there was an association between measured NO_2 and respiratory symptoms such as chest tightness after the statistical analysis was done. Chest tightness have a relationship with the reduction in FEV_1. FEV_1 is caused due to the obstruction in the respiratory system. This obstruction will cause the occurrence of chest tightness among individual who have abnormal FEV_1 status.

CHAPTER 6

STUDY LIMITATION, CONCLUSION AND RECOMMENDATIONS

6.1 Study Limitation

There were few limitations found in this study such as the study design. A cross-sectional study assessed both exposure and outcome simultaneously. The primary limitation of the cross-sectional study design is that because the exposure and outcome are simultaneously assessed, there is generally no evidence of a temporal relationship between exposure and outcome. Without longitudinal data, it is not possible to establish a true cause and effect relationship. A true measure of association can only be determined if the entire population participates in this study. Besides that, the study population included in this study was in between 9 to 11 years old, Malay ethnic children, thus the results cannot be generalized for other ethnicities in Malaysia due to different characteristics such as different lung capacity.

On the other hand, this study might result in information bias as the respondent's parents or guardian might face some difficulties in recalling the information and details regarding their children for the questionnaire. Hence, in order to minimize this bias,

questions in the questionnaire shall be constructed as a close-response format such as "Do you think your house is free from dust; Yes or No. Next, one of the major weakness in this study was this study relies on self-reported information for respiratory symptoms and background exposure. Thus, in order to overcome this issue, the validity of the information provided by parent or guardian need to be deeply evaluated to prevent any bias to surface.

Furthermore, this study does not focus on the assessment of exposure of children to TRAP concentration at home. Home exposure is also important in order to evaluate whether the children are also exposed to TRAP at home and to determine the synergistic effect of both exposures towards the respiratory health of children. In addition, there are currently no standards established for indoor air assessment for building in non-occupational settings such as homes or schools in Malaysia. There is also no policy regarding school citing and determination of the proximity of school away from traffic prior to decision making.

6.2 Conclusion

The findings from this study can be concluded that traffic-related air pollution exposure to children might increase the risk of reduction in lung function as well as the occurrence of respiratory health symptoms such as chest tightness. This study shows that there were significant differences of traffic-related air pollution (TRAP) concentrations in schools especially for (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, TVOC) between the exposed and

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comparative group, where the TRAP concentrations in the exposed group were significantly higher compared to the comparative group. Besides, respiratory symptoms were found to be significantly higher in the exposed group than the comparative group. The hypotheses of the study were in line with the findings of related local and international studies.

Statistical analysis performed to test the hypotheses of this study proved that:

1. TRAP concentrations at schools were significantly higher in primary school at heavy traffic density area compared to primary school in low traffic density area.
2. Reported respiratory symptom in children from exposed area was significantly higher compared to schools in comparative area
3. Lung function status among children in heavy traffic density area are significantly lower compared to children in low traffic density area.
4. There is a significant association between TRAP and lung function between exposed and comparative group.
5. There is a significant association between reported respiratory symptoms between primary school children in heavy traffic density area and primary school children in low traffic density area.
6. The main factor that influenced respiratory symptoms among study respondents after controlling the confounders is exposure to NO_2.

7. The main factor that influenced lung function among study respondents of traffic after controlling the confounders is exposure to NO_2.

6.3 Recommendation

Based on this study, it is advisable to improve the level of awareness for parents, school management as well as the public regarding the risk of getting respiratory disease due to TRAP exposure. An annual meeting can be held among teachers, parents and professionals to discuss the current issue on emerging issues on respiratory problems among school children exposed to TRAP. This will enhance integrated corporation between different level in the effort to mitigate the problem. There are additional opportunities for future research such as impacts between TRAP concentrations and respiratory health symptoms among primary school children exposed to high traffic density could be investigated further.

Moreover, it is recommended for the policymakers to construct an action plan on addressing the issue of exposure of TRAP towards children early developmental. Additionally, enforcement of standards and limits should be established by the authority to reduce the exposure of air pollution from road traffic in the urban area. The local authority is advised to encourage people to reduce the usage of vehicles, encourage usage of public transportation, and supporting the uptake of new technologies in reducing the emission of pollutants.

Besides that, the ministry should reconstruct the method of school siting and introduce environmental health impact assessment (EHIA) prior to any construction of the school to determine the best possible decision that will result in less health impact to children. Moreover, by making EHIA as mandatory as environmental impact assessment (EIA), short-term and long-term effect towards the student who attends the school can be measure and assess. Therefore, suitable mitigating plans may be established to overcome any health problem that may arise from the exposure of school children to TRAP.

Plus, improvement in terms of ventilation in school that sitting near the heavy roadway is required. Most of the student spend a quarter of their day at school in their classroom. From this study, it was proven that most of the pollution came from outdoor which most probably was from traffic due to the distance of the classroom to the roadway was near. One of the systems that can be implemented for school in Malaysia is by installing Heating, Ventilation and Air-Conditioning (HVAC) system. It was proven in one of the studies conducted by Wargocki *et al.*, (2010) that improvement for indoor air quality not just preventing children from exposure to high pollutants that may affect their health, it also helps the student to improve their performance.

Last but not least, in order to respond to this emerging issue, an action plan need to be formed for implementing a public health response and for reinforcing existing action plan such as action plan from National Environmental Health Action Plan (NEHAP). This action plan must incorporate health literacy improvements such as planning,

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implementation and evaluation. Thus, this action plan is not a short-term plan. This action plan also needs to collaborate with health professionals and the public so that it will be a multi-level involvement from the various part. Lastly, periodically update of specific guidelines in association with this field of research is strongly recommended.

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APPENDIX 1: GANTT CHART

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No	Activities	2018				2019					
		Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
1	Proposal Preparation										
2	Ethic Application										
3	Pre-Study										
4	Proposal Presentation										
5	Site Visit										
6	Data Collection (Air Sampling Assessment & Physiological Assessment										
7	Data Analysis										
8	Data Interpretation										
9	Thesis Writing										
10	VIVA										
11	Thesis Review										
12	Thesis Submission										

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APPENDIX 2:

MOE

APPROVAL

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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(2626)
Tarikh : 17 Disember 2018

MUHAMMAD AFIF MOHD JUHARI
NO. KP : 960813035365

LOT PT 166, JALAN MAHMOOD
PASIR MAS 17000 PASIR MAS
KELANTAN

Tuan,

KELULUSAN BERSYARAT UNTUK MENJALANKAN KAJIAN :
ASSOCIATION BETWEEN TRAFFIC-RELATED AIR POLLUTION AND LUNG FUNCTION RESPIRATORY SYMPTOMS AMONG PRIMARY SCHOOL CHILDREN IN KLANG VALLEY, SELANGOR, MALAYSIA.

Perkara di atas adalah dirujuk.

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

" SILA MOHON KEBENARAN IBUBAPA DAN PENTADBIR SEKOLAH BAGI MELAKSANAKAN KAJIAN "

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 **1 Februari 2019** hingga **1 Julai 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 SELANGOR
JABATAN PENDIDIKAN WILAYAH PERSEKUTUAN KUALA LUMPUR

* SURAT INI DIJANA OLEH KOMPUTER DAN TIADA TANDATANGAN DIPERLUKAN *

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APPENDIX 3: ETHICAL COMMITTEE APPROVAL

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

Research title	:	**Association Between Traffic-Related Air Pollution, Lung Function And Respiratory Smptoms Among Primary School Children in Klang Valley, Selangor, Malaysia**
Study Site	:	**Klang Valley**
JKEUPM Ref No.	:	**JKEUPM-2018-381**
Researcher	:	**Muhammad Afif bin Mohd Juhari**
Supervisor	:	**Assoc Prof. Dr. Juliana Jalaludin**

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 29/10/2018
2. Respondent Information Sheet & Guardian's/Parent's Consent (Malay), Version 3 dated 10/1/2019
3. Proposal (English), Version 2 dated 14/12/2018
4. Questionnaires/ Interviews (Malay), Version 1 dated 29/10/2018
5. Curriculum Vitae of:
    a. Assoc Prof. Dr. Juliana Jalaludin

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

Decision by JKEUPM:

[X] Approved

[ ] **Permission MUST BE OBTAINED from the respective hospitals/ institutions before conducting the research**

[ ] Disapproved

Please note that the approval is **VALID UNTIL 16 JANUARY 2020**

Researchers should comply with the following:

I. Complete a Study Final Report upon study completion (Form 3.2).

II. Ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.

III. Applicable for Clinical Trial Studies and Clinical interventional Studies only: Progress Report has to be submitted to JKEUPM at every 6 months from the date of approval (Form 3.1). Report

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APPENDIX 4:
CONSENT
FORM

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

FORM 2.5: RESPONDENT'S INFORMATION SHEET AND GUARDIAN'S/PARENT'S CONSENT

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

1. STUDY TITLE:

Association Between Traffic-Related Air Pollution, Lung Function and Respiratory Symptoms Among Primary School Children in Klang Valley, Selangor, Malaysia.

2. INTRODUCTION:

The purpose of this study is to help us determine there is an association between urban traffic related air pollution with lung function and respiratory health among primary school children in Klang Valley, Selangor. This study will also help us in identifying the concentration of Traffic-Related Air pollutants (VOC, PM10, PM2.5, NO2, CO) at schools' whether it is nearby heavy traffic density area or low traffic density area. By conducting this study, it will help to identify the risk factor that contribute to the respiratory problem among school children in Klang Valley, difference between the respiratory symptoms among primary school children with primary school in heavy traffic density area (exposed group) and primary school in low traffic density area (comparative group), lung function status between child in exposed group and in control group and lastly identify association between traffic-related air pollutants (PM10, PM2.5, NO2, CO, VOC) and respiratory symptoms among study respondents.

3. WHAT WILL YOU HAVE TO DO?

Respondents are required to read and understand the details in this Description Form. If respondent voluntarily agree to participate in this study, the respondent must fill in and sign the agreement on the page 3. The parent / guardian description and consent form must be returned upon completion

Parents/ guardian of respondents are required to fill out a questionnaire on child and family information, home environment information, child health information, related disease information and family health history. The child's lung function, height measurements and weight measurements will be taken during school hours at each school.

This measurement only will be done with the presence of teacher or any school personnel. The child's lung function assessment, height and weight measurements will be conducted by a medical assistant at the school. No interaction with the children will take place without the presence of teachers or school personnel.

Your children's involvement in this study is voluntary. Parents/guardian have the right to withdraw from this study and there will be no penalties imposed upon withdrawals.

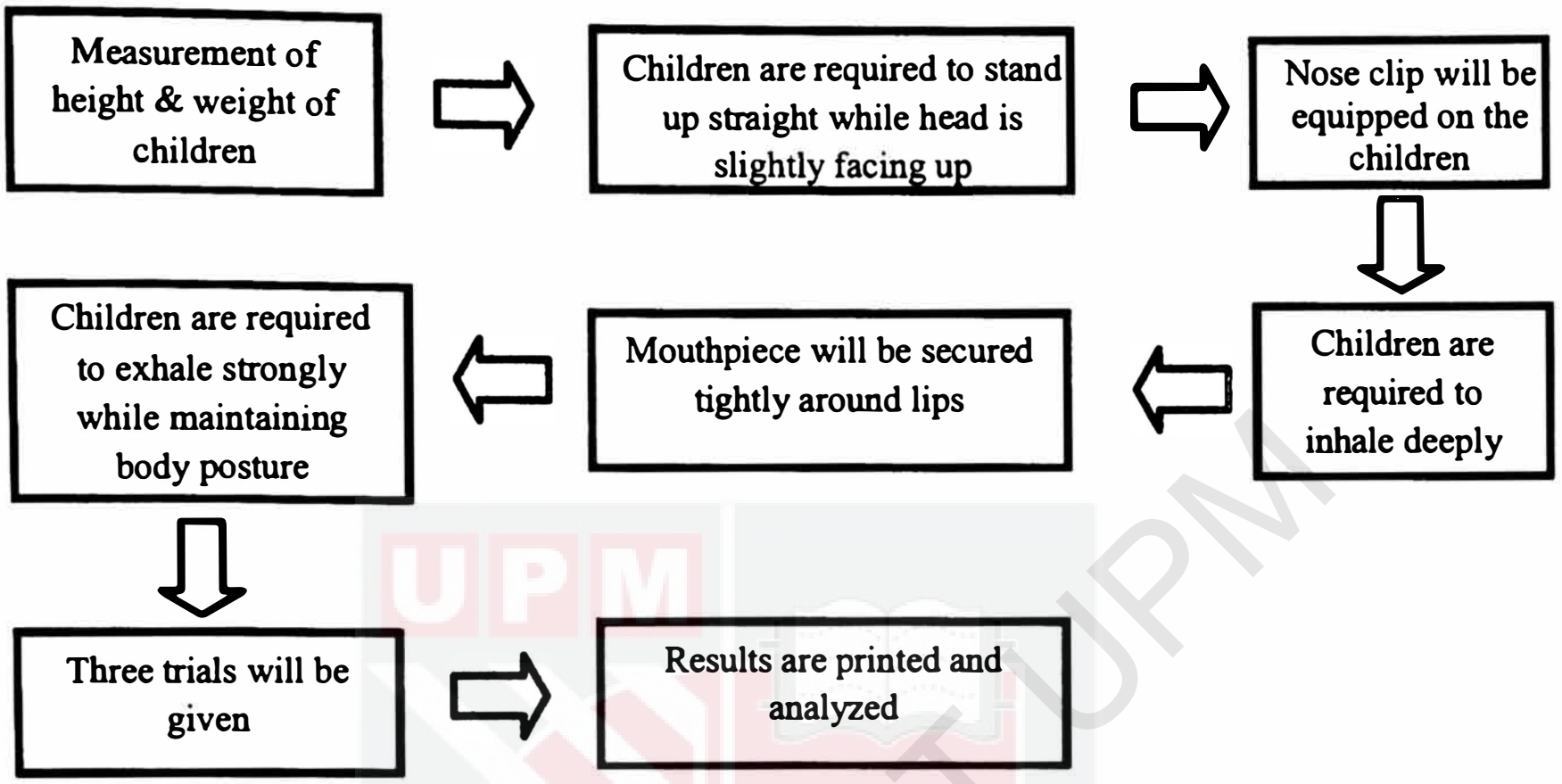


Figure 1: Spirometry Test Procedures
(Source: American Thoracic Society)

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

1. Children aged less than 7 years old
2. Children aged over 11 years old or in examination year (UPSR)
3. Children who is non- Malaysian citizen
4. Children who have a history of past respiratory illness

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO RESPONDENT?

This study will explain whether the status of air quality in the vicinity of traffic can cause problems to the respiratory system or not to primary school children. If the concentrations of air pollutants are high and may affect the respondents, further action can be taken based on the results of this study. Additionally, this study will help you to determine the best way to prevent early respiratory illness among family members especially on children if the air quality related to the traffic and the ambient air and the interior are not satisfactory. However, there is no direct benefit to respondents and, some token of appreciation will be given for the respondent's participation.

(b) TO RESEARCHER?

The result of this study will provide information on the level of lung function of children living in high traffic density and low traffic density, level of Particulate Matter (PM), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO) and Volatile Organic Compound (VOC). The findings will also provide basic information to future researchers and serve as a guide to address traffic related air pollution and mitigating measures that can be done.

6. WHAT ARE THE POSSIBLE RISKS?

This study possesses a very low risk because it only involves measurement of lung function, height and weight. Moreover, mouthpiece used will be discarded upon usage and new mouthpiece will be used for different respondents for hygiene purposes and to avoids unnecessary contamination.

7. WILL IDENTITY & INFORMATION PROVIDED REMAIN CONFIDENTIAL?

Any information about the respondents is confidential and will only be used for academic purposes only. The researcher will not disclose the name and any other details to the other party.

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

If you have any questions, you may contact:

(a) Research Supervisor : Prof. Madya Dr. Juliana Jalaludin
(H/P No: 017-6834103)
(No. Pejabat: 03-89472401)

(b) Researcher : Muhammad Afif Bin Mohd Juhari
(H/P No: 018-7779552)
(Email: afifmjuhari@gmail.com)

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

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9. GUARDIAN'S/PARENT'S CONSENT

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

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

I* wish / do not wish to know the results related to my *son's / daughter's / ward's participation in the research

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

* delete where necessary

Signature ..... Signature .....
(*Parent/Guardian*) (*Witness*)

Date :..... Name :.....

I/C No. :.....

I confirm that I have explained to the respondent's parent/guardian the nature and purpose of the above-mentioned research.

Date ..... Signature .....
(*Researcher*)

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APPENDIX 5:
QUESTIONNAIRE

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

BORANG SOAL SELIDIK

TAJUK:

Penilaian Genotoksisiti dan Pengubahsuaian Epigenetik dalam Kalangan Kanak-kanak Sekolah yang Terdedah kepada Pencemaran Udara Berkaitan Trafik di Lembah Klang

TARIKH SOAL SELIDIK DILENGKAPKAN:

□□/□□/□□□□
Hari Bulan Tahun

TARIKH PERSAMPELAN (diisi oleh penyelidik):

□□/□□/□□□□
Hari Bulan Tahun

Tandakan √ pada yang berkenaan

SOAL SELIDIK DILENGKAPKAN OLEH:

1. Ibu kanak-kanak □
2. Bapa kanak-kanak □
3. Penjaga kanak-kanak. Nyatakan. _____ □

Terima kasih atas kesudian anda untuk menyertai penyelidikan saintifik ini. Kerjasama anda untuk memberikan jawapan yang jujur dan tepat amat diperlukan bagi menjayakan kajian ini. Selepas mengisi soal selidik ini, anda dikehendaki mengembalikan soal selidik dalam sampul yang diberikan serta menurunkan tandatangan di atas pembuka sampul yang telah digam pada belakang sampul tersebut.

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BAHAGIAN A: BUTIRAN DIRI (KANAK-KANAK DAN WARIS)

A1. BUTIRAN DIRI KANAK-KANAK

1. Jantina : a. Lelaki ☐ b. Perempuan ☐

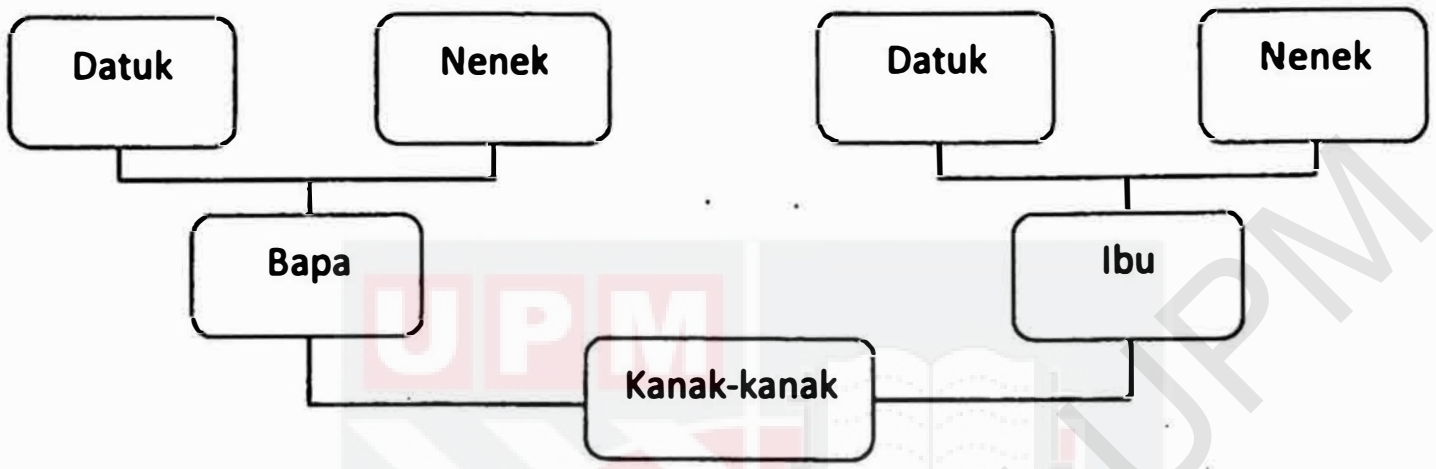
2. Tarikh Lahir : _____ (Hari/Bulan/Tahun)

3. Sudah berapa lama tinggal di alamat sekarang : ☐☐ tahun ☐☐ bulan

4. Tahun berdaftar di sekolah ini : ☐☐☐☐

5. Keturunan **(sila isikan di dalam petak di bawah)**

   Melayu: **M** Cina : **C** India: **I** Lain lain: **O**



A2. BUTIRAN DIRI WARIS (sila isikan yang berkenaan untuk yang masih hidup sahaja)

1. Pendidikan Bapa/Penjaga Lelaki
   - a. Tidak Bersekolah ☐
   - b. Sekolah Rendah ☐
   - c. Tingkatan 3 ☐
   - d. Tingkatan 5 ☐
   - e. Sijil ☐
   - f. STPM/Diploma ☐
   - g. Ijazah ☐
   - h. Sarjana ☐
   - i. Doktor Falsafah ☐
   - j. Lain-lain. Nyatakan _____ ☐

2. Pendidikan Ibu/Penjaga Perempuan
   - a. Tidak Bersekolah ☐
   - b. Sekolah Rendah ☐
   - c. Tingkatan 3 ☐
   - d. Tingkatan 5 ☐
   - e. Sijil ☐
   - f. STPM/Diploma ☐
   - g. Ijazah ☐
   - h. Sarjana ☐
   - i. Doktor Falsafah ☐
   - j. Lain-lain. Nyatakan _____ ☐

3. Pekerjaan Bapa/Penjaga Lelaki
   - a. Majikan ☐
   - b. Kakitangan Kerajaan ☐
   - c. Kakitangan Swasta ☐
   - d. Bekerja Sendiri ☐
   - e. Tidak Bekerja ☐
   - f. Pesara ☐

4. Pekerjaan Ibu/Penjaga Perempuan
   - a. Majikan ☐
   - b. Kakitangan Kerajaan ☐
   - c. Kakitangan Swasta ☐
   - d. Bekerja Sendiri ☐
   - e. Tidak Bekerja ☐
   - f. Pesara ☐

5. Anggaran pendapatan kasar sebulan
   - a. Bapa/Penjaga Lelaki RM _____
   - b. Ibu/Penjaga Perempuan RM _____

BAHAGIAN B: STATUS KESIHATAN

	YA	TIDAK
1. Adakah kanak-kanak ini pernah menjalani rawatan di bawah dalam tempoh berkenaan:		
a) Kemoterapi (dalam tempoh 6 bulan lepas)	☐	☐
b) Radioterapi (dalam tempoh 6 bulan lepas)	☐	☐

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	YA	TIDAK
c) X-ray (dalam tempoh 3 bulan lepas)		
d) Lain-lain. Nyatakan: _____		
2. Adakah kanak-kanak ini menghidap penyakit kronik? **Jika YA, sila nyatakan:** _____		
3. Adakah ahli keluarga terdekat (ibu, bapa, adik-beradik, atuk, nenek) menghidap penyakit kronik? **Jika YA, sila nyatakan:**		

Penyakit: _____ **Siapa:** _____

BAHAGIAN C: SEJARAH KESIHATAN RESPIRATORI

C1. BATUK

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

C2. KAHAK

		YA	TIDAK
1.	Adakah anak anda kerap mengalami sesak nafas atau mengeluarkan kahak berserta selesema? **Jika YA sila jawab soalan seterusnya.**		
2.	Adakah anak anda mengalami sesak nafas dan mengeluarkan kahak pada kebanyakan hari (≥ 4 hari dalam seminggu) selama 3 bulan berturut-turut dalam setahun?		
3.	Sudah berapa tahunkah anak anda mengalami kahak seperti ini?		tahun
4.	Adakah anak anda pernah mengalami serangan batuk, sesak nafas atau berkahak selama seminggu atau lebih dalam masa setahun yang lalu?		
5.	**Jika YA (Soalan 4),** sudah berapa lamakah masalah ini berlaku?		

C3. DADA BERBUNYI

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

C4. KESAKITAN DADA

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

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

C6. PENYAKIT-PENYAKIT LAIN

Adakah anak anda mempunyai penyakit-penyakit seperti di bawah? **Jika YA**, pada umur berapakah penyakit itu dikesan?	YA	TIDAK	Umur dikesan
a) Campak			
b) Bronkitis (radang paru-paru)			
c) Emfisema (paru-paru mengembang dan rosak)			
d) Asma (lelah/semput)			
e) Pneumonia (jangkitan paru-paru)			
f) Ekzema (gatal kulit)			

BAHAGIAN D: PENDEDAHAN KEPADA ASAP ROKOK

		YA	TIDAK
1.	Adakah ahli keluarga yang tinggal di rumah anda/pengasuh anak anda seorang perokok? **Jika YA,** sila nyatakan siapa: _____		
2.	Dalam tempoh 7 hari lepas, di manakah lokasi pendedahan asap rokok kepada anak anda?		
	a) Di dalam/luar rumah sendiri		
	b) Di dalam kereta sendiri		
	c) Di dalam kenderaan awam/orang lain		
	d) Di kawasan luar		
	e) Di rumah saudara/kenalan		
	f) Di rumah pengasuh/pusat jagaan kanak-kanak		
	g) Lain-lain. Sila nyatakan: _____		
	h) Anak saya tidak terdedah kepada asap rokok		

BAHAGIAN E: PERSEKITARAN RUMAH

1. Apakah jenis rumah yang didiami sekarang?
   a) Teres ☐ d) Flat ☐ g) Kampung ☐
   b) Berkembar (*Semi-D*) ☐ e) Pangsapuri ☐ h) Lain-lain. Nyatakan: ☐
   c) Banglo ☐ f) Kondominium ☐
   _____

2. Di manakah lokasi perumahan anda?
   a) Bandar ☐ b) Sub-bandar ☐ c) Luar Bandar ☐

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

4. Berapakah anggaran keluasan tempat kediaman anda? _____

5. Bahan apakah yang digunakan dalam pembinaan rumah anda?
   a) Batu-bata ☐ c) Konkrit ☐ d) Lain-lain. Nyatakan: ☐
   b) Papan ☐
   _____

6. Adakah sebahagian daripada rumah anda dicat dalam tempoh 12 bulan yang lepas? Ya ☐ Tidak ☐

7. Adakah lantai rumah anda baru ditukar sejak 12 bulan yang lepas? Ya ☐ Tidak ☐

8. Adakah terdapat binatang peliharaan di dalam kediaman anda? Ya ☐ Tidak ☐
Jika YA, apakah binatang itu? Nyatakan: _____

9. Berapakah bilangan bilik yang terdapat di dalam rumah anda? ____ bilik

10. Berapakah bilangan orang yang tinggal di dalam rumah anda? ____ orang

11. Kanak-kanak ini tidur/tinggal di dalam bilik
a) sendiri ☐ c) berkongsi dengan 2 orang ☐
b) berkongsi dengan 1 orang ☐ d) berkongsi dengan ≥ 3 orang ☐

12. Apakah bahan api yang digunakan untuk memasak di dalam rumah anda?
a) Elektrik ☐ c) Minyak Tanah ☐ e) Arang ☐
b) Gas ☐ d) Kayu Api ☐ f) Lain-lain. Nyatakan: _____ ☐

13. Berapa kali dalam sehari anda menggunakan bahan api di atas untuk memasak? ____ kali

14. Adakah anda menggunakan alat penyedut asap di dapur? Ya ☐ Tidak ☐

15. Semasa memasak, adakah anda membuka tingkap atau pintu untuk membenarkan pengaliran udara di dalam rumah? Ya ☐ Tidak ☐

16. Apakah alat yang digunakan untuk menyejukkan udara di dalam rumah?
a) Penyaman Udara ☐ b) Kipas ☐ c) Lain-lain. Nyatakan: _____ ☐

17. Adakah anda menggunakan bahan tertentu untuk mengelakkan serangan nyamuk? Ya ☐ Tidak ☐

18. **Jika YA,** apakah jenis yang selalu digunakan?
a) Lingkaran biasa ☐ c) Semburan aerosol ☐
b) Elektrik ☐ d) Lain-lain. Nyatakan _____ ☐

19. Berapa banyakkah kuantiti yang digunakan untuk setiap malam? ____

20. Di manakah bahan penghalau nyamuk digunakan di dalam rumah?
a) Ruang tamu ☐ b) Bilik tidur ☐ c) Lain-laln. Nyatakan: _____ ☐

21. Apakah alat yang digunakan untuk membersihkan rumah anda? _____

22. Berapa kerapkah anda membersihkan rumah anda dalam seminggu? ____ kali

23. Adakah anda menggunakan karpet di rumah anda? Ya ☐ Tidak ☐

24. Adakah anda menggunakan sebarang wangian di rumah anda? Ya ☐ Tidak ☐

25. **Jika YA,** nyatakan jenis pewangi:
a) Semburan ☐ b) Cairan ☐ c) Ketulan ☐

26. Nyatakan di mana anda menggunakan pewangi tersebut di rumah anda. _____

27. Nyatakan kekerapan penggunaan pewangi tersebut dalam seminggu. ____ kali

28. Adakah anda meletakkan ubat gegat di dalam almari pakaian anak anda? Ya ☐ Tidak ☐

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29. Lokasi rumah dari kilang:
a) < 2.5 km dari kilang ☐
b) 2.5 – 4.9 km dari kilang ☐
c) ≥ 5 km dari kilang ☐

30. Lokasi rumah dari stesen janakuasa elektrik:
a) < 2.5 km dari stesen janakuasa ☐
b) 2.5 – 4.9 km dari stesen janakuasa ☐
c) ≥ 5 km dari stesen janakuasa ☐

31. Apakah pendapat anda mengenai persekitaran di rumah anda?
a) Sangat berhabuk ☐ b) Sederhana berhabuk ☐ c) Kurang berhabuk ☐

32. Adakah anda kerap melakukan pembakaran terbuka di luar rumah seperti membakar daun-daun kering? Ya ☐ Tidak ☐

33. Jika YA, berapa kerapkah anda melakukan aktiviti pembakaran tersebut?
a) Hampir setiap hari ☐ b) Sekali seminggu ☐ c) Sekali sebulan ☐

BAHAGIAN F: TABIAT PEMAKANAN ANAK ANDA SEKARANG

Kekerapan (Isikan dengan 1x, 2x, 3x, >3x)	Sekali (1x), 2 Kali (2x), 3 Kali (3x), Lebih 3 Kali (>3x)			
	Tidak Pernah	Sehari	Seminggu	Sebulan
1. Berapa kerapkah anak anda makan daging?				
2. Berapa kerapkah anak anda makan ikan? Nyatakan jenis ikan._____				
3. Berapa kerapkah anak anda makan makanan laut? Nyatakan jenis makanan laut._____				
4. Berapa kerapkah anak anda makan buah-buahan? Nyatakan jenis buah. _____				
5. Berapa kerapkah anak anda makan ulam-ulaman?				
6. Berapa kerapkah anak anda makan sayur yang dimasak? Nyatakan jenis sayur. _____				
7. Berapa kerapkah anak anda minum susu?				
8. Berapa kerapkah anak anda mengambil makanan tenusu? (yogurt, keju, dan lain-lain)				
9. Berapa kerapkah anak anda makan makanan segera? (burger, pizza, hotdog, nugget, dan lain-lain)				
10. Berapa kerapkah anak anda minum jus buah-buahan?				
11. Berapa kerapkah anak anda minum air bergas?				
12. Berapa kerapkah anak anda mengambil makanan tambahan seperti vitamin atau jus kesihatan? Nyatakan. _____				
13. Berapa kerapkah anak anda makan masakan panggang yang menggunakan arang? (ayam, daging, dan lain-lain)				

13. Apakah jenis minyak masak yang sering digunakan di rumah anda?
a) Minyak kelapa sawit ☐ c) Minyak jagung ☐ e) Mentega ☐
b) Minyak sayuran ☐ d) Marjerin ☐ f) Lain-lain. Nyatakan: ☐

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BAHAGIAN G: PENDEDAHAN TERHADAP PENCEMARAN UDARA TRAFIK DI KAWASAN RUMAH

1. Apakah kenderaan yang paling kerap digunakan oleh anak anda untuk ke sekolah?

a) Kereta ☐
b) Bas ☐
c) Basikal ☐
d) Motosikal ☐
e) Van ☐
f) Berjalan kaki ☐

2. Berapa lamakah masa diambil untuk anak anda pergi ke sekolah? _____ minit

3. Lokasi rumah dari jalan utama:

a) < 100 m dari jalan utama ☐
b) 100 – 199 m dari jalan utama ☐
c) 200 – 299 m dari jalan utama ☐
d) 300 – 399 m dari jalan utama ☐
e) 400 – 499 m dari jalan utama ☐
f) ≥ 500 m dari jalan utama ☐

4. Lokasi rumah dari lebuhraya:

a) < 100 m dari lebuhraya ☐
b) 100 – 199 m dari lebuhraya ☐
c) 200 – 299 m dari lebuhraya ☐
d) 300 – 399 m dari lebuhraya ☐
e) 400 – 499 m dari lebuhraya ☐
f) ≥ 500 m dari lebuhraya ☐

Sila tandakan yang berkenaan.

	Tidak Pernah	Jarang	Kerap	Berterusan
5. Sekiranya anak anda ke sekolah menaiki kereta, bas atau van, adakah tingkap kenderaan tersebut dibuka semasa kenderaan bergerak?				
6. Adakah kawasan tempat tinggal anda mengalami kesesakan lalu lintas kereta?				
7. Adakah kawasan tempat tinggal anda mengalami kesesakan lalu lintas lori?				
8. Adakah kawasan tempat tinggal anda mengalami pencemaran bunyi disebabkan kesesakan lalu lintas?				
9. Adakah asap hitam daripada kenderaan dapat dilihat di kawasan rumah anda?				
10. Adakah anda menghidu bau asap daripada kenderaan di kawasan rumah anda?				
11. Adakah pencemaran udara trafik yang dilepaskan daripada kenderaan di kawasan rumah anda memberi kesan kesihatan kepada anak anda?				

Kekerapan (Isikan dengan < 50 / 50 - 99 / 100 - 499 / ≥ 500)	< 50 / 50 - 99 / 100 - 499 / ≥ 500	
	Hari bekerja	Hari minggu
12. Berapakah anggaran bilangan kereta yang lalu di kawasan tempat tinggal anda?		
13. Berapakah anggaran bilangan bas yang lalu di kawasan tempat tinggal anda?		
14. Berapakah anggaran bilangan lori yang lalu di kawasan tempat tinggal anda?		
15. Berapakah anggaran bilangan motosikal yang lalu di kawasan tempat tinggal anda?		

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