
**UNIVERSITI PUTRA MALAYSIA**

# *TRAFFIC AIR POLLUTANT EXPOSURE, GENOTOXICITY AND RESPIRATORY HEALTH AMONG TRAFFIC POLICE OFFICERS IN THE KLANG VALLEY, MALAYSIA*

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# TRAFFIC AIR POLLUTANT EXPOSURE, GENOTOXICITY AND RESPIRATORY HEALTH AMONG TRAFFIC POLICE OFFICERS IN THE KLANG VALLEY, MALAYSIA

By

MOHD FAIRUS BIN AWANG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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**January 2020**

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**Faculty : Medicine and Health Sciences**

Traffic-related air pollution (TRAP) is one of the most recent environmental pollution issues widely debated and studied throughout the world. Those who work outdoors such as traffic policemen are the most vulnerable to TRAP exposure and increase in health risks. The aim of this study was to determine the level of TRAP exposure that could affect the respiratory health and chromosomal damage among traffic policemen in Klang Valley. A cross-sectional comparative study was conducted between traffic policemen (160) and office workers (149) who employed more than one year in the Klang Valley (Kuala Lumpur, Petaling Jaya, Subang Jaya, Serdang, Shah Alam, Klang, Gombak, Ampang, Kajang, Putrajaya, and Sepang). A standard set of questionnaire adapted from American Thoracic Society (ATS) was distributed to respondents to gather information on respiratory health symptoms, history of exposure, and demographic information. Personal and workplace air pollutant exposures to benzene, toluene, ethylbenzene, xylene (BTEX), and particulate matter with diameter ≤ 2.5 µm ($PM_{2.5}$) were collected during working hours. The lung function status among respondents was assessed using Spirometer H1105 Chest Graph. Meanwhile, chromosomal damage was detected using micronucleus (MN) assays from the respondents' buccal epithelial cells. The data analysis was performed using Statistical Package for Social Science Version 23 (SPSS Ver. 23). The results showed that the levels of personal and workplace air pollutant exposures to BTEX and $PM_{2.5}$ ($p$<0.001), cough symptom ($p$ = 0.018) and MN frequencies ($p$<0.001) among traffic policemen were significantly higher than among office workers. The present study also found that the FVC, $FEV_1$, FVC% predicted, and $FEV_1$% predicted were significantly lower among traffic policemen compared to office workers. Only $PM_{2.5}$ showed significant association with cough symptom at $p$ < 0.001. All pollutants measured in this study had significant associations with the abnormality of FVC% predicted and MN frequencies among the respondents. $PM_{2.5}$ was the most significant pollutant associated with the cough symptom (B

= 1.20, $p$ = 0.013, PR = 3.30, 95% CI = 1.29 – 8.44), FVC% predicted abnormality (B = 1.01, $p$ = 0.032, PR = 1.75, 95% CI = 1.01 – 2.45), and $FEV_1$% predicted abnormality (B = 1.07, $p$ = 0.030, PR = 1.67, 95% CI = 1.12 – 2.31) among respondents. Meanwhile, multiple linear regressions showed that the most significant pollutants related to MN frequency were $PM_{2.5}$ and benzene. The equation model explains that, if $PM_{2.5}$ level increases by 1 μg/m$^3$ provided that the concentration of benzene unchanged, the MN frequency will increase by 0.018 frequencies and if benzene level increases by 1 μg/m$^3$ and provided that the concentration of $PM_{2.5}$ unchanged, the MN frequency will increase by 0.013 frequencies. Thus, shows a high risk of developing cancer among traffic policemen. This study has concluded that, exposure to high level of TRAP among traffic policemen can cause higher prevalence of cough symptom, reduced lung function, and increased MN formation compared to office workers. In order to reduce the health effects among traffic policemen, this study suggests that the Malaysian Police Department should monitor TRAP exposure, health inspections for at least once every six months and use face masks while performing duties among traffic policemen.

**Keywords**: traffic-related air pollution, traffic policemen, respiratory health, chromosomal damage, BTEX, $PM_{2.5}$

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

**PENDEDAHAN BAHAN PENCEMAR TRAFIK, GENOTOKSISITI, DAN KESIHATAN RESPIRATORI DALAM KALANGAN ANGGOTA POLIS TRAFIK DI LEMBAH KLANG, MALAYSIA**

Oleh

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**Januari 2020**

**Pengerusi : Profesor Madya Juliana Jalaludin, PhD**
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Pencemaran udara trafik (TRAP) adalah salah satu masalah pencemaran alam sekitar yang sering diperkatakan dan dikaji pada masa kini di seluruh dunia. Mereka yang bekerja di luar bangunan seperti polis trafik adalah yang paling berisiko kepada TRAP dan meningkatkan risiko kesihatan. Tujuan kajian ini adalah untuk menentukan tahap pendedahan pencemaran trafik yang boleh menjejaskan kesihatan pernafasan dan kerosakan kromosom dalam kalangan anggota polis trafik di Lembah Klang. Kajian keratan rentas perbandingan di antara polis trafik (160) dan pekerja pejabat (149) yang berkhimat lebih dari satu tahun telah dilakukan di Lembah Klang (Kuala Lumpur, Petaling Jaya, Subang Jaya, Serdang, Shah Alam, Klang, Gombak, Ampang, Kajang, Putrajaya dan Sepang). Set soal selidik piawai yang diadaptasi daripada *American Thoracic Society* (ATS) telah diedarkan kepada responden untuk mengumpulkan maklumat berkaitan dengan simptom kesihatan respiratori, sejarah pendedahan dan maklumat demografi. Pendedahan bahan pencemar udara untuk peribadi dan di tempat kerja untuk benzena, toluena, etilbenzena, xylene (BTEX) dan zarah partikulat dengan diameter ≤ 2.5 μm ($PM_{2.5}$) telah dijalankan dalam kalangan anggota polis trafik dan pekerja pejabat. Status fungsi paru-paru dalam kalangan responden dinilai dengan menggunakan Spirometer H1105 Chest Graph. Kerosakan kromosom dikesan dengan menggunakan ujian mikronukleus (MN) dari sel pipi responden. Pendedahan bahan pencemaran udara untuk individu dan juga di tempat kerja bagi BTEX dan $PM_{2.5}$ ($p$<0.001), gejala batuk ($p$ = 0.018) dan frekuensi MN ($p$<0.001) dalam kalangan anggota polis trafik adalah jauh lebih tinggi berbanding pekerja pejabat. Kajian ini juga mendapati bahawa FVC, $FEV_1$, FVC% peratusan dan $FEV_1$% peratusan adalah jauh lebih rendah dalam kalangan polis trafik berbanding pekerja pejabat. Hanya $PM_{2.5}$ yang mempunyai hubungan yang signifikan dengan gejala batuk pada $p$ <0.001. Kesemua bahan pencemar yang diukur dalam kajian ini mempunyai hubungan yang ketara dengan

ketidaknormalan FVC% peratusan dan frekuensi MN dalam kalangan responden. $PM_{2.5}$ merupakan bahan pencemar utama yang mempunyai hubungan ketara dengan simptom batuk (B = 1.20, p = 0.013, PR = 3.30, 95% CI = 1,29-8,44), ketidaknormalan FVC% peratus (B = 1.01, p = 0.032, PR = 1.75, 95% CI = 1.01–2.45) dan ketidaknormalan $FEV_1$% peratus (B = 1.07, *p* = 0.030, PR = 1.67, 95% CI = 1.12 – 2.31) dalam kalangan responden. Sementara itu, ujian regresi linear berganda menunjukkan bahawa bahan pencemar yang mempunyai hubungan yang signifikan dengan frekuensi MN adalah $PM_{2.5}$ dan benzena. Model persamaan yang diperolehi menjelaskan bahawa jika tahap $PM_{2.5}$ meningkat sebanyak 1 $\mu g/m^3$ dengan syarat kepekatan benzena tidak berubah, frekuensi MN meningkat sebanyak 0,018 kekerapan dan jika tahap benzena meningkat sebanyak 1 $\mu g/m^3$ dan dengan syarat kepekatan $PM_{2.5}$ tidak berubah, frekuensi MN akan meningkat sebanyak 0.013 frekuensi. Oleh itu, menunjukkan risiko tinggi mendapat kanser di kalangan polis trafik. Secara amnya, pendedahan kepada pencemaran trafik pada tahap yang tinggi dalam kalangan anggota polis trafik boleh meningkatkan risiko gejala batuk, mengurangkan fungsi paru-paru dan meningkatkan pembentukan MN berbanding dengan pekerja pejabat. Bagi mengurangkan kesan kesihatan di kalangan anggota polis trafik, kajian ini mencadangkan Jabatan Polis Malaysia harus memantau pendedahan TRAP, pemeriksaan kesihatan sekurang-kurangnya sekali setiap enam bulan dan menggunakan topeng muka semasa melakukan tugas dalam kalangan anggota polis trafik.

**Kata Kunci**: pencemaran udara trafik, polis trafik, kesihatan pernafasan, kerosakan kromosom, BTEX, $PM_{2.5}$

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| < | Less than |
| μg/m$^3$ | micrograms per cubic meter air |
| 1-OHPG | urinary 1-hydroxy pyrene glucuronide |
| 8-OHdG | urinary 8-hydroxy-2'-deoxyguanosine |
| ADS | Asian dust storm |
| API | Air Pollution Index |
| ATS | American Thoracic Society |
| BC | Black carbon |
| BTEX | Benzene, Toluene, Ethylbenzene, and Xylene |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| COPD | Chronic obstructive pulmonary disease |
| DNA | Deoxyribonucleic acid |
| DoE | Malaysia's Department of Environment |
| DOSM | Department of Statistics Malaysia |
| DPM | Diesel particulate matter |
| EEA | European Environment Agency |
| FeH2S | Exhaled hydrogen sulfide |
| FeNO | Exhaled nitric oxide |
| $FEV_1$ | Forced expiratory volume in 1 second |
| FVC | Forced vital capacity |
| GC | Gas chromatography |
| HRQoL | Health-related quality of life |
| IARC | International Agency for Research on Cancer |
| IQR | Interquartile range |
| JPJ | Malaysia's Road Transport Department |
| MN | Micronucleus |
| MS | Mass spectrometry |

| | |
|---|---|
| $NO_2$ | Nitrogen dioxide |
| $NO_x$ | Nitrogen oxide |
| $O_3$ | Ozone |
| PAH | Polycyclic aromatic hydrocarbon |
| PEF | Peak expiratory flow |
| PEL | Permissible Exposure Limit |
| PM | Particulate matter |
| $PM_1$ | The sum of all particles less than 1 μm in diameter |
| $PM_{10}$ | Particulate matter less or equal to 10 μm in aerodynamic diameter |
| $PM_{2.5}$ | Particulate matter less or equal to 2.5 μm in aerodynamic diameter |
| ppm | Part per million |
| $SO_2$ | Sulphur dioxide |
| TD | Thermal Desorption |
| TRAP | Traffic-related air pollution |
| TSP | Total suspended particles |
| TWA | Time-weighted average |
| US EPA | United States Environmental Protection Agency |
| VOC | Volatile organic compound |
| WHO | World Health Organization |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Urbanisation is a process in which towns and cities develop and become larger due to the increase in population. In addition, urbanisation increases the number of vehicles on the road. This may consequently lead to many problems and one of the problems faced by the community is air pollution. Urban air pollution is caused by a variety of sources including industry (Levy et al., 2014) and traffic air ( Patton et al., 2014; Zheng et al., 2013). Furthermore, air pollution not only deteriorates the air quality, but it also contributes to health problems among urban dwellers.

Traffic-related air pollutants are major contributors to air pollution in urban areas (Hung et al., 2012). Their main source comes from vehicle exhaust engine during combustion of fossil fuel (Jamhari et al., 2014). Both diesel and petrol exhaust engines produce multiple pollutants such as carbon monoxide (CO), nitrogen dioxide ($NO_2$), carbon dioxide ($CO_2$), particulate matter (PM), volatile organic compounds (VOCs), heavy metals, and ozone ($O_3$) (Demarini, 2013). Han et al. (2006) reported that about 50% of particulate matter (PM) in urban areas are generated from traffic-related air pollutants. In addition, PM consists of multiple chemical compounds, such as water-soluble ions, trace elements (Amil et al., 2016), polycyclic aromatic hydrocarbon (PAHs) (Hung et al., 2012; Jamhari et al., 2014), and dinitroarene group (Lemos et al., 2016). These chemical compounds have negative impacts on the environment such as global warming (D'Amato et al., 2013) and health effects. For example, $NO_2$ has a positive correlation with several causes of death of residents (Crouse et al., 2015) and PAH is a precursor of mutagenic action in biological systems (Silva et al., 2015).

Pollutant emissions from vehicle exhaust have a negative impact on our health. Among those effects are cardiovascular disease, lung disease, respiratory disease, and cancer. Residents living near a busy street tend to develop diseases related to respiratory and cardiovascular (Demarini, 2013). According to the European Environment Agency (EEA), long-term exposure of $PM_{2.5}$ and less had an influence on 432,000 premature deaths in Europe (EEA, 2015). Moreover, $PM_{2.5}$ tends to cause chronic diseases because the properties of this particulate when retained in the alveolar area in the lung can induce inflammation, oxidative stress, and blood coagulation (Ceretti et al., 2014; Silva et al., 2015). Women who live in areas polluted with high levels of $PM_{2.5}$ are more susceptible to high risk of death due to breast cancer (Hung et al., 2012). Engine exhaust also produces volatile organic compounds (VOCs). About 60% of the VOC emissions in urban area originate from vehicle engine exhausts

(Singla et al., 2012). Benzene, toluene, ethylbenzene, and xylene known as BTEX are compounds used for monitoring VOC levels in the air either indoor or outdoor environment. These compounds have negative effects on health such as drowsiness, impaired coordination, neurological effects, and attack on central nervous system (Xiong et al., 2016). According to the International Agency for Research on Cancer (IARC), benzene is categorised as a Group 1 carcinogen (IARC, 1989).

Rapid urbanisation in Malaysia has a greater impact on ambient air quality especially in urban areas and poses health risks among the community. The Klang Valley area is located in Selangor, known as "Greater Kuala Lumpur". This area is also known as a developing area with a large population density. Moreover, the numbers of vehicles keep increasing every year in this area. According to Malaysia's Road Transport Department (JPJ), the annual increase of vehicles on the road is about 4 per cent yearly (based on 2012 to 2014 reports). As a result, this increases the number of vehicles on the road and promotes the generation of anthropogenic air pollution in the area as well as affecting the locals' health. According to Leh et al. (2012), in Malaysia, there was no specific set of environmental health indicators for the establishment and implementation of air pollutant exposure. In addition, research on the relationship between environmental data and epidemiology in Malaysia are limited especially in relation to air pollution studies with health effects on the local communities (Afroz et al., 2003; Mahiyuddin et al., 2013).

Workers who work in urban areas such as traffic police are particularly vulnerable to TRAP. Traffic policemen are those who direct traffic or serve in the traffic unit and are responsible to enforce the road rules. Therefore, they are highly exposed to air pollution caused by traffic which leads them to have higher risks of health effects. In addition, traffic policemen are representatives of people who are persistently exposed to high levels of pollutants from traffic pollution (Tamura et al., 2003). In this study, traffic policemen were selected as a sample as they are often exposed to traffic air pollution from vehicle exhausts. The results obtained from this study will enable a better understanding of TRAP trends during peak hours and its impact on human health.

## 1.2 Problem Statement

The effects of air pollution not just cause global warming and climate change but can also cause illness and death. Based on WHO data, exposure to outdoor air pollution causes 29% of lung cancer deaths and diseases, 17% of lower respiratory infection deaths and illnesses, 24% of stroke deaths, 25% of cardiac ischemia deaths and illnesses, and 43% of chronic obstructive pulmonary disease (COPD) deaths and illnesses worldwide (WHO, 2018). WHO in 2016 estimated the number of premature deaths around the world to be about 4.2 million due to exposure to outdoor air pollution (WHO, 2018). In addition, about 91% of the world population in 2016 were living below the

guideline limit of air pollution (WHO, 2018). In Malaysia, the percentage of deaths due to ischaemic heart disease increases every year. It is also the leading cause of death in Malaysia. In 2018 the percentage of deaths due to ischaemic heart disease was 15.9% compared to 13.9% in 2017. Results from studies conducted by Thurston et al., (2016) and Xu et al (2017) found that long-term exposure to $PM_{2.5}$ from fossil fuel combustion has a significant relationship with ischaemic heart disease.

Fossil fuel combustion from vehicle exhaust generates multiple mixtures of hazardous compounds that can influence the wellbeing of humans. Particulates generated from the combustion process, especially diesel exhaust particulates, are more potent in posing adverse health effects than particulates generated from non-combustion process (Han et al., 2006). IARC stated that pollutants from both gasoline and diesel engine exhausts are Group 2B and Group 2A carcinogen (IARC, 1989). However, on 2012, IARC reclassified pollutants from diesel engine exhaust as a Group 1 carcinogen (IARC, 2012). Moreover, pollutants emitted from vehicle exhausts such as from buses, cars, motorcycles, and lorries are the main contributors to TRAP that deteriorate the urban air quality (Han et al., 2006). Additionally, around 76% of $PM_{10}$ suspended in the urban air originate from vehicle emissions (Ismail et al., 2015). Meanwhile, according to Tamura et al. (2003), about 70% of total $PM_{10}$ concentration in ambient air is $PM_{2.5}$.

During the combustion of gasoline in a vehicle engine, VOCs such as benzene are released to the atmosphere and deteriorate air quality. Long-term exposure to low VOC concentrations, especially BTEX, poses a lot of adverse effects on human health (Chauhan et al., 2014). Benzene is well known as a Class 1 carcinogen (IARC, 2013), while toluene, ethylbenzene, and xylene are known to affect the human central nervous system (Singla et al., 2012). In Europe, the concentration of benzene in the ambient air is set at $5\mu g/m^3$ yearly (European Commission, 2008; IARC, 2013). However, most of the countries around the world do not have guideline limits for BTEX concentrations in ambient air.

In urban areas, the population is large and the demand for vehicles continues to increase from year to year. With the increase in the number of vehicles, it leads to an increase in the amount of fuel combustion, which affects the quality of outdoor air. Increased concentration of air pollutants may pose health risks among residents at the particular area. In addition, those who live less than 50 m from busy roads have higher mortality risks (Cesaroni et al., 2013). Furthermore, there is a positive association between long-term exposure to ambient pollution and TRAP with mortality rate and cardiovascular disease (Crouse et al., 2015). Exposure to TRAP will cause DNA damage as an initial impression on the risk of cancer (Tan et al., 2017).

Traffic policemen are police officers who control the movement of traffic flow or who serve in enforcing traffic regulations. They ensure there is no traffic congestion in any area and ensure that road users comply with the road rules.

This caused them to stand for hours at the intersection of major roads to monitor and ensure the traffic flow smoothly. Therefore, the nature of work for traffic policemen is usually at peak hours with more than eight hours of duty. The concentration of air pollutants was high during peak hours due to traffic condition (Huong et al., 2014; Liu, Chen, & Xue, 2017). This situation puts them at high risk exposed to TRAP that contains hazardous pollutants such as benzene and $PM_{2.5}$ that pose health risks such as cancer. They can represent roadside occupational exposure (Shakya, Peltier, Zhang, & Pandey, 2019; Crebelli et al., 2001). In addition, the profession of traffic policemen was categories as the most stressful occupation according to Occupation Disease Intelligence Network System for Surveillance of Occupational Stress and Mental illness (Baliga et al., 2017). However, in Malaysia studies on traffic policemen and health risk especially cancer risks are limited. In this regard, it is of interest to study the effects of TRAP exposure among traffic policemen in the Malaysia environment.

In Malaysia, data on air pollution in urban area and its impact on health including mortality and hospitalisation are very limited (Mahiyuddin et al., 2013; Manan et al., 2018; Tajudin et al., 2019; Wong et al., 2017). Moreover, some of the pollutants such as BTEX do not have concentration guideline limits for Malaysian ambient air. Malaysia's Department of Environment (DoE) in 2015 reported that vehicular emissions and industrial activities are still the major sources of air pollution in Malaysia (DoE, 2015). The Klang Valley is the most developed region in Malaysia and more prone to air pollution because of its geographical setting, development of large scale industrial and commercial activities, densely populated areas, and also high vehicular traffic (Amil, et al., 2016; Binyehmed, Abdullah, & Zainal, 2016; Jamhari et al., 2014). Therefore, more studies on the behaviour of TRAP in either its trend or health impact in the Malaysian environment should be further intensified for the community.

## 1.3 Study Justification

Outdoor activities carried out daily such as jogging and gardening expose us to the threat of ambient air pollution. In urban areas, traffic-related air pollutants are major contributors that deteriorate the ambient air quality (Abd Hamid et al., 2019; Ee-Ling et al., 2015; Singla et al., 2012). Therefore, this research aims to obtain a better understanding of ambient air quality, especially during peak hours as the number of vehicles on the road is more than usual due to human activities. Urban workers especially those who work outdoors are the most affected community exposed to TRAP.

Inhalation of air pollutants has a positive association and connection to health risks, such as lung disease (Patton et al., 2014), cancer (Vineis et al., 2005; Wong et al., 2014) and respiratory mortality (Cesaroni et al., 2013). Moreover, exposure to low-level BTEX concentrations has significant effects on health such as DNA and chromosomal damage (Fenga et al., 2017). Therefore, it is

important to create awareness among the urban communities of the dangers they face from exposure to TRAP.

In this study, the target group is traffic policemen, who are involved in traffic control in selected Klang Valley areas. The pollutants that were analysed in this present study were BTEX and $PM_{2.5}$. In addition, the effects of TRAP exposure on respiratory health symptoms, lung function status, and the formation of micronuclei (MN) were further examined among the traffic policemen and also office workers. These served to assess the impact of exposure to TRAP experienced by traffic policemen compared to those working in the office.

Traffic policemen are workers who work outdoors and are often exposed to TRAP. Each of them experiences different levels of exposure to TRAP due to traffic volume and traffic density during their working hours. Exposure to traffic-related air pollutants (BTEX and $PM_{2.5}$) can affect respiratory health and cause chromosomal damage. In this regard, efforts to decrease the degree of air pollution exposure should be intensified to minimise health risks among them. The formation of micronuclei (MN) in cell biology caused by chromosomal damage is an early sign of cancer (Ceretti et al., 2014). The MN assay test was used to identify genotoxic properties of the pollutants that can cause chromosomal damage. Previous studies suggested that MN frequency is a high-sensitivity method for genotoxic assessment to detect chromosomal damage in an organism (Čupr et al., 2013). The lung function test was conducted among respondents in order to measure breathing status and how well the lungs are functioning. In addition, a questionnaire on respiratory health symptoms was also administered to the study subjects.

The findings of this study can contribute to new knowledge and data, particularly in Malaysia. Comparison of air pollutant concentrations between outdoor and indoor microenvironments was further explored. Furthermore, the level of air pollutants during peak hours was assessed within the Klang Valley area. The TRAP effects are more pronounced in urban workers such as traffic policemen. The results of this present study can indicate the TRAP levels and trends in Malaysian ambient air. Moreover, the health effects among urban workers exposed to TRAP were further explored. The data and results obtained from this study can be used as a guideline for government to set up concentration limits for air pollutants in ambient air especially BTEX, as there are no guidelines limits being enforced in Malaysia. Furthermore, the data and results gathered from this study can help other researchers in the future especially to get better understanding of TRAP trends, how to reduce air pollution levels in urban areas as well as how to manage traffic density in order to minimise air pollution levels. Additionally, the results from this study can educate the public on the dangers of exposure to TRAP as well as the effects of such exposure on their health. Therefore, this study is significant because it can help to reduce health risks among the community and create a healthier way of life.

**Figure 1** presents the conceptual framework for this study. The study focuses on the exposure to TRAP among traffic policemen in Klang Valley and the health impact assessment. Respiratory diseases are a major impact on human health because of the exposure to multiple air pollutants (Crouse et al., 2015; D'Amato et al., 2013; Lung et al., 2014). In this case, the assessment of respiratory health symptoms and pulmonary function status among the respondents was conducted to assess differences between exposed and comparison groups. Questionnaires were distributed for evaluation of respiratory health symptoms. The questionnaire used was adapted from a validated questionnaire from American Thoracic Society for respiratory disease ATS-DLD-78 for adults in epidemiology research. Meanwhile, Spirometry instrument was used for the assessment of lung function status among respondents. In addition, some of air pollutants from traffic can act as a genotoxic that can cause chromosomal damage (Wong et al., 2014).

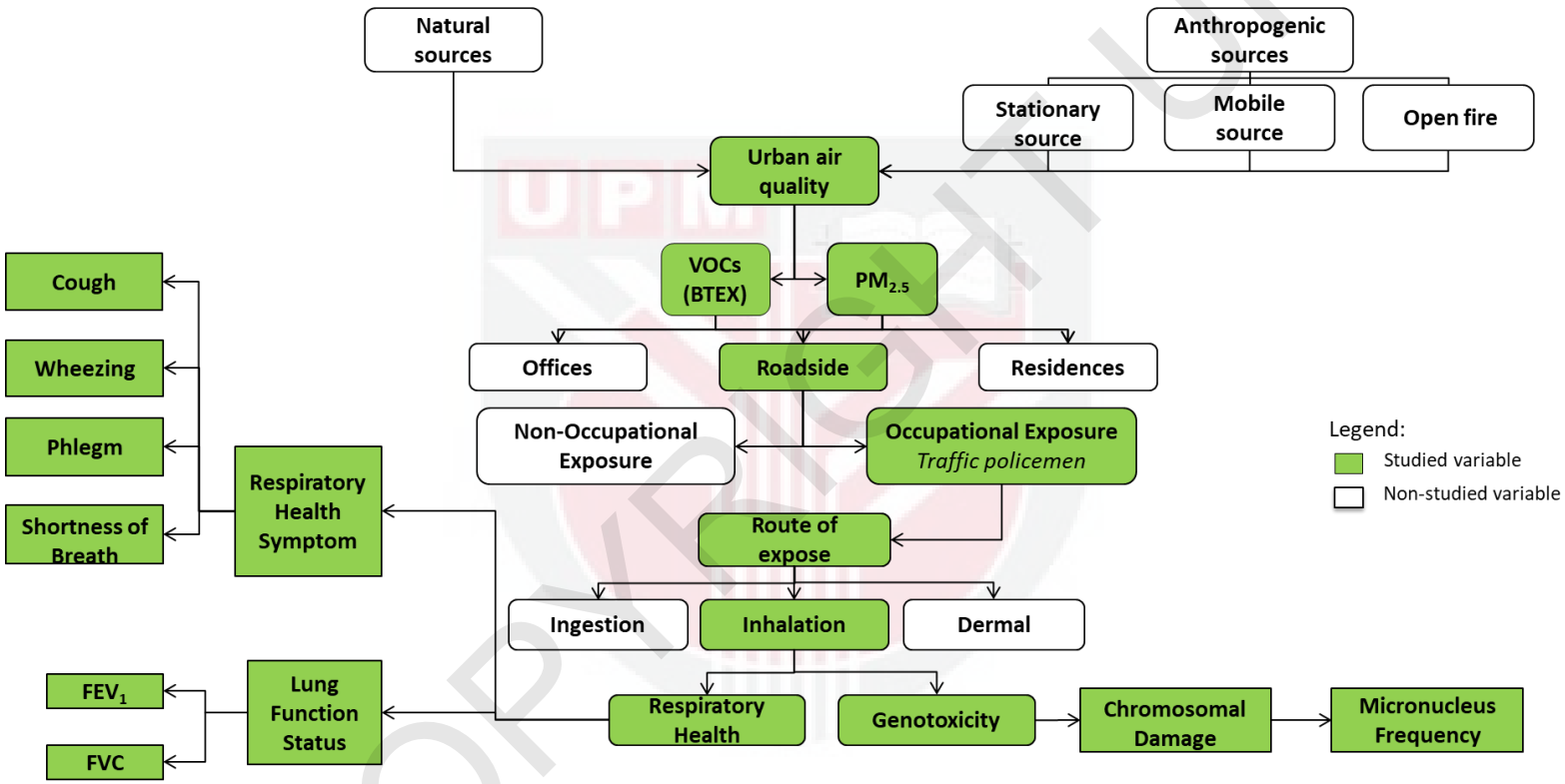


**Figure 1: Conceptual Framework**

## 1.4 Study Objectives

### 1.4.1 General Objectives

To determine the exposure levels of traffic-related air pollutants and their associations with respiratory health and chromosomal damage among traffic policemen in Klang Valley.

### 1.4.2 Specific Objectives

1. To determine the socio-demographic characteristics, residential air pollutants, indoor air pollution exposure, and work place information for traffic policemen and office workers in the Klang Valley.
2. To compare personal air pollutants exposure and workplace air pollutant levels consisting of particulate matter with a diameter less than 2.5 μm ($PM_{2.5}$), and Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) concentrations during working hours between the exposed and the comparative groups in Klang Valley.
3. To compare respiratory health symptoms, lung function status, and micronucleus (MN) frequencies between the exposed and the comparative groups in Klang Valley.
4. To determine the relationship between personal air pollutants exposure levels and respiratory health symptoms among study groups.
5. To determine the relationship between personal air pollutants exposure levels and lung function status among study groups.
6. To determine the relationship between personal air pollutants exposure levels and MN frequencies among the respondents.
7. To determine the significant traffic-related air pollutants (BTEX and $PM_{2.5}$) associated with respiratory symptoms after controlling the confounders in this study
8. To determine the significant traffic-related air pollutants (BTEX and $PM_{2.5}$) associated with lung function status after controlling the confounders in this study.
9. To determine the significant traffic-related air pollutants (BTEX and $PM_{2.5}$) associated with MN frequencies after controlling the confounders in this study.

## 1.5 Study Hypothesis

1. There is a significant difference of socio-demographic characteristics, residential air pollutants, indoor air pollution exposure, and work place information for traffic policemen and office workers in the Klang Valley.
2. Traffic policemen significantly experience higher levels of personal and workplace air pollutants exposure compare to office workers in Klang Valley.
3. Traffic policemen significantly having higher prevalence in respiratory health symptoms and MN frequency but decrease in lung function status compare to office workers in Klang Valley.
4. Exposure to high levels of BTEX and $PM_{2.5}$ has positive relationships with the prevalence of respiratory health symptoms among study groups.
5. Exposure to high levels of BTEX and $PM_{2.5}$ has positive relationships with the prevalence of abnormal lung function status among study groups.
6. Exposure to high levels of BTEX and $PM_{2.5}$ has positive relationships with high MN frequencies among the respondents.

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