UNIVERSITI PUTRA MALAYSIA

ASSOCIATION BETWEEN TRAFFIC-RELATED AIR POLLUTIONS (TRAPS) WITH AIR QUALITY PERCEPTION AND RESPIRATORY SYMPTOMS AMONG PEDESTRIAN AND CYCLISTS IN UNIVERSITI PUTRA MALAYSIA

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BY

MOHAMAD FADHIL BIN ZAKARIA

Thesis submitted in fulfillment 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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ABSTRACT

ASSOCIATION BETWEEN TRAFFIC-RELATED AIR POLLUTIONS (TRAPS) WITH AIR QUALITY PERCEPTION AND RESPIRATORY SYMPTOMS AMONG PEDESTRIAN AND CYCLISTS IN UNIVERSITI PUTRA MALAYSIA

MOHAMAD FADHIL BIN ZAKARIA

Introduction: Air pollution has recently received greater attention as a cause of respiratory disease, and research has shown that air pollutants and traffic in urban areas lead to the occurrence and worsening of respiratory diseases especially for those with active transport like cyclists and pedestrian when ventilation take into accounts. **Objectives**: To determine an association between traffic-related air pollutions with air quality perception and respiratory symptoms among pedestrian and cyclists in Universiti Putra Malaysia UPM campus. **Methodology**: A self-administered, validated and pre-tested questionnaire was used to collect data on sociodemographic, air quality perception and respiratory health symptoms in a university campus from January to March 2018 among pedestrian (N=90) and cyclists (N=90). Air quality assessment was conducted in three different roads around UPM including Jalan Alpha, Jalan Alpha-Kolej 2 and Jalan Universiti 1. All measurements were taken during three-time rush hour (morning, afternoon and evening) which include parameters of $PM_{2.5}$, PM_{10} and ozone (O_3) simultaneously with traffic count. **Results and Discussion:** Among 180 respondents, 89 (49.4%) of respondents believed that air quality was better than six months ago. The results of this study reveal that the study roads in UPM suffer with high concentration of air pollutants (PM_{10} = 83.8 μg/m^3; $PM_{2.5}$ = 48.9 μg/m^3; O_3 = 314.9 μg/m^3) during rush hour which exceeded the 1-hour and 24-hour standards. Most of respondents (52.8%) indicated that old vehicles and too many private vehicles were the major contributor of air pollution. Most of respondents agreed with initiatives that carpooling, reducing number of private vehicles, improving the facilities of pedestrian and cyclists' lane and also walking and cycling to class could reduce air pollution emission from vehicles. Traffic volume was significantly corelated with the traffic-related air pollutants (PM_{10}, $PM_{2.5}$ and O_3). Most of the pollutants were significantly associated with all six respiratory health symptoms (p = 0.001). **Conclusion**: The finding concluded that air quality in UPM campus was good. Old vehicles and too many private vehicles were the main contributor of air pollution. The highest concentration of air pollutants (PM_{10}, $PM_{2.5}$ and O_3) was recorded in Jalan Alpha – kolej 2 and Jalan Universiti 1. Therefore, the findings from this study suggest the need for the university management to improve air quality and facilities, to more effectively and efficiently control and reduce traffic air pollution in UPM campus.

Keywords: traffic-related air pollutions, air quality perception, respiratory health symptoms

ABSTRAK

HUBUNGKAIT ANTARA PENCEMARAN UDARA BERKAITAN LALU LINTAS DENGAN PERSEPSI KUALITI UDARA DAN GEJALA PERNAFASAN DALAM KALANGAN PEJALAN KAKI DAN PENUNGGANG BASIKAL DI UNIVERSITI PUTRA MALAYSIA (UPM)

MOHAMAD FADHIL BIN ZAKARIA

Pengenalan: Pencemaran udara baru-baru ini mendapat perhatian yang lebih besar sebagai penyebab penyakit penafasan, dan penyelidikan menunjukkan bahawa pencemaran udara yang berkaitan dengan lalu lintas di kawasan bandar menyebabkan terjadinya penyakit penafasan terutama bagi mereka yang menggunakan pengangkutan aktif seperti penunggang basikal dan pejalan kaki jika penafasan diambil kira. **Objektif:** Untuk menentukan hubung kait antara pencemaran udara yang berkaitan dengan lalu lintas dengan persepsi kualiti udara dan gejala-gejala kesihatan penafasan dalam kalangan pejalan kaki dan penunggang basikal di Universiti Putra Malaysia (UPM). **Metodologi:** Satu soal selidik yang diselia sendiri, disahkan dan disemak telah digunakan untuk mengumpul data mengenai simptom sosiodemografi, kualiti udara dan gejala pernafasan di kampus universiti dari Januari hingga Mac 2018 di kalangan pejalan kaki (N=90) dan penunggang basikal (N=90). Penilaian kualiti udara dijalankan di tiga jalan yang berlainan di sekitar UPM termasuk Jalan Alpha, Jalan Alpha-Kolej 2 dan Jalan Universiti 1. Semua ukuran telah diambil pada tiga waktu puncak (pagi, petang dan malam) termasuk parameter $PM_{2.5}$, PM_{10} dan ozon (O_3) serentak dengan jumlah lalu lintas. **Keputusan dan Perbincangan:** Antara 180 responden, 89 (49.4%) responden percaya kualiti udara lebih baik dari enam bulan yang lepas. Keputusan kajian ini menunjukkan bahawa jalan kajian di UPM mengalami kepekatan tinggi bahan pencemar udara (PM_{10}=83.8 µg/m^3; $PM_{2.5}$=48.9 µg /m^3; O_3=314.9 µg/m^3) semasa waktu puncak yang melebihi piawai 1 jam dan 24 jam . Kebanyakan responden (52.8%) menunjukkan bahawa kenderaan lama dan terlalu banyak kenderaan persendirian merupakan penyumbang utama terhadap pencemaran udara. Kebanyakan responden bersetuju dengan inisiatif yang kongsi kenderaan, mengurangkan bilangan kenderaan persendirian, memperbaiki kemudahan laluan pejalan kaki dan basikal dan juga berjalan dan berbasikal ke kelas dapat mengurangkan pelepasan bahan pencemar udara dengan ketara. Jumlah lalu lintas berkait rapat dengan pencemaran udara berkaitan lalu lintas. Kebanyakan bahan pencemar itu dikaitkan dengan kesemua enam gejala kesihatan pernafasan (p=0.001). **Kesimpulan:** Hasil kajian menyimpulkan bahawa kualiti udara di kampus UPM adalah baik. Kenderaan lama dan terlalu banyak kenderaan persendirian merupakan penyumbang utama kepada pencemaran udara. Pencemaran udara tertinggi (PM_{10}, $PM_{2.5}$ dan O_3) dicatatkan di Jalan Alpha – Kolej 2 dan Jalan Universiti 1. Justeru, penemuan kajian ini mencadangkan keperluan pengurusan universiti untuk meningkatkan mutu udara dan kemudahan, untuk mengawal dan mengurangkan pencemaran udara di kampus UPM dengan lebih berkesan dan cekap.

Kata Kunci: pencemaran udara berkaitan lalu lintas, persepsi terhadap kualiti udara, gejala-gejala kesihatan pernafasan.

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LIST OF ABBREVIATIONS

<	Less than
>	More than
$\mu g/m^3$	Microgram per metre cube
ATS	American Thoracic Society
AQP	Air Quality Perception
CDC	Centers for Disease Control
CI	Confidence Interval
CO	Carbon Monoxide
COPD	Chronic Obstructive Pulmonary Disease
CO_2	Carbon Dioxide
DOSH	Department of Occupational Safety and Health
IQR	Interquartile Range
IUATLD	International Union Against Tuberculosis and Lung Diseases
IARC	International Agency Research on Cancer
km	Kilometre
m	Metre
MAPI	Malaysian Air Pollution Index
MOE	Ministry of Education
NIOSH	National Institute of Occupational Safety and Health
NIESH	National Institute of Environmental Health Sciences
NO_X	Nitrogen Oxides
OR	Odd Ratio
O_3	Ozone
$PM_{2.5}$	Particulate matter with up to 2.5 micrometres aerodynamic diameter
PM_{10}	Particulate matter with up to 10 micrometres aerodynamic diameter
ppb	Parts per billion
ppm	Parts per million

POR	Prevalence Odd Ratio
PR	Prevalence Rate
RMAQG	Recommended Malaysian Air Quality Guideline
RTI	Respiratory Tract Infection
SD	Standard Deviation
SPSS	Statistical Package for Social Science
TRAPS	Traffic-Related Air Pollutions
UPM	Universiti Putra Malaysia
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

Air quality plays an important role in the quality of life, affecting humans' health and also welfare. Poor air quality is closely related to adverse health effects or even premature death, especially of individuals who are susceptible such as children and elderly (WHO, 2016). A World Health Organization (WHO) report in order to promote health and well-being, how much and in what ways that improving environment can contribute to those items. Pruss-Ustun *et al.* (2016), stated that 23% of global death in children aged below five years could have prevented if environmental risks able to manage or change.

Air quality is a main contributor of the environmental risks including air, water, soil quality and climate change. Household and ambient air pollution (WHO, 2016) are linked with diseases such as respiratory infections, asthma, chronic obstructive pulmonary disease, cardiovascular diseases, cancers, tuberculosis, neonatal conditions, as well as mental, behavioural and neurological disorders. This is line with the study conducted by Pruss-Ustun *et al.* (2016), where all of those diseases contribute to the environmental burden of the disease in 2012 which exceeded 46% worldwide.

Several epidemiological studies' reviews or meta-analyses have demonstrated the adverse effects of air quality on human health like respiratory disease, coronary heart disease, cerebrovascular disease and lung cancer (Kim *et al.*, 2013; Shah *et al.*, 2015; Zheng *et al.*, 2015). In Southern European areas, the findings suggest among numerous of studies, increased risk association of particulate matter (PM) and respiratory disease, cerebrovascular disease and lung cancer (Beelen *et al.*, 2014; Faustini *et al.*, 2013) for nitrogen oxides (NO_x) and coronary heart disease and cerebrovascular disease (Katsoulis *et al.*, 2014) and for ozone (O_3) and mortality, which is during heat waves episodes (Analitis *et al.*, 2014). Other studies have reported that air quality especially from traffic-related factors influence not only respiratory disease like asthma, but also occurrence of the allergic diseases (C. Lee *et al.*, 2015; Jung *et al.*, 2015) although some studies did not find the association (Bowatte et al., 2015)

The main concern is focusing on traffic-related air pollutant exposures to the street users during active transportation which including walking and cycling whereby linked to adverse health effects and associated with of increased mortality (Macnaughton, Melly, Vallarino, Adamkiewicz, & Spengler, 2014). A study in Santa Monica, California found that walking and cycling are associated with highest particle number and $PM_{2.5}$ respiratory exposure than driving (Quiros, Lee, Wang, & Zhu, 2013). Another study by Macnaughton *et al.* (2014), found that the impact of bicycle route type on exposure to pollutants from traffic were to have significantly higher concentrations of black carbon (BC) and nitrogen dioxides in bike lanes than in bike paths. Another similar study in Lisbon, Portugal found that PM concentrations in different cycling routes indicates that using a bicycle commute route of lower traffic intensity showed a reduction in exposure. Therefore, route selection is very significant factor in order to decrease cyclist exposure to air pollutants from traffic. During walking and cycling, the healthy population is not immune to the adverse effects of the PM inhalation. In 2013, PM as a human carcinogenic from group 1 have been declared by the International Agency for Research on Cancer (IARC) from World Health Organization (WHO) (IARC, 2013). This population is at greater risk to nasopharyngeal irritation, acute airway inflammation and decreased in lung function (Cole-hunter *et al.*, 2013; Park, Gilbreath, & Barakatt, 2017) although some studies did not find the association (Jarjour *et al.*, 2013) but few studies suggest further study to determine long-term health effects (Park *et al.*, 2017).

In order to reduce human health risks, several strategies and preventive public health measures have been implemented (Pruss-Ustun *et al.*, 2016). The way people perceive environmental stimuli depends on the people's behavior and also response to the preventive measures, therefore in order to protect public health through adaptation and mitigation measures it is very fundamental to take into account people's perception and behavioural changes (Berry *et al.*, 2011). In the study of Kamp, Leidelmeijer, & Marsman (2003), the sense of air quality, involves subjective perceptions and attitudes which differ among groups and individuals.

Last but not least, exposure to air pollutants can cause respiratory health infection which is the major concern in air quality. Based on National Health Services, respiratory tract infections (RTIs) are any infection of the sinuses, throat, airways or lungs. Therefore, this study aims to explore air quality perception, traffic-related air pollutants level and respiratory health symptoms among pedestrian and cyclists in university campus, UPM.

1.2 Problem Statement

In Malaysia, 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 contribute to outdoor air pollution especially in urban areas (Health Effects Institute, 2010). The anthropogenic sources primarily from the automobile exhaust the ambient air pollutants comprise of carcinogenic and mutagenic compounds and lead to possible health risk among the population especially young adults that are very active outdoor.

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

As mention earlier, the prevalence of respiratory illness such as asthma, allergy and respiratory disease among adult is also high and increases by day. Because of that, monitoring and study of asthma and lung disease have been established around the globe. A project called the International Union Against Tuberculosis and Lung Disease or IUATLD study developed a standardized case definition, questionnaire and methodology, and established databases for tuberculosis and lung disease. The focus has been in improving tuberculosis control and have targeted acute respiratory infections in children and chronic airways diseases in adults and in children (IUATLD, 1995).

Traffic-related air pollution is a major hazard especially in urban areas. The adverse effects of traffic-related air pollution among pedestrian and cyclists is well recognized worldwide, but there are still limited studies in Malaysia. Therefore, it is utmost importance to carry out this study to explore traffic-related air quality perception among them in order to suggest improvement of transportation system in the campus and reducing personal's risk to adverse health effects.

1.3 Study Justification

The purpose of this study is to determine the association between traffic-related air pollutions (TRAPs) with air quality perception and respiratory symptoms among pedestrian and cyclists in Universiti Putra Malaysia. This study will add to knowledge and benefits to the topic.

Since there is less study performed locally studying the perception and respiratory symptoms on traffic-related air pollutions among pedestrian and cyclists in

Malaysia, especially in university campus. Therefore, this study needed to perform in order to reveal and evaluate the exposure of particulate matter (PM_{10}, $PM_{2.5}$), ozone level and air quality perception. This will help to add, widen and diverse the air quality perception. In addition, this study will be able to provide data on the air quality and traffic-related air pollutants in campus area. This data will be used to provide tools for transportation system planners and managers to more explicitly consider the health risks of air pollution in decision making, and for students to make informed choices about their own travel.

Other than that, the participants were university students since they are call to later hold-decision making positions, in both public and private sectors. It is very important to assess the exposure of traffic-related air pollutions in order to reduce the risk of adverse health effects. In a study by Liu *et al.* (2001) found a significant relationship between chronic low-level traffic-related air pollution exposure and neurobehavioral function in exposed adults.

The Green Mandate is one of the important milestones in Universiti Putra Malaysia's towards Green Campaign in order to turn UPM to green campus. This study is relevant because perception's students towards air quality in UPM campus are very helpful and important. We consider this is crucial since students' participation in such university agenda can lead to generate strategies for a better environment.

On the other side, this study also hopefully will give benefit to regulatory bodies. It can be used to identify strategies or intervention by health care professionals for improving the quality and overall health safety of the students.

1.4 Conceptual Framework

The aim of this study was to determine the association between traffic-related air pollution with air quality perception and respiratory symptoms among pedestrian and cyclists in UPM. From the conceptual framework (Figure 1), the studied pollutants are $PM_{2.5}$, PM_{10}, and ozone. Exposure to these pollutants is from the vehicles in campus. There are three main routes of exposure which are; ingestion, inhalation and direct contact. The exposure from inhalation is being highlighted because it is the main route for air pollutants and will give adverse health effect to student's respiratory system.

This research has focused on the perception of traffic pollution and the effect of pollutant to the student's respiratory health, where the exposure level of pollutant through inhalation during peak time was measured by the suitable instruments. The respiratory health air quality perception was assessed and determined by using modified questionnaire from IUALTD and Air Quality Perception (AQP) scale.

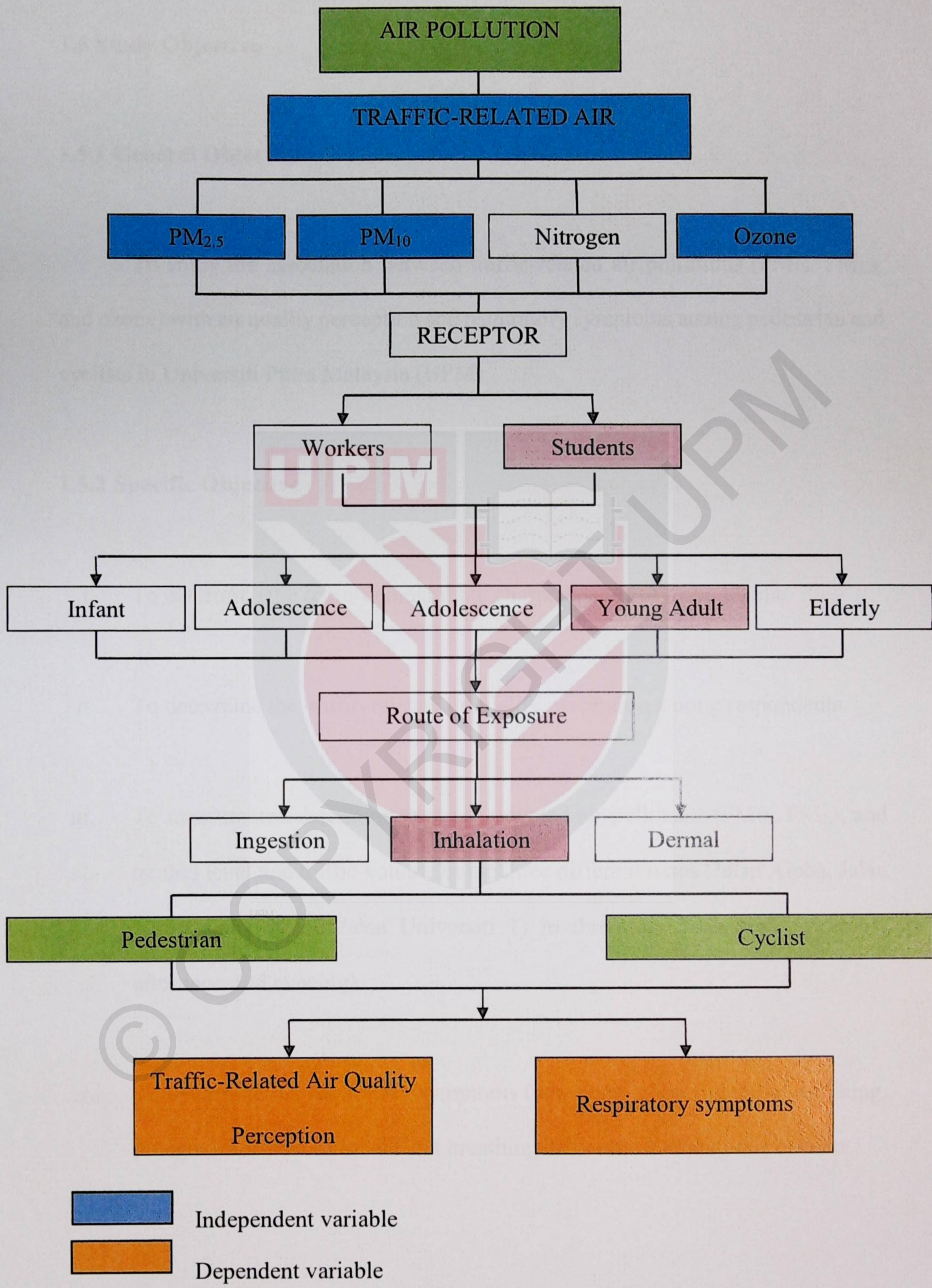

Figure 1: Conceptual framework of research activities

1.5 Study Objective

1.5.1 General Objective

To study the association between traffic-related air pollutions (PM_{10}, $PM_{2.5}$, and ozone) with air quality perception and respiratory symptoms among pedestrian and cyclists in Universiti Putra Malaysia (UPM).

1.5.2 Specific Objective

i. To determine the socio-demographic characteristics of respondents.

ii. To determine the traffic-related air quality perception among respondents.

iii. To measure and determine the traffic-related air pollutants (PM_{10}, $PM_{2.5}$, and ozone) level and traffic volume in the three different roads (Jalan Alpha, Jalan Alpha-Kolej 2 and Jalan Universiti 1) in three-time rush hour (morning, afternoon and evening).

iv. To determine the respiratory symptoms (wheezing, chest tightness, coughing, phlegm, shortness of breath and breathing difficulties) among respondents.

v. To determine the correlation between traffic volume and traffic-related air pollutants (PM_{10}, $PM_{2.5}$, and ozone) level in the three different roads (Jalan Alpha, Jalan Alpha-Kolej 2 and Jalan Universiti 1).

vi. To determine the association between the exposure to PM_{10}, $PM_{2.5}$, and ozone level with traffic-related air quality perception among respondents.

vii. To determine the association between the exposure to PM_{10}, $PM_{2.5}$, ozone level with respiratory symptoms (wheezing, chest tightness, coughing, phlegm, shortness of breath and breathing difficulties) among respondents.

1.6 Study Hypothesis

1. There is a significant correlation between traffic volume and traffic-related air pollutants (PM_{10}, $PM_{2.5}$, and ozone) level in the three different roads (Jalan Alpha, Jalan Alpha-Kolej 2 and Jalan Universiti 1).

2. There is a significant association between the exposure to PM_{10}, $PM_{2.5}$, and ozone level with traffic-related air quality perception among respondents.

3. There is a significant association between the exposure to PM_{10}, $PM_{2.5}$, ozone level with respiratory symptoms (wheezing, chest tightness, coughing, phlegm, shortness of breath and breathing difficulties) among respondents.

1.7 Definition of Variables

1.7.1 Conceptual Definition

Traffic-Related Air Pollution

The principal air quality pollutant emissions from petrol, diesel, and alternative fuel engines are carbon monoxide, oxides of nitrogen, un-burnt hydrocarbons and particulate matter. It includes nitrogen oxides (NOx), particulate matter (PM), hydrocarbon (HC) and carbon monoxide (CO). (Vehicle Certification Agency, 2017).

Perception

Perception can be defined as important component of behavior change and plays a major role in public response to environmental exposures (Berry et al., 2011), influenced by visual and olfactory experience, experience of psychological and physical effects or impacts on health (Oltra & Sala, 2014).

Respiratory Health Symptom

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

Healthy Young Adults

An adult is a person older than 19 years age unless national law delimits an earlier age (World Health Organization, 2016).

1.7.2 Operational Definition

Traffic-Related Air Pollutions

In this study, traffic-related air pollution is assessed by measuring the traffic-related air pollutants in the studied location. Traffic-related air pollutants that will be studied are particulate matter (PM_{10}, $PM_{2.5}$) and ozone (O_3). These pollutants are measured by using respective suitable traffic-related air pollutants instruments.

Perception

Perception in this study can be defined as students' perception towards traffic-related air pollution among pedestrian and cyclists regarding to the exposure towards this air pollutants during to class. Perception is based on three which are perception about the cause and sources of traffic pollution, perception about the level of air pollution and perception about the health effects of air pollution.

Respiratory Health Symptom

Respiratory health is the dependent variable in this study and will be presented with respiratory health symptoms (wheezing, coughing, phlegm, breathing difficulties, shortness of breath and chest tightness). The data is taken by using a modified questionnaire from The International Union Against Tuberculosis and Lung Disease (IUALTD) based on related symptoms that appear in participants for the past three months.

Healthy Young Adults

An adult is a person in aged range from 19 to 22 years old that walking and cycling to the academic zones and free from history of respiratory diseases which involved in this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Air Pollution

Air pollution refers to the emission of pollutants into the atmosphere that are deleterious to human health and the planet as a whole (NRDC, 2016). A National Institute of Environmental Health Sciences (NIEHS) define air pollution as a mixture of natural processes as well as anthropogenic substances in the air we breathe (NIEHS, 2017).

Natural sources of air pollution like volcanic eruptions, forest fires and windblown dust. While, anthropogenic air pollution from sources like motor vehicles and industries countries that become a major and serious problem worldwide (Figure 2.1). Its thoughtfulness is due to the fact that elevated air pollutant levels from man-made sources tend to occur in environments where serious harm to human health and welfare is more likely, namely the more densely populated urban areas (Jamal *et al.*, 2004). The Klang Valley of Malaysia, which includes the largest city of Kuala Lumpur and the new capital city of Putrajaya, is one such area.

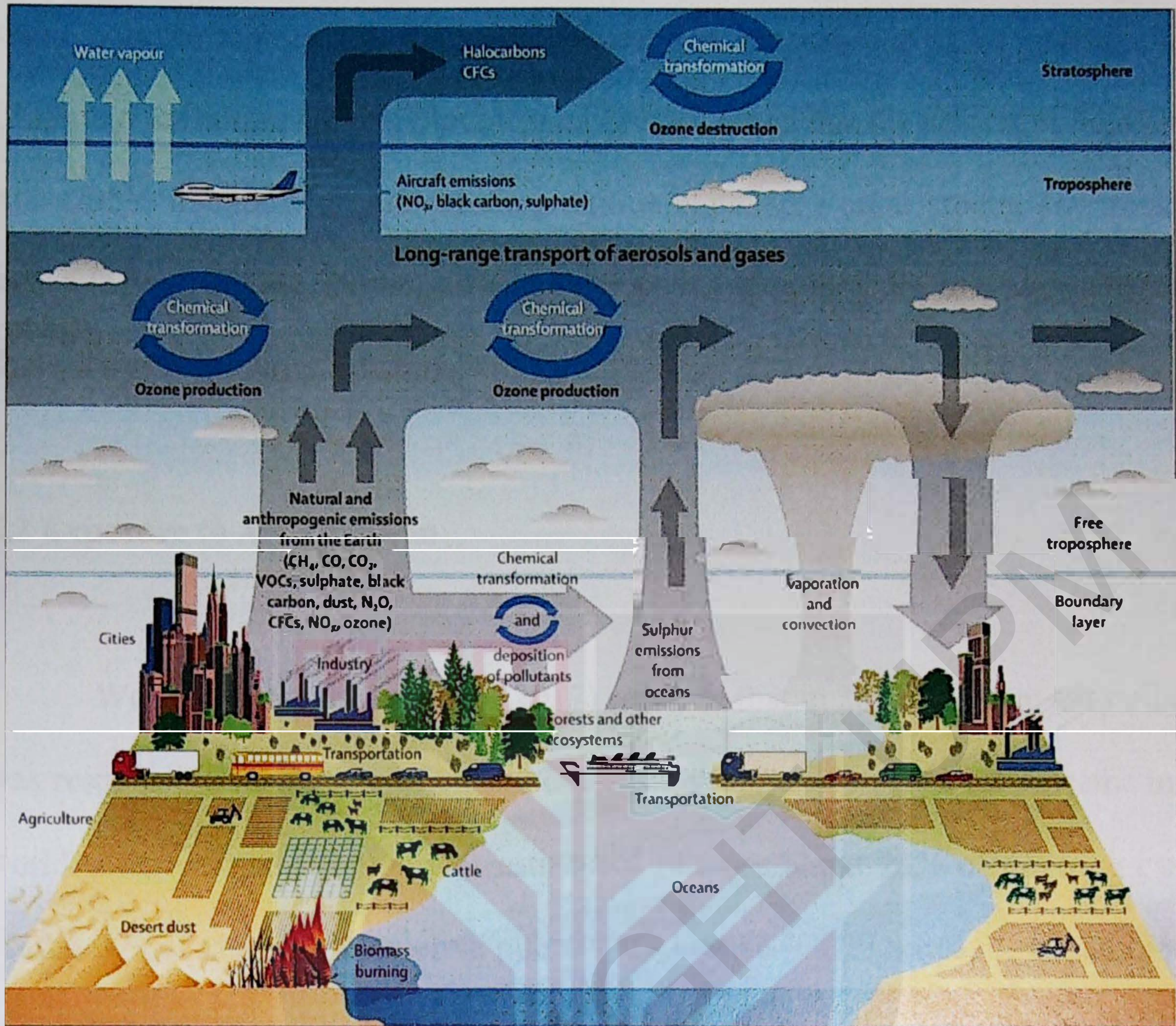

Figure 2.1: Sources, transport, transformation and fate of atmospheric pollutants
(Adapted from https://ars.els-cdn.com/content/image/1-s2.0-S0140673614606176-gr1.jpg)

A National Institute of Environmental Health Sciences (NIESH) categorized air pollution into two categories which are outdoor air pollution and indoor air pollution. Outdoor air pollution involves exposure that take place outside of the built environment. Meanwhile, indoor air pollution defines as exposures to particulates, carbon oxides and other pollutants carried by indoor air dust. Examples of pollutants of outdoor air pollution like fine particles that produced by the burning of fossil fuels, noxious gases and ground-level ozone. Indoor air pollution includes gases, household products and chemicals, building materials, outdoor indoor allergen, tobacco smoke and also mold and pollen (NIESH, 2017). However, outdoor air pollution was the major concern among environmental issues that can cause adverse health effects (Guarnieri & Balmes, 2014). Burnett *et al.* (2014), stated that the percent of population attributable fractions to ambient air pollution exposure varied among countries for ischemic heart disease, stroke, chronic obstructive pulmonary disease, lung cancer and acute lower respiratory infection.

2.2 Exposure to Air Pollution

World Health Organization (2017) reported that in 2012, ambient air pollution was responsible for three million deaths, representing 5.4% of the total deaths in the world. Ambient air pollution was estimated to cause about 25% of the lung cancer deaths, 8% of chronic obstructive pulmonary disease (COPD) deaths, about 15% of ischemic heart disease and stroke, and about 17% of respiratory infection death. Thus, particulate matter pollution is an environmental health problem that affects people worldwide (Kim *et al.*, 2014) but low-and middle-income countries disproportionately experience this burden (WHO, 2017). Exposure to particulate matter increases the risk of many acute and chronic respiratory and cardiovascular conditions in children and/or adults (WHO, 2017).

2.3 Traffic-Related Air Pollution

Motor vehicles are a significant source of urban air pollution and are increasingly important contributors of carbon dioxide (CO_2), particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAH), and volatile organic compounds (VOCs) (Health Effects Institute, 2010). In urban environments, motor vehicles are a significant source of particulate matter smaller than 2.5 micrometer in diameter ($PM_{2.5}$), coarse particulate matter (PM_{10}) and ozone (O_3) (Advisory Committee on Tunnel Air Quality, 2014).

2.3.1 Components of Traffic-Related Air Pollution

2.3.1.1 Particulate Matter (PM_{10} and $PM_{2.5}$)

Particulate matter (PM) is a heterogenous mixture of particles from natural sources such as dust storms, vegetation, and/or anthropogenic sources like industry and vehicles (Kim et al., 2013). The USEPA has been has been 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 (USEPA, 2016). In a review studies by Kim *et al.* (2014), states that the size of particles precisely linked to being 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. Numerous of epidemiological studies reviews point out evidence that exposure to PMs has been identified as the cause of diverse health problems (Kim *et al.*, 2013; Kim *et al.*, 2015).

2.3.1.2 Ozone (O_3)

As the chief component of urban smog, ozone is formed by photochemical reaction in ambient air through a chemical interaction between sunlight and gases like nitrogen oxides, carbon monoxide and volatile organic compounds (VOCs) (US. EPA, 2017). These happens when pollutants emitted by cars, power plant and other sources. United States Environmental Protection Agency states that ozone is most likely to reach unhealthy levels on hot sunny days in urban environments and also can be transported long distances by wind, so even rural areas can experience high levels (US. EPA, 2017).

Ozone in the air we breathe may cause harm to our health. People most at risk from breathing air containing ozone include people with asthma, children, older adults and people who are active outdoors, especially outdoor workers. Exposure to ozone may trigger a diverse of health problems including chest pain, coughing, throat irritation, and airway inflammation. This exposure can reduce lung function and harm lung tissues. Meanwhile, the worst case of exposure to ozone may lead to bronchitis, emphysema, and asthma (US. EPA, 2017).

2.4 Mechanism of How Particulate Material Deposited in Human Body

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 (US. 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 (US. EPA, 2002). United States Environmental Protection Agency is concerned about particles that 10 micrometers 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 the 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 particle with an aerodynamic diameter of 10 μm whereas fine particulate matter with an aerodynamic diameter of 2.5 μm (US. EPA, 2016). The coarse particulate matter will be deposited into 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). Figure 2.2 below shows mechanism of particulate matter when entering human body.

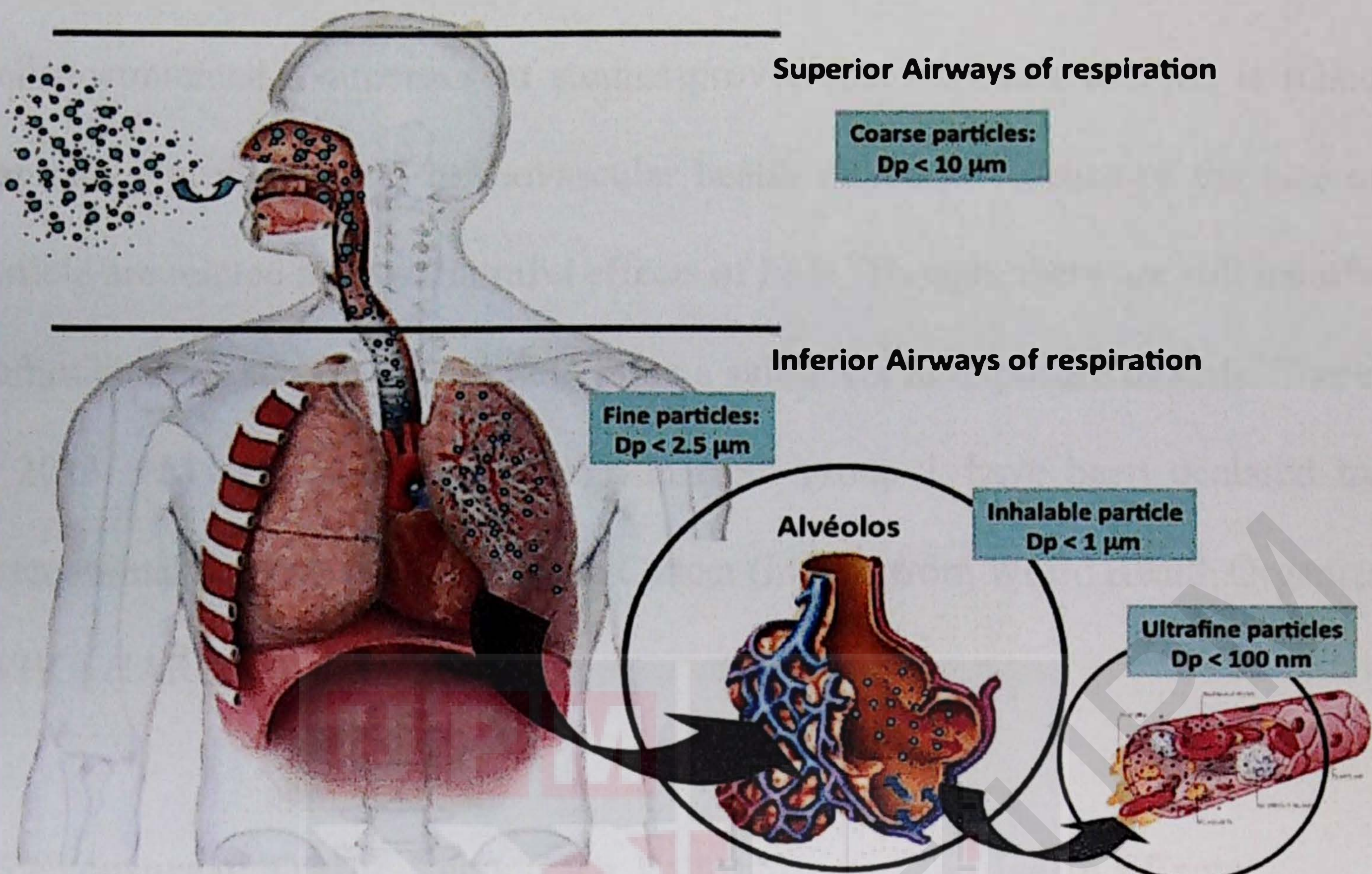

Figure 2.2: Mechanism of Particulate Matter in Human Body

(Adapted from http://www.intechopen.com/)

Nevertheless, researcher consider 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 into 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 of studies proved that exposure to PMs is related to respiratory problems and cardiovascular health effects. Evidence of the size of the particle are related to 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 have been declared by the International Agency for Research on Cancer (IARC) from World Health Organization (WHO) (IARC, 2013).

2.5 Exposure of Traffic-Related Air Pollutants and Its Health Effects

Traffic-related air pollution is one of the significant environmental issues in densely populated urban areas including Malaysia. Traffic congestion increase vehicle emission that contribute to urban air pollution. In most high-income countries, the vehicular emissions and ambient concentrations of traffic-related air pollutants have decreased due to the improvements in vehicular emission control technologies and also air quality regulations. However, those positive development unable to compensate the rapid growth of the world's motor vehicle population, economic improvement, increased vehicular congestion and also the presence of the older vehicles on the road (Health Effects Institute, 2010).

A Health Effects Institute (2010) report that large quantities of nitrogen dioxide (NO_2), particulate matter (PM) and ozone (O_3) emit motor vehicles. In addition, Health Effects Institute (2010) report that the epidemiologic associations between exposure to pollutants from traffic and health outcomes like cardiovascular morbidity and mortality, asthma and respiratory symptom, allergy and cancer.

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, estimating has been made based on three major assumptions which are causality of the epidemiological associations, linearity of exposure-response relations and threshold is absent or has very low value, this is consistent with the review studies by Kim *et al.*, (2015).

According to systematic review studies in Southern European areas, incre increased risk association of particulate matter (PM) and respiratory disease, cerebrovascular disease and lung cancer (Beelen *et al.*, 2014; Faustini *et al.*, 2013; Moustris *et al.*, 2015; Raaschou-Nielsen *et al.*, 2013), for nitrogen oxides (NO_X) and coronary heart disease and cerebrovascular disease (Katsoulis *et al.*, 2014) and for ozone (O_3) and mortality, which is during heat waves episodes (Analitis *et al.*, 2014).

2.6 Active Travel Impact: Walking and Cycling

The major concern is about the traffic-related air pollutant exposures of street users during active transportation which are walking and cycling which have been linked to adverse health effects and associated with increased mortality (P. MacNaughton *et al.*, 2014). A study in California found that active transportation modes which were cycling and walking are associated with highest particle number and $PM_{2.5}$ respiratory exposure than passive modes for driving (D.C Quiros *et al.*, 2013).

Another study by P. MacNaughton *et al.* (2014), found that the impact of bicycle route type on exposure to pollutants from traffic were to have significantly higher concentrations of black carbon (BC) and NO_2 in bike lanes (adjacent to traffic) than in bike paths (separated from vehicle traffic).

Another similar study in Portugal found that PM concentration in different cycling routes indicates that using a bicycle commute route of lower traffic intensity compared to heavy traffic intensity showed a reduction in exposure. During exercise in active transportation (walking and/or cycling), the healthy population is not immune to the adverse effects of the PM inhalation. In 2013, PM as a human carcinogenic from group 1 have been declared by the International Agency for Research on Cancer (IARC) from World Health Organization (WHO) (IARC, 2013). This population is at greater risk to nasopharyngeal irritation, acute airway inflammation and decreased in lung function (Cole-Hunter *et al.*, 2013; Park *et al.*, 2017) although some studies did not find the association (Jarjour *et al.*, 2013) but few studies suggest further study to determine long-term health effects (Jarjour *et al.*, 2013; Park *et al.*, 2017).

2.7 Perception on Air Quality

Perception plays a fundamental role on people's response to preventive measures (Pantavou *et al.*, 2017), in consistent with study by Berry *et al.* (2011), states that people's behaviour and response to preventive measures depends on the way they perceive environmental stimuli, therefore to protect public health through adaptation measures it is significant to consider people's perception and behavioural changes. In another study of air quality perception, they found that sense of air quality varies among groups and individuals (Van Kamp *et al.*, 2003).

However, a study on indoor and outdoor air quality perception by Dorizas *et al.* (2015), found that there is no significant association of perceived air quality to the measured pollutants concentrations. According to a study conducted in Mediterranean of urban outdoor air quality perception, found that particulate matter concentrations were associated with dust perception, while NO_X and CO associated with overall quality. People more likely to perceive dusty or poor air quality conditions when the respective pollutant concentrations increased. Thus, air quality perception affected by personal factors like age, area of residence and health symptoms (Pantavou *et al.*, 2017).

In another study in Rural Alaska (Region 1 and Region 2) of indoor and ambient air pollution perception and sources, found that the most frequently reported air concerns in Region 1 are from smoke (21.2%) and road dust (6.6%). Meanwhile, in Region 2, most concerns of outdoor air are open burning or smoke (11.5%), road dust (6.9%), vehicles/ATV snow machines (4.6%). The main findings in this study are even in rural, there were many sources of particulate matter ($PM_{2.5}$) from indoor (wood stoves, fuel stoves, dust) and outdoor (road dust, vehicle emission from snow machines) (Ware *et al.*, 2013).

In the study by Ramirez *et al.* (2017), found that the major environment issues were air pollution (74%) and water pollution (77.89%). When deciding leading environmental problem in the city, about 40% of the participants select air pollution among others. Proportion was higher in large cities, about 60% of the response. Meanwhile, perception on local air quality. With OR > 1, CI > 1, and p-values < 0.05, found an association between the size of the participants city of the residence and the perception on high local air pollution. They concluded that person living in a larger city is likely to have a negative perception on its air quality condition. While other variables like gender, age, socioeconomic strata showed not statistical significance.

2.8 Scenario in Malaysia

The rapid development in infrastructure, industrialization, and urbanization including transportation in Malaysia causes the quality of urban air turned to unhealthy air (Abdullah *et al.* 2012; Afroz *et al.*, 2003; Ash'aari *et al.*, 2015; Rahman *et al.*, 2015; Talib *et al.*, 2014). The urban environment experiences poor air quality due to the increasing number of vehicles as the major sources of air pollutants. There are various studies attempted to provide an overview of the air pollution trend in Malaysia, especially in Klang Valley. The Klang Valley is one of the economic zones in

Malaysia. It consists of Kuala Lumpur, Putrajaya and adjoining cities and towns in the State of Selangor such as Petaling Jaya, Shah Alam, Gombak, Hulu Langat and Sepang.

Abdullah *et al.* (2012), found the overall air quality was moderate for 66% of the days throughout the year of 2009 while only 5% of the days were classified at the unhealthy level in Klang Valley. Shah Alam and Kuala Lumpur were recorded the highest number of unhealthy days from 2001-2009. In addition, some places around Klang Valley are suffering from quite acidified rain due to the heavy air pollution that are still occurring in some areas around the Klang Valley.

In the study of trend and status of air quality monitoring stations in Klang Valley, the heavy traffic in Petaling Jaya cause higher concentration of carbon monoxide (CO), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2). There are relatively stronger inter-pollutant correlations at the stations of Gombak and Shah Alam and the result also suggest that heavy traffic flow induces high concentrations of PM_{10}, CO, NO_2 and SO_2 at Petaling Jaya, Gombak and Shah Alam monitoring stations (Azmi *et al.*, 2010).

The major problem of urban air pollution, with its long- and short-term impacts on human health has been widely recognized. There are numerous of studies in Malaysia have been studies related to air pollution and health impacts (Afroz, Hassan, & Akma, 2003; Talib, Dominick, Ahamad, Khan, & Juneng, 2014; Rozita *et al.*, 2013; Mabahwi, Ling, Leh, & Omar, 2015), significant associations for PM_{10}, O_3, NO_2, SO_2

with natural mortality (Rozita *et al.*, 2013), respiratory problems including bronchitis, emphysema and asthma (Mabahwi *et al.*, 2015; Afroz *et al.*, 2003).

2.9 Air Quality Standard

2.9.1 World Health Organization (WHO) Standards

Based on a systematic review of literature on adverse health effects of air pollution, the World Health Organization has updated its Air Quality Guidelines in 2005. The current update is intended to be relevant and applicable worldwide and takes into consideration large regional inequalities in exposures to air pollution. It recommends guideline levels for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, as well as the set of interim targets for these pollutants' concentrations, encouraging gradual improvement of air quality and reduction of health impacts of the pollution (Krzyzanowski & Cohen, 2008). Table2.1 below shows the WHO air quality guidelines.

Table 2.1: National Ambient Air Quality standards by World Health Organization

Pollutants	Averaging Time	Ambient Air Quality Standard
		$\mu g/m^3$
$PM_{2.5}$	1-year	10
	24-hour	25
PM_{10}	1-year	20
	24-hour	50
SO_2	1-hour	20
	24-hour	500
NO_2	1-hour	40
	24-hour	20
O_3	1-hour	N/A
	8-hour	100

Adapted from World Health Organization (2005)

2.9.2 National Ambient Air Quality (NAAQ) Standards

According to USEPA after reviewing scientific studies, standards for PM_{10} which were intended to regulate "inhalable coarse particles" that ranged from 2.5 to 10 micrometers in diameter meanwhile, they also concluded that fine particles ($PM_{2.5}$) had a greater association with morbidity and mortality rate compared to PM_{10} (USEPA, 1997b). Therefore, the national ambient air quality standards in the CLEAN Air Act require EPA to review every five years to determine whether the standards should be revised. The last version to the air quality standard for particulate was done in 2016 revising $PM_{2.5}$ 24-hour standard from 35 µg/m^3 to 15 µg/m3. EPA with National Ambient Air Quality Standards for Particle Pollution (NAAQS) retaining the 24-hour standards for PM_{10}, however they had revoked the annual PM_{10} standard (USEPA, 2012). Table 2.2 below shows standard of particulate matter for $PM_{2.5}$, PM_{10}, NO_2, CO, SO_2 and O_3.

Table 2.2: National Ambient Air Quality standards by Environmental Protection Agency

Pollutants	Averaging Time	Ambient Air Quality Standard
		µg/m^3
$PM_{2.5}$	1-year	15
	24-hour	35
PM_{10}	1-year	N/A
	24-hour	150
SO_2	1-hour	75^
	3-hour	0.5*
NO_2	1-year	53^
	1-hour	100
O_3	1-hour	N/A
	8-hour	0.070*

*ppm, ^ppb
Adapted from United States Environmental Protection Agency (2016)

2.9.3 Malaysia Ambient Air Quality Guidelines (MAAQG)

Malaysia has adopted a similar United States Environmental Protection Agency (USEPA) Pollutants Standards Index (PSI) system called Air Pollutant Index (API). Department of Environment (DOE), Malaysia had developed and modified the Malaysian API to suit Malaysian guidelines. The API provides a uniform system of measuring air pollution levels. The measured levels of five pollutants (PM_{10}, NO_2, CO, SO_2 and O_3) are converted to an index from 0 to 500. The most important number on this index is 100, which is assigned to the concentration of the 24-hour standards in the respective countries since it corresponds to the level at which health effects can occur (Harrop, 2002). In this case, the Malaysian 24-hour PM standard is equivalent to the comparable 24-hour PM_{10} US National Ambient Air Quality Standard (NAAQS). Table 2.3 below shows the New Malaysia Ambient Air Quality Standard.

Table 2.3: New Malaysia Ambient Air Quality Standard

Pollutants	Averaging Time	Ambient Air Quality Standard		
		IT-1 (2015)	IT-1 (2018)	IT-1 (2020)
		μg/m³		
PM_{10}	1-year	50	45	40
	24-hour	150	120	100
$PM_{2.5}$	1-year	35	25	15
	24-hour	75	50	35
SO_2	1-hour	350	300	250
	24-hour	105	90	80
NO_2	1-hour	320	300	250
	24-hour	75	75	70
O_3	1-hour	200	200	180
	8-hour	120	120	100
*CO	1-hour	35	35	30
	8-hour	10	10	10

*mg/m³
Adapted from Department of Environment (2013)

CHAPTER 3

METHODOLOGY

3.1 Study Design

The study design is a cross-sectional study. It is an observational study that intends to determine the association between traffic-related air pollutions (TRAPs) with air quality perception and respiratory symptoms among pedestrian and cyclists at the same time. This study has been conducted from February 2018 to April 2018.

3.2 Study Location

A list of colleges situated in main campus of Universiti Putra Malaysia (UPM) in Serdang was acquired. Permission from UPM was obtained prior to carry out the study in residential college. After getting the list and permission, the choice of the college then was narrowed with the location of the colleges with academic zone and availability of pedestrian and cyclist's lane. A few lists that were available then were selected as study location. Below are the criteria of college and road selection:

a) Residential college of UPM

b) A college that located within 5 km radius to academic zones

c) A college that has pedestrian and cyclist's lane

The choices of college and roads were selected in UPM, Serdang consisting of Kolej Kedua, Kolej Keenam, Kolej Kelima, Kolej Tun Dr Ismail, Kolej Canselor, Kolej Tun Perak, Kolej Pendeta Zaaba dan Kolej Sultan Alaeddin Suleiman Shah (KOSASS) (Figure 3.1). This colleges were chosen because it was located nearest to the pedestrian and cyclist's lane, with majority of the students go to the class by cycling or walking and near to the high traffic volume (Jalan Persiaran Universiti 1) which major sources of pollutants from transport vehicles and this may affect the population that use active transportation (cycling or walking) as main mode of transportation.

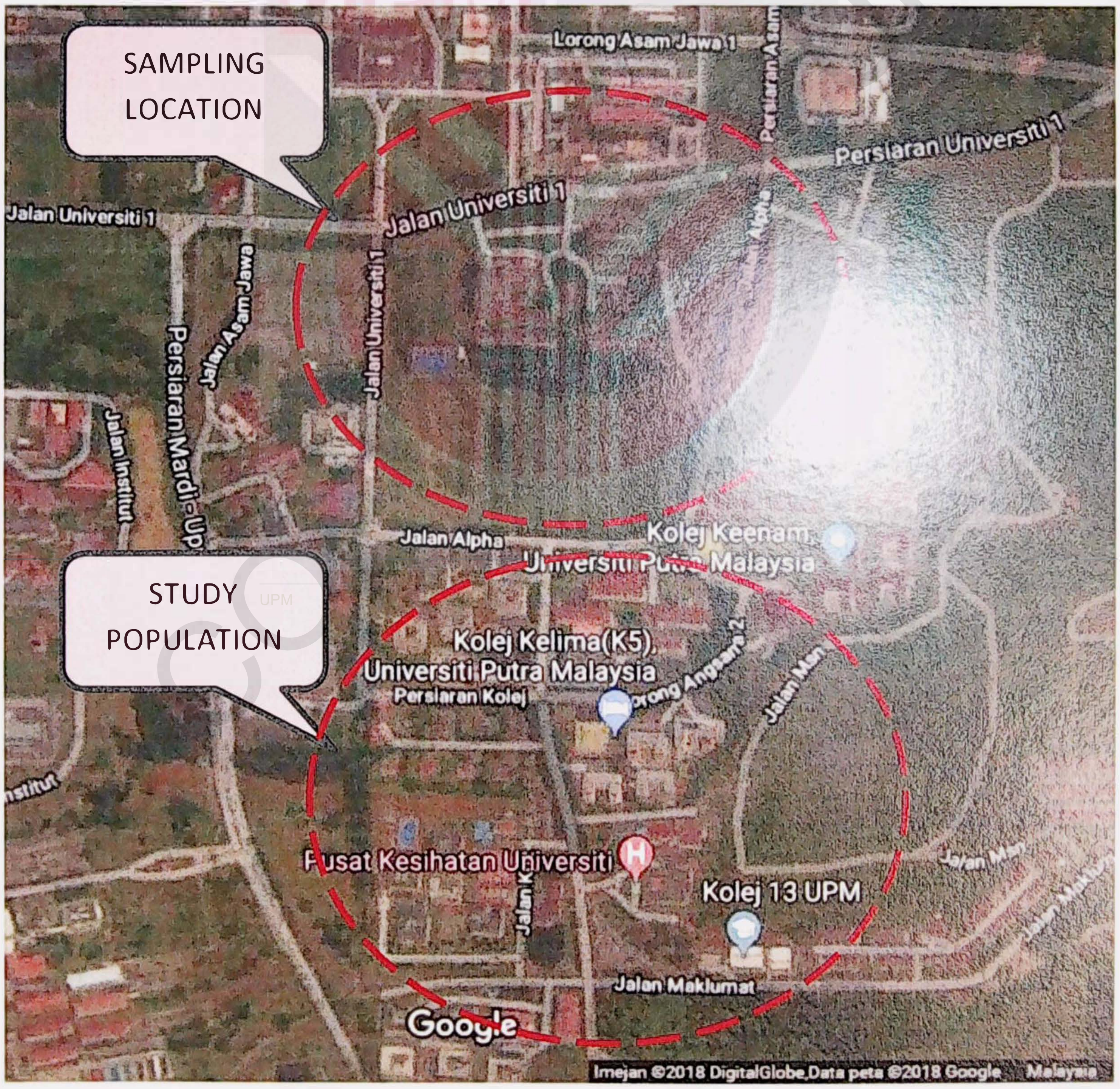

Figure 3.1: Map of study population and sampling location

Adapted from Google Map

3.3 Sampling

3.3.1 Sample Population

A total of 180 students from first year and second year from residential of eight colleges (Kolej Kedua, Kolej Keenam, Kolej Kelima, Kolej Tun Dr Ismail, Kolej Canselor, Kolej Tun Perak, Kolej Pendeta Zaaba dan Kolej Sultan Alaeddin Suleiman Shah) were included in this study. From that, both male and female students were selected. Only pedestrian (N=90) and cyclists (N=90) were included in this study.

3.3.2 Sampling Frame

Sampling frame includes all male and female students registered at Universiti Putra Malaysia, Serdang to participate in the study. All respondents were from first year and second year. However, only those who fulfilled the inclusion and exclusion criteria were included in this study.

3.3.3 Study Sample

In this study, 90 pedestrians and 90 cyclists were selected in eight colleges (Kolej Kedua, Kolej Keenam, Kolej Kelima, Kolej Tun Dr Ismail, Kolej Canselor, Kolej Tun Perak, Kolej Pendeta Zaaba dan Kolej Sultan Alaeddin Suleiman Shah). The total number of study sample is 180 respondents.

3.3.4 Sample Size Calculation

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

Formula,

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

Where,

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

$\mu 1$ = Estimated mean (larger)

$\mu 2$ = Estimated mean (smaller)

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

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

Prevalence of reported coughing among study group:

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

n = 50 (Andrew and Juliana, 2015)

Based on the formula, 50 respondents are needed for each study area. Thus, the total number of respondents is 100. The number is increased by 20% for the strength of analysis of the study and to take account for non-responsive respondents, missing data and errors. The total respondents are 120. However, the convenience sampling was used to select the respondents, the design effect might be estimated as 1.5. This means that in order to obtain the same precision, half as many individuals must be studied. Hence, 180 subjects will be required.

3.3.5 Sampling Method

There were total of 17 colleges in Universiti Putra Malaysia. Next, through purposive sampling, the colleges which are Kolej Kedua, Kolej Keenam, Kolej Kelima, Kolej Tun Dr Ismail, Kolej Canselor, Kolej Tun Perak, Kolej Pendeta Zaaba dan Kolej Sultan Alaeddin Suleiman Shah (KOSASS) were selected. Finally, by using convenience sampling. The respondents were only selected when fulfilled the inclusion and exclusion criteria based on the questionnaire that they are answered using an online platform (Google Form). Incomplete questionnaires were excluded.

3.3.6 Inclusive Criteria

1. **Students**

   The subjects were selected among UPM students from First Year and Second Year with age ranged from 19 to 22 years old. The participants were university students since they are call to later hold-decision making positions, in both public and private sectors. It is very important to assess the exposure of traffic-related air pollutions in order to reduce the risk of adverse health effects. According to *Liu et al.* (2001) found a significant association between chronic low-level traffic-related air pollution exposure and neurobehavioral function in exposed adults.

2. **Without chronic respiratory disease history**

   Individuals with pre-existing diseases are more susceptible to particulate exposure (Sacks et al., 2011) and susceptible people with existing respiratory inflammation might be a central mechanism for the toxicity of particulate matter (Bateson and Schwartz, 2004). Due to this concern, subjects eligible only without these chronic respiratory diseases that had been diagnosed by a doctor in order to understand their current exposure were not influenced by their medical status.

3. **Pedestrian and cyclist**

   Only pedestrian and cyclists were being selected.

4. **Living within 5 km radius from the academic zone**

   Each selection selected were purposively sampled based on the distance of their residential college with less than 5 km radius from the selected colleges. The selection being made to minimize the potential confounder that might subjectively to the results validity and remove the possibility of other factors affect the subjects and also to homogenize the air pollutants ambient.

5. **Use pedestrian and cyclist's lane**

   Only students that walking and cycling to class and use the pedestrian and cyclists lane as a main road.

3.4 Study Procedure

3.4.1 Questionnaire

In early stage, the questionnaire was distributed throughout the social media via two outlets: WhatsApp and Facebook to the potential respondents. The link of the survey was posted throughout this two-social media by forwarding it through personal contact or through group contact. The questionnaire has been distributed from January 2018 to March 2018.

This study used modified questionnaire based on two internationally standardized and recognized questionnaires which are questionnaire set by the

International Union Against Tuberculosis and Lung Diseases (IUATLD) and also questionnaire on air quality perception from the Air Quality Perception (AQP) Scale from previous study by Liao *et al.* (2015) and Deguen *et al.* (2012). The IUALTD questionnaire was used to collect information on sociodemographic and respiratory symptoms. Meanwhile, AQP questionnaire was used to gather data on the respondents' perception towards air quality.

3.4.2 Traffic-related Air Pollutants (TRAPs) Assessment

The TRAPs assessment was conducted to measure the quality of air and presence of traffic air pollutants in three sampling roads (Jalan Alpha, Jalan Alpha-Kolej 2 and Jalan Universiti 1) representing environment with distinct traffic patterns. The parameters that being measured in this study were $PM_{2.5}$, PM_{10}, and ozone as general, all of these parameters were taken at the height of 1.1 m above the ground (Pantavou, Lykoudis & Psiloglu, 2017) to represent the breathing zone level of the students.

To assess air pollution-related factors, measurements were carried out at the three sampling roads (Jalan Alpha, Jalan Alpha-Kolej 2 and Jalan Universiti 1) along the routes that being used by students to walk or cycle to academic zones (Figure 3.2). Previous studies measured the following air pollutants related to higher prevalence of respiratory symptoms: PM_{10}, $PM_{2.5}$, ozone (Ngalai, 2004; Mukherjee *et al.*, 2015; Muhammad *et al.*, 2014; Patil *et al.*, 2014). To assess road traffic, we determined the volume of vehicles that operated in the sampling location zone during sampling was operated. Measurements were conducted at four sites included one site for background measurement in the sampling location during rush hour period involved morning, afternoon and evening rush hour period begins at 7.00 a.m. till 8.00 a.m., 1.00 p.m. till 2.00 p.m. and 5.00 p.m. till 6.00 p.m. respectively per site between February and March in 2018 (excluding semester break or rainy day). PM_{10}, $PM_{2.5}$, and ozone (average of one reading per five minutes) were measured at one site on the sampling road in each road. The sampling periods in the route are five days per road.

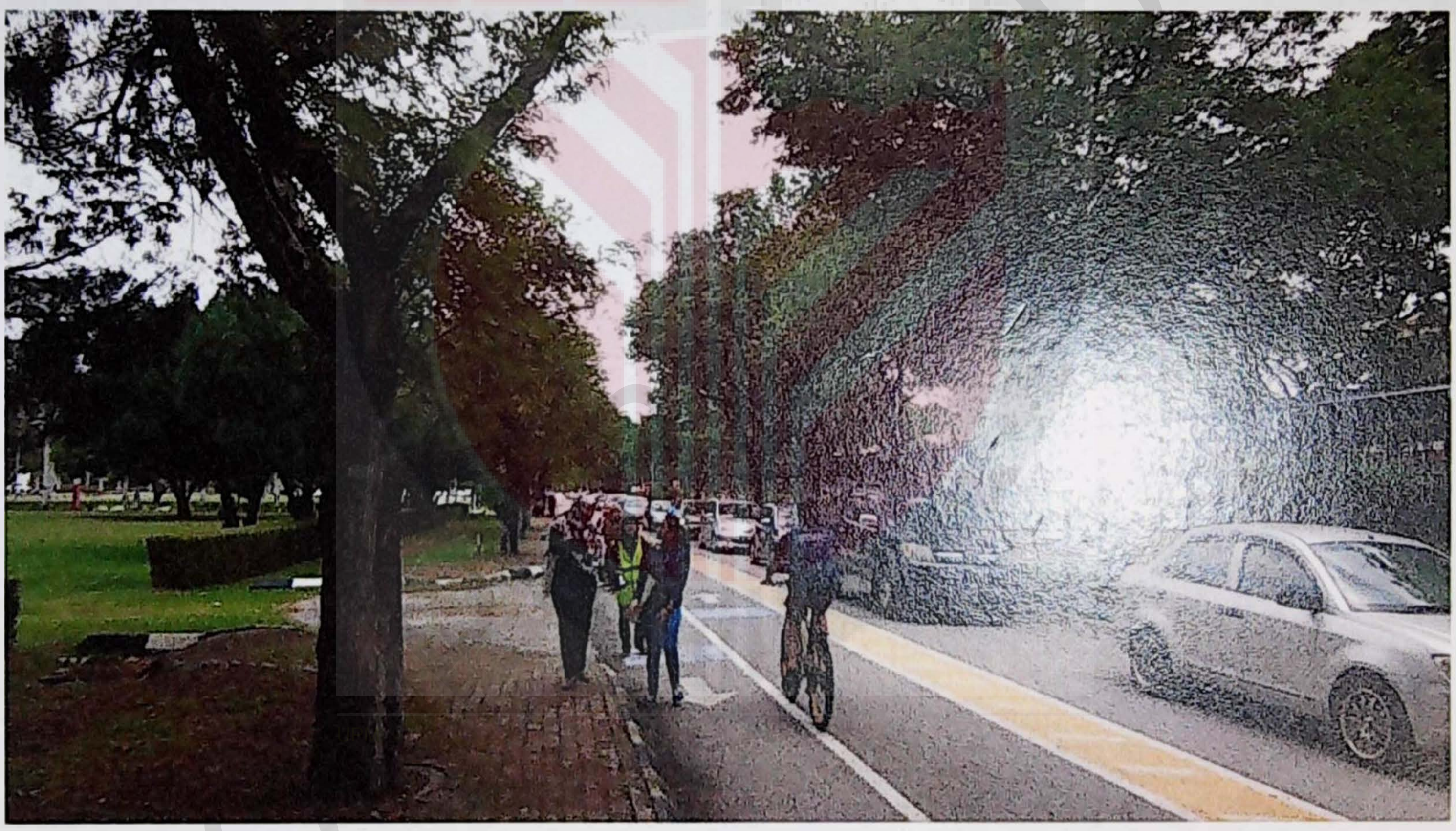

Figure 3.2: Pedestrian and cyclists using the bicycle lane to class

Direct reading instrument of air monitoring tool (TSI DustTrak™ II Aerosol Monitor 8532, TSI SidePak™ Personal Aerosol Monitor AM520 and Aeroqual™ Series 500) was used to measure aerosol with an upper particle size limit of 10 μm, aerosol with an upper particles size limit of 2.5 μm and ozone respectively.

In this present study, DustTrak, SidePak and Aeroqual was used for the monitoring of PM_{10}, $PM_{2.5}$ and ozone respectively. Arrangement of this equipment was done before any measurements were made. All of this equipment was placed on the bench at the height of 1.1 m above the ground (Pantavou, Lykoudis & Psiloglu, 2017) at the roadside, the same level of pedestrian and cyclists breathing zone, for the entire of rush hour period (Figure 3.3). Each measurement taken with the present of the researcher to ensure the results is valid.

Figure 3.3: The measurements of traffic-related air pollutants and traffic count by researcher at sampling location

Measurement of $PM_{2.5}$, PM_{10} and Ozone

DustTrak™ II Aerosol Monitor 8532 (Figure 3.4) was used to measure PM_{10}. This device is a handheld battery-operated, data-logging, light-scattering laser photometer that gives real-time aerosol mass readings. It uses a sheath air system that isolates the aerosols in the optics clean for improved reliability and low maintenance.

It is suitable for clean office settings as well as harsh industrial workplaces, construction and environmental sites, and other outdoor applications. The DustTrak™ II Aerosol Monitor 8532 measures aerosol contaminants such as dust, smoke, fumes and mists corresponding to PM_1, $PM_{2.5}$, Respirable or PM_{10} size fraction with a concentration range from 0.001 to 150 mg/m^3.

SidePak™ Personal Aerosol Monitor AM520 (Figure 3.5) was used to measure $PM_{2.5}$ in the routes. It is a rugged, lightweight, belt mounted laser photometer, weighing as little as 450g. it is compact and quiet. The AM520 personal aerosol monitor's easy-to-read display shows of data in both real-time aerosol mass concentration and eight-hour-time-weighted average (TWA_8). The AM520 personal aerosol monitor can be used as personal exposure monitoring, ambient monitoring, environmental sampling and others.

Aeroqual™ Series 500 – Portable Air Quality Monitor (Figure 3.6) was used to measure ozone level in the study area.

Figure 3.4: DustTrak™ II Aerosol Monitor 8532

Adapted from TSI Website

Figure 3.5: SidePak™ Personal Aerosol Monitor AM520

Adapted from TSI Website

Figure 3.6: Aeroqual™ Series 500

Adapted from Aeroqual System Website)

3.4.3 Reference Site Measurements

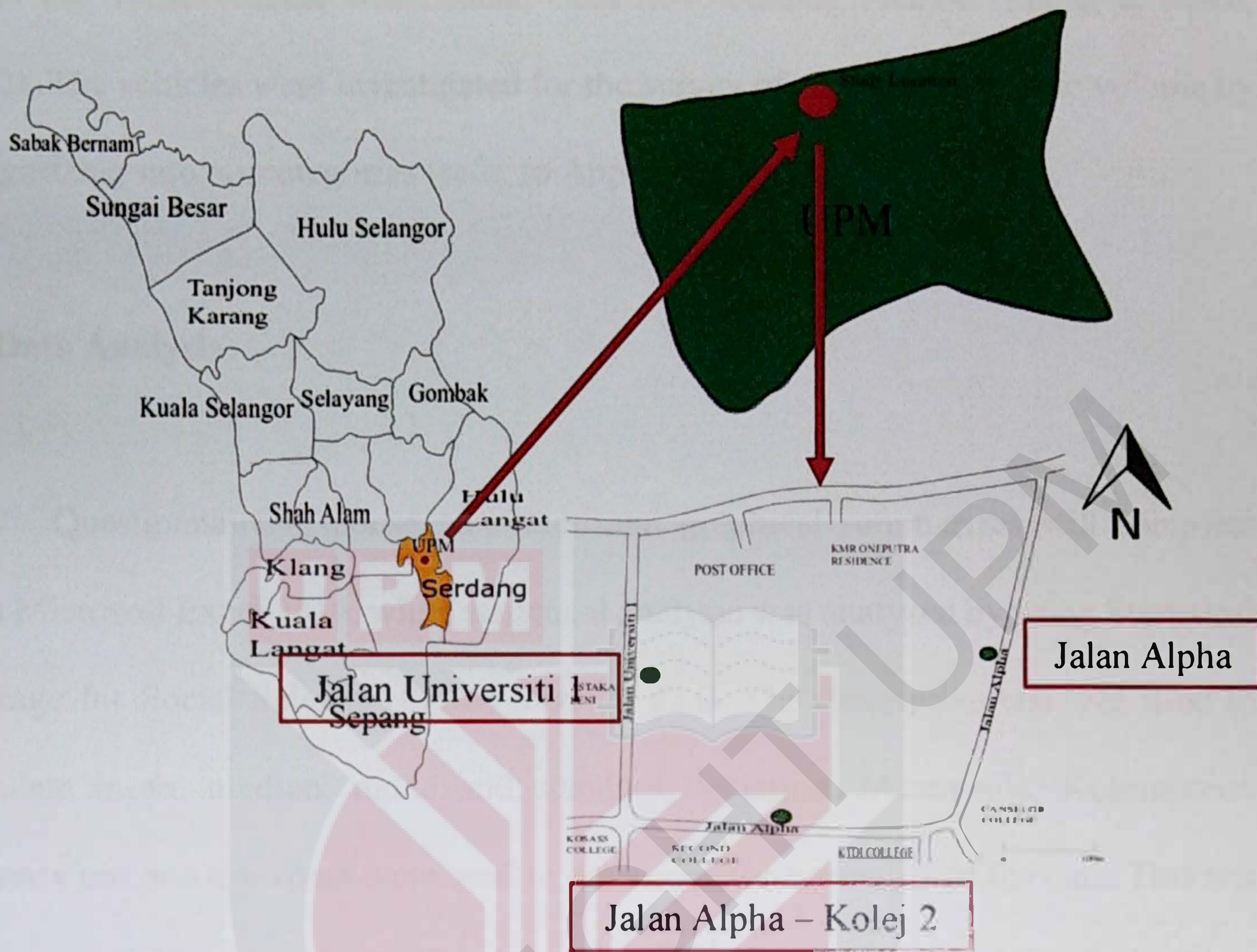

Figure 3.7: Map of sampling location in UPM campus

To record day-to-day differences in background concentrations, the measurements was collected at a reference site for 30 minutes before and after each monitoring run (we did not have the necessary equipment to maintain a permanent reference site). The reference was in a sports field which is about 100 metres from the nearest major road as shown in Figure 3.7

3.4.3 Assessment of Traffic Volume

In order to assess the contribution of traffic pollutants, a survey of traffic volume by vehicle type was conducted. The survey of traffic volume was conducted in three different rush hours as mentioned in sampling duration. The method used to count the traffic volume was manual classified counting method (Zheng & Mike, 2012). The vehicles were investigated for the survey of site-specific traffic volume by categorizing into six categories (refer to Appendix).

3.5 Data Analysis

Questionnaire response tabulation and graphical summarizes will complete with Microsoft Excel 2016, while statistical analysis was analyzed by using Statistical Package for Social Science (SPSS) Version 22.0. The descriptive test was used to calculate mean, median, mode and standard deviation. Meanwhile, Kolmogorov Smirnov test and skewness were used to determine the normality of the data. This test is very crucial in determining the appropriate test that will be used for further data analysis. Below are the tests that were used to analyze the objectives of the study:

Objective 1 : To determine the socio demographic data of respondents.
Statistical Analysis : Descriptive test

Objective 2 : To determine traffic-related air quality perception
Statistical Analysis : Descriptive test

Objective 3 : To measure and determine the traffic-related air pollutants (PM_{10}, $PM_{2.5}$ and ozone) level and traffic volume
Statistical Analysis : Descriptive test

Objective 4 : To determine the respiratory symptoms (cough, phlegm, wheezing, chest tightness, shortness of breath and breathing difficulties) among respondents.

Statistical Analysis : Chi-square test

Objective 5 : To determine the correlation between traffic volume and traffic-related air pollutants (PM_{10}, $PM_{2.5}$ and ozone) level

Statistical Analysis : Pearson correlation

Objective 6 : To determine the association between the exposure to PM_{10}, $PM_{2.5}$, ozone level and air quality perception

Statistical Analysis : Chi-square test

Objective 7 : To determine the association between the exposure to PM_{10}, $PM_{2.5}$, ozone level and respiratory symptoms (cough, phlegm, wheezing, chest tightness, shortness of breath and breathing difficulties) among respondents

Statistical Analysis : Chi-square test

3.7 Quality Control

To ensure data collections was reliable and valid, quality control on the instruments and procedures were taken as followed.

3.7.1 Questionnaire

The questionnaire content was validated and amendments were made accordingly by an expert in the field. The questionnaire was prepared in Malay and English and it underwent a back-to-back translation to ensure that the questionnaires suggest similar meaning.

Pre-testing was conducted prior to the study in the 13th College. Approximately, total of 18 respondents which are nine pedestrians and nine bicyclist who fulfill the inclusion and exclusion criteria were selected to pre-test the questionnaire. The selection of the pre-test respondents was made as closely as to the characteristics of the subjects in the real study. The clarity of instructions on the questionnaires and understanding of the questions was evaluated. Subsequently, problems encountered by the pedestrian and cyclists in answering any of the questions were identified and corrected. The pedestrian and cyclists selected for pre-testing was not included in the data collection of the study. The result was tested by using Cronbach's Alpha Test where value of 0.7 and above shows acceptable reliability and validity.

3.7.2 Traffic-Related Air Pollutants (TRAPs) Assessment

Instruments used in this study was zero calibrated and instruments was switched on and leave 10 minutes to stabilize before the actual data collection were made to ensure that the instruments were in good condition when taking measurement, eliminate any possible error of data and give an accurate result during the sampling. The manufacturer has calibrated all the equipment used in this study using standard and recommended procedure before starting the measurements. The equipment was tested many times before starting data collection. This is to maintain the quality of the test and also to reduce errors during the actual data collection. The same type of equipment was used throughout the study to ensure accuracy and precision of the data thus, reduce the systematic error. Besides, the same researcher remained throughout the study process to prevent from random errors.

3.7.3 Traffic Count Survey

Traffic count was carried out by screen line counts which was imaginary line to make sure all the vehicles were counted during assessment was carried out.

3.8 Ethical Approval

Ethics approval was obtained from the Ethic Committee for Research Involving Human Subjects in Universiti Putra Malaysia (JKEUPM) with the reference number of JKEUPM-2017-197. Meanwhile, permission to conduct study in the selected colleges was obtained from the college management. Informed consent form was distributed to the respondents along with questionnaire distribution and the anonymity of the participants was maintained at all times.

CHAPTER 4

RESULTS

This present study was conducted to determine the association between traffic-related air pollutions with air quality perception and respiratory health symptoms among pedestrian and cyclist in UPM campus. The results were described in the following five sections: (1) Sociodemographic information, (2) Traffic-related air quality perception (PM_{10}, $PM_{2.5}$, ozone) level, (3) Traffic-related air pollutions (PM_{10}, $PM_{2.5}$, ozone) level, (4) Traffic volume, and (5) Respiratory health symptoms.

4.1 Response Rate

A list of sampling frame for this study comprised of pedestrian and cyclists from First Year and Second Year in selected residential college. The response rate for both pedestrian and cyclists was respectively 100%.

4.2 Socio-Demographic Data of Respondents

This study has been carried out among a total of 180 respondents between pedestrian (N=90) and cyclists (N=90). Selection of the respondents was based on the representativeness and the fulfillment of the respondents to the inclusive criteria involved such as healthy young adults of First Year and Second Year which cycling or walking to by using pedestrian and cyclist lane as a main road, no history of respiratory disease and living within the selected areas.

In Table 4.1 below shows the respondents distribution of age, gender, ethnicity, year of study, residential college, smoking status and second-hand exposure to tobacco smoke. For pedestrian, comprised respondents mostly aged 21-22 with 46 (51.1%), 43 (47.8%) with age 19-20 years and only 1 (1.1%) with age more than 22 years old. For cyclists, also comprised respondents mostly aged 21-22 with 46 (51.1%), 44 (48.9%) with age 19-20 years old and there were no respondents aged more than 22 years old. In term of gender, majority of respondents from both group were female about 61 (67.8%) for pedestrian and 47 (52.2 %) for cyclists. For both transportation mode, most of the ethnicity was Malay for 72 (80%) and 45 (50%) respectively followed by Chinese, Indian and others.

Table 4.1 also showed year of study of respondents, there was almost equal distribution between first year and second year. As for the residential college, higher proportion for pedestrian were residents of Kolej Kelima 17 (18.9%) while for cyclist were residents of Kolej Chancellor 22 (24.4%). Majority of pedestrian and cyclists were not smoking and also not second-hand smokers.

Table 4.1: Distribution of respondents' sociodemographic characteristics

Socio-demographic characteristics	Pedestrian (n=90)	Cyclist (n=90)
	n (%)	
Age (years)		
19 - 20 years old	43 (47.8)	44 (48.9)
21 - 22 years old	46 (51.1)	46 (51.1)
> 22 years old	1 (1.1)	0 (0.0)
Gender		
Male	29 (32.2)	43 (47.8)
Female	61 (67.8)	47 (52.2)
Ethnicity		
Malay	72 (80.0)	45 (50.0)
Chinese	9 (10.0)	25 (27.8)
Indian	5 (5.6)	15 (16.7)
Others	4 (4.4)	5 (5.6)
Year of study		
First year	42 (46.7)	44 (48.9)
Second year	48 (53.3)	46 (51.1)
Residential college		
Kolej Kedua	8 (8.9)	9 (10.0)
Kolej Kelima	17 (18.9)	4 (4.4)
Kolej Enam	14 (15.6)	8 (8.9)
Kolej Canselor	11 (12.2)	22 (24.4)
Kolej Tun Perak	5 (5.6)	16 (17.8)
KOSASS	12 (13.3)	9 (10.0)
Kolej Pendeta Zaaba	13 (14.4)	14 (15.6)
Kolej Tun Dr Ismail	10 (11.1)	8 (8.9)
Smoking		
Yes	5 (5.6)	3 (3.3)
No	85 (94.4)	87 (96.7)
Second hand exposure to tobacco smoke		
Yes	13 (14.4)	12 (13.3)
No	77 (85.6)	78 (86.7)

(N=180)

4.3 Traffic-related Air Quality Perception

4.3.1 Air Quality and Traffic as Source of Pollution

Among the 180 respondents, 89 (49.4%) thought the air quality of UPM campus area was better compared to six months ago, while 48 (26.7%) believed that air quality was poor compared to six months ago (Figure 4.1).

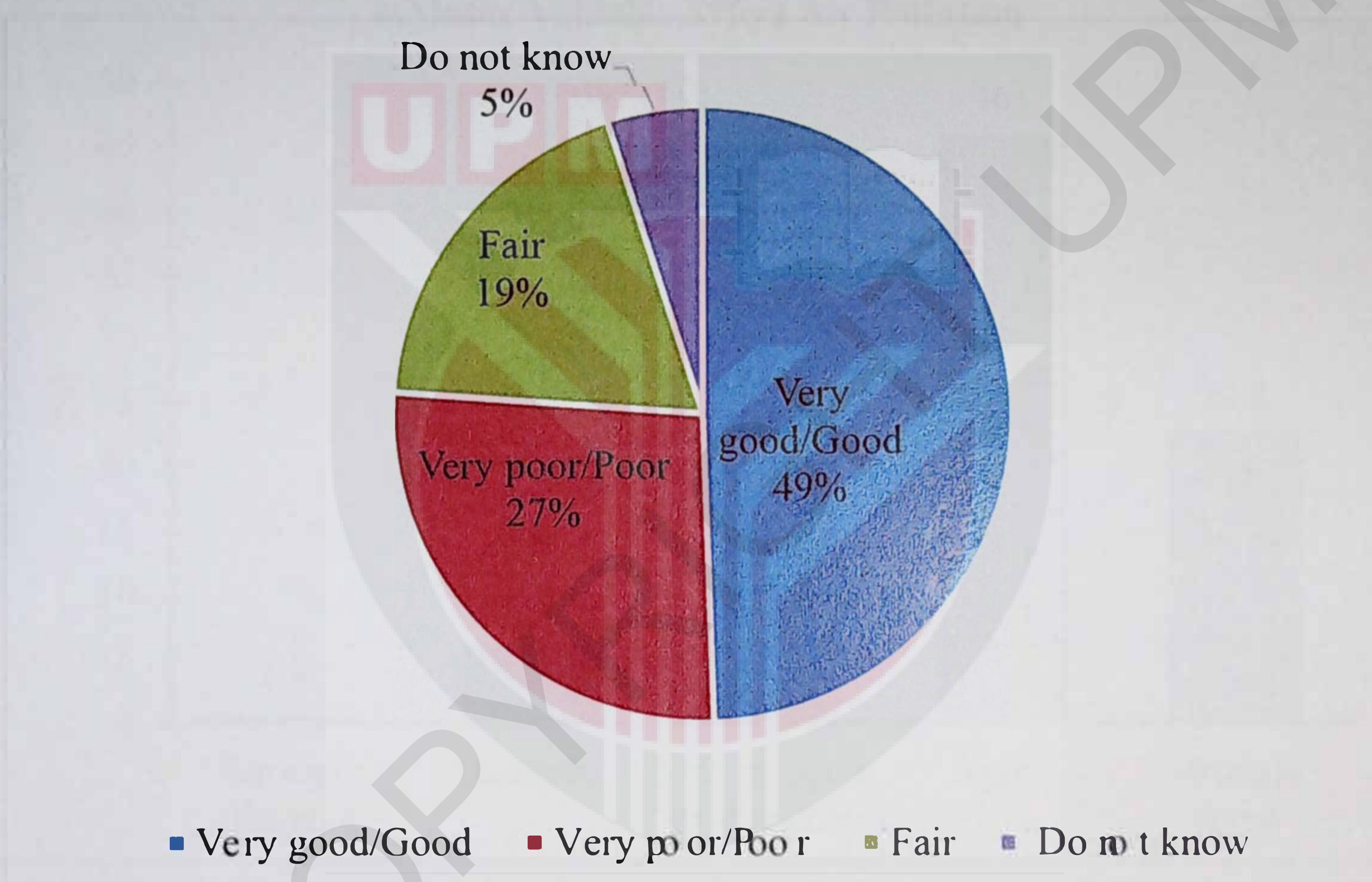

Figure 4.1: Overall air quality rating in the campus area

4.3.1.1 Motor Vehicles Affect Air Pollution

Figure 4.2 shows the results with the percentage of people believes that motor vehicles as a source of air pollution. The percentage values are as follows: the percentage for strongly disagree was 0.6%, the percentage for disagree was 6.1%, the percentage for neither agree or disagree was 24.4%, the percentage for agree was

46.1% and the percentage for strongly agree was 22.8%. Apparently, respondents thought that motor vehicles are the primary source of air pollution. Respondents also thought that motor vehicles not as source of air pollution but with low percentage which only 6.7%. Based on these results, the respondents' perception may be aligned with the measurement of traffic volume in Table 4.5.

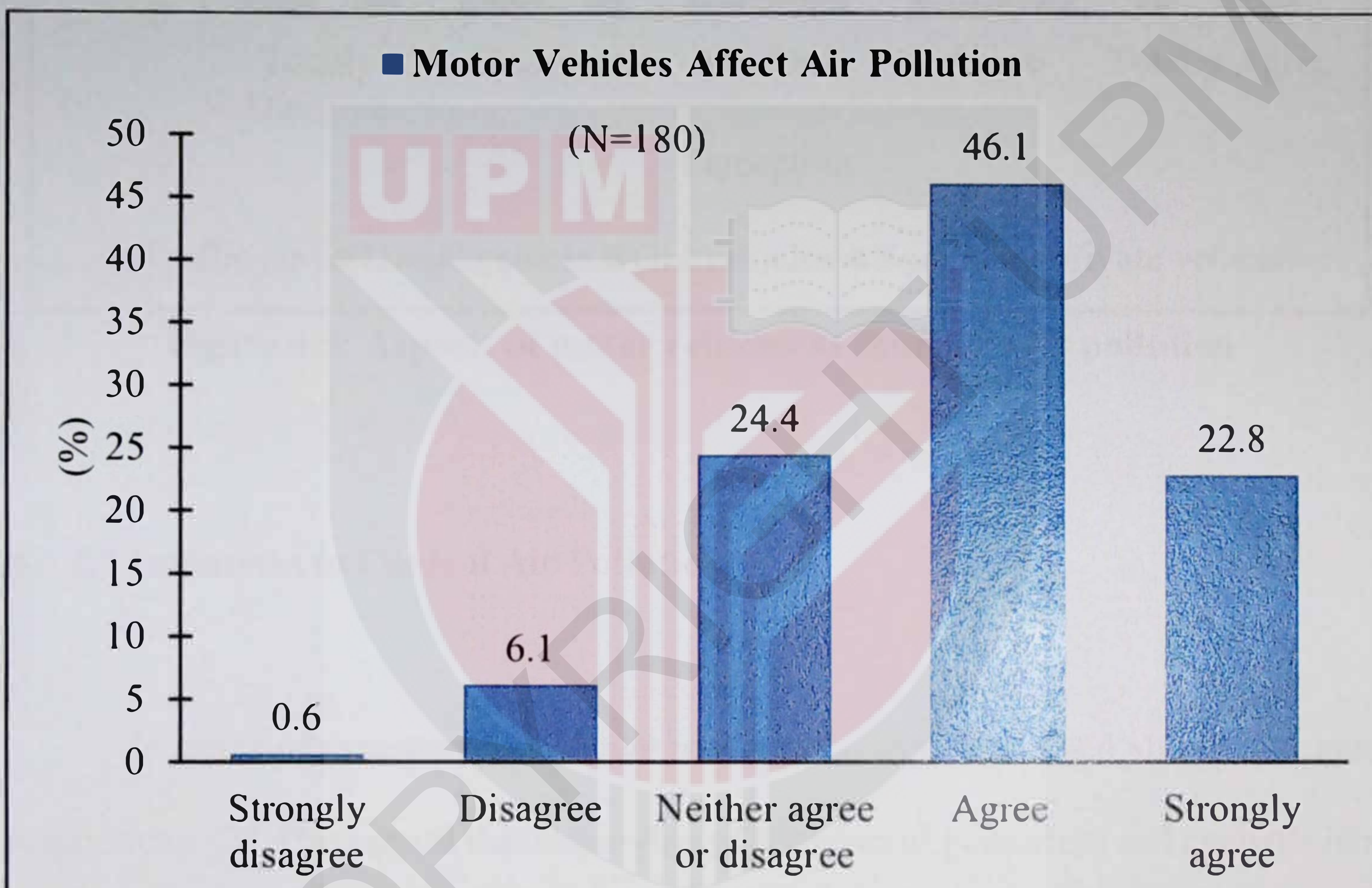

Figure 4.2: Perception of motor vehicles as source of air pollution

4.3.1.2 Traffic-Related Circumstances that Affect Air Pollution in Campus Area

In terms of the sources of air pollution, majority (83.4%) of the respondents agreed that the problem of traffic pollution was old vehicles in campus area. They also agreed that too many private vehicles (51.1%) also contributed to traffic pollution. Moreover, respondents (81.1%) did not agree that diesel vehicles and traffic jam contribute to air pollution (Figure 4.3).

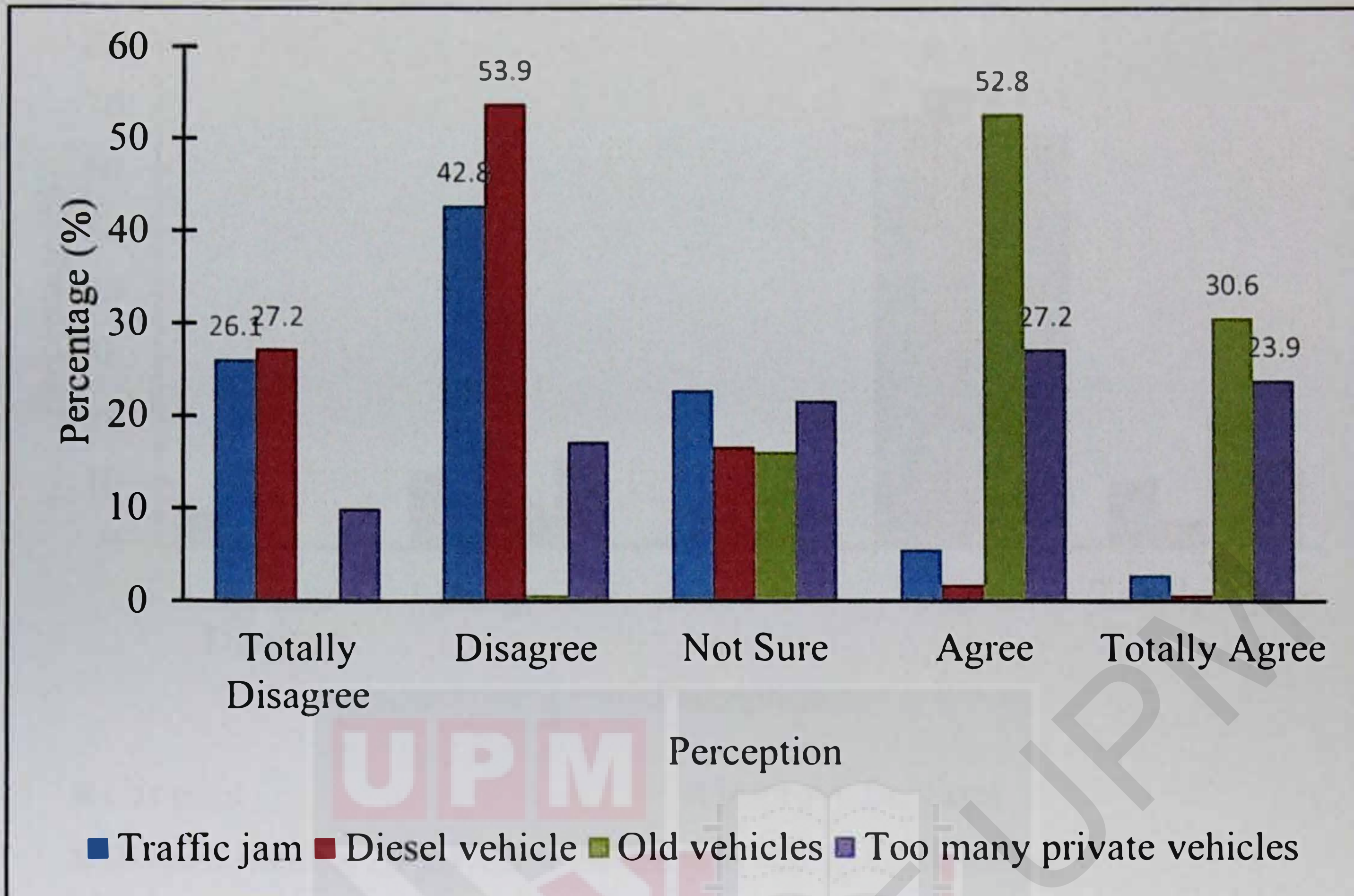

Figure 4.3: Aspects of motor vehicles as source of air pollution

4.3.1.3 Initiatives to Control Air Pollution

In terms of measures to mitigate traffic pollution, Figure 4.4 shows that most respondents (73.3%) agreed that improving of facilities of pedestrian and cyclist's lane would be one of the main measures to reduce air pollution. Other measures which were agreed to by majority of the respondents were carpooling (68.9%), reduce number of private vehicles (66.7%) and walking and cycling (66.1%) to academic zones.

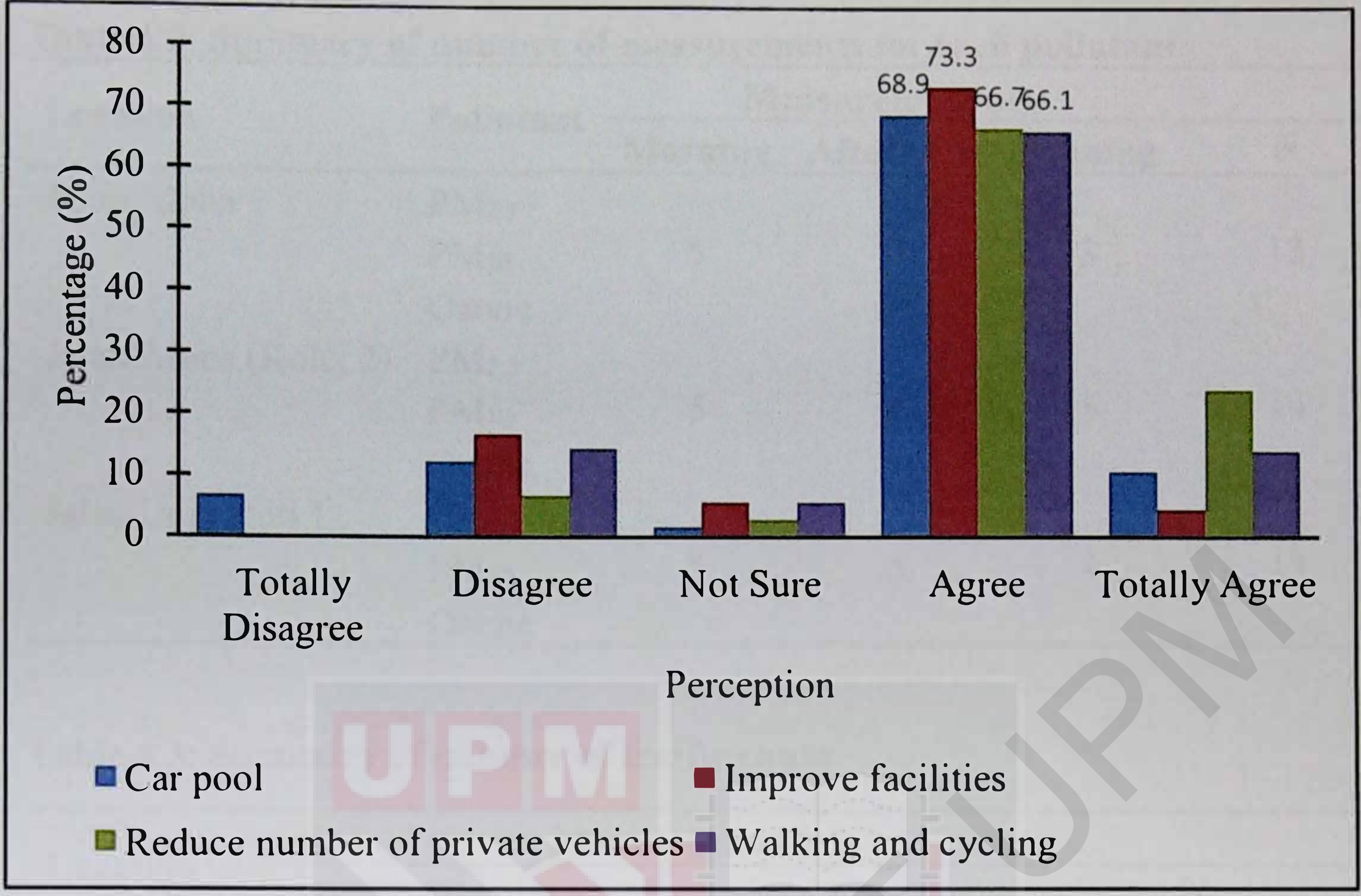

Figure 4.4: Initiatives to control and reduce air pollution

4.4 Traffic-related Air Pollutions

4.4.1 Summary of measurements of air pollutants and traffic count

Table 4.2 below shows the summary of number of measurements for each pollutant ($PM_{2.5}$, PM_{10} and ozone) in three different sampling locations in three-time rush hour (morning, afternoon, evening). Table 4.3 presented the summary number of traffic count that have been conducted simultaneously with the traffic-related air pollutants measurements. Unfortunately, not all measurements being taken due to the rainfall for each rush hour especially during afternoon. Total number of sample for Jalan Alpha was 13 samples and 14 samples for both Jalan Alpha-Kolej 2 and Jalan Universiti 1.

Table 4.2: Summary of number of measurements for each pollutant

Location	Pollutant	Measurement (n)			
		Morning	Afternoon	Evening	N
Jalan Alpha	$PM_{2.5}$				
	PM_{10}	5	5	3	13
	Ozone				
Jalan Alpha (Kolej 2)	$PM_{2.5}$				
	PM_{10}	5	4	5	14
	Ozone				
Jalan Universiti 1	$PM_{2.5}$				
	PM_{10}	5	5	4	14
	Ozone				

Table 4.3: Summary of number of traffic count

Location	Measurement (n)			
	Morning	Afternoon	Evening	N
Jalan Alpha	5	5	3	13
Jalan Alpha (Kolej 2)	5	4	5	14
Jalan Universiti 1	5	5	4	14

4.4.2 Level of Traffic-related Air Pollutants ($PM_{2.5}$, PM_{10}, Ozone)

Mean concentration of traffic-related air pollutants were compared to several guidelines as in Table 4.4. The $PM_{2.5}$ measurements exceed the 24-hour measurement standard of WHO (25 $\mu g/m^3$) and NAAQS (35 $\mu g/m^3$) and was the highest in Jalan Alpha (Kolej 2) during morning (48.97 $\mu g/m^3$) and Jalan Universiti 1 during afternoon (44.07 $\mu g/m^3$) and also evening (43.53 $\mu g/m^3$). PM_{10} also exceed the 24-hour measurement standards of WHO (50 $\mu g/m^3$) and was higher in Jalan Alpha (Kolej 2) during morning (83.77 $\mu g/m^3$) and also evening (53.0 $\mu g/m^3$) and Jalan Universiti 1 during afternoon (77.8 $\mu g/m^3$). The measurement results for ozone were also exceed 1-hour and 8-hour of MAAQG and NAAQ standards especially during afternoon and evening but did not exceed during morning. The highest measurement was in Jalan

Alpha (Kolej 2) during afternoon and evening with reading (302.97 $\mu g/m^3$) and (314.97 $\mu g/m^3$) respectively.

Table 4.4: Concentration of pollutants in comparison with guidelines

Location	Time	Avg. time	PM2.5	PM10	Ozone
				Mean (SD) ($\mu g/m^3$)	
Jalan Alpha	Morning	1-h	34.13 (9.72)	72.4 (30.25)	22.8 (8.06)
	Afternoon		25.73 (21.05)	58.27 (36.32)	194.33 (171.73)
	Evening		21.63 (21.64)	39.33 (36.47)	158.97 (165.55)
Jalan Alpha (Kolej 2)	Morning	1-h	48.97 (13.11)	83.77 (18.23)	31.4 (8.84)
	Afternoon		35.87 (17.11)	70.57 (35.55)	302.97 (234.07)
	Evening		26.8 (17.41)	53.0 (36.93)	314.97 (137.83)
Jalan Universiti 1	Morning	1-h	40.7 (14.12)	76.53 (26.87)	21.8 (4.93)
	Afternoon		44.07 (12.7)	77.8 (26.05)	127.47 (78.25)
	Evening		43.53 (72.28)	38.83 (27.95)	180.53 (147.35)
MAAQG (2016)		1-h			200
		24-h		120	120 (8-hour)
WHO (2006)		1-h			
		24-h	25	50	
NAAQS (2016)		1-h			
		24-h	35	150	70 (8-hour)

4.4.3 Daily Mean Concentration of Air Pollutants ($PM_{2.5}$, PM_{10}, Ozone)

Figure 4.5 shows the daily mean concentration of air pollutants in three-time rush hour ($PM_{2.5}$, PM_{10} and ozone) at Jalan Alpha. The highest measurement of PM_{10} was observed during morning. The trend of measurement between $PM_{2.5}$ and PM_{10} is quite similar on 14 February till 20 February except for morning measurements on 20 February that shows the peak was very high. However, the trend of measurement of O_3 did not follow of both trend measurement of $PM_{2.5}$ and PM_{10} during afternoon and evening.

Figure 4.6 below shows the daily mean concentration of air pollutants in three-time rush hour ($PM_{2.5}$, PM_{10} and ozone) at Jalan Alpha-Kolej 2. Both measurement of $PM_{2.5}$ and PM_{10} during three-time rush hour were showing the same trend. Trend measurement of O_3 was lower compared to afternoon and evening measurements and the peaks was showing high during afternoon and evening on 21st March.

The daily mean concentration of air pollutants in three-time rush hour ($PM_{2.5}$, PM_{10} and ozone) at Jalan Universiti 1 was shown in Figure 4.7. The highest PM_{10} was observed during morning with peak shows on 19th February and 1st and 24th March. The rest trend of measurement between $PM_{2.5}$ and PM_{10} is quite similar during afternoon and evening. Nonetheless, the trend of O_3 measurements was high during afternoon and evening.

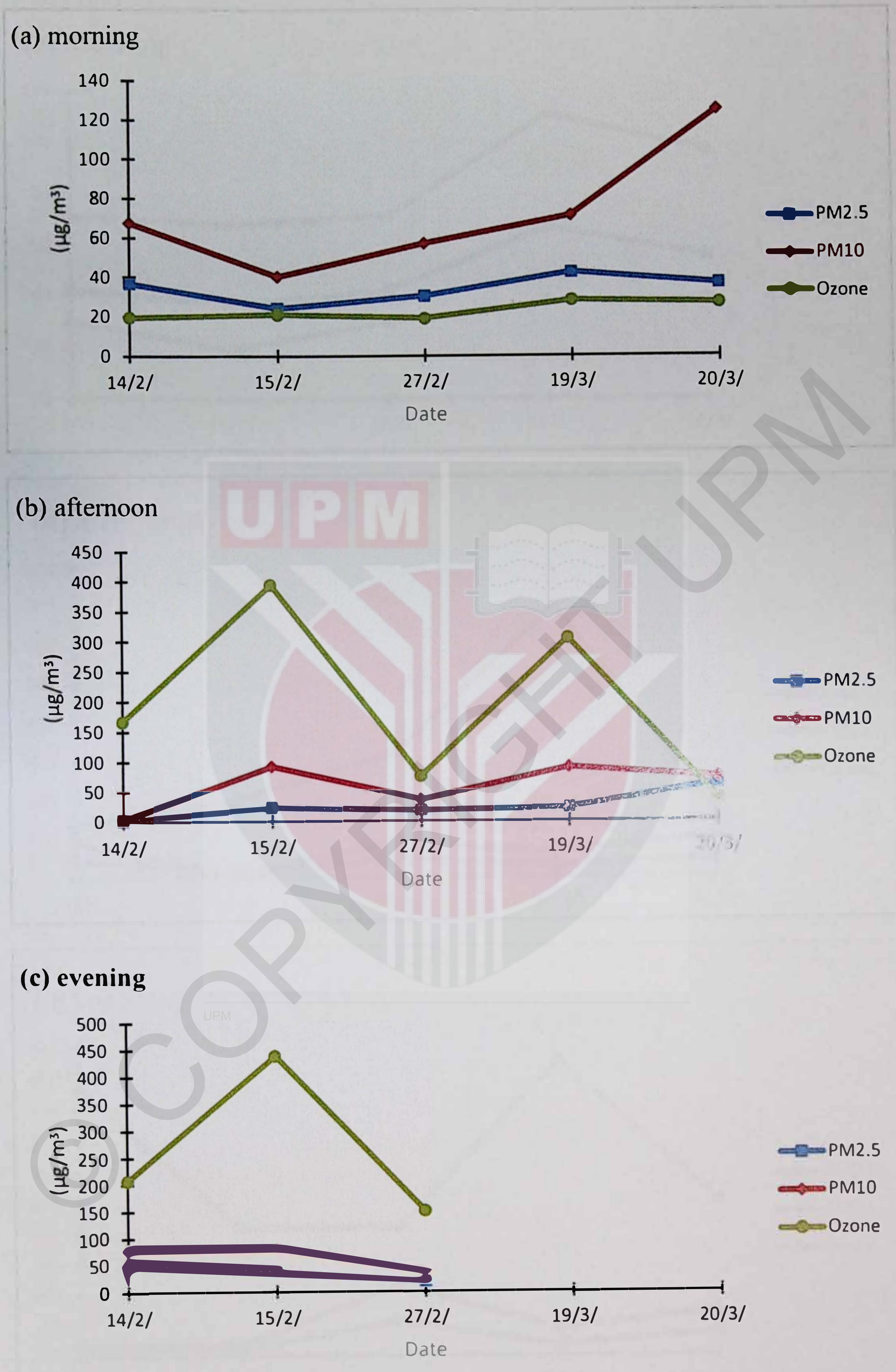

Figure 4.5: Daily mean concentration of air pollutants in three different time (a) morning, (b) afternoon and (d) evening at Jalan Alpha

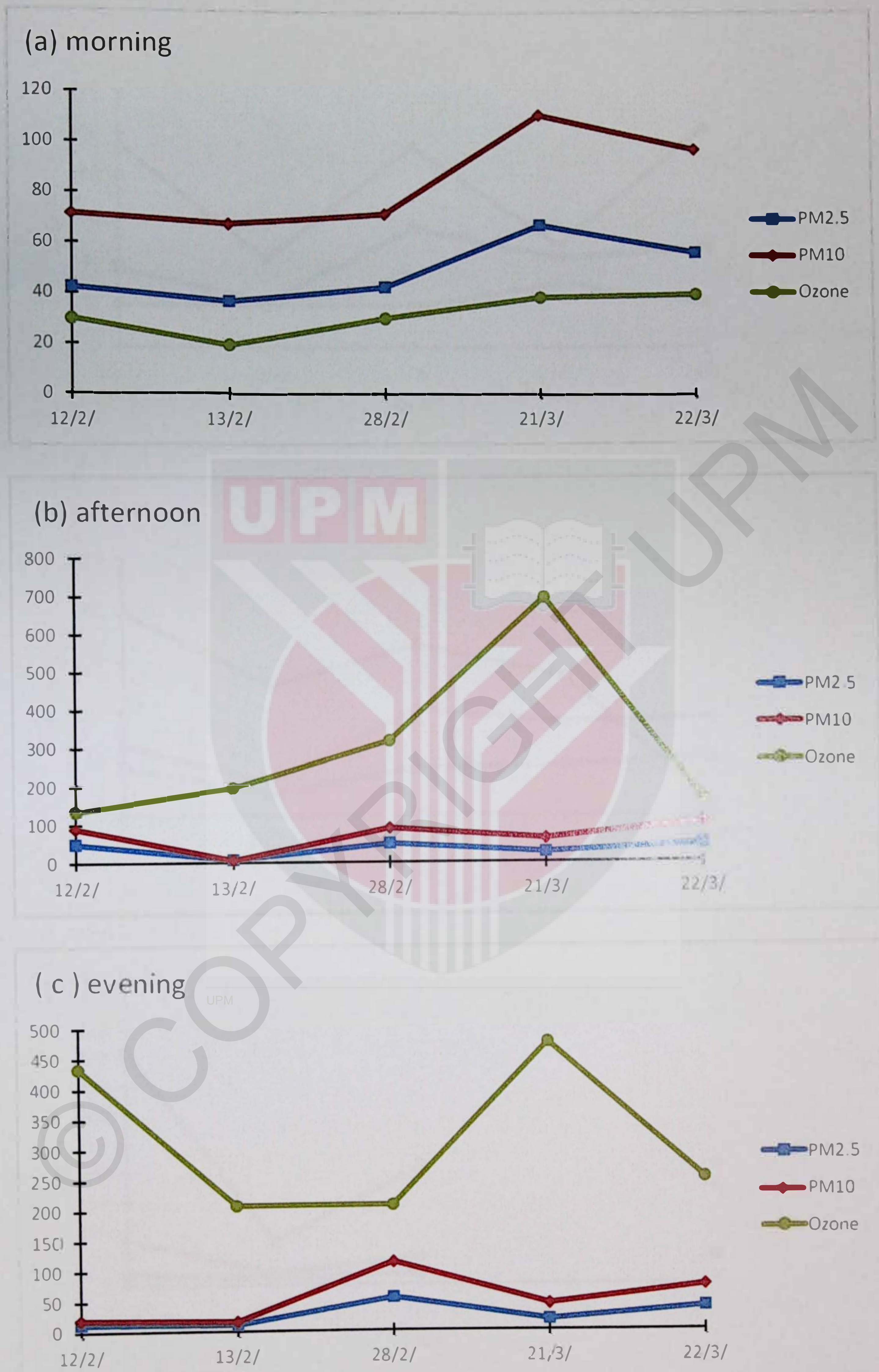

Figure 4.6: Daily mean concentration of air pollutants in three different time (a) morning, (b) afternoon and (c) evening at Jalan Alpha-Kolej 2

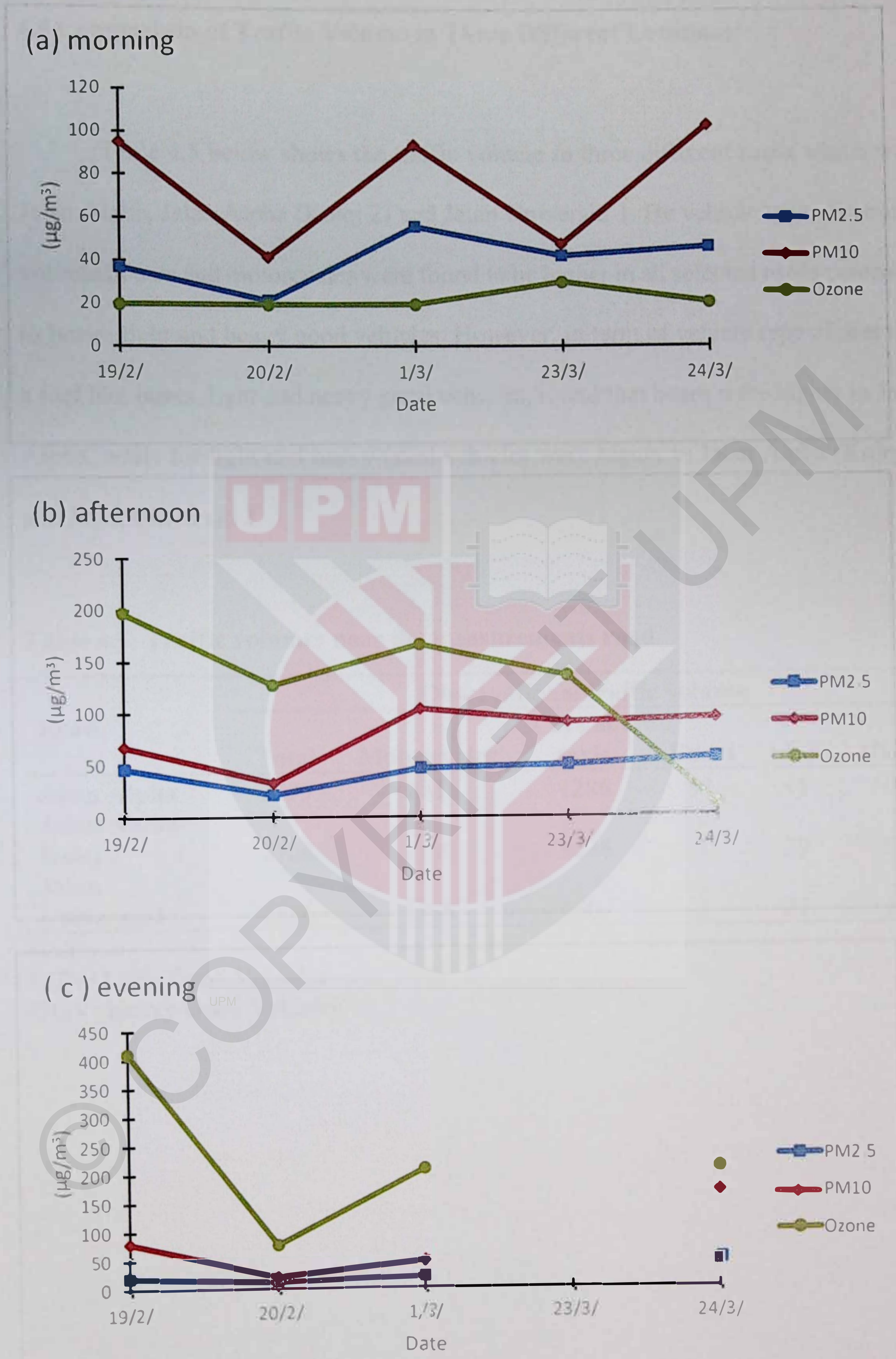

Figure 4.7: Daily mean concentration of air pollutants in three different time (a) morning, (b) afternoon and (c) evening at Jalan Universiti 1

4.5 Comparison of Traffic Volume in Three Different Locations

Table 4.5 below shows the traffic volume in three different roads which were Jalan Alpha, Jalan Alpha (Kolej 2) and Jalan Universiti 1. By vehicle type, the traffic volume of cars and motorcycles were found to be higher in all selected roads compared to buses, light and heavy good vehicles. However, in term of vehicle type of diesel as a fuel like buses, light and heavy good vehicles, found that buses were higher in Jalan Alpha, while for light and heavy good vehicles were higher in Jalan Alpha (Kolej 2) and Jalan Universiti 1.

Table 4.5: Traffic volumes near the measurements road

Road	Observational traffic volume					
	Total	Motorcycles	Cars and taxis	Buses	LGV	HGV
Jalan Alpha	2299	881	1286	91	41	0
Jalan Alpha-Kolej 2	2760	1190	1526	2	39	3
Jalan Universiti1	2886	1338	1507	3	37	1

Note:
LGV: Light Good Vehicles
HGV: Heavy Good Vehicles

Table 4.6: Comparisons of traffic volume in three different locations

Location	Time	Average time	Traffic Volume		
			Total (n)	Min	Max
Jalan Alpha (n = 13)	Morning	1- hour	784	133	178
	Afternoon		918	138	219
	Evening		748	231	278
Jalan Alpha – Kolej 2 (n = 14)	Morning	1- hour	957	123	228
	Afternoon		1143	176	338
	Evening		702	61	217
Jalan Universiti 1 (n = 14)	Morning	1- hour	1081	123	323
	Afternoon		1117	181	338
	Evening		767	61	326

4.6 Comparison of Respiratory Health Symptoms Among Respondents

Respiratory symptoms in this study were identified using the questionnaire adapted from International Union Against Tuberculosis and Lung Diseases (IUATLD). It was used to determine the symptoms of respiratory disease among respondents of the study areas as this was the fourth objective of the study. The parameters for respiratory symptoms were wheezing, chest tightness, shortness of breath, cough, phlegm and breathing difficulties. As present in Table 4.6 below, a significant difference and higher reported among pedestrian of respiratory symptoms except for coughing and breathing difficulties. The probability of getting wheezing, chest tightness, shortness of breath and phlegm among pedestrian as approximately 1 times higher than cyclists.

Table 4.7: Occurrence of respiratory health symptoms among respondents by using a Pearson's chi-square test (N=180)

Respiratory Symptoms	Pedestrian (n=90) Number (%)	Cyclists (n=90) Number (%)	χ^2 value	*p* value	PR	95% CI
Wheezing						
Yes	43 (47.8)	40 (44.4)	0.201	0.654	1.144	0.636-2.056
No	47 (48.5)	50 (48.5)				
Chest Tightness						
Yes	38 (42.2)	37 (41.1) 53	0.023	0.800	1.047	0.579-1.893
No	52 (49.5)	(50.5)				
Shortness of Breath						
Yes	26 (28.9)	22 (24.4)	0.455	0.500	1.256	0.647-2.436
No	64 (48.5)	68 (51.5)				
Coughing						
Yes	55 (61.1)	66 (73.3)	3.051	0.081	0.571	0.304-1.074
No	35 (38.9)	24 (26.7)				
Phlegm						
Yes	25 (27.8)	18 (20.0)	1.497	0.221	1.538	0.770-3.075
No	65 (72.2)	72 (80.0)				
Breathing Difficulties						
Yes	28 (31.1)	27 (30.0)	0.026	0.871	0.949	0.503-1.790
No	62 (68.9)	63 (70.0)				

*significant at $p<0.05$, Prevalence Ratio (PR) significantly at 95% Confidence Interval (CI)>1

4.7 Correlation between Traffic Volume and Traffic-Related Air Pollutants ($PM_{2.5}$, PM_{10}, Ozone)

Pearson correlation test was computed to assess the relationship between traffic-related air pollutants ($PM_{2.5}$, PM_{10}, Ozone) and traffic volume in three different roads (Jalan Alpha, Jalan Alpha – Kolej 2 and Jalan Universiti 1). There was a positive correlation between traffic volume and traffic-related air pollutants. Overall, there was significantly with strong relationship between traffic volume and air pollutants ($PM_{2.5}$ and PM_{10}) in Jalan Alpha, Jalan Alpha – Kolej 2 and Jalan Universiti 1. However, there was no significantly relationship between traffic volume and ozone in three different roads.

Table 4.8: Correlation between air pollutants ($PM_{2.5}$, PM_{10}, Ozone) and traffic volume

		Traffic Volume	
Location	**Pollutants**	****Coefficient correlation, *r***	***p*-value**
Jalan Alpha	$PM_{2.5}$	0.613	**<0.001**
	PM_{10}	0.409	0.061
	O_3	0.290	0.654
Jalan Alpha – Kolej 2	$PM_{2.5}$	0.981	**<0.001**
	PM_{10}	0.581	**0.041**
	O_3	0.261	0.072
Jalan Universiti 1	$PM_{2.5}$	0.676	**<0.001**
	PM_{10}	0.583	0.081
	O_3	0.413	0.221

**Pearson correlation, *significant at $p<0.05$

4.8 Association between Traffic-Related Air Pollutions (TRAPs) with Air Quality Perception among Respondents

In order to associate traffic-related air pollutions with air quality perception, all pollutants were categorized based on their median value. A value that was higher than median was categorized as high while the value that was lower than median was categorized as low. This test only involved those who perceived air quality as poor (n=60) and good (n=77) (Section 4.3.1). Table 4.7 shows the association between traffic-related air pollutions and air quality perception among pedestrian and cyclists.

The Pearson's chi square test results show a significant association between all pollutants ($PM_{2.5}$, PM_{10}, and ozone) with air quality perception among respondents as (p= 0.000, PR= 13.404, 95% CI= 3.877-46.347), (p= 0.000, PR= 13.404, 95% CI= 3.877-46.347) and (p= 0.011, PR= 0.391, 95% CI= 0.188-0.811) respectively.

It is suggested that, the probability of active traveler who exposed to high level of $PM_{2.5}$ and PM_{10} perceived air quality as poor was 13.4 times higher than those who did not exposed. The probability of active travelers who exposed to high level of ozone perceived air quality as poor was less than 1 time than those who did not expose. This prevalence was small enough.

Table 4.7: The association between traffic-related air pollutions with air quality perception among respondents by using Pearson's chi-square test (N=137)

Variables	Air Quality Perception		χ^2 value	p value	PR	95% CI
	Poor Air Quality(n=48)	Good Air Quality(n=89)				
$PM_{2.5}$						
High (>37$\mu g/m^3$)	45	47	**23.196**	**0.001***	13.404	3.877-46.347
Low (<37$\mu g/m^3$)	3	42				
PM_{10}						
High (>64$\mu g/m^3$)	45	47	**23.196**	**0.001***	13.404	3.877-46.347
Low (<64$\mu g/m^3$)	3	42				
Ozone						
High (>125 $\mu g/m^3$)	24	64	**6.516**	**0.011***	0.391	0.188-0.811
Low (<125 $\mu g/m^3$)	24	25				

*significant at p<0.0, Prevalence Ratio (PR) significantly at 95% Confidence Interval (CI)>1

4.9 Association between Traffic-Related Air Pollutions (TRAPs) with Respiratory Health Symptoms among Respondents

Further analysis was done to determine an association between traffic-related air pollutions exposure with respiratory health symptoms among the active travelers by using the median value. The results were tabulated in Table 4.8, Table 4.9 and Table 4.10.

From Table 4.8 and Table 4.9, there is a significant association between high level of $PM_{2.5}$ and PM_{10} with five respiratory health symptoms which are wheezing (p= 0.000, PR= 0.047, 95% CI= 0.021-0.107), chest tightness (p= 0.000, PR= 0.108, 95% CI= 0.052-0.225), shortness of breath (p= 0.000, PR= 0.142, 95% CI= 0.060-0.340), coughing (p= 0.000, PR= 0.158, 95% CI= 0.079-0.315) and phlegm (p= 0.006, PR= 0.349, 95% CI= 0.0163-0.748). It is suggested that, the probability of active travelers who exposed to high level of $PM_{2.5}$ and PM_{10} to get wheezing, chest tightness, shortness of breath, coughing and phlegm were less than 1 times higher than those who exposed to the low level. This odd very small.

For ozone (Table 4.10), there is significant association between high level of ozone with five respiratory health symptoms which are wheezing (p= 0.002, PR= 2.849, 95% CI= 1.464-5.541), chest tightness (p= 0.000, PR= 4.229, 95% CI= 2.141-8.354), shortness of breath (p= 0.001, PR= 3.128, 95% CI= 1.557-6.283), phlegm (p= 0.041, PR= 2.098, 95% CI= 1.029-4.299) and breathing difficulties (p= 0.039, PR= 0.495, 95% CI= 0.252-0.972). It is suggested that, the probability of active travelers who exposed to high level of ozone to get wheezing and phlegm were 2 times higher than those who exposed with low level of ozone. Meanwhile, the probability of active traveler who exposed to high level of ozone to get shortness of breath and chest tightness were 3 times and 4 times higher than who exposed to the low level of ozone.

Table 4.8: The association between exposure of $PM_{2.5}$ with respiratory health symptoms among respondents by using Pearson's chi-square test (N=180)

Respiratory Symptoms	$PM_{2.5}$ (High)	$PM_{2.5}$ (Low)	χ^2 value	p value	PR	95% CI
	Number					
Wheezing						
Yes	74	9	68.297	**0.001***	0.047	0.021-0.107
No	27	70				
Chest Tightness						
Yes	63	12	40.607	**0.001***	0.108	0.052-0.225
No	38	67				
Shortness of Breath						
Yes	41	7	22.826	**0.001***	0.142	0.060-0.340
No	60	72				
Coughing						
Yes	85	36	29.458	**0.001***	0.158	0.079-0.315
No	16	43				
Phlegm						
Yes	32	11	7.689	**0.006***	0.349	0.163-0.748
No	69	68				
Breathing Difficulties						
Yes	34	21	1.047	0.306	1.402	0.733-2.679
No	67	58				

*significant at $p<0.05$, Prevalence Ratio (PR) significantly at 95% Confidence Interval (CI)>1

Table 4.9: The association between exposure of PM_{10} with respiratory health symptoms among respondents by using Pearson's chi-square test (N=180)

Respiratory Symptoms	PM_{10} (High)	PM_{10} (Low)	χ^2 value	p value	PR	95% CI
	Number					
Wheezing						
Yes	74	9	68.297	**0.001***	0.047	0.021-0.107
No	27	70				
Chest Tightness						
Yes	63	12	40.607	**0.001***	0.108	0.052-0.225
No	38	67				
Shortness of Breath						
Yes	41	7	22.826	**0.001***	0.142	0.060-0.340
No	60	72				
Coughing						
Yes	85	36	29.458	**0.001***	0.158	0.079-0.315
No	16	43				
Phlegm						
Yes	32	11	7.689	**0.006***	0.349	0.163-0.748
No	69	68				
Breathing Difficulties						
Yes	34	21	1.047	0.306	1.402	0.733-2.679
No	67	58				

*significant at $p<0.05$, Prevalence Ratio (PR) significantly at 95% Confidence Interval (CI)>1

Table 4.10: The association between exposure of ozone with respiratory health symptoms among respondents by using Pearson's chi-square test (N=180)

Respiratory Symptoms	Ozone(High)	Ozone(Low)	χ^2 value	p value	PR	95% CI
	Number					
Wheezing						
Yes	49	34	9.838	**0.002***	**2.849**	1.464-5.541
No	78	19				
Chest Tightness						
Yes	40	35	18.356	**<0.001***	**4.229**	2.141-8.354
No	87	18				
Shortness of Breath						
Yes	25	23	10.751	**<0.001***	**3.128**	1.557-6.283
No	102	30				
Coughing						
Yes	81	40	2.320	0.128	1.747	0.848-3.600
No	46	13				
Phlegm						
Yes	25	18	4.912	**0.041***	**2.098**	1.029-4.299
No	102	35				
Breathing Difficulties						
Yes	33	22	4.248	**0.039***	0.495	0.252-0.972
No	94	31				

*significant at p<0.05, Prevalence Ratio (PR) significantly at 95% Confidence Interval (CI)>1

CHAPTER 5

DISCUSSION

5.1 Socio-demographic

The results showed that majority of pedestrian and cyclists were female aged 21-22 years old and also not smoking with majority of them from residents of Kolej Kelima and also Kolej Canselor. Omid *et al.*, (2013) also reported disproportionate gender distribution of female to male in public university in Malaysia. The proportion of female students were higher compared to male students. The demographic data may suggest that many young healthy adults have a growing awareness of air pollution, and they want the management to change the situation.

5.2 Traffic-related Air Quality Perception

These results contribute with evidence about students' perception on traffic pollution issues in UPM campus area. As well as previous studies by (Gracia & Jaula, 2006; Ramirez, 2015), our findings aim to improve the understanding of UPM's air pollution condition and to highlight the potential of including student's perception as a way to support local action to address air pollution problems. Taking advantage of the university students, we were able to have about 180 respondents in total, from different college around main campus area in UPM. As far as we are aware, this is the first study addressing students' perception, examining about air quality, its causes and health impacts especially on respiratory symptoms.

There is a widespread concern about air quality within the participants. Among the 180 respondents, 89 (49.4%) thought the air quality of UPM campus area was better compared to six months ago, while 48 (26.7%) believed that air quality was poor compared to six months ago. The fact that all participants were undergraduate students from non-environmental programme is of course giving a certain heterogeneity to the sample, but it must however be notices that it covers people from a broad range of ages and different residents in UPM campus.

Majority of the respondents 83.4% agreed that air pollution was motor vehicles. These findings can be linked with the measurements of traffic volume as stated in section 4.4. The highest average number of traffic volume was recorded in Jalan Universiti 1 with 2886 number of vehicles, followed by Jalan Alpha-Kolej 2 with 2760 and the least traffic volume in Jalan Alpha 2299 number of vehicles. This is consistent with the previous research that highlight public perception on traffic pollution in Federal Territory, Kuala Lumpur has shown that the main sources of air pollution were motor vehicles (Shafie & Mahmud, 2017). Similarly, a previous study from New Zealand has shown that the main sources of air pollution were motor vehicles, coal combustion, wood sources, and unknown sources (Ancelet *et al.*, 2014). On the other hand, research findings have shown that people largely perceive automobiles as the main source of air pollution (Gordon, Howel & Brandao, 2003). In Kuwait, people identified air pollution to be the fifth most important consequence of traffic congestion out of eight possible consequences. But few parents were willing to use a free school bus service if provided (Koushki *et al.*, 2002).

Air pollution problems are complex and multidimensional, which demands to involve different perspective for its analysis and management (Lezama, 2004; Funtowictz & Ravetz, 1990; Cupples; 2009). It is not about reducing the discussion to relativistic approaches, but a complete understanding of the local air quality scenario should include people's perception of the problem as part of its indicator in order to reduce and control air pollution. In UPM, it is time to start building and strengthening the existing university environmental policy together with students. We consider this is crucial since student's participation in such university agenda can lead to generate strategies for a better environment. Therefore, these findings agreed by the majority of the respondents to suggest that improving facilities of pedestrian and cyclists' lane (73.7%), car-pooling (68.9%), reduced the number of private vehicles (66.7%) and also walking and cycling (66.1%) to the academic zones as control measures to reduce air pollution in campus area.

5.3 Traffic-Related Air Pollutants (PM_{10}, $PM_{2.5}$, Ozone) Level

In this study, the mean concentration of air pollutants was exceeded the 24-hour and 1-hour standards. The highest average concentration of $PM_{2.5}$ was recorded in Jalan Alpha-Kolej 2 during morning (48.9±13.1 μg/m^3) while during afternoon (44.1±12.7 μg/m^3) and evening (43.5±72.3 μg/m^3) were in Jalan Universiti 1. PM_{10} also was recorded highest reading in Jalan Universiti 1 during afternoon (77.8±26.1 μg/m^3) while Jalan Alpha-Kolej 2 during morning (83.8±18.2 μg/m^3) and evening (53.0±36.9 μg/m^3). Ozone was recorded with highest reading in Jalan Alpha-Kolej 2 in two-time rush hour (afternoon and evening) with (302.9±234.1 μg/m^3) and (314.9±137.8 μg/m^3) respectively, but the ozone concentration was below the 1-hour standard during morning. Ozone was beginning with the low values in the early morning. As the solar intensity increases, ozone begins to accumulate and reaching the maximum at its midday peak during afternoon. As solar energy decreases, ozone begins to decline and reaches its minimum at evening. This is because ozone can be formed as the result of the sunlight induced oxidation of precursor pollutants emitted into the atmosphere (NO_x) (Moser, 1986).

This study found that Jalan Alpha- Kolej 2 was suffered with high concentration of air pollutants (PM_{10}, $PM_{2.5}$ and ozone) in three-time rush hour (morning, afternoon and evening) followed by Jalan Universiti 1 and the least concentration of air pollutants recorded was in Jalan Alpha. This is because the location of Jalan Alpha-Kolej 2 is near to the residential area, the road was intersection besides the high density of traffic that contributed to the high concentration of traffic-related air pollutants as compared to Jalan Alpha and Jalan Universiti 1. Previous study also found that highest air pollutant concentrations were observed at intersection (Hankey & Marshall, 2015).

Based on the traffic count survey, the number of small size vehicles (motorcycles) (3409) and medium size vehicles (cars and taxis) (4319) are the highest among large size vehicles (buses, light and heavy good vehicles). Even though, the small size vehicles producing low concentration of traffic-related air pollutants but with the high number of small size vehicles will contribute to high emission of traffic-related air pollutants (Zuurbier *et al.*, 2010). Zuurbier *et al.* (2010) also states that concentration of traffic-related air pollutants was significantly influenced by the road design and fuel type.

Based on the survey, De Kok *et al.* (2006) states that traffic is the major source of PM mainly originating from the wear of vehicle components such as brakes and tires as well as suspension of road dust. This was also reported by Ferm and Sjoberg (2015), that in their study, indicating that most of the $PM_{2.5}$ particles originate from the exhaust pipes and the coarse fraction of PM_{10} comes from the road.

5.4 Correlation between Traffic Volume and Traffic-Related Air Pollutants ($PM_{2.5}$, PM_{10}, Ozone)

This study shows that there was a positive, significant direct strong relationship between the traffic volume and air pollutants ($PM_{2.5}$ and PM_{10}) in three different roads (Jalan Alpha, Jalan Alpha – Kolej 2) and Jalan Universiti 1). This finding is similar from the finding of other studies, as it is found that the concentration of $PM_{2.5}$ and PM_{10} from road traffic were significantly correlated with the traffic volume (Ferm & Sjoberg, 2015). Pant and Harrison (2013) stated that road traffic significantly contribute to airborne concentration of particulate matter (PM) with 5%-80% depending on site and location. The factors that contribute to emission of air pollutants based on the fleet mix, type of road, traffic characteristics and fuel type (Pant & Harrison, 2013).

However, the results show that there was positive, insignificant direct fair correlation between traffic volume and ozone. Even though the traffic volume was recorded high during morning but the sunlight was minimal during morning. The ozone concentration starts to increases during afternoon and evening with good intensity of the sunlight. The sunlight acts as catalysts in order to oxidize the NO_x and VOCs to ozone (Ling & Guo, 2014).

5.5 Association Between TRAPs (PM_{10}, $PM_{2.5}$, Ozone) with Air Quality Perception

There is a statistical evidence for the relationship between perception on the air quality and PM_{10}, $PM_{2.5}$ ($\chi^2 = 23.20, p < 0.001$) and ozone ($\chi^2 = 6.516, p = 0.011$). In general, the importance of vehicular traffic as a source of air pollution, rises as the air quality perception perceived as poor. This is in accordance with the results from previous studies (Sakseena, 2011), where studies have stressed the daily experience on how people perceived the quality of air. Most studies have highlighted that the real-world experience of the respondents including the smells of pollutants and what they have seen were the major influenced of their perception on the air pollution levels (Bickerstaff and Walker 2001; Howel *et al.*, 2003). However, not much work has been done to study how human perception correlate with physical measurements of pollution. Our findings are also in line with some other studies by Liao *et al.* (2015), they found that the levels of ozone and visibility were more correlated with perceived air quality. This also agreed to the findings from previous literature by Modig and Forsberg (2007) which mentioned those who perceived annoyance in relation with rising level of vehicle exhaust concentrations.

5.6 Association Between TRAPs (PM_{10}, $PM_{2.5}$, Ozone) with Respiratory Health Symptoms

Regarding the consequences of traffic-related air pollution, many studies have reported a correlation between the exposure level to car-emitted pollutants and various health effects including respiratory disease and decline of human body functions. These effects are greater among infirm, elderly people and children, who have weaker immune systems (Annesi-Maesano *et al.*, 2007; Garcia Gallardo *et al.*, 2013). However, young healthy adults also not excluded from these effects because they are very active and spend most of their time outdoors (Juneng L. *et al.*, 2009). In particular, studies have reported that traffic-related factors influence not only occurrence of allergic disease, but also respiratory disease (e.g., asthma) (Brunekreef *et al.*, 1997; Crilly *et al.*, 2013). Air pollution has recently received greater attention as a cause of respiratory disease, and research has shown that air pollutants and traffic in urban areas lead to the occurrence and worsening of respiratory diseases especially for those with active transport mode like cyclists and pedestrian when ventilation take into accounts (Leikauf, 2002; Abramson, 2006; Jonathan *et al.*, 2012). Furthermore, studies have verified that short-term exposure to diesel emissions may cause hypersensitive allergies and asthma-like symptoms (McCreanor *et al.*, 2007; Patel *et al.*, 2011).

In this study, statistical evidence ($p < 0.001$) demonstrated that the higher the concentration of traffic-related air pollutants (PM_{10}, $PM_{2.5}$, and ozone), the higher the chance to have respiratory symptoms (wheezing, shortness of breath, coughing and phlegm). For exposure of air pollutants, PM_{10} and $PM_{2.5}$ shows significant association ($p < 0.001$) with wheezing, chest tightness, shortness of breath, coughing and phlegm. This is consistent with previous research that highlight the statistically significant association of PM_{10} (OR = 1.012; 95% CI, 0.997-1.026) with coughing. Ozone (O_3) show significant association ($p < 0.001$) with wheezing, chest tightness, shortness of breath, phlegm and breathing difficulties. Similarly, this result also was supported by Norback *et al.* (2000) study where they found a significant relationship between various types of indoor gaseous and particulate pollutants with nasal effects. International study by Madureira *et al.* (2015) stated that some air pollutants, even at low exposure levels, were related to the development of respiratory symptoms.

5.7 Study Limitation

The present study conducted was through cross-sectional design, which we cannot predict whether certain variables precedes the other, such as the traffic-related air pollutants was causing respiratory health symptoms or whether it is after they have respiratory health symptoms, they exposed to the traffic-related air pollutants. This also applies to other variables, where causal relationship was not being able to established.

Another major limitation was regarding the sample size, where minimum sample size was hardly achieved, as potential respondents was not answering the questionnaire even have been posted or blasted throughout the social media. In addition, the short study duration made those who answered beyond the questionnaires beyond the time given unable to be included in this study.

Apart from that, as this study is based on self-reported of respiratory symptoms, without verifying it with clinical or laboratory reports, recall bias might be present. Also, for traffic-related air pollutants assessment, there are still no standards established for $PM_{2.5}$. In this study, traffic-related air pollutants assessment was done for 1 hours for every rush hour periods. Therefore, Recommended Malaysian Air Quality Guideline (RMAQG) or other reference standard may not be suitable for comparing the exposure as most of it was based on 8-hour or 24-hour exposure.

Last but not least, this study has the limitation of not being able to represent the general population of UPM that also include staffs and students that use passive transportation as a main transportation to class.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Students' perception on traffic-related air pollution, level of traffic-related air pollutants and respiratory health symptoms were explored among pedestrian and cyclists in UPM.

The present study strongly suggested that 89 (49.4%) of respondents believed that air quality was better compared to six months ago. The respondents identified that traffic pollution is influenced by the old vehicles and too many private vehicles in campus area. Most of the respondents were favorable to policies and strategies that reduce the number of private vehicles, carpooling, improving facilities of pedestrian and cyclist's lane and also walking and cycling to class can control and reduce the traffic emission. The highest mean concentration of $PM_{2.5}$ were found in Jalan Alpha – Kolej 2 (morning: 49.0±13.1 $\mu g/m^3$) and Jalan Universiti 1 (afternoon: 44.1±12.7 $\mu g/m^3$). The highest mean concentration of PM_{10} were found in Jalan Alpha – Kolej 2 (morning: 83.7±18.2 $\mu g/m^3$; evening: 53.0±37.0 $\mu g/m^3$) and Jalan Universiti1 (afternoon: 77.8±26.1 $\mu g/m^3$). The highest mean concentration of ozone (O_3) was found in Jalan Alpha – Kolej 2 (morning: 194.3±171.7 μg/m^3) and Jalan Universiti 1 (afternoon: 315.0±137.9 μg/m^3; evening: 180.5±147.4 μg/m^3).

The widespread perception of poor air quality and level of air pollutants concentration should be a call for the university management to initiate or intensify monitoring, and emissions control programs. The findings of this study should, therefore, be taken into account by the university management in formulating policies and measures to mitigate traffic pollution in UPM.

6.2 Recommendation

6.2.1 University Management

Managing air quality in university should be consider as first priority because the students' performance in class are significantly associated with the exposure to outdoor air pollution. The university management should ensure that the air pollution is well regulated and below the standards at all times by strategize an action and policies to address this problem. As this study found that the sources of air pollution in UPM campus was traffic pollution. Therefore, the measures should be taken regarding to the transportation in campus area. Transportation system plays an important role on the carbon emission and pollutant level in university. Transportation policy to limit the number of motor vehicles in campus, the use of campus bus and bicycle will encourage a healthier environment. The pedestrian policy will encourage students and staff to walk around campus and avoid using private vehicles. The use of environmentally friendly public transportation will decrease carbon footprint around campus. The transportation policy designed to limit or decrease the parking area on campus and the transportation initiatives to limit or decrease private vehicles on campus. Other than that, university management also should maintain the pedestrian and cyclist lane in a good condition.

6.2.2 Campus shuttle service

The peak level of particles ($PM_{2.5}$ and PM_{10}) and ozone might due to the traffic congestion near the residential and pedestrian and cyclist lane. The presence of campus shuttle service and other vehicles waiting for the students in morning, afternoon and evening may disperse these pollutants throughout the roadside near to the pedestrian and cyclist lane. Thus. Eliminating pollutant sources should help to minimize the student's exposure. This low-cost option can be easily implemented by university management.

6.2.3 Students

Students should practice to take care of their personal hygiene and also their environment. The students should also wear the facemask if they found that the air quality in their campus was poor during walking or cycling to class in order to minimize the exposure because during this activity they may exposed directly to the particles that remain in environment.

6.2 Recommendation for Future Studies

This present study shows the state of traffic pollution in the roadsides is very limited particularly between traffic-related air pollutions with air quality perception and respiratory symptoms among university students especially to those that travel to class by cycling or walking. There are still limited studies on how human perception correlate with physical measurements of pollution and also the mechanism effects of the particulate matter and ozone on respiratory symptoms are still not clearly understood. Further research need to be conducted in the future on measurements of other traffic-related air pollutants (carbon monoxide, black carbon, sulphur dioxide, nitrogen dioxide, and VOCs) and particles in depth with their mixture components in order to determine in detail the significant differences with a large number of sample sizes.

At closing, more research is needed to determine the range of traffic pollution issues in university and brings forward to the urban are with high population. Hopefully with different studies on traffic-related air pollutions conducted in Malaysia may help Ministry of Higher Education (MOHE) to generate a good policy and made known to the community so a better liability will be taken together.

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APPENDICES

APPENDIX 1:

Ethical Approval

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

Research title	:	**Association Between Traffic-Related Air Pollutions (TRAPS) With Air Quality Perception and Respiratory Symptoms Among Pedestrian and Cyclists in Universiti Putra Malaysia**
Study Site	:	**UPM**
JKEUPM Ref No.	:	**JKEUPM-2017-197**
Researcher	:	**Mohamad Fadhil bin Zakaria**
Supervisor	:	**Dr. Nor Eliani bt Ezani**

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 31/10/2017
2. Respondent Information Sheet & Consent (English), Version 2 dated 16/11/2017
3. Respondent Information Sheet & Consent (Malay), Version 2 dated 16/11/2017
4. Proposal (English), Version 3 dated 8/1/2018
5. Questionnaire (English), Version 1 dated 31/10/2017
6. Curriculum Vitae of:
   a. Dr.Nor Eliani bt Ezani

The University Research Ethics Committee, Universiti Putra Malaysia (JKEUPM) operates in accordance 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 8 JANUARY 2019**

Researchers should comply with the following:

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

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

APPENDIX 2:

Information Sheet and

Consent Form

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

FORM 2.4: RESPONDENT'S INFORMATION SHEET AND INFORMED CONSENT FORM

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

1. STUDY TITLE :

A field study approach of traffic-related air quality perception and health impact among pedestrian and cyclists in University campus.

2. INTRODUCTION:

Air quality plays an important role in the quality of life, affecting humans' health and also welfare. Poor air quality is closely related to adverse health effects or even premature death. Bicyclists and pedestrian enjoy the health benefits of increased physical activity, but with the major potential drawback of an increased uptake of traffic-related air pollutants which have been linked to adverse health effects and associated with increased mortality. Therefore, it is utmost importance to carry out this study to explore traffic-related air quality perception among them in order to suggest improvement of transportation system in the campus and reducing personal's risk to adverse health effects.

3. WHAT WILL YOU HAVE TO DO?

As a respondent, you are needed to sign the consent form which indicated you are interested and willing to cooperate with this study. Then, you are asked to complete the questionnaire.

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

Respondent who are not travel with bicycle or by walking to/from class

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

There are no individual benefit when taking part in this research study

(b) TO THE INVESTIGATOR?

The researcher hope that the finding of this study will provide data to know perception of bicyclist and pedestrian towards air quality in university campus in order to suggest improvement of transportaion system in the campus and reducing personal's risk to adverse health effects.

6. WHAT ARE THE POSSIBLE RISKS?

There are no possible risks known for joining this study.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

All the information and identity that are provided by the respondents will remain confidential.

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

If you have any inquiries you can contact the researcher responsible for the study or the project leader of the researcher.

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

9. CONSENT

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

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 I have 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 my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

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

* delete where necessary

Signature .... (Respondent)

Date :..

Signature .... (Witness)

Name :..

I/C No. :..

I confirm that I have explained to the respondent the nature and purpose of the above-mentioned research.

Date ....

Signature .... (Researcher)

APPENDIX 3:

Questionnaire Form

KOD RESPONDEN

DEPARTMENT OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH

FACULTY OF MEDICINE AND HEALTH SCIENCES

UNIVERSITI PUTRA MALAYSIA

ASSOCIATION BETWEEN TRAFFIC-RELATED AIR POLLUTIONS (TRAPS) WITH AIR QUALITY PERCEPTION AND RESPIRATORY SYMPTOMS AMONG PEDESTRIAN AND CYCLIST IN UPM

INSTRUCTION:

1. This questionnaire contain of SEVEN (7) sections:

Section A : Sociodemographic Information

Section B : Residential Information

Section C : Active Travel Mode

Section D : Environmental Tobacco Smoke

Section E : Perception Towards Traffic-Related Air Quality

Section F : Respiratory Health Symptoms

SECTION A: SOCIODEMOGRAPHIC INFORMATION

1. Gender: ◻ Male ◻ Female
2. Races: ◻ Malay ◻ Chinese ◻ Indian ◻ Others (…………………)
3. Age: ◻ 19 – 20 years ◻ 21 – 22 years ◻ More than 22 years
4. Nationality: ………..
5. Year of study: ◻ First Year ◻ Second Year

SECTION B: RESIDENTIAL INFORMATION

1. What is your current residence?

   ………..................................

2. How long have you been lived here?

   ………...................................

3. What is the estimated distance from your residence to class?

   ………..

4. Do you live nearest to the busy road?

   ◻ Yes ◻ No

5. If YES, what is the estimated distance from your residence to the busy road?

   ◻ Less than 100 meters ◻ 100-500 meter ◻ >500-1000 meter

   ◻ >1000 meter

5. How is your residential college surroundings?

   ◻ Less dusty ◻ Fairly dusty ◻ Heavy dusty

SECTION C: ACTIVE TRAVEL MODE

Please answer the following questions regarding to how you commute from/to class:

1. How do you go to class? ◻ Walking

   (If you are walking, answer question no 2, and skip question no 3)

   ◻ Cycling

   (If you are cycling, answer question no 3, and skip question no 2)

2. How many days a week did you walk to class?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐5

3. How many days a week did you cycle to class?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐5

5. Which type of route did you usually use to class?

☐ Off-road (eg: sport field) ☐ On-road (eg: bicycle/pedestrian lane)

6. If you are walking and cycling to/from the class, how frequent of cycling and how frequent of walking in 5 days of class:

(e.g.: Cycling: 3, Walking: 2)

Walking: ...., Cycling: ....

8. What is the duration of commuting to/from the class?

☐ < 5 minutes ☐ 5 – 10 minutes ☐ > 10 minutes

10. When do you heading home from class?

(e.g.: 6.00 p.m.)

....

21. How many days a week do you cycling/walking to class?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

SECTION D: ENVIRONMENTAL TOBACCO SMOKE

1. Is there any of your housemate smoking?

☐ Yes ☐ No

2. If YES, how many of your housemate who live with you are smoking?

☐ 1 ☐ 2 ☐ 3 ☐ More than 3

4. Are you often exposed to cigarettes in the room?

☐ Yes ☐ No

5. Do you smoke?

☐ Yes ☐ No

7. If YES, at what age did you start smoking?

…………………………………………….

SECTION E: PERCEPTION TOWARDS TRAFFIC-RELATED AIR QUALITY

Instruction: Please answer the following questions:

1. How would you rate the overall air quality in your campus, compared will last six months?

☐ Very good ☐ Good ☐ Fair ☐ Do not know ☐ Poor

☐Very Poor

2. Do you agreed that motor vehicles affect air pollution in your campus?

☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree

☐ Strongly agree

3. How much do you believed each of the following traffic-related circumstances affects air pollution in your campus

Source of Air Pollution	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. Traffic jam					
2. Diesel vehicle					
3. Old vehicles					
4. Too many private vehicles					

4. What is your initiatives to control and reduce air pollution due to traffic in your campus?

Initiatives	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. Carpooling					
2. Walking and cycling					
3. Improve facilities of cyclist lane					
4. Reduce number of many private vehicles					

SECTION F: RESPIRATORY HEALTH SYMPTOMS

To answer the questions, please tick the appropriate box. If you are unsure of the answer please tick "NO".

WHEEZING AND TIGHNESS IN THE CHEST

1. Have you had wheezing or whistling in your chest, at any time in the last three months?

☐ Yes ☐ No

2. If YES, how long this condition occurred?

……………………………………………..

SHORTNESS OF BREATH

3. Have you woken up with the feeling of tightness in your chest first thing in the morning, at any time in the last three months?

☐ Yes ☐ No

4. If YES, how long this condition occurred?

……………………………………………..

No	Question	Yes	No
5	Have you at any time in the last three months, had an attack of shortness of breath that came on during the day when you were not doing anything strenuous?		
6	Have you had an attack of shortness of breath that came after you stopped exercising at any time in the last three months?		
7	Have you, at any time in the last three months, been woken up at night by an attack of shortness of breath?		

COUGH AND PHLEGM

No	Question	Yes	No
8	Have you at any time in the last three months, been woken at night by an attack of coughing?		
9	Do you usually cough first in the morning?		
10	Do you usually bring up phlegm from your chest first thing in the morning?		

ILLNESS

No	Question	Yes	No
12	Have you ever had an attack of asthma?		
13	Have you had an attack of asthma at any time in the last three months?		
14	Are you currently taking medicines, pills or inhalers for asthma?		

THANK YOU