UNIVERSITI PUTRA MALAYSIA

EXPOSURE TO FINE PARTICLE ($PM_{2.5}$) AND ITS ASSOCIATION WITH RESPIRATORY HEALTH OF WORKERS AT A BUS TERMINAL IN KUALA LUMPUR

NUR IZZATI BINTI GHAZALI

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FPSK4 2013 12

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NUR IZZATI BINTI GHAZALI

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

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ABSTRACT

EXPOSURE TO FINE PARTICLE ($PM_{2.5}$) AND ITS ASSOCIATION WITH RESPIRATORY HEALTH OF WORKERS AT A BUS TERMINAL IN KUALA LUMPUR

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Introduction: Exposures to $PM_{2.5}$ have been shown to affect the respiratory health of the workers. **Objectives:** The aim of this study was to determine the association between particulate matters 2.5 ($PM_{2.5}$) and its association with respiratory health. **Methods:** 50 study participants at the bus terminal were selected randomly. Exposure level of $PM_{2.5}$was measured at three different places in bus terminal. All respondents were participated in lung function test and the analysis of urine IL-6 concentration. Questionnaire adapted from International Union against Tuberculosis and Lung Disease (IUATLD) Bronchial Symptoms Questionnaires were distributed to the selected potential study participants. **Result:** The result shown that exposure level of $PM_{2.5}$ at ticketing counter and boarding area were higher compared to the office. The average $PM_{2.5}$ level for eight hours of monitoring at the management office, ticketing counter and boarding area were 5.44, 31.61 and 32.19 $\mu g/m^3$ respectively (World Health Organization PM2.5 level of 25 $\mu g/m^3$). Prevalence of cough was higher among the non-office study participants (32%) compared to office study participants (16%). Mann-Whitney U test results showed that the mean exposure levels of IL-6 for office study participants were 0.25±0.13 pg/ml and non-office study participants were 0.21±0.09 pg/ml. There is no significant difference between IL-6 among office and non -office study participants, z=-1.56, p=0.12. Negative correlations were found between the exposure levels of $PM_{2.5}$and concentration of IL-6. Spearman correlation test was used to see the correlation between lung function and concentration of IL-6. From the analysis result, the FEV1% predicted and FVC % predicted showed no significant association r=0.18; p=0.21 and r=-0.10; p=0.51 respectively. However, for ratio FEV1/FVC showed significant association with concentration of IL-6, r=0.31 p=0.03. Results also showed that there was negative correlation between lung function and concentration of $PM_{2.5}$. However, the study participants who were exposed to higher level of $PM_{2.5}$ were more likely to report respiratory illnesses compared to those exposed to lower levels of $PM_{2.5}$. **Conclusion**: Although the level of IL-6 and $PM_{2.5}$were only slightly higher than the given standards, more attention should be given on the control of high level of exposure to $PM_{2.5}$ in order to minimize the adverse health effects among the study participants in bus terminal.

Keywords: $PM_{2.5}$, IL-6, lung function, respiratory symptoms, bus terminal

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ABSTRAK

PENDEDAHAN KEPADA $PM_{2.5}$ DAN HUBUNGKAIT DENGAN KESIHATAN PERNAFASAN KALANGAN PEKERJA DI TERMINAL BAS DI KUALA LUMPUR

NUR IZZATI GHAZALI

Pengenalan: Pendedahan kepada $PM_{2.5}$ memberi kesan kepada kesihatan pernafasan pekerja. **Objektif:** Tujuan kajian ini adalah untuk menentukan hubungan antara partikulat 2.5 ($PM_{2.5)}$ dan kaitannya dengan kesihatan pernafasan. **Kaedah**: 50 peserta kajian di terminal bas telah dipilih secara rawak. Tahap pendedahan $PM_{2.5}$ diukur di tiga tempat yang berbeza di terminal bas. Semua responden telah mengambil bahagian dalam ujian fungsi paru-paru dan analisis air kencing IL-6. Soalan kaji selidik di adaptasi dari Kesatuan Antarabangsa terhadap Tuberculosis dan Penyakit paru-paru (IUATLD) Gejala bronkial telah diedarkan kepada peserta kajian yang terpilih. **Keputusan**: Hasil kajian menunjukkan bahawa tahap pendedahan $PM_{2.5}$ di kawasan kaunter tiket dan menaiki adalah lebih tinggi berbanding ke pejabat. Tahap purata selama lapan jam pemantauan di pejabat pengurusan, kawasan kaunter tiket dan menaiki bas adalah 5.44, 31.61 dan 32,19 µg / m^3. Mann-Whitney U keputusan ujian menunjukkan bahawa tahap pendedahan purata IL-6 untuk pekerja pejabat adalah 0.25 ± 0.13 pg / ml dan bukan pekerja pejabat adalah 0.21 ± 0.09 pg / ml. Tiada perbezaan yang ketara antara pejabat dan tidak ada pekerja pejabat, $z = -1,56$, $p = 0.12$. Korelasi negatif yang ditemui antara tahap pendedahan PM2.5 dan kepekatan IL-6. Ujian korelasi Spearman digunakan untuk melihat hubungan antara fungsi paru-paru dan kepekatan IL-6. Dari hasil analisis, FEV1% yang diramalkan dan FVC% yang diramalkan tidak menunjukkan hubungan yang signifikan $r = 0.18$, $p = 0.21$ dan $r = -0.10$, $p = 0.51$ masing-masing. Walau bagaimanapun, bagi nisbah FEV1/FVC menunjukkan hubungan yang signifikan dengan kepekatan IL-6, $p = 0.03$. Keputusan juga menunjukkan bahawa terdapat hubungan yang negatif antara fungsi paru-paru dan kepekatan $PM_{2.5}$. Walau bagaimanapun, pekerja-pekerja yang terdedah tahap pada lebih tinggi $PM_{2.5}$ adalah berisiko tinggi untuk mendapat penyakit pernafasan berbanding dengan tahap pendedahan $PM_{2.5}$ yang lebih rendah . Kelaziman batuk adalah lebih tinggi di kalangan pekerja bukan pejabat (32%) berbanding dengan pekerja pejabat (16%). **Kesimpulan**: Walaupun tahap IL-6 dan $PM_{2.5}$ adalah rendah daripada standard yang diberikan, perhatian yang lebih harus diberikan kepada kawalan tahap pendedahan kepada $PM_{2.5}$ untuk mengurangkan kesan-kesan kesihatan yang buruk di kalangan pekerja dalam bas terminal.

Kata kunci: $PM_{2.5}$, IL-6, fungsi paru-paru, gejala pernafasan, terminal bas.

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LIST OF TABLES

Table 2.1 Comparisons of fine and coarse particle matter 20

Table 4. 1 Socio-Demographic Data of Respondents 49

Table 4. 2 Anthropometrical Measurement and Working Experiences Data of Respondents 49

Table 4. 3 Levels of PM2.5 at different location inside the bus terminals 50

Table 4. 4 Comparison of IL-6 among office and ticketing and boarding respondents 52

Table 4. 5 Correlations between exposure level to PM2.5 and IL-6 among the respondent 53

Table 4. 6 Correlations between exposure level to IL-6 and working duration among the respondents 54

Table 4. 7 Comparison prevalence of respiratory health symptoms among respondents' gender 55

Table 4. 8 Prevalence of Respiratory Symptoms Between office and ticketing and boarding respondents. 56

Table 4. 9 The difference of lung function between between office and ticketing and boarding respondents 57

Table 4. 10 Comparison of lung function abnormalities between office and ticketing and boarding respondents 58

Table 4. 11 Correlations between exposure level of IL-6 and lung function among the respondents 59

Table 4. 12 Correlations between exposure level to PM2.5 and lung function among the respondents 60

Table 4. 13 Factors influencing the concentration level of IL-6 among respondents 61

Table 4. 14 Factors influenced the FEV_1% predicted among the respondents after controlling all the confounders' in the study 62

Table 4. 15 Factors influenced the FVC% predicted among the respondents after controlling all the confounders' in the study 63

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LIST OF FIGURES

Figure 2.1 Size of the particle pollution 19

Figure 2.2 Areas where particulate matter is deposited in the body 25

Figure 4.1 Five parameter logistics 51

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LIST OF APPENDIX

Appendix 1	Ethic Consent letter	95
Appendix 2	Participant Consent form	96
Appendix 3	Information on research to respondents	97
Appendix 4	Questionnaire	98
Appendix 5	Schedule of Study for Research Project	99
Appendix 6	Research photograph	100

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LIST OF ABBREVIATIONS

$\mu g/m^3$	microgram per meter cube
ACS	American Cancer Society
ATS	American Thoracic Society
ELISA	Enzyme-Linked Immunosorbent Assay
EPA	Environmental Protection Agency
FEV1	Forced Expiratory Volume In Second
FVC	Forced Vital Capacity
IL-6	interleukin-6
IQR	interquatile range
IULTD	International Union against Tuberculosis and Lung Disease
NAAQS	National Ambient Air Quality Standards
OR	odd ratio
pg/ml	pictogram per millimetre
PM10	particulate matter 10 micron
PM2.5	particulate matter 10 micron
SPSS	Statistical Packages for Social Sciences
TNF-ą	Tumor Necrosis Factor Alpha
UFP	ultrafine particle
WHO	World Health Organization

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TABLE OF CONTENTS

DECLARATION		**ii**
SIGNATURE OF SUPERVISOR/INTERNAL EXAMINER		**iii**
ACKNOWLEDGEMENT		**iv**
ABSTRACT		**v**
ABSTRAK		**vi**
LIST OF TABLES		**vii**
LIST OF FIGURES		**viii**
LIST OF APPENDICES		**ix**
LIST OF ABBREVIATIONS		**x**
CHAPTER 1: INTRODUCTION		**1**
1.1	BACKGROUND	2
	1.1.1 Problem statement	4
	1.1.2 Study justification	7
1.2	RESEARCH OBJECTIVES	8
	1.2.1 General objective	8
	1.1.1 Specific objective	8
	1.2.2 Hypothesis	9
1.3	CONCEPTUAL FRAMEWORK	10
1.4	VARIABLE(S)	11
1.5	DEFINITION(S)	11
	1.5.1 Theoretical definition	12
	1.5.2 Operational definition	15
1.6	STUDY LIMITATIONS	17

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CHAPTER 2 : LITERATURE REVIEW **18**

2.1 Particulate matter, 2.5μm ($PM_{2.5}$) 18

2.2 Particulate matter 2.5 and lung 23

2.3 Interleukine-6 and role of cytokines in innate inflammation 26

CHAPTER 3 : METHODOLOGY **31**

3.1 STUDY DESIGN 31

3.2 SAMPLING FRAME 31

3.3 SAMPLING METHOD 32

3.4 SAMPLE SIZE 32

3.5 LOCATION OF STUDY 33

3.6 INSTRUMENTATION 34

3.6.1 Human Interleukin-6 ELISA kit 34

3.6.2 Anthropometry measurement equipments 36

3.6.3 Measurement of Area Exposure Level of $PM_{2.5}$ 39

3.7 DATA COLLECTION 40

3.7.1 Questionnaire distribution 40

3.7.2 Urine sample collection 41

3.7.3 Lung function test /spirometry 41

3.7.4 Statistical Analysis 46

3.8 RESEARCH ETHICS 47

CHAPTER 4 : RESULT **48**

4.1 Descriptive Analysis 48

4.2 Particulate Matter 2.5 ($PM_{2.5}$) levels at the bus terminals 50

4.3 Correlation between exposure level of $PM_{2.5}$ and IL-6 concentration 52

4.4 Correlation between exposure level of IL-6 concentration and working duration among the respondents 53

4.5 Prevalence of respiratory health symptoms among the respondents. 54

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4.6 Prevalence of Lung Function and Lung Abnormalities 57

4.7 Factors influenced the IL-6, FEV_1% and FVC% level among the respondents after controlling all the confounders' in the study 60

CHAPTER 5 : DISCUSSION **64**

5.1 Respondent background 64

5.2 Comparison of PM2.5 concentration level 65

5.3 Comparison of IL-6 concentration level among office and ticketing and boarding respondents. 67

5.4 Relationship between exposure level to PM2.5 and IL-6 concentration 69

5.5 Relationship between PM2.5 and prevalence of respiratory symptoms 71

5.6 Comparison of Lung Function 72

5.7 Relationship between PM2.5 and lung function 74

5.8 Relationship between IL-6 and lung function 75

5.9 Factors influenced the IL-6 concentration level, and abnormality of FEV_1% and FVC% among the respondents after controlling all the confounders' in the study 77

CHAPTER 6 : CONCLUSION AND RECOMMENDATION **80**

6.1 CONCLUSION 80

6.2 RECOMMENDATION 81

ACKNOWLEDGEMENT 83

REFERENCES 88

APPENDICES 99

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CHAPTER 1

1 INTRODUCTION

1.1 BACKGROUND

In Malaysia, the need for an efficient public transport system becomes more important as Malaysia continues to become a high-income nation with increasing population and economic growth. Transport networks must be able to support the economic growth, growing populations and diverse of urban activities. However, the increasing needs of transportation may lead to the increase air pollution.

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A bus terminal is a structure where city or intercity bus stops to pick up and drops off passengers. It may be intended as a terminal station for a number of routes or as a transfer station where the routes continues. Bus terminal is a place which may contributes a large amount of pollutants emission to the surrounding mainly caused by the emissions from the busses and other vehicles as well that would cause health hazard for the locals who work or use the bus terminal (Heng et al. 2011). Knibbs et al (2010) measured $PM_{2.5}$ and UFP levels inside trains, buses, ferries, and automobiles in Sydney, suggesting that both $PM_{2.5}$ and UFP levels inside buses were highest. Air quality inside buses is usually worse than that in other transportation vehicles.

The World Health Organization (WHO) of the European Region stated that the rapid increase in private cars and in goods transported by lorries, in combination with a decline in public transport, have turned road transport into an increasing contributor to air pollution. WHO 2005 report on health effects of transport-related air pollution stated that the transport sector is an important source of emissions of a wide range of gaseous air pollutants and of suspended particulate matter (PM) of different sizes and compositions. The emissions of primary particles from road transport account for up to 30% of fine PM (less than 2.5 μm in aerodynamic diameter: $PM_{2.5}$) in urban areas. Other emissions from road transport such as those

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from resuspended road dust are important contributors to the coarse fraction of particulate matter (WHO, 2006).

Airborne particulate matter refers to particles or droplets of various sizes, physical characteristics and chemical compositions present in the air. Previously, environmental epidemiologists had mainly focused on particulate matter with an aerodynamic diameter equal to or less than 10 μm (PM_{10}). In toxicological and controlled human exposure studies, several physical, biological and chemical characteristics of particles have been found to elicit cardiopulmonary responses . Fine PM (< 2.5 μm, $PM_{2.5}$) are believed to act through biologic pathways, thereby increasing cardiovascular risk (WHO, 2003). Exposure of $PM_{2.5}$ was linked to various respiratory and its cardiopulmonary impacts (Goldberg et al., 2001; Janssen et al., 2002; Magari et al., 2002). Exposure assessments of $PM_{2.5}$ are also associated with increased hospitalization (Neuberger et al. 2004) and mortality due to cardiovascular disease (Morgan et al. 1998).

Long-term ambient exposure to ambient particulate matter concentrations may lead to a reduction in life expectancy which is primarily due to the increase of cardio-pulmonary and lung cancer mortality (Brooks et al. 2010). The increase of

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cases were likely in lower respiratory symptoms and reduced lung function in children, and chronic obstructive pulmonary disease and reduced lung function in adults (WHO, 2003).

It has been suggested that inhaled pollutants can initiate local airway inflammation, leading to a systemic inflammatory state (Brook et al., 2004). There is also evidence of associations between ambient particulate matter (PM) levels and intermediary inflammatory outcomes, such as white blood cells, interleukin (IL)-6, tumor necrosis factor alpha (TNF-α), C-reactive protein, and fibrinogen (Delfino et al., 2008; Dubowsky et al., 2006; Rückerl et al., 2007; Samet & Krewski, 2007; Schwartz, 2001).

1.1.1 Problem statement

The designated bus station in Kuala Lumpur is located at the busy road where the bus station faces traffic congestion and the high frequency of bus shuffling. Lack of maintenance at the bus station may cause the environment to face pollution and dirtiness. People in Kuala Lumpur are highly dependent on motorized transportation, such as cars, motorcycles and also buses. Movement of people in the city and the

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daily hectic travel of busses through and from to the bus station require energy which mostly from the burning of fossil fuels, might cause air pollution to the bus station. The effects of air pollution may not only bring discomfort to the users of the bus terminal but also to the workers in the bus terminal. As a central for transportation, a bus station contributes a large share of pollutants mainly by the emissions of the fuels of the buses itself, taxis, and also through the surrounding terminal and offices.

The terminal is almost totally closed with the exception of the bus entrance and exit openings that provide natural ventilation. The station is the road based public transport serving the southern part of the peninsular of Malaysia. The concourse on the ground floor in this bus terminal has terminal management office bus and taxi stand, and car park. The central areas on the third are ticket counters, bus information centre, and waiting areas for passengers and fourth floors are food court. There are 19 bus departure bays and 18 arrival bays for passengers boarding or exiting buses at the second floor.

The potential respondents are separated from the outside environment by sliding doors but there are still chances for the outdoor air to be dispersed in as the doors opened. Although the PM is emitted from the vehicles outside, indoor air

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pollution can be influenced from the outdoor air pollution. The PM emitted was directly from the buses are likely to be accumulated within the building and could possibly adversely affects the health of passengers as have been shown in other study (Cheng et al. 2011). Previous studies have demonstrated that the amount of particles emitted from vehicles could be increased when vehicles were forced to stop, idle, or accelerate from a stationary position due to higher engine loads, such as that which occurs at transport corridors, transit hubs, pedestrian crossings, signalled intersections and bus stations (Yip et al., 2006; Kinsey et al., 2007; Richmond-Bryant et al., 2009; Jayaratne et al., 2009; Wang et al., 2010). According to these studies, passengers waiting at the bus stations could be exposed to a high PM level.

Workers in the bus terminal are also highly exposed to the traffic air pollutants that came from the outside of the building. The respondents are vulnerable to respiratory health symptoms as they spend more than 8 hours per day in their work environment. They are prone to be exposed to the ambient air pollutant from the exhaust emissions from the buses and others vehicles as the terminal is located along a side street. Thus, they are prone in getting respiratory and lung diseases due to the exposure to traffic air pollutant emitted by buses and others vehicle that would accumulate within the building (Jenkins et al. 1992). Study done by Kavitha in 2010 and 2011 shown that the exposure level of PM_{10}, $PM_{2.5}$ and Ultrafine particle (UFP) were significantly higher among the bus drivers compared to administrative group

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and there was correlations between exposure level of particulate matters and the concentrations of biomarkers. Both study also shown that the prevalence of respiratory health higher among the bus drivers. Short and long term exposure to $PM_{2.5}$ is associated with respiratory and cardiovascular disease.

1.1.2 Study justification

A bus terminal was selected as the focus in this study because there was a study done at an intercity bus terminal in Taiwan which had shown that fine and ultrafine PM in the station were from the vehicles outdoors (Cheng et al. 2011). The fine and ultrafine PM in the station concourse were from outside traffic that was likely caused directly from buses inside the building. Measurement results from the study suggested that PM levels on the station concourse were governed by coarse PM; however, those at waiting areas were dominated by fine PM.

This study had been done among the respondents at bus terminals as the respondents are vulnerable to respiratory health symptoms as they spend more than 8 hours per day in their work environment. They are prone to be exposed to the ambient air pollutant from the exhaust from the buses and others vehicles as the terminal is located in the middle of town and along a side street.

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In addition, this study was done to determine the level of exposure to $PM_{2.5}$ in the terminal bus as the information about particulate matter at the bus terminal in Malaysia was lacking. Therefore, this study would be a preliminary study conducted in a bus terminal in Malaysia and will also serve as the baseline for the employer and the respondents for their records in the future. This study was done to identify the exposure level of respondents at bus terminals exposure to particulate matter $PM_{2.5}$ and the prevalence of respiratory health to see how the PM exposure affects their respiratory health.

1.2 RESEARCH OBJECTIVES

1.2.1 General objective

To determine the relationship between the air pollutants of $PM_{2.5}$ and its association with respiratory health among respondents at terminal bus in Kuala Lumpur.

1.1.1 Specific objective

1. To identify socio-economic and demographic status of respondents.
2. To determine the level of exposure to $PM_{2.5}$ in the bus terminal.

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3. To determine prevalence of respiratory health symptoms among the respondents.

4. To determine the concentration level of interleukin-6 among the respondents in bus terminals.

5. To determine relationship between $PM_{2.5}$ and interleukin-6.

6. To determine the association between exposure to $PM_{2.5}$ and lung function among the respondents.

7. To determine the association between exposure to $PM_{2.5}$ and prevalence of respiratory health among the respondents

8. To determine the factors that contributes to the level of interleukin-6 concentration and the abnormality of lung function.

1.2.2 Hypothesis

1. The exposure level of $PM_{2.5}$ is significantly higher among the bus terminal ticketing and boarding respondents than office respondents.
2. The level of interleukin-6 concentration significantly is higher among the bus terminal ticketing and boarding respondents than office respondents.
3. There is significant association between the levels of $PM_{2.5}$ exposure with the level of urinary interleukin-6 among the respondents.

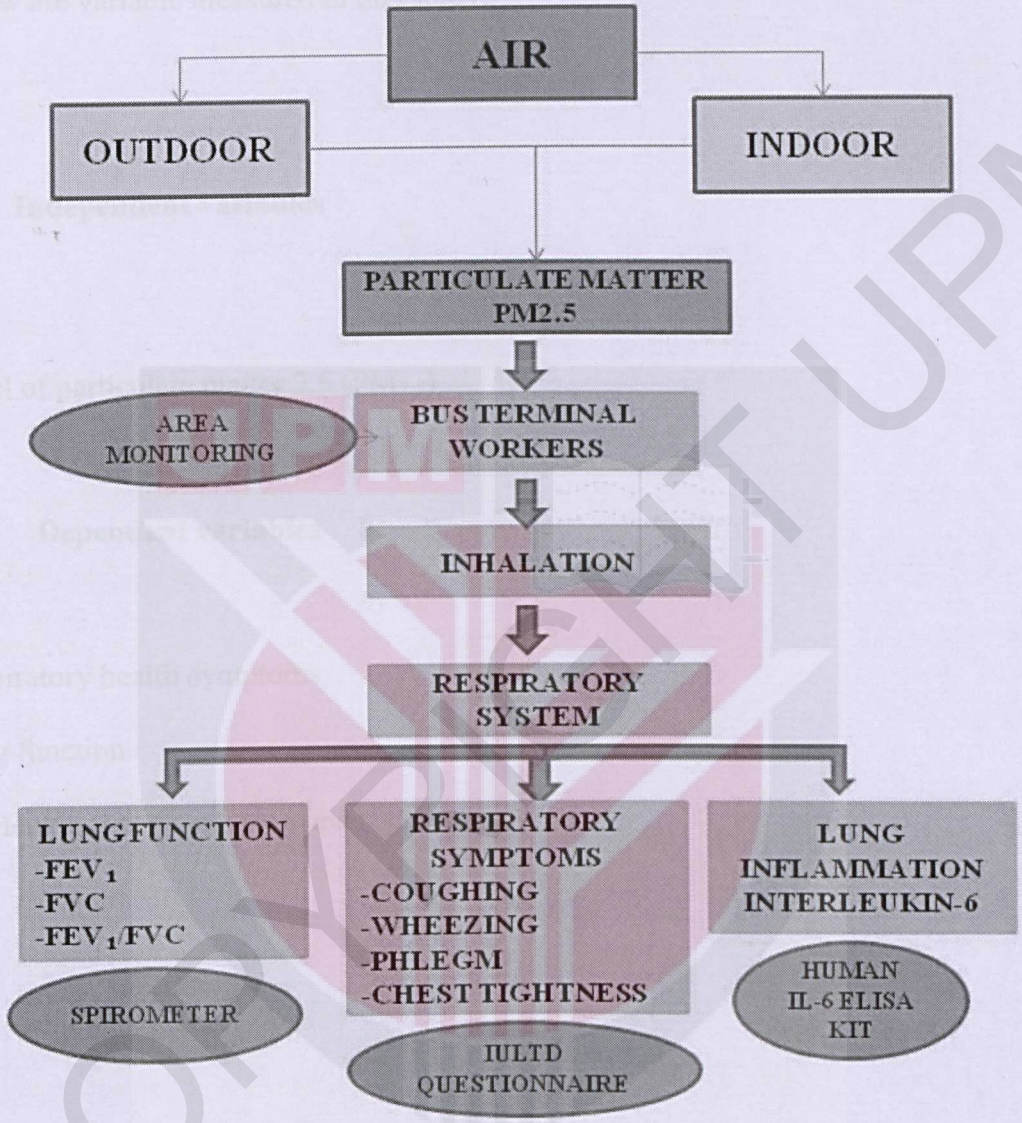
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4. There is a significant association between the exposures to $PM_{2.5}$ with the respiratory health symptoms of the respondents.
5. There is a significant association between the exposures to $PM_{2.5}$ with the lung function among the respondents.

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1.3 CONCEPTUAL FRAMEWORK



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1.4 VARIABLE(S)

Below are variable measured in this study:

Independent variables

Level of particulate matter 2.5 ($PM_{2.5}$)

Dependent variables

Respiratory health symptoms

Lung function

Interleukin-6 concentration level

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1.5 DEFINITION(S)

1.5.1 Theoretical definition

Interleukine-6

Interleukin 6 (IL-6) is 'a biological response modifier and a substance that can improve the body's natural response to infection and disease' (Kirk et al., 2000). Interleukin (IL)-6 is produced at the site of inflammation and plays a key role in the acute phase response as defined by a variety of clinical and biological features such as the production of acute phase proteins. IL-6 in combination with its soluble receptor sIL-6Rα, dictates the transition from acute to chronic inflammation by changing the nature of leukocyte infiltrate (from polymorphonuclear neutrophils to monocyte/macrophages). In addition, IL-6 exerts stimulatory effects on T- and B-cells, thus favouring chronic inflammatory responses (Gabay 2006).

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Particulate matter, 2.5µm ($PM_{2.5}$)

$PM_{2.5}$ may also be referred to as fine particulate matter. "Fine particles," such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air. (Environmental Protection Agency or EPA, 2012).

FEV1- forced expiratory volume in second

The volume of air exhaled during the first second of FVC, expressed in litres (American Thoracic Society or ATS, 1994).

FVC- forced vital capacity

Maximal volume of air exhaled with maximally forced effort from a position of maximal inspiration (ATS, 1994).

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Chronic cough

Previous symptoms on most days for consecutive months and more during the year (Chen et al, 1998).

Chronic phlegm

Having phlegm for at least 4 days in one week for at least 3 consecutive months during the years (ATS, 1978).

Wheezing

Having wheezing or whistling sound in breathing associated with breathlessness on most days or nights (ATS, 1978).

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Chest tightness

A combination of cough or phlegm or increase of cough of phlegm in cases where the respondents cough or having phlegm continuously (ATS, 1978).

1.5.2 Operational definition

Interleukine-6

IL-6 concentration measured using Human IL-6 ELISA Kit.

Particulate matter 2.5 µm

The level of exposures to PMs was measured using SidePak™ AM510 Personal Aerosol Monitor for 8hours. During the exposure measurement, the instruments were placed within the working zone of the respondents (Kavitha, 2011). The area monitoring will be done if the respondents are only working in their room without

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going to other place for approximately 8 hours. If the area of monitoring is not practicable, personal monitoring will be done.

FEV1- forced expiratory volume in second

The measurement of maximal volume of air exhaled in 1second of FVC by using Spirolab II Model.

FVC- forced vital capacity

Measurement of maximally and forcefully exhales the volume of air by using Spirolab II Model.

Chronic cough

Chronic cough identified from the questionnaires adapted from the International Union against Tuberculosis and Lung Disease (IUATLD) Bronchial Symptoms Questionnaires (IULTD, 1984).

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Chronic phlegm

Chronic phlegm identified from the questionnaires adapted from the International Union against Tuberculosis and Lung Disease (IUATLD) Bronchial Symptoms Questionnaires (IULTD, 1984).

Wheezing

Wheezing identified from the questionnaires adapted from the International Union against Tuberculosis and Lung Disease (IUATLD) Bronchial Symptoms Questionnaires (IULTD, 1984).

Chest tightness

Chest tightness identified from the questionnaires adapted from the International Union against Tuberculosis and Lung Disease (IUATLD) Bronchial Symptoms Questionnaires. (IULTD, 1984)

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1.6 STUDY LIMITATIONS

1. Information bias since health status information was based on questionnaires
2. Samples of urine could not be duplicated because of time and budget constraint.
3. Samples could not be collected at precisely the end of the shifts due to time constraints and

   The scheduling of the workers in the morning, afternoon or the night shifts

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CHAPTER 2

2 LITERATURE REVIEW

2.1 Particulate matter, 2.5µm ($PM_{2.5}$)

Particulate matter (PM) is the term used for a mixture of solid particles and liquid droplets suspended in the air. These particles originate from a variety of sources, such as power plants, industrial processes, and diesel trucks, and they are formed in the atmosphere by transformation of gaseous emissions. Their chemical and physical compositions depending on location, time of year, and weather. PM is composed of both coarse and fine particles. $PM_{2.5}$ is also called as fine particles that have an aerodynamic diameter less than 2.5mm (Fierro et al, 2000).

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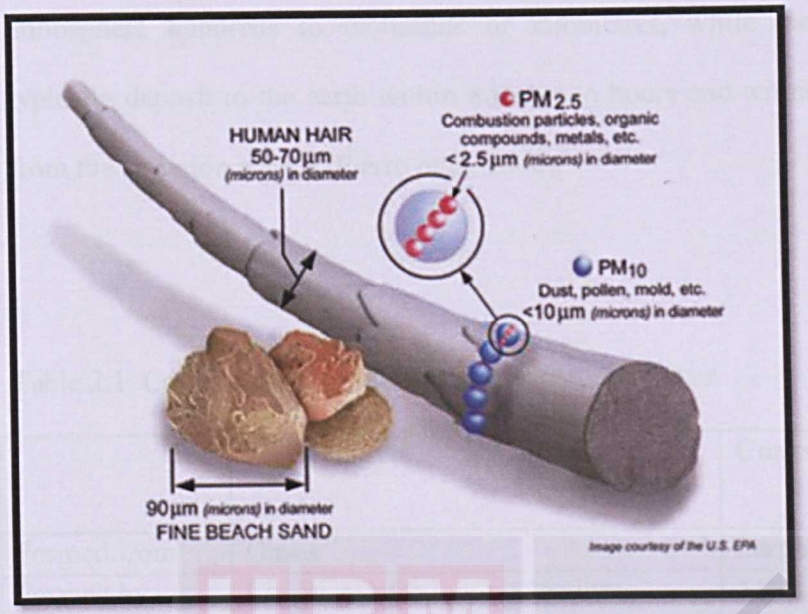


Figure 2.1 Shows size of the particle pollution

Source: US EPA (1996) accessed from http://www.epa.gov/pm/basic.html

Fine and coarse particles are distinct in terms of the emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters (Table 2.1). These particles are formed from gas and condensation of high-temperature vapours during combustion, and they are composed of various combinations of sulfate compounds, nitrate compounds, carbon compounds, ammonium, hydrogen ion, organic compounds, metals (Pb, Cd, V, Ni, Cu, Zn, Mn, and Fe), and particle bound water. The major sources of $PM_{2.5}$ are fossil fuel combustion, vegetation burning, and the smelting and processing of metals. Fine particles can remain in the atmosphere for days to weeks and travel through the

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atmosphere hundreds to thousands of kilometres, while most coarse particles typically deposit to the earth within minutes to hours and within tens of kilometres from the emission source (Fierro et al, 2000).

Table 2.1. Comparisons of fine and coarse particle matter

	Fine Particle	**Coarse Particle**
Formed from	Gases	Large solids/droplets
Formed by	Chemical reaction; nucleation; condensation, coagulation; evaporation of fog and cloud droplets in which gases have dissolved and reacted	Mechanical disruption (e.g. crushing, grinding, abrasion of surfaces); evaporation of sprays; suspension of dusts
Composed of	Sulfate (SO_4^{2-}); Nitrate (NO^{-}_3); ammonium (NH_4^+); hydrogen ion (H^+); elemental carbon; organic compounds (e.g. PAHs, PNAs); metals (Pb, Cd, V, Ni, Cu, Zn, Mn, Fe); particle bound water	Resuspended dust (e.g. soil dust, street dust); coal and oil fly ash; metal oxides of crustal elements (Si, Al, Ti, Fe); $CaCO_3$, NaCl, sea salt; pollen, mould spores; plant/animal fragments; tyrewear debris
Sources	Combustion of coal, oil, gasoline, diesel, wood; atmospheric transformation products of NOx, SO_2 and organic compounds including biogenic species (e.g. terpenes); high temperature processes, smelters, steel mills, etc.	Resuspension of industrial dust and soil tracked onto roads; suspension from disturbed soil (e.g. farming, mining, unpaved roads); biological sources; construction and demolition; coal and oil combustion; ocean spray
Lifetimes	Days to weeks	Minutes to Hours
Travel distance	100s to 1000s of kilometres	<1 to 10s of kilometers

Source: EPA (1996)

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Respirable PM from combustion sources ($PM_{2.5}$) has been associated with increased respiratory symptoms, including cough, wheeze and shortness of breath (Koren , 1995; Neas et al. 1995, Roemer et al. 1993). $PM_{2.5}$ levels were associated with moderate to severe cough and shortness of breath (Liao et al. 1999). Perales et al. (2007) demonstrated that $PM_{2.5}$ levels inside mini buses and buses were 49 mg/m^3 and 52 mg/m^3, respectively, and significantly higher than those inside metro trains in Mexico City.

From the study Indoor Air Quality and Occupational Exposures at a Bus Terminal by Mutasem et al (2010), the sampled TSP levels are highly correlated with the fine PM, which are also subject to deposition but at a slower rate than the coarse PM, which have a lifetime of minutes in indoor environments. Once deposited, both types of particulate matter are subject to re-entrainment, with fine PM being re-entrained faster. The measured levels included the potential contribution of outdoor sources from the outside building.

Outdoor fine particulate matter ($PM_{2.5}$) concentration are usually about 45 to 65 percent the concentration of PM_{10} which in turn constitute 70 percent of total suspended particulate concentration (WHO,1999). The percentage for indoor environment are expected to be higher as a result of low air currents and the fast deposition rate of course particles that have a life time of minutes in indoor

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environments. In addition, diesel particulate matter emissions are mostly in the form of fine particles (WHO, 2000).

Transportation has been recognized as a significant source of ambient PM in urban areas (Charron and Harrison, 2005; Allaban et al., 2007). The fine and ultrafine PM in the station concourse were from outside vehicles. The PM emitted directly from buses can accumulate within the buildings, which can adversely affecting the health of passengers and respondents in the terminal (Cheng Y., Chang H., & Hsieh C., 2011). The study results suggest that PM levels on the station concourse were governed by coarse PM however, those at waiting areas were dominated by fine PM. The PM_{10} and $PM_{2.5}$ levels inside the bus terminal were roughly 1.5 and 1.4 times higher than those measured inside buses, respectively (Cheng Y., Chang H., & Hsieh C., 2011).

World Health Organization (WHO) set an annual average concentration of 10 µg/m3 was chosen as the long-term guideline value for $PM_{2.5}$, whereas 25 $\mu g/m^3$ as 24 hours average concentration. This represents the lower end of the range over which significant effects on survival were observed in the American Cancer Society's (ACS) study (Pope et al., 2002).

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The January 15, 2013 Environmental Protection Agency (EPA) had done revisions of the existing (2006) annual health-based ("primary") standard for fine particulate matter 2.5 micrometers or less in diameter (or $PM_{2.5}$), lowering the allowable average concentration of $PM_{2.5}$ in the air from the current level of 15 micrograms per cubic meter (μg/m3) to a limit of 12 μg/m3. The annual $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) is set so as to address human health effects from chronic exposures to the pollutants. The existing "24-hour primary standard" for $PM_{2.5}$ that was reduced from 65 μg/m3 to 35 μg/m3 in 2006 was retained, as was the existing standard for larger, but still inhalable, coarse particles less than 10 micrometers in diameter, or PM_{10}.

2.2 Particulate matter 2.5μm ($PM_{2.5}$) and lung

A large number of epidemiological studies showed that particulate matter which includes both fine and coarse particles has adverse health effects. In 1987, the regulatory focus shifted from total suspended particles to particles that could readily penetrate and deposit in the tracheobronchial tree, or PM_{10} (PM with a median aerodynamic diameter of 10 μm). In 1997, the US EPA promulgated 24-hour and annual average standards for $PM_{2.5}$ (PM with median aerodynamic diameter 2.5 μm), comprising the size fraction that can reach the small airways and alveoli. The complex nature of PM, it has been measured and regulated based primarily on mass

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within defined size ranges The aerodynamic properties of particles determine how PM is transported in air and how they can be removed from it, how far they get into the air passages of the respiratory system and provide information on the chemical composition and the sources of particles. $PM_{2.5}$ can penetrate deeper and deposited higher in airways and lungs as the primary target organs and can deposit in alveoli, where they interact with macrophages, neutrophils and epithelial cells (Salvi and Holgate., 1999; Pozzi et al., 2003; Oberdorster et al., 2005). The finest particles had properties of surface reactivity (Wilson et al., 2002) and produce reactive oxygen species (ROS), known to mediate particulate matter respiratory effects (Tao et al., 2003).

EPA groups regulated particle pollution into two categories: "Coarse particles," which are larger than 2.5 micrometers and “fine particles” which are smaller than 10 micrometers in diameter. These particles are deposited into the airways in the head region when inhaled. "Fine particles," are 2.5 micrometers ($PM_{2.5}$) in diameter or smaller and when inhaled they are deposited into lung airways or the tracheobronchial region (Figure 2.2).

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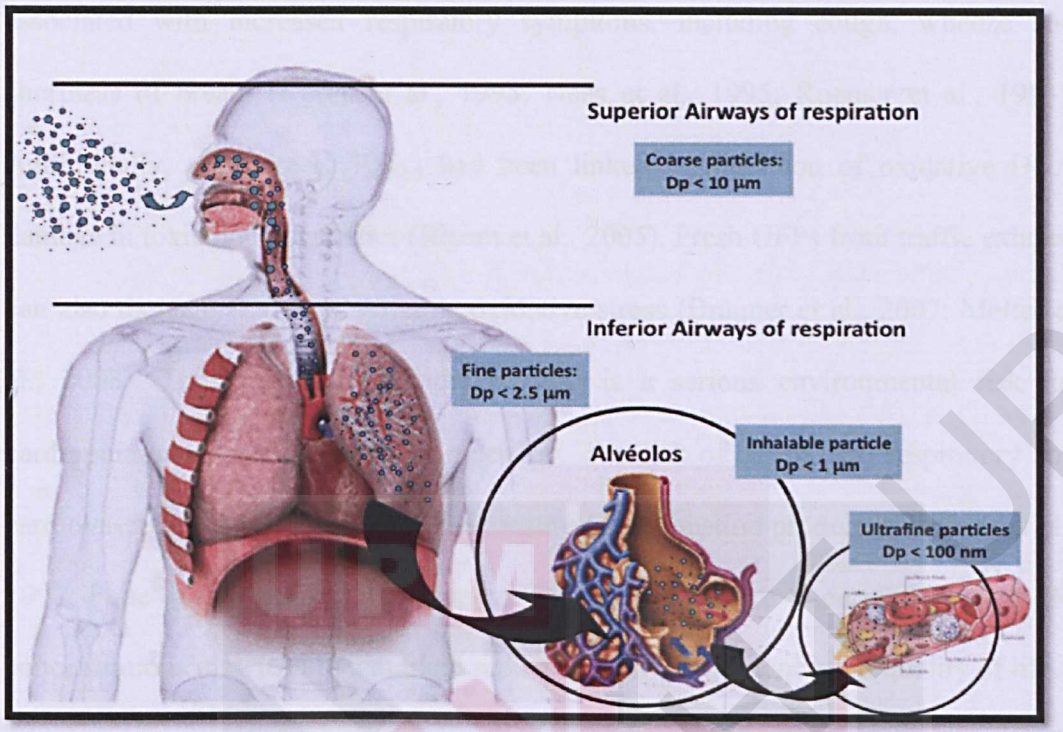


Figure 2.2 represents the areas where particulate matter is deposited in the body

Source: LÃlian Lefol Nani Guarieiro, Aline Lefol Nani Guarieiro, Vehicle Emissions: What Will Change with Use of Biofuel? *Book Article Biofuels - Economy, Environment and Sustainability* 2013 2013-01-23 42164 http://www.intechopen.com/books/biofuels-economy-environment-and-sustainability/vehicle-emissions-what-will-change-with-use-of-biofuel-

Short- and long term exposure to $PM_{2.5}$ is associated with various health effects, including respiratory and cardiovascular diseases (Pope et al., 2004; Dominici et al., 2006). Respirable particulate matter from combustion sources was

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associated with increased respiratory symptoms, including cough, wheeze and shortness of breath (Koren et al., 1995; Neas et al., 1995; Roemer et al., 1993). Additionally, exposure to $PM_{2.5}$ had been linked to induction of oxidative DNA damage in toxicological studies (Risom et al., 2005). Fresh UFPs from traffic exhaust can also damage DNA via systemic oxidative stress (Bräuner et al., 2007; Møller et al., 2008). Thus, exposure to ambient PM is a serious environmental risk for cardiopulmonary and lung cancer mortality. The risk of cancer and respiratory and cardiovascular diseases is related to exposure to combustion products (Boffetta et al., 1997; Pope et al., 2002). Thus, long-term ambient exposure to current ambient PM concentrations may lead to a marked reduction in life expectancy and quality of life.

The other short term effect of exposure to particles such as ambient, diesel exhaust particles or carbon black ultrafine particles is an airway inflammation (Ghio and Huang, 2004), then increased secretion of pro-inflammatory mediators such as Interleukin-8 (Stenfors et al., 2004). The systemic inflammation caused by PM can contribute to the cardiovascular effects (Mills et al., 2007). An vitro study have shown that the production of pro-inflammatory cytokines favouring the attraction and activation of immune cells are involved in both airway epithelial cells (nasal, bronchial and alveolar) and macrophages (Ishii et al., 2005).

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2.3 Interleukine-6 and role of cytokines in innate inflammation

Interleukin (IL)-6 is produced at the site of inflammation and plays a key role in the acute phase response as defined by a variety of clinical and biological features such as the production of acute phase proteins (Gabay C., 2006). The acute phase proteins have been defined as a set of plasma proteins with concentrations that increase (positive acute phase proteins) or decrease (negative acute phase proteins) by at least 25% in inflammatory disorders (Gabay et al., 1999; Gitlin et al 1987). In addition, IL-6 exerts stimulatory effects on T- and B-cells, thus favouring chronic inflammatory responses. Strategies targeting IL-6 and IL-6 signalling led to effective prevention and treatment of models of rheumatoid arthritis and other chronic inflammatory diseases.

The inflammatory process in the lungs is characterized by the production of leukotrienes, histamine, bradykinin, and a variety of cytokines and chemokines by tissues and migrating cells. Among the proinflammatory cytokines, interleukin-6 (IL-6) is considered to contribute to the initiation and extension of the inflammatory process. IL-6 is a multifunctional cytokine that is produced by a wide range of cells (Baumann et al., 1984; Jirik et al., 1989; Nijsten et al., 1987), usually at sites of tissue inflammation. It induces fever, activates B and T lymphocytes, and stimulates

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hepatocytes to produce acute phase proteins. Some studies have shown that IL-6 also has potent anti-inflammatory and protective properties. These include the ability to inhibit the production of tumor necrosis factor (TNF), IL-1, and macrophage inflammatory protein-2; to decrease neutrophil sequestration; to increase levels of IL-1 receptor antagonist and TNF-soluble receptor; to stimulate the production of metalloproteinase inhibitors; to reduce intracellular superoxide production; to reduce tissue matrix degradation; and to inhibit cellular apoptosis (Jordan et al., 1995; Mizuhara et al., 1994; Rollwagen et al., 1998; Shingu et al., 1994, 1995; Tilg et al., 1994; Ulich et al., 1991; Xing et al., 1998).

Result from the previous study implicated that a strong correlation may exist between IL-6 expression and pulmonary inflammation or injury (Yu et al. 2002). The study was to examine the role of cytokine interleukine-6 in environmental air pollutant induced pulmonary inflammation, injury and repair. The use of IL-6 knockout mice makes it possible to investigate the role of cytokine in various model of inflammation. IL-6 stimulated cell produce cytokine, the hormone like proteins that serve in either autocrine, paracrine as intercellular messenger, and then give rise to general symptom such as fever, headache and malaise, respiratory symptom and lung function decrement (Neta et al., 1991).

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Chronic inflammation is associated with lung carcinogenesis. In previous studies, have shown that C-reactive protein (CRP), a systemic marker of chronic inflammation, is associated with increased lung cancer risk (Allin et al 2009., Chaturvedi el al 2010). Furthermore, it is suggested that circulating proinflammatory cytokines may be associated with lung cancer; interleukin 6 (IL-6) and interleukin 8 (IL-8) are of particular interest because they are expressed in premalignant epithelial cells, and their expression is associated with a poor prognosis in lung cancer patients (Davalos et al 2010., and Seike et al 2007). High circulating levels of IL-6 and IL-8 were reported to be associated with lung cancer (Bichory et al 2001., Kamirska et al 2006., Orditura et al 2002), but there were too few case patients to examine subgroups. None of the reports included multivariable analyses to adjust for potential confounding such as smoking. Adjustment for smoking is particularly relevant because IL-8 expression is higher in small-airway epithelial cells in smokers, and serum IL-6 and IL-8 levels are higher in smokers (Bermudez et al 2002., Kluft et al 2002).

Increased concentrations of IL-6 are associated with an increased risk of cardiovascular events and mortality. Serum Il-6, IL-1β, and granulocyte macrophage colony stimulating factor are increased in healthy male subjects after exposures to increased air pollution due to forest fires and are increased in vitro with exposure of human lung macrophages to urban PM10. Il-6 is directly involved in regulation of the synthesis of C-reactive protein in the liver. CRP is a sensitive indicator of

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infection, injury, and inflammation and is linked to increased risk of cardiovascular disease. CRP concentration has been shown to be positively associated with exposure to total suspended particles and PM_{10} (Yanli et al 2013).

In the lung, a variety of cells such as alveolar macrophage, lymphocytes, alveolar epithelial cells are capable of producing IL-6 (Arcangeli et al., 2001; Bankey et al., 1995; Frampton et al., 1999; Kayoma et al., 1998; Mosmann and Sad., 1996; Yu et al., 2002). Figure 2.3 shows the possible role played by IL-6 in the shift from acute to chronic inflammation. Stage 1: following acute inflammatory response, IL-6 can bind with sIL-6R. Stage 2: trans-signalling through gp130 leads to monocyte recruitment. Stage 3: prolonged IL-6 leads to neutrophilic apoptosis, phagocytosis and mononuclear accumulation at the site of injury. IL, interleukin; JAK, Janus activated kinase; MCP, monocyte chemoattractant protein; PMN, polymorphonuclear neutrophil; sIL-6R, soluble IL-6 receptor.

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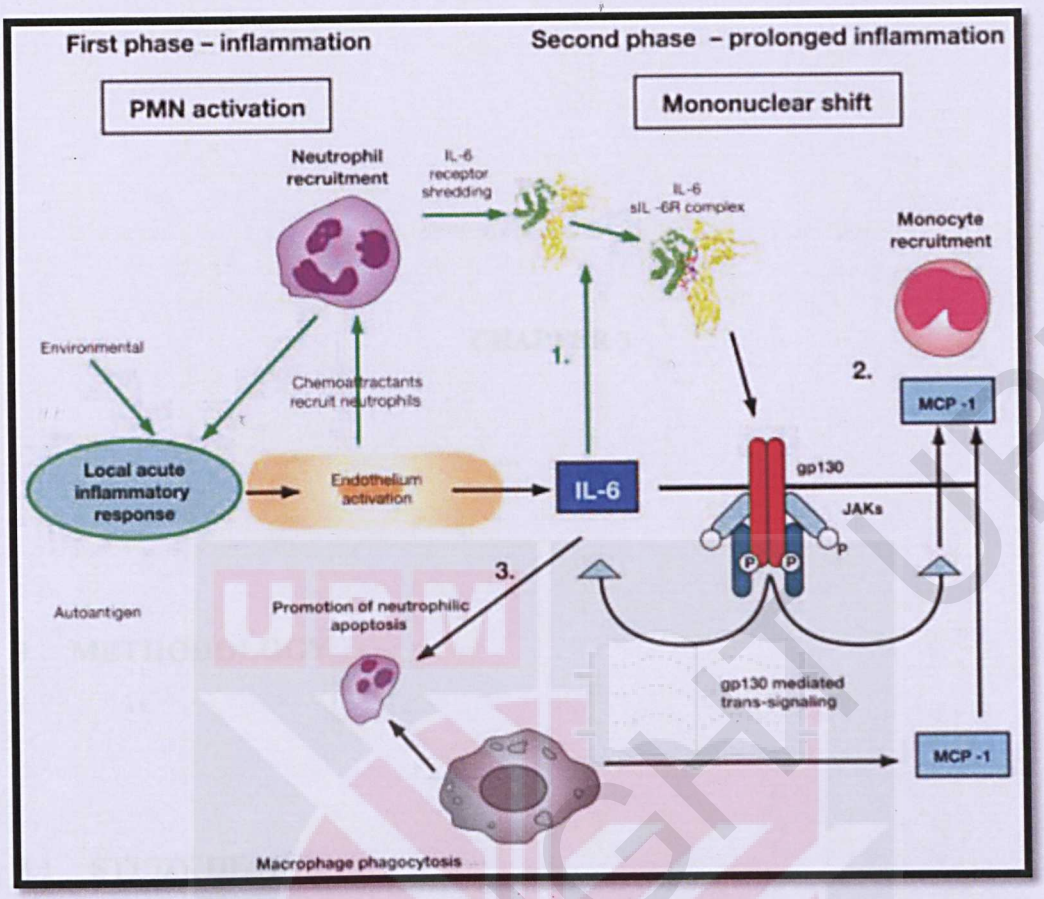


Figure 3.3 shows the possible role played by IL-6 in the shift from acute to to chronic inflammation chronic inflammation

Source from: Gabay C. (2006) *Proceedings Interleukin-6 and Chronic Inflammation Arthritis Research & Therapy* 2006, 8(Suppl 2):S3doi:10.1186/ar1917

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CHAPTER 3

3 METHODOLOGY

3.1 STUDY DESIGN

A cross sectional study was performed among bus terminal's respondents at bus terminal as the exposed group to see the relationship between the level of exposure of $PM_{2.5}$ and respiratory health symptoms.

3.2 SAMPLING FRAME

The respondents were selected based on the list given by the administrative office of bus terminal.

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3.3 SAMPLING METHOD

Random sampling method based on the list from the administrative office of the bus terminals. The inclusive criteria for this study were nonsmokers, age between 20 to 65 years, Malaysian nationality and with no history of chronic lung and respiratory diseases.

3.4 SAMPLE SIZE

Fifty respondents comprises of male and female working in the bus terminal. The sample size for this study was calculated using the Kirkwood Formula 1998.

$$N = \frac{P(1-P)}{e^2}$$

N= sample size

e= the proportion of sampling error in a given situation

= 0.05

P= prevalence of chronic respiratory symptom of exposed group, bus drives (Kavita, 2010)

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=85.7%

Therefore, the minimum sample size was 49 respondents.

3.5 LOCATION OF STUDY

This study was conducted at the Terminal Bersepadu Selatan bus terminal facility in Kuala Lumpur City. The terminal was located near a street leading to a main arterial road. The terminal is located in both residential and commercial area with little to no industrial activities, which limits the sources of air pollution to mainly indoor sources and outside traffic.

3.6 INSTRUMENTATION

3.6.1 Human Interleukin-6 ELISA kit

The human IL-6 ELISA is an enzyme-linked immunosorbent assay for the quantitative detection of human IL-6. The concentrations of the Interleukin-6 in urine were analyzed using Human Interleukin-6 Enzyme-Linked Immunosorbent Assay

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(ELISA) according to the manufacturer's instruction. The IL-6 concentration of the respondents was determined from a standard curve for IL-6. The biomarker analysis was conducted at the Chemical Pathological Laboratory, Department of Pathology, University Putra Malaysia. The procedure of the ELISA analysis was as follow:

1. Firstly, the number of microwell strips required was determined.

2. The microwell strips twice were washed with Wash Buffer.

3. Standard dilution on the microwell plate: Add 100 µl Assay Buffer (1x), in duplicate, to all standard wells. Prepared standard was pipetted 100 µl into the first wells and create standard dilutions by transferring 100 µl from well to another well. Discard 100 µl from the last wells. Alternatively external standard dilution in tubes (see 9.5.1): Pipette 100 µl of these standard dilutions in the microwells.

4. 100 µl Assay Buffer (1x), in duplicate, was added to the blank wells.

5. 50 µl Assay Buffer (1x) was added to sample wells.

6. 50 µl samples in duplicate, was added to designated sample wells.

7. Biotin-Conjugate was prepared and added 50 µl Biotin-Conjugate to all wells.

9. Microwell strips was covered and incubated 2 hours at room temperature (18° to 25°C).

10. Streptavidin-HRP was prepared.

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11. Microwell strips were emptied and washed 4 times with Wash Buffer.

12. 100 µl diluted Streptavidin-HRP was added to all wells.

13. Microwell strips was covered and incubated 1 hours at room temperature (18° to 25°C).

14. Microwell strips were emptied and washed 4 times with Wash Buffer.

15. 100 µl of TMB Substrate Solution was added to all wells.

16. The microwell strips were incubated for about 10 minutes at room temperature (18°to 25°C).

17. Then, 100 µl Stop Solution was added to all wells.

18. The colour intensity was measured at 450 nm using the plate reader.

3.6.2 Anthropometry measurement equipments

a. SECA 206 BODYMETER SCALE

SECA 206 Body Meter Scale was an instrument that used to measure the height. The scale range was 0 - 220 cm. This instrument was used to measure the

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height of respondents in this study in bare footed and standing in straight position. The instruments was be calibrated each time before starting the measurement.

b. SECA Weighing Machine

SECA Weighing Machine (Model Tanita) was used to measure the body weight. The capacity of measurement was up to 150kg. This instrument was be used to measure the weight of respondents in this study. The weighing scale was being placed on the flat surface during measurement. The instruments were calibrated each time before starting the measurement.

Spirometer

Spirometer Spirolab II model was used in the lung function test which was purposely to measure the volume of air in the lungs and the volume that able to breathe out in one second. The function of this instrument is as follow:

- Measures air flow by electronic or mechanical displacement principles, and uses a microprocessor and recorder to calculate and plot air flow.

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- Records the amount and the rate of air that respondents breathe in and out over a period of time-spirogram.
- The recording, called a spirogram, shows the volume of air moved and the rate at which it travels into and out of the lungs.

For the purpose of this study, two parameters were measured which Forced Vital Capacity (FVC) and Forced Expired Volume in one second (FEV_1). FVC was the maximal volume of air exhaled with maximally forced effort from a position of maximal inspirtaion expressed in liters. While FEV_1 was the volume of air expired in the first second of maximal expiration after a maximal inspiration and is a useful measurement of how quickly full lungs can be emptied.

The type of spirometer that was used in this study was Spirolab II Model. The data of respondents including age, gender, height (cm), weight (kg) and also date was be recorded in the spirometer before spirometry test being handled. Spirometry maneuver was being performed appriopriately to produce good result. Below was the maneuvers performance recommendations based on the American Thoracic Society (1995) was be followed while performing lung function tets:

i. The spirometer was checked and calibrated.

ii. The respondents was explained about the testing procedures and to get their fullest cooperation.

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iii. The test procedures were instructed and demostrated to respondents.

a. Respondents need to correct posture with head elevated and standing in straight position

b. Respondents must inhaled completely

c. Respondents need to position mouthpiece and exhaled with maximal force

iv. Performed manuever.

a. Have respondents assume correct posture

b. The nose clip was attached using a nose clip

c. Irespondents must inhaled completely; the inhalation should rapid but not forced

d. The mouthpiece must be placed in the mouth of the respindents and close around mouthpiece.

e. The respondentss must exhaled maximally the air from their lungs, then continue to encourage respondents to fully exhale.

3.6.3 Measurement of Area Exposure Level of PM2.5

Exposures to PMs were measured using SidePak™ AM510 Personal Aerosol Monitor. The area monitoring was done at working place. Below was the measuring procedure for $PM_{2.5}$

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1. SIDEPAK was used to measure the ambient air particulate matter of $PM_{2.5}$
2. Initially, the battery level, flow rate (flow check) of SIDEPAK was checked to 1.7L/min.
3. Button of "ON/OFF was pressed. SIDEPAK was turned on for 60 seconds to ensure the device warmed up. When the SIDEPAK was in survey mode, the ON/OFF button was pressed to select menu and data log. Later, the button " ⇨ '' was pressed to enter and start the air sampling procedure.
4. When the run manual was on SIDEPAK, the button " ⇨ '' was pressed to enter. When there was log in data on SIDEPAK, the button was pressed again to record data in 20 minutes.
5. After 20 minutes, the data finished recording. The button was pressed to stop record.
6. The results were obtained by transferring the reading from SIDEPAK to computer using the TrackPro software.

3.7 DATA COLLECTION

This study presented an air quality assessment at the main bus terminal facility in Kuala Lumpur. For this purpose, field surveys and observations were conducted to determine the level of $PM_{2.5}$ and its health effect. $PM_{2.5}$, were used as an indicators and air samples were collected and analyzed for their level in the air.

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The selection of $PM_{2.5}$ as indicator was mainly based on their correlation with diesel emissions from the vehicles from the outside of the terminal building as ambient PM that may penetrate into the indoor environment as additional sources of PM found indoors in addition to their attributed health problems. Respiratory health symptoms were determined by sample of urinary interleukin-6 and lung function test to indicate the respiratory health problem among respondents at the terminal bus.

3.7.1 Questionnaire distribution

Questionnaire which was adapted from the International Union against Tuberculosis and Lung Disease (IUATLD) Bronchial Symptoms Questionnaires was distributed to the entire respondents that be selected at the beginning. Then, the questionnaire was completed by the respondents.

For quality control of questionnaire, pre-test was conducted on 10% of the sample size to determine the validity and reliability of the questionnaire.

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3.7.2 Urine sample collection

The urinary samples were taken after measurement of exposure to particulate. 50ml of urine was taken from each respondent and then put in polyethylene 60ml bottles. All samples were labeled and placed in polystyrene containing ice to maintain the temperature less than 4 °C to stabilize the condition of sample. The samples were taken to the laboratory to be analyzed using Human IL-6 ELISA kit. Urine sample were centrifuged to remove any particulates by centrifugation for 15 minutes at 1000x g, 2 - 8°C and assay immediately or aliquot and the samples stored at -20°C or -80 °C.

3.7.3 Lung function test /spirometry

a. Calibration

Prior of using the spirometer, it has to be calibrated. Calibration on the spirometer was performed on the recommendations by ATS standardization of spirometry. Spirometer was calibrated by injecting 3 liters of air into the spirometer using a three liters syringe. Error allows in 3% or 50mL of air.

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b. Pre-test spirometry

Before conducting the test, the measurement of height and weight of respondents was taken. The height and weight of respondents was recorded by measuring using SECA weighing machine for measuring weight and SECA Bodymeter for measuring height. During the measurement, the respondents was to be ensured that all the things that can give error to the measurement such as the watch, handphone, wallet and so on removed from the body. Three times of measurements were obtained to get the accurate body weight and height of the respondents. Then, the value of the measurement of height and weight of respondents were inserted into spirometer measurement.

c. Spirometry test

Spirometry test was performed to all fifty respondents in this study for both exposed group and comparative group. Firstly, the important information such as identity card, date of test, age, gender and height and weight measurement of respondents were entered into spirometer equipment. Then, before performing the maneuver of the lung function test, the right explanation with simple language about the testing procedure were given to the respondents. Next, the test procedure were

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demonstrated the test procedure to explained to the respondents, including correct posture with head elevated and standing in straight position, inhale completely, showing proper mouthpiece position and exhale with maximal effort.

After that, the respondents were asked to performed the maneuver. The respondents were asked to stand during the examination and be sure the bench was positioned behind the respondents. Ask the respondents also to loosen any tight clothing and remove dentures (if not secured). Place noseclip on nose but it may be removed between trials. Then, ask respondents to elevate the chin and extend neck slightly.When the ready signal is given, respondents had to inhale as deep as they can and then place mouthpiece in the mouth and the respondents was to be ensured that their lips tight properly around the mouthpiece. Lastly, they had to blast the air into the tube as hard and fast as they can. This test was to be done for 3 trials and the highest of trials is used for evaluation of breathing.

d. Acceptance of spirometry test

The American Thoracic Society has set standard to control the quality of spirometer in 1978. The result was valid if subject give a full cooperation during the test. At least 3 acceptable results were taken. Validity requirements depend on the

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subject that was not doing the activity of coughing, completing the expiration too early, and obstruction of tongue or teeth.

e. Quality control of spirometry usage

American Thoracic Society had recommended some quality control for spirometry test. Some of them are have to loosen the tight attire, be in ready and standing posture and remove the false teeth if present before starting the test. Besides that, respondents were provided clear explanation on the procedure of the test to respondents. During the beginning of the test, the respondents were asked to give the full maximal inspiration besides provide more time for the subjects to perform this test. Last but not least, the ATS also required that the researcher to identify the unsatisfactory result and also take the maneuver for at least 3 acceptable maneuver.

The criteria of maneuver that accepted for this test were the test should begin after the maximal inspiration, with the maximal effort, continuous expression at least for 4 seconds, no coughing and only the best maneuver from the three valid and identical maneuvers being accepted.

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f. Calculations of spirometry test

For calculation of lung function tests, the data for the prediction of individual's FVC and FEV_1 above the age of 20 years gave an equation for the males and female as below (Singh et al., 1993 – Malaysian Standard 20-69 years of age):

For male:

FVC = 0.0407 (height) - 0.0296 (age) - 2.3430 L

FEV1 = 0.0353 (height) - 0.0315 (age) - 1.7840 L

And for female:

FVC = 0.0312 (height) - 0.0220 (age) - 1.6400 L

FEV1 = 0.0294 (height) - 0.0238 (age) - 1.6090 L

FVC% predicted = (FVC measured/ FVC predicted) x 100

FEV1% predicted = (FEV1 measured/ FEV1 predicted) x 100

Ratio FEV1/FVC = FEV1% / FVC%

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g. Evaluation of spirometry test

The FVC and FEV_1 value was automatically corrected to body temperature (BTPS) by the spirometer. Evaluation process was done by comparing the observation spirometer value obtained from this test with the predicted value from study of Singh et al., (1993). This was because the value that was being obtained was assumed to have similarity with the Malaysian's population which consists of variety of race and economic status. The varieties of respondents in this study include body weight, height, environment and also altitude.

3.7.4 Statistical Analysis

Data were analyzed using Statistical Packages for Social Sciences (SPSS, version 21). Statistical methods that will be used were bivariate Man- Whitney U test and Independent T test to compare the mean between quantitative variables. Pearson's and Spearman correlation were run to compare respiratory status of respondents. Multivariate logistic regression and linear regression method was conducted to obtain the main factor influencing the concentration of interleukine-6 and abnormality of FVC% and FEV_1% after controlling confounding factors.

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3.8 RESEARCH ETHICS

The present study had obtained approval from the Committee of Ethics of Faculty of Medicine and Health Sciences, University Putra Malaysia to conduct this study. Permission to conduct this study was also granted by the bus terminal's management. This research were conducted on voluntary basis where all respondents were given briefings on conduct of the experiment and later on all respondents were asked to give their written permission using agreement forms.

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CHAPTER 4

4 RESULT

4.1 Descriptive Analysis

Socio-Demographic Data of Study respondents

The study respondents were comprised of 20 males and 30 females. In this study, all of the study respondents were Malay. Out of 50, there were 49 (98%) Malays and 1 (2%) was Chinese. Table 4.1 shows the number of sample population according to gender and race. Table 4.2 shows the anthropometrical information and working experiences of study respondents at the bus terminals. Basically, the means of age for the study group was 27.18±6.51 years. The mean height of the study group was 161.13±9.92 cm, whereas the mean weight was 67.29±16.68 kg. The mean of

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working experience (month) was 49.91±58.57, mean of working duration (hour) in a day was 11.12± 2.02 and the means of days of working were 5.14±0.41.

Table 4. 1 Socio-Demographic Data of Study respondents

Variables	Number (%)
Race	
Malay	49(98)
Chinese	1(2)
Gender	
Male	20(40)
Female	30(60)

Table 4. 2 Anthropometrical Measurement and Working Experiences Data of Study respondents

Variable	Means	Standard deviation	median	IQR	95%CI	
					Lower	Upper
Age (years)	27.18	6.51	26	6	25.33	29.03
Weight (kg)	67.29	16.68	63.50	15.63	62.55	72.03
Height (cm)	161.13	9.92	161.50	16.05	158.31	163.95
Working experience (months)	49.41	58.57	24	48	31.6	67.22
Work Hours	11.12	2.02	12	3	10.547	11.69
Work day	5.14	0.41	5	0	5.03	5.25

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IQR= interquatile range

4.2 Particulate Matter 2.5 ($PM_{2.5}$) levels at the bus terminals

Table 4.3 presents $PM_{2.5}$ levels at the three monitoring sites. The results demonstrate that $PM_{2.5}$ levels at ticketing counter and boarding area were significantly higher than at the management management office. The average level for eight hours of monitoring at the management management office, ticketing counter and boarding area was 5.44, 31.61 and 32.19 µg/m³ respectively.

Normality test was carried out to assess the distribution of $PM_{2.5}$ concentrations. The result of normality test showed that $PM_{2.5}$ concentration was not normally distributed ($p<0.05$).

Table 4. 3 Levels of $PM_{2.5}$ at different location inside the bus terminals

Variables	Average (µg/m³)	Maximum (µg/m³)	Minimum (µg/m³)
Management office	5.44	12.69	2.36
Ticketing counter	31.61	36.25	27.55
Boarding area	32.19	39.15	29.97

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Normality test was also conducted to determine the distribution of IL-6 concentration. The result showed that IL-6 concentration levels were not normally distributed ($p<0.05$). The concentration of IL-6 was obtained by using a 5-parameter curve fit through the points of graph in the Figure 4.1. The mean of IL-6 for management office study respondents was 0.25±0.13 pg/ml and ticketing and boarding study respondents were 0.21±0.09 pg/ml (Table 4.4). There was no significant difference between management office and no management office study respondents ($z=-1.56$, $p=0.12$). The mean of $PM_{2.5}$ for ticketing and boarding study respondents were 30.99 ± 4.52 pg/ml. For $PM_{2.5}$ 5 concentration level, there was significant difference between management office and ticketing and boarding study respondents ($z=-5.97$, $p<0.001$). This result indicates that, ticketing and boarding study respondents were exposed to higher $PM_{2.5}$ concentration levels than management office study respondents.

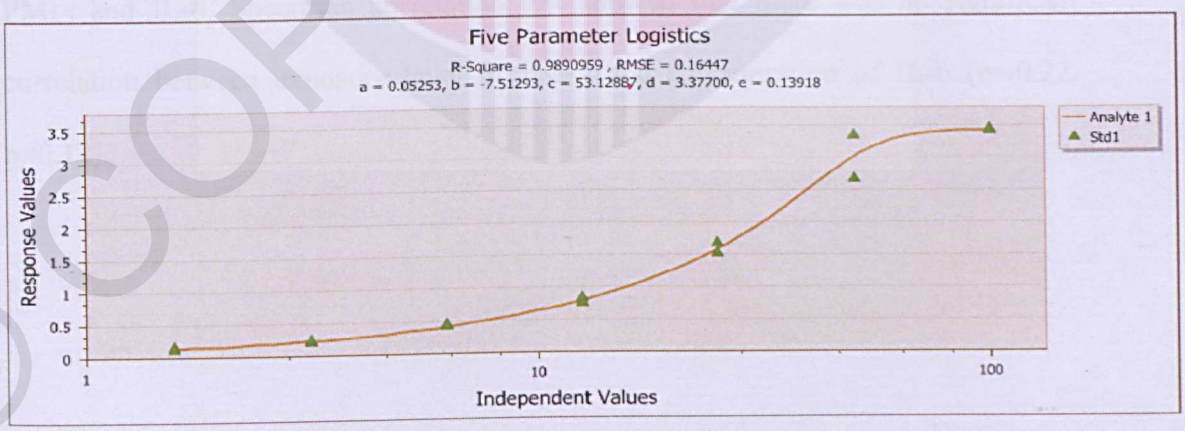


Figure 4.1 five parameter logistics

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Table 4. 4 Comparison of IL-6 among management office and ticketing and boarding study respondents

	STUDY GROUP		z-value	P-value
	management office Mean ± SD	Ticketing and boarding Mean ± SD		
IL-6(pg/ml)	0.25(0.13)	0.21(0.09)	-1.56	0.12

*Significant at $p<0.05$

Man-Whitney test

4.3 Correlation between exposure level of $PM_{2.5}$ and IL-6 concentration

Relationship between $PM_{2.5}$ concentrations was compared with IL-6 level. Normality test with Shapiro-Wilk analysis was performed for $PM_{2.5}$ and IL-6. The concentration of IL-6 was found not normally distributed as well as $PM_{2.5}$ levels. Therefore, Spearman Correlation test was performed to see the correlation between $PM_{2.5}$ and IL-6. Spearman correlation test showed that there was no significant correlation between exposure level of $PM_{2.5}$ and concentration of IL-6 ($r=-0.22$, $p=0.12$).

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Table 4. 5 Correlations between exposure level to $PM_{2.5}$ and IL-6 among the study respondents

Biomakers	PM exposure	Study group	
		r	p
IL-6 (pg/mL)	$PM_{2.5}$	-0.22	0.12

Significant at $p<0.05$

4.4 Correlation between exposure level of IL-6 concentration and working duration among the respondents

Spearman Correlation test was performed to see the correlation of working duration (hours) and IL-6. Results from Spearman correlation test showed that there was significant correlation between working hour duration and concentration of IL-6 ($r=-0.29$, $p=0.04$). Result showed that the Spearman correlation coefficient was negative which indicate that there was negative correlation between level of IL-6 concentrations and duration of working.

Table 4. 6 Correlations between exposure level to IL-6 and working duration among the study respondents

Variables	Study group	
	r	p
Months	-0.18	0.23
Hours	-0.29	0.040*
Days	-0.072	0.619

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*significant at $p<0.05$

4.5 Prevalence of respiratory health symptoms among the study respondents.

The respiratory symptoms studied were chough, phlegm, chest tightness, difficulty in breathing, wheezing and asthma. The results from the statistical analysis demonstrated that there was no significant difference for the prevalence of all respiratory symptoms between the studies. However, the prevalence for cough among the female study respondents was higher than male for both ticketing and boarding (32.4%) and management office study respondents (37.5%).

Table 4. 7 Comparison prevalence of respiratory health symptoms among respondents' gender.

		Ticketing and Boarding			
Respiratory Symptoms		Male	female	X^2	p-value
		Frequency (%)			
Cough	**Yes**	6(17.6)	11(32.4)	0.49	0.49
	No	8(23.5)	9(26.5)		
Phlegm	**Yes**	1(2.9)	2(5.9)	0.08	0.77
	No	13(38.2)	18(52.9)		
Chest tightness	**Yes**	2(5.9)	4(11.8)		
	No	12(35.3)	16(47.1)	0.19	0.67

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Wheezing	**Yes**	1(2.9)	1(2.7)		
	No	13(38.2)	19(55.9)	0.07	0.79
		Management office			
Cough	**Yes**	1(6.3)	6(37.5)	2.86	0.09
	No	5(31.3)	4(25.0)		
Phlegm	**Yes**	0	3(18.8)	2.22	0.14
	No	6(37.5)	7(43.8)		
Chest tightness	**Yes**	0	2(12.5)		
	No	6(37.5)	8(50.0)	1.37	0.24
Wheezing	**Yes**	0	3(18.8)		
	No	6(37.5)	7(43.8)	2.22	0.14

Significant at $p<0.05$

Statistical analysis of $PM_{2.5}$ level and the prevalence of respiratory symptoms, the result demonstrated that the prevalence of respiratory symptoms were not significant among the study respondents at both ticketing and boarding respondents and management office respondents for all the respiratory symptoms. However, the prevalence for cough was higher at ticketing and boarding area (32%) than the management office (16%).

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Table 4. 8 Prevalence of Respiratory Symptoms Between management office and ticketing and boarding study respondents.

Respiratory Symptoms		Management Management office	Ticketing/ boarding	X^2	p
		Frequency (%)			
Cough	Yes	8(16)	16(32)	0.14	0.71
	No	10(20)	16(32)		
Phlegm	Yes	3(6)	3(6)	0.58	0.45
	No	15(30)	29(58)		
Chest tightness	Yes	2(4)	6(12)	0.50	0.48
	No	16(32)	26(52)		
Wheezing	Yes	3(6)	2(4)	1.39	0.24
	No	15(30)	30(60)		

4.6 Prevalence of Lung Function and Lung Abnormalities

The mean of FVC% predicted for management office and ticketing and boarding study respondents were 67.8±19.35 and 68.94±15.65 respectively. There was no significant difference lung abnormality between management office and ticketing and boarding study respondents (z=-0.02, p=0.83). The mean of FEV1% predicted for management office and ticketing and boarding study respondents were 74.16 ± 22.84 and 74.67±16.36 respectively. For FEV1% predicted, there was no significant difference between management office and ticketing and boarding group (z=-0.09, p=0.93). The mean of ratio FEV1/FVC for management office and

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ticketing and boarding study respondents were 1.12±0.12 and 1.12±0.02 respectively and there was no significant difference (z=-0.81, p=0.42).

Table 4. 9 The difference of lung function between between management office and ticketing and boarding study respondents

Lung function variable (Percentage)	Studied Group			
	management office Mean±SD/ median±IQR	Ticketing and boarding Mean ± SD/ median±IQR	z/t-value	P-value
FEV_1 litre [a]	1.87±0.49	2.05±0.58	-1.10	0.28
FVC litre [a]	1.95±0.51	2.14±0.66	-0.98	0.33
FVC% predicted [a]	67.84±19.35	68.94±15.65	-0.02	0.83
FEV_1% predicted [a]	74.16±22.84	74.67±16.36	-0.09	0.93
Ratio FEV_1/FVC [b]	1.12±0.12	1.12±0.02	-0.81	0.42

Significant at $p<0.05$ a= Independent t-test b= Man-Whitney U test

Table 4.10 presents the difference of lung function abnormality among management office and ticketing and boarding study respondents. 22% of the management office study respondents and 48% of the ticketing and boarding study respondents showed an abnormal lung function which was demonstrated by the value of FVC% predicted. 22% of the management office study respondents and 38% of ticketing and boarding study respondents show an abnormal lung function which was demonstrated by the value of FEV_1% predicted.

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Table 4. 10 Comparison of lung function abnormalities between management office and ticketing and boarding study respondents

Lung function variable (Percentage)	Status	Group study	
		Management office (N = 16)	Ticketing and boarding (N = 34)
FVC% predicted	Normal	5(10)	10(20)
	Abnormal	11(22)	24(48)
FEV_1% predicted	Normal	5(10)	15(30)
	Abnormal	11(22)	19(38)
Ratio FEV_1/FVC	Normal	15(30)	34(68)
	Abnormal	1(2)	0

Spearman correlation test was used to analyze the correlation between lung function and concentration of IL-6. Result showed that the FEV1% predicted and FVC % predicted showed very low correlation r= 0.18, p= 0.21 and r= -0.10, p= 0.51 respectively. However, for ratio FEV1/FVC showed significant value since the p= 0.03, but the r value showed that there is low correlation between lung function and concentration of IL-6.

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Table 4. 11 Correlations between exposure level of IL-6 and lung function among the study respondents

Lung function	Study group	
	r	p
FEV_1 liter [a]	-0.06	0.68
FVC liter [a]	-0.07	0.65
FEV_1% predicted [a]	0.18	0.21
FVC% predicted [a]	0.10	0.51
Ratio FEV_1/FVC [b]	0.31	0.03*

*significant at $p<0.05$ a= Pearson's correlation b= Spearman correlation

Table 4.12 showed that there was also significant correlation between lung function and the $PM_{2.5}$ level when the FEV1% predicted and FVC % predicted showed very low correlation r=-0.09, p= 0.53 and r=-0.11, p= 0.44 respectively. FEV1/FVC showed that r= -0.06 and p= 0.70.

Table 4. 12 Correlations between exposure level to $PM_{2.5}$ and lung function among the study respondents

Lung function	Exposure	Study group	
		r	p
FEV_1 liter [a]	$PM_{2.5}$	0.20	0.16
FVC liter [a]		0.19	0.20
FEV_1% predicted [a]		0.09	0.53
FVC% predicted [a]		0.11	0.44
Ratio FEV_1/FVC [b]		-0.06	0.70

*significant at $p<0.05$ a= Pearson's correlation test b= Spearman correlation test

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4.7 Factors influenced the IL-6, FEV_1% and FVC% level among the study respondents after controlling for potential confounders' in the study

Regression of linear analysis using 'enter' method was used to analyze the factors that most influenced the level of IL-6 among the study respondents. The result of the regression analysis is shown in Table 4.14. The risk factors of age, gender, smoking, working duration, working days, working experiences and level of $PM_{2.5}$ concentration were included. Results showed that working experience and age of study respondents significantly contributed to the production of IL-6 concentration level. The results implicated that 29% (adjusted R^2= 0.29) production of IL-6 in urine samples were influenced by age and working experiences.

Table 4. 13 Factors influencing the concentration level of IL-6 among study respondents

Independent variables	Coefficient regression (β)	t-value	p-value
constant	0.02	0.08	0.94
Age	0.01	3.81	<0.001*
Gender	0.04	1.42	0.17
Smoking	0.02	0.66	0.52
Work duration (hours)	-0.01	-0.92	0.37
Working days	0.01	0.09	0.93
Working experience	-0.001	-3.05	<0.001*
$PM_{2.5}$	-0.001	-0.39	0.70

Method = ENTER Statistical F model= 3.511

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R model value = 0.637 significant at $p<0.001$

R^2 value = 0.406 (adjusted R^2= 0.29)

Logistic regression using 'enter' method was run to determine the main factors that contributed the abnormality of FEV_1% and FVC% among study respondents (see Table 4.15). The risk factors for the abnormality of FEV_1% included in this analysis were age, gender, smoking, $PM_{2.5}$ concentration level, working experience, working days and working duration which potentially influence the abnormality of FEV_1%. Results showed that all risk factors were not significantly contributed to the abnormality of FEV_1%, age (OR=0.99, 95%CI=0.87-1.13), gender (OR=1.23, 95%CI=0.25-6.02), smoking (OR=1.25, 95%CI=0.23-6.81), working duration (OR=0.52, 95%CI=0.21-1.25), working days (OR=4.91, 95%CI=0.29-82.27), working experience (OR=1.01, 95%CI=0.99-1.03) and $PM_{2.5}$ (OR=1.11, 95%CI=0.99-1.26). The results implicated that 25% abnormality of FEV_1% were influenced by $PM_{2.5}$.

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Table 4. 14 Factors contributed the FEV_1% predicted among the study respondents after controlling all the confounders' in the study

Independent variables	B	S.E	p-value	OR	95%CI	
					Lower	Upper
constant	-4.44	6.89	0.52	0.01		
Age	-0.01	0.07	0.89	0.99	0.87	1.13
Gender	0.21	0.81	0.80	1.23	0.25	6.02
Smoking status	0.22	0.87	0.80	1.25	0.23	6.81
Work duration (hours)	-0.66	0.45	0.14	0.52	0.21	1.25
Working days	1.59	1.44	0.27	4.91	0.29	82.27
Working experience	0.01	0.01	0.17	1.01	0.99	1.03
$PM_{2.5}$	0.11	0.06	0.07	1.11	0.99	1.26

Nagelkerke R Square= 0.253 Significant at $P<0.05$

Table 4.15 measured the risk factors for the abnormality of FVC% including age, gender, smoking, $PM_{2.5}$ concentration level, working experience, working days and working duration. Result showed that all risk factors were not significantly contributed to the abnormality of FVC%, age (OR= 1.01, 95%CI= 0.88-1.16), gender (OR= 3.76, 95%CI= 0.56-25.09), smoking (OR= 2.15, 95%CI= 0.32-14.26), working duration (OR= 0.54, 95%CI= 0.23-1.24), working days (OR=2.15, 95%CI= 0.11-41.01), working experience (OR= 1.00, 95%CI= 0.99-1.02) and $PM_{2.5}$ (OR= 1.07, 95%CI=0.96-1.19).

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Table 4. 15 Factors influenced the FVC% predicted among the study respondents after controlling all the confounders' in the study

Independent variables	B	S.E	p-Value	OR	95%CI	
					Lower	Upper
constant	-0.10	7.92	0.90	0.37		
Age	0.07	0.07	0.92	1.01	0.88	1.16
Gender	1.32	0.97	0.17	3.76	0.56	25.09
Smoking status	0.76	0.97	0.43	2.15	0.32	14.26
Work duration (hours)	-0.62	0.43	0.15	0.54	0.23	1.24
Working days	0.77	1.50	0.61	2.15	0.11	41.01
Working experience	0.00	0.01	0.97	1.00	0.99	1.02
$PM_{2.5}$	0.06	0.06	0.26	1.07	0.96	1.19

Nagelkerke R Square= 0.232 Significant at P<0.05

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CHAPTER 5

5 DISCUSSION

5.1 Respondent background

Subjects ranged in age from 20 to 61 years with a mean age of 27.18±6.51 years and comprised of 20 males and 30 females. Most of respondents were Malays (98%). For respondents' anthropometrical measurement, the mean height was 161.31±16.68cm and the mean weight was 67.29±9.92 kg. The result showed that exposure level of $PM_{2.5}$ at ticketing counter and boarding area was higher compared to the office. The average level for eight hours of monitoring at the management office, ticketing counter and boarding area were 5.44, 31.61 and 32.19 $\mu g/m^3$ respectively. Mann-Whitney U test results showed that the mean exposure levels of IL-6 for office study respondents were 0.25±0.13 pg/ml and ticketing and boarding

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study respondents were 0.21±0.09 pg/ml. There was no significant difference between office and no office study respondents, z=-1.56, p=0.12. Negative correlations were found between the exposure levels of $PM_{2.5}$ and concentration of IL-6. Spearman correlation test was used to see the correlation between lung function and concentration of IL-6. From the analysis result, the FEV1% predicted and FVC % predicted showed no significant association r=0.18, p=0.21 and r=-0.10, p=0.51 respectively. However, for ratio FEV1/FVC showed significant association with concentration of IL-6, p=0.03. Results also showed that there was negative correlation between lung function and concentration of $PM_{2.5}$. However, the study respondents who exposed to higher level of $PM_{2.5}$ were of higher risk of getting respiratory illnesses compared to a lower level of $PM_{2.5}$. Prevalence of cough was higher among the ticketing and boarding study respondents (32%) compared to office study respondents (16%).

5.2 Comparison of $PM_{2.5}$ concentration level

Table 4.3 shows that study respondents who worked at ticketing counter and boarding area were exposed to higher level of $PM_{2.5}$ compared to the worker work at the office. Hypothesis was accepted because the result found that the average exposure to $PM_{2.5}$ among the study respondents work at ticketing counter (31.61

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µg/m³) and boarding area (32.19 µg/m³) were exposed to higher level of $PM_{2.5}$ compared to the worker working at the office (5.44µg/m³).

There were a few factors that may affect $PM_{2.5}$ level in the building. It may be affected from the outdoor and indoor sources that contribute to a large amount of pollutants emission to the surrounding mainly caused by the emissions from the busses and other vehicles as well that would cause health hazard for those who works at the bus terminal. Management office was located at the ground level of terminal where there was car park, shuttle bus and taxi stand. This would be factors that will affect the $PM_{2.5}$ exposure. Study respondents who work in the office was less exposed to $PM_{2.5}$ as the office had installed access door that will always closed so that particulate matter from outside would not get into the office. Whereas worker at ticketing counter, the high $PM_{2.5}$ were affected directly from the outdoor environmental conditions such as traffic volume of buses and other vehicles such as car and also from the movement of passengers (Cheng et al., 2011). Level of $PM_{2.5}$ was found lower in this present study than reported in the previous study which its mean was 48 µg/m³, where the short term PM was taken for every 15 minutes at five sampling site. In addition, level of $PM_{2.5}$ of this study could be compared to the mean of indoor exposure to $PM_{2.5}$ concentrations measured in Malaysian school 19.8±6.9 µg/m³ as the background level for $PM_{2.5}$ (Abidin et al. 2012)

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A study by Cheng et al. (2011) conducted at a bus terminal in Taiwan showed that PM_{10} and $PM_{2.5}$ levels inside the bus terminal were roughly 1.5 and 1.4 times higher than those measured inside buses, respectively. From the result of the study had suggest that the PM on the station suspended more than that at waiting area as the passenger activity was greater than at waiting areas.

World Health Organization (WHO) had set 25µg/m³ as 24 hours average concentration of $PM_{2.5}$ as permissible limit, whereas Environmental Protection Agency (EPA) was 35µg/m³ as 24 hours average concentration. Based on measurement result, the $PM_{2.5}$ levels in the bus terminal were lower than WHO and EPA's standards. Hypothesis of this study was accepted where the exposure level of $PM_{2.5}$ higher among the ticketing and boarding area compared to the office.

5.3 Comparison of IL-6 concentration level among office and ticketing and boarding study respondents.

There was significant relationship between working hours and the IL-6 concentration level (r=-0.29, p=0.04) but at low correlation. Duration of work may influence the risk of getting respiratory symptoms (Jones et al., 2006). From the

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study, the respiratory symptoms among the exposed study respondents who are bus driver were higher as the work duration increased.

Man-Whitney U test had been used to compare the mean of IL-6 concentration level among the office 0.25±0.13 pg/ml and ticketing and boarding respondents 0.21±0.09 pg/ml. From the statistical analysis, there were no significant differences between these groups. The differences were not significant since the sample size was not large. Furthermore, the low detection of IL-6 concentration may due to the time of each study respondents urinated was at different time. For this study, the urine samples were taken during the work shift which was taken as cross-sectional. The sample should be collected before the workers started their shift work and after their shift to see the different level of IL-6 concentration.

Biomarkers were used as a surrogate to understand the physiology of pulmonary inflammation affected by indoor air pollutants. The marker used is IL-6 as it is one of the cytokine known for it role in the respiratory inflammation (Nazariah et al, 2013). Urinary Il-6 was collected because is directly involved in regulation of the synthesis of C-reactive protein in the liver. CRP is a sensitive indicator of infection, injury, and inflammation and is linked to increased risk of

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cardiovascular disease. CRP concentration has been shown to be positively associated with exposure to total suspended particles and PM_{10}.

In addition, IL-6 was produced depend at the site of inflammation (Baumann et al., 1984; Jirik et al., 1989; Nijsten et al., 1987), in this case the exposure to $PM_{2.5}$ cause pulmonary inflammation, thus the site of inflammation should be at the lung or pulmonary. That was why the detected IL-6 concentration level was low in urine. The IL-6 concentration level was detected at very low concentration because the cell from kidney produced low IL-6 since the levels of IL-6 were present in the serum but not in the urine of healthy individuals. In contrast, both serum and urine of renal transplant recipients contained high levels of IL-6 directly after transplantation and during acute rejection episodes. Moreover, the sensitivity of the bioassay will allow to measure IL-6 activity in the serum and urine for detailed studies as to the biological significance of IL-6 in health and disease. (Oers et al, .1998).

Several study on $PM_{2.5}$ level and the concentration level of IL-6 been done by Kavitha et al (2011) among bus drivers in Klang Valley. The previous study collected saliva sample to detect the level of IL-6 concentration after the exposure of $PM_{2.5}$. The result from the study, the mean for study group was 6.36±3.88 pg/ml and comparative was 5.28±4.14 pg/ml. The mean was higher compared to the present study. The level of interleukin-6 concentration is higher among the office

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respondents compared to ticketing and boarding area respondents. Null hypothesis was accepted.

5.4 Relationship between exposure level to PM2.5 and IL-6 concentration

Spearman correlation test showed that there was no significant correlation between exposure level of $PM_{2.5}$ and concentration of IL-6 ($r=-0.22$, $p=0.12$). The IL-6 concentration levels were not significantly associated with the exposure of $PM_{2.5}$. From table 4.3, the level of $PM_{2.5}$ did not exceed the EPA standards, which were 35µg/m³. The low IL-6 concentration level was due to low exposure of $PM_{2.5}$ during they worked. IL-6 is a multifunctional cytokine that is produced by a wide range of cells (Baumann et al., 1984; Jirik et al., 1989; Nijsten et al., 1987) usually at sites of tissue inflammation. IL-6 is considered to contribute to the initiation and extension of the pulmonary inflammatory process. Other than that, other studies had done implicated that a strong correlation may exist between IL-6 expression and pulmonary inflammation or injury (Yu M et al 2002). The study to examine the role of cytokine interleukine-6 in environmental air pollutant induced pulmonary inflammation, injury and repair.

This study was contradicted from the previous study by Kavitha et al (2010) revealed that the level of IL-6 among the bus drivers was higher compared to the

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comparative group due to higher exposure to ultrafine particle (UFP) among the bus drivers. Null hypothesis of this study was accepted. There is no association between the levels of $PM_{2.5}$ exposure with the level of urinary interleukin-6.

5.5 Relationship between PM2.5 and prevalence of respiratory symptoms

There were several parameters of respiratory symptoms were studied using the questionnaire IULTD. Prevalence of respiratory health among the ticketing and boarding study respondents showed that the prevalence for cough among the female study respondents was higher than male for both ticketing and boarding (32.4%) and office study respondents (37.5%). Prevalence of cough was high among ticketing and boarding study respondents (32%) although there was not significant prevalence of respiratory symptoms among the office and ticketing and boarding study respondents for all the respiratory symptoms. On other hand there was no significant in prevalence of phlegm, wheezing and the breathing difficulties.

This finding was no consistent with the finding of study done by Kavitha et al (2010) which found that there was high the prevalence of respiratory symptoms cough and phlegm among the bus drivers compared to administrative staffs. This present study also assessed the prevalence of respiratory symptoms and indoor air

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pollutants inside homes. However, study by Nazariah (2013) showed both course and fine particulate matter $PM_{2.5}$ and PM_{10} were significantly correlated with all respiratory symptoms except for chest tightness.

Extensive epidemiological studies evidence supports the association of particulate matter with the prevalence of respiratory symptoms which might lead to adverse health effects and mortality (Ostro et al., 2007; Nicolai et al., 2003). Study by Neuberger et al. (2004), from the results on hospital admissions $PM_{2.5}$ was the PM fraction most sensitive for respiratory health effects in both sexes. The increase of respiratory admissions per mg/m^3 of $PM_{2.5}$ was found higher in that study than reported for areas with higher exposures (Moolgavkar. 2000; Stieb et al., 2000). From toxicokinetics the mass of particles with aerodynamic diameters <10 and > 2:5 mm cannot be expected to play an important role in diseases of the lower respiratory tract and the lung (Asgharian et al., 2003), but contaminants adsorbed even on coarse particles might be involved in oxidative damage and the release of inflammatory mediators (Pozzi et al., 2003).

The concentration of indoor $PM_{2.5}$ in bus terminal associated with the prevalence of cough among the respondents. Hypothesis of this study was accepted.

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5.6 Comparison of Lung Function

The lung function test was performed by 50 study respondents using Spirolab II spirometer. The procedure to performed lung function test was recommended by American Thoracic Society (1991). Lung function status among study respondents evaluated base on FEV% predicted, FVC% predicted and FEV/FVC predicted parameters.

For the comparison of lung function between office and ticketing and boarding study respondents, the mean of FVC% predicted for office and ticketing and boarding study respondents were 67.84±19.35 and 68.94±15.65 respectively. There was no significant difference between office and ticketing and boarding study respondents since the value of z=-0.02, p=0.83. The mean of FEV1% predicted for office and ticketing and boarding study respondents were 74.16±22.84 and 74.67±16.36 respectively. For FEV1% predicted, there is no significant difference since the value of z=-0.09, p=0.93 as well as ratio FEV1/FVC there is no significant difference since the value of z=-0.81, p=0.42.

For the comparison of abnormality of lung function among office and ticketing and boarding study respondents, 22% of the office study respondents and 48% of the ticketing and boarding study respondents showed an abnormal lung

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function according to FVC% predicted. 22% of the office study respondents and 38% of ticketing and boarding study respondents show an abnormal lung function of FEV_1% predicted.

As the result from the monitoring, the level of $PM_{2.5}$ at office was lower than ticketing and boarding area. Due to high exposure to $PM_{2.5}$ level, it will cause damage to lung development. $PM_{2.5}$ can penetrate deeper and deposited higher in airways and lungs as the primary target organs and can deposit in alveoli, where they interact with macrophages, neutrophils and epithelial cells (Salvi and Holgate., 1999; Pozzi et al., 2003; Oberdorster et al., 2005). Thus, exposure to ambient PM is a serious environmental risk for cardiopulmonary and lung cancer mortality. The risk of cancer and respiratory and cardiovascular diseases is related to exposure to combustion products (Boffetta et al., 1997; Pope et al., 2002). Thus, long-term ambient exposure to current ambient PM concentrations may lead to a marked reduction in life expectancy and quality of life.

5.7 Relationship between $PM_{2.5}$ and lung function

Statistical analysis revealed there was also correlation of lung function and the $PM_{2.5}$ level when the FEV1% predicted and FVC % predicted showed very low

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correlation r=-0.09, p=0.53 and r=-0.11, p=0.44 respectively. FEV1/FVC showed that r=-0.06 and p=0.70.

In this study, FEV_1% predicted and FVC% predicted had significant inverse relationship to exposure $PM_{2.5}$. It is because the lung capabilities to inhale and exhale would decrease as the person was exposed to $PM_{2.5}$. Acute respiratory symptoms would appear such as cough, phlegm and chest tightness, but in longer period of exposure would result in chronic health effect such as asthma and lower respiratory health problems. $PM_{2.5}$ was significantly associated with reduction of pulmonary function. Concentrations of PM above the standards may result in harmful health effects. Since the small particles that make up PM can easily penetrate deep into the lungs, scientists have studied the effects of this type of pollution on human health. Both short- and long-term exposures to PM have been shown to lead to harmful health effects.

5.8 Relationship between IL-6 and lung function

Spearman correlation test was used to see the correlation between lung function and concentration of IL-6. From the analysis result, the FEV1% predicted

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and FVC % predicted showed very low correlation r=0.18, p=0.21 and r=-0.10, p=0.51 respectively. However, for ratio FEV1/FVC showed significant value since the p=0.03, but the r value showed that there is low correlation between lung function and concentration of IL-6. Although the result showed significant p value, negative correlation showed that inflammation of pulmonary induces the release of IL-6. Study by Carpagnano et al (2002) to determine whether the concentrations of the proinflammatory cytokine, interleukin (IL)-6 stated that there is increased in the exhaled breath condensate of smokers and whether the number of cigarettes smoked has any influence on the exhaled concentrations, a negative correlation between exhaled IL-6 concentrations, FEV_1 and FVC was observed, thus suggesting that measurement of inflammation may be useful in predicting the early onset of lung function impairment.

Chronic obstructive pulmonary disease (COPD) is known to be characterized by an intense local inflammatory response in the lungs, recent research strongly implicates the role of systemic inflammation as well (Corsonella et al 2011., Gan et al 2004., Gompertz et al 2001). Raised levels of the representative pro-inflammatory cytokines, interleukin (IL)-6 and C-reactive protein (CRP) have been shown to be associated with low forced expiratory volume in one second (FEV1) and FEV1/FVC (forced vital capacity) indices of chronic pulmonary obstruction in two population-based studies (Chang et al 2011., Mannino et al 2003), as well as in patients with

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stable-state obstructive airway disease (Gan et al 2004., Gompertz et al 2001., Chang et al 2011., Mannino et al 2003) and during exacerbation (Hurst et al 2006). The presence of systemic inflammation may explain the known observation that COPD is frequently found co-morbid with other systemic diseases such as atherosclerotic disease, diabetes, heart failure, chronic kidney disease, osteoporosis, sarcopenia, cognitive impairment and depression which are also characterized by raised levels of proinflammatory cytokines (Corsonella et al 2011., Gan et al 2004., Gompertz et al 2001).

As the lung function was decreasing, the more IL-6 produced. The increase in the level of IL-6 was correlated with effects on human airways. Study by Turgeor (1996) summarizes that IL-6 plays the role in the inflammatory response and injury in the lung of mice after the exposure to environmental air pollutants. Another study by Mukherjee at al. (2003) stated that works who involve in transportation industries are at higher risk to develop lung disease due to inhalation of particulate matter from the diesel emission.

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5.9 Factors influenced the IL-6 concentration level, and abnormality of FEV_1% and FVC% among the study respondents after controlling all the confounders' in the study

Linear regression using 'enter' method was performed to determine the main factor that influenced the IL-6 concentration level among study respondents. The analysis was carried out by taking into the consideration of the risk factors including age, gender, smoking, $PM_{2.5}$ concentration level, working experiences, working days and working duration which potentially influence the level of IL-6 biomarkers. Result from the analysis discovered age ($p<0.001$) and working experiences ($p<0.001$) were significantly contributed the production IL-6 level. Study by Nazariah et al (2013) suggested that school children who live in urban area of Klang Valley were exposed to a higher level of indoor particulate pollutants inside home environment. Both PM_{10} and $PM_{2.5}$ reported as one of the contributor factor to the increase level of IL-6 measured through sputum samples. However, this particulate matter cannot be solely predictor to the production of IL-6 in respect to respiratory implication. Higher levels of IL-6 in smokers than in control subjects were observed (Carpagnano et al, 2002). The impact of smoking on IL-6, and the interaction between smoking and systemic inflammation with the IL-6 gene, suggests that smoking might affect airway diseases in a differential way according to the IL-6 genetic predisposition (Sunyer et al. 2009)

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Result from the logistic regression analysis discovered that all the risk factors were not significantly contributed the abnormality of FEV_1% and FVC%. However, there was strong association between abnormality of FEV_1% and working days, where the risk was about 4.9 times, and 2.1 times to get abnormal FVC% if working more than 5 days a week. The risk for abnormality of FEV_1% and FVC% among smokers were about 1.2 and 2.1 times respectively of those non-smoking study respondents. The risk for abnormal FVC% among the female was about 3.7 times of that male respondents.

The present study has strengths and limitations. This population-based study is largely free of clinical selection bias from over-sampling of severe cases of diseases, and also controlled for important potential confounding by age, sex, smoking, body composition and chronic inflammatory diseases in the analysis. Pulmonary obstruction was analyzed as a continuous variable using spirometric indices, while excluding known cases of asthma and COPD. The cross-sectional study design also limits direct causal inferences from the observed associations; future studies should use longitudinal designs to assess the association of depression with proinflammatory immune profiles over time: whether changes in proinflammatory immune factors are associated with changes in pulmonary functions Weaknesses of the present study were may consist in the selection of the study population, bus terminal study respondents which could affect the generalizability of

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our results. The low detected IL-6 concentration levels may due to urine collection that had been made at early shift of works. The urine sample should collect at end of the worker's shift. For any future study, the urine collection should be conducted at two times, which were early of shift and end of shift, so that we can see the difference of IL-6 urine production.

The association of exposure of $PM_{2.5}$ and respiratory health was determined using 3 different tests, which were by questionnaire to determine the prevalence of respiratory health, spirometer test that it can detect abnormalities in lung function even when no signs or symptoms of disease are evident and detects disease at an early stage before the onset of symptoms) and by IL-6 urine collection to detect the IL-6 concentration level after exposure to $PM_{2.5}$.

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CHAPTER 6

6 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

The present study shown that the exposure level of $PM_{2.5}$ were higher among the ticketing and boarding respondents at ticketing counter and waiting and boarding area in the bus terminal compared to office respondents. The decrease lung function of respondents shows elevated of higher level of IL-6 concentration. The prevalence of respiratory symptoms (cough and phlegm) was also found higher among the female and respondents if prolonged exposure to $PM_{2.5}$ concentration level.

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This study has profitably answered to the research hypotheses as shown below:

1. The exposure level of $PM_{2.5}$ higher among the ticketing and boarding area compared to the office. Hypothesis accepted.
2. The level of interleukin-6 concentration is higher among the office respondents compared to ticketing and boarding area respondents. Null hypothesis accepted.
3. There is no significant association between the levels of $PM_{2.5}$ exposure with the level of urinary interleukin-6.
4. The concentration of indoor $PM_{2.5}$ in bus terminal associated with the prevalence of cough among the respondents.
5. There is a significant association between the exposures to $PM_{2.5}$ with the ratio FEV1/FVC among the study participants.

6.2 RECOMMENDATION

As reported by this present study, respondents at the ticketing and boarding area in bus terminal were known to expose higher level of $PM_{2.5}$. The respondents are vulnerable to respiratory health symptoms as they spend more than 8 hours per day in their work environment. They were prone to be exposed to the ambient air pollutant from the exhaust from the buses and others vehicles as the terminal is

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located along a side street. Further exposure may lead to prolong respiratory disease. Therefore, control measure must be taken to minimize the exposure of $PM_{2.5}$ and others indoor air pollutants so that the adverse health effect may also minimize.

Managing the indoor air quality in the bus terminals should involved with responsibility of respondents' health issues. The bus terminal should make sure that the ventilation systems in the bus terminal are well maintained so that the PM concentrations level is below the permissible limit of EPA standards. This is because poorly maintained bus terminal are likely to contain higher level of particulate matter. As the respondents are continuously exposed to particulate matter, medical surveillances for respiratory health should be introduced by the terminal management. Workplace ambient surveillance also can be done to monitor the trend of air quality in the terminal bus.

Relevant authority party such as Ministry Of Transport Malaysia and Suruhanjaya Pengangkutan Awam Darat (SPAD) should enforce and encourage the maintenance within the bus terminal by following the policy, standards or guidelines provided by Department of Occupational Health (DOSH) or Department of Environment (DOE) to maintain air quality in the building.

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Further research should be conducted in the future which may include of measurement of others indoor pollutants. Indoor sources should be considered and need to be investigating more detail to understand the effect of pollutants to respondents health specifically who works in the bus terminal in main city. For future study, researcher can expand the study to others terminal in Malaysia so that we can compare the level of $PM_{2.5}$ concentrations so that authority party could improve the terminals to the healthier conditions for respondents. Perhaps, in the future saliva or other serum is collected to analyze the concentration of interleukin-6.

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APPENDIX 1

(EVIDENCE OF APPROVAL

ETHIC BY MEDICAL RESEARCH

ETHICS COMMITTEE)

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APPENDIX 2

CONSENT FORM

(MALAY VERSION)

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

TAJUK PENYELIDIKAN :

EXPOSURE TO PARTICULATE MATTER 2.5 (PM2.5) AND THE LEVELS OF INTERLEUKIN-6 AMONG WORKERS AT BUS TERMINALS IN KUALA LUMPUR

(Pendedahan Partikel Ternafas (PM2.5) Dan Tahap Interleukin-6 Di Kalangan Pekerja Di Dalam Terminal Bas Di Kuala Lumpur.)

PENYELIDIK : NUR IZZATI GHAZALI

Saya..... no pengenalan diri.....

alamat.....

..... dengan ini secara sukarela bersetuju untuk mengambil bahagian dalam penyelidikan klinikal * (kajian klinikal, soal selidik / percubaan dadah) yang dinyatakan di atas.

Saya telah dimaklumkan tentang penyelidikan klinikal dari segi metodologi, kemungkinan kesan komplikasi dan buruk (rujuk kepada Lembaran Maklumat). Saya memahami bahawa saya mempunyai hak untuk menarik diri daripada penyelidikan klinikal ini pada bila-bila masa tanpa memberikan sebarang alasan. Saya juga memahami bahawa kajian ini adalah sulit dan semua maklumat yang diberikan berhubung identiti saya akan kekal sulit dan persendirian.

Saya ingin * **tahu / tidakingin** tahu keputusan ujian yang dilakukan ke atas sampel saya.

* potong yang berkenaan

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SELANGOR, MALAYSIA

tandatangan..... tandatangan.....

(*Respondent*) (*saksi*)

Tarikh :..... nama :.....

I/C No. :.....

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

Tarikh ..... tandatangan .....

(Penyelidik)

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APPENDIX 3

INFORMATION SHEET

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FACULTY OF MEDICIE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

RESPONDENT'S INFORMATION SHEET

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

STUDY TITLE

EXPOSURE TO $PM_{2.5}$ AND ITS ASSOCIATION WITH RESPIRATORY HEALTH OF WORKERS AT A BUS TERMINAL IN KUALA LUMPUR

INTRODUCTION

This research was brought in under the interest of the researcher to determine indoor air exposure to $PM_{2.5}$ and the levels of interleukin-6 among workers at bus terminal in Kuala Lumpur. This study is going to identify the level of workers at bus terminals exposure to particulate matter $PM_{2.5}$ and prevalence of respiratory health syndromes by measuring the level of interleukine-6 to see how the particulate exposure affect their health.

Workers involved in transportation industry are highly exposed to the traffic air pollutants including the bus ticketing workers, and support staff such as cleaner in the terminal bus. Thus, they are at high risk in getting respiratory and lung diseases due to the exposure to traffic air pollutant emitted by buses and others vehicle and would seem to deserve particular attention for risk assessment.

WHAT WILL YOU HAVE TO DO?

Respondents are required to answer the questionnaires which are divided into sections such as general information, and socioeconomic information. You just need to sign in the Written Permission Form to indicate your interest and willingness to cooperate in this research activity. This Written Permission Form must be returned to the researcher during the study. Below are several types of test will require respondents to complete in this study:

Test types

1. Questionnaires

   All respondents will be given questionnaires form and requested to answer the questions to the best of their ability.

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2. Personal exposure monitoring

Exposures to PMs will be sampled using SidePak™ AM510 Personal Aerosol Monitor and P-Trak Ultrafine Particle Counter. For each respondent, the exposure level of PM was measured for eight hours. During the exposure measurement, the instruments were placed within the working zone workers

3. Urinary Interleukin-6 collection

The urinary samples are taken after measurement of exposure to particulate. 50ml of urine will be taken from each respondent by researcher and then put in polyethylene 60ml bottle. All the samples will be labelled and placed in polystyrene containing ice to maintain the temperature less than 4 ^{0}C to stabilize the condition. The sample will be taken to the laboratory to be analyzed using Human IL-6 ELISA kit.

4. Lung Function Test

Spirometer was be used in the lung function test which was purposely to measure the volume of air in the lungs and the volume that able to breathe out in one second.

WHO SHOULD NOT ENTER THE STUDY?

This study will exclude those who are smokers, age below 20 and above 55 years, and with history of chronic lung and respiratory diseases.

WHAT WILL BE BENEFITS OF THE STUDY?

(a) TO YOU AS THE SUBJECT?

All of the information given and obtained in this research will benefit the respondents directly where it will provide opportunity for respondents to document and verify the problems faced by them while performing the job tasks in the bus

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terminals. From the study, further improvement in the either tasks administration could be proposed to the management for further actions to reduce the particulate matter exposure to them and thus, increased their productivity and job performance.

b) TO THE INVESTIGATOR?

Based on area/personal monitoring, and biological sample will be taken, we can identify the possibility of exposure and the prevalence of respiratory health. We can identify the level of particulate matter 2.5 based on the monitoring. We also can verify the problems faced by them while performing the job tasks in the bus terminals and further improvement in the either tasks administration could be proposed to the management for further actions to reduce the particulate matter exposure to them

ARE THERE ANY RISKS?

Participation on this study is free from any risks as no intrusive questions and biological samples are involved.

WHAT ARE THE POSSIBLE DRAWBACKS?

This research requires voluntary participations from all respondents. Any respondents has the right to withdraw their consent at any time should they feel uncomfortable at any stages of the research. No penalties will be given to those who withdrawn.

WILL THE INFORMATION AND MY IDENTITY REMAIN CONFIDENTIAL?

All individual information given in the questionnaires and tests results will be treated as confidential. Any results to be used will be summarized as collective results, not as individual.

WHO SHOULD I CONTACT IF I HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

Please do not hesitate to ask questions to the researcher should you need further clarification. You can contact me Nur Izzati Bt Ghazali at 013-9870453 or e-mail at ghazalinurizzati@gmail.com.

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APPENDIX 4

QUESTIONNAIRE

(MALAY VERSION)

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

TAJUK:

Pendedahan Partikel Ternafas (PM2.5) Dan Tahap Interleukin-6 Di Kalangan Pekerja Di Dalam Terminal Bas Di Kuala Lumpur

NO. SIRI: ☐☐☐

TARIKH KAJIAN: _____

NO. TELEFON: (Hp) ☐☐☐-☐☐☐☐☐☐☐

BAHAGIAN A: MAKLUMAT PERIBADI

1. Jantina: Lelaki ☐ Perempuan ☐
2. Umur: ☐
3. Berat : ☐☐
4. Tinggi : ☐☐☐
5. Etnik (Bangsa):
   a. Melayu ☐
   b. India ☐
   c. China ☐
   d. Lain-lain _____(sila nyatakan)
6. Kenegaraan :
   a. Warganegara ☐ b. Bukan warganegara ☐

BAHAGIAN B: MAKLUMAT PEKERJAAN

1. Jenis pekerjaan: _____
2. Jangkamasa bekerja : ☐ tahun (termasuk kerja sebelum ini)
3. Apakah kerja sebelum ini? Jika ada, sila nyatakan: _____
4. Berapa jam kerja dalam sehari?
   _____ jam
5. Berapa hari kerja dalam seminggu: _____ hari

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6. Adakah anda mengalami sebarang penyakit dibawah (Anda boleh tanda lebih dari satu jika berkenaan)

a. Sesak nafas ☐ b. Batuk ☐
c. Sakit dada ☐ d. Kahak yang teruk ☐
e. Tercungap – cungap ☐ f. Tiada sebarang penyakit ☐

BAHAGIAN C: MAKLUMAT KESIHATAN

Sila pilih kotak jawapan yang betul dan sesuai bagi setiap soalan; jika anda tidak pasti tentang soalan yang ditanyakan, sila jawab "TIDAK".

1. Sepanjang 12 bulan lepas, adakah anda pernah mengalami nafas berbunyi?

☐ YA ☐ TIDAK

2. Sepanjang 12 bulan lepas, adakah anda mengalami rasa ketat dada pada awal pagi?

☐ YA ☐ TIDAK

3. Sepanjang 12 bulan lepas, adakah anda mengalami serangan sesak nafas di siang hari apabila tidak melakukan pekerjaan berat?

☐ YA ☐ TIDAK

4. Sepanjang 12 bulan lepas, adakah anda pernah mengalami serangan sesak nafas apabila berhenti bersenam?

☐ YA ☐ TIDAK

5. Sepanjang 12 bulan lepas, adakah anda pernah terjaga pada waktu malam disebabkan serangan sesak nafas?

☐ YA ☐ TIDAK

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6. Sepanjang 12 bulan lepas, adakah anda pernah terjaga pada waktu malam disebabkan batuk?

☐ YA ☐ TIDAK

7. Adakah anda selalu batuk pada awal pagi?

☐ YA ☐ TIDAK

***Jika YA pada soalan 7, jawab (a) dan (b):**

a) Adakah anda mempunyai serangan batuk hampir setiap awal pagi selama 3 bulan?

☐ YA ☐ TIDAK

b) Sudah berapa tahun anda mengalami batuk seperti ini?

☐ YA ☐ TIDAK

8. Adakah anda mempunyai kahak pada waktu pagi?

☐ YA ☐ TIDAK

***Jika YA pada soalan 8, jawab (a) dan (b):**

a) Adakah anda mempunyai kahak hampir setiap awal pagi selama 3 bulan?

☐ YA ☐ TIDAK

b) Sudah berapa tahun anda mengalami kahak seperti ini?

☐ YA ☐ TIDAK

9. Pilih pernyataan yang paling tepat yang dapat menggambarkan tentang pernafasan anda. (Pilih SATU jawapan sahaja)
   a) Saya tidak pernah atau jarang mepunyai masalah pernafasan ☐

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b) Saya seringkali mempunyai masalah dengan pernafasan saya tetapi selalunya beransur baik dan sembuh. ☐

c) Saya mempunyai pernafasan yang sentiasa tidak baik atau kurang elok. ☐

10. Jika anda berada dikawasan berhabuk di dalam rumah atau bersama haiwan (seperti anjing, kucing atau kuda) atau dekat pada benda-benda yang berbulu (bantal dan bulu pelepah), adakah anda pernah:

a) Rasa sakit di bahagian dada? ☐

b) Mula rasa sukar untuk bernafas? ☐

11. Adakah anda pernah mempunyai (lelah)?

☐ YA ☐ TIDAK

12. Sepanjang 12 bulan ini, adakah anda pernah mengalami serangan lelah?

☐ YA ☐ TIDAK

13. Adakah anda sedang mengambil ubat (inhaler, aerosol atau tablet) untuk lelah?

☐ YA ☐ TIDAK

14. Adakah anda pernah merokok sekurang-kurangnya selama 1 tahun? Kalau tidak, sila ke soalan .....

☐ YA ☐ TIDAK

15. Adakah anda: (Pilih SATU jawapan sahaja)

a) Masih merokok? ☐

b) Pernah berhenti merokok tetapi kurang dari 4 minggu lepas? ☐

c) Pernah berhenti merokok sekurang-kurangnya 4 minggu lepas? ☐

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16. Sekiranya anda merokok, sudah berapa tahun anda merokok? _____

17. Anda biasa menghisap: (Pilih SATU jawapan sahaja)

a) Rokok? ☐
b) Paip? ☐
c) Cerut? ☐

18. Berapa batang rokok yang anda hisap dalam sehari, secara purata? _____

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APPENDIX 5

(SCHEDULE OF STUDY FOR RESEARCH PROJECT)

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WORK ACTIVITY PLANNING (GANNT CHART)

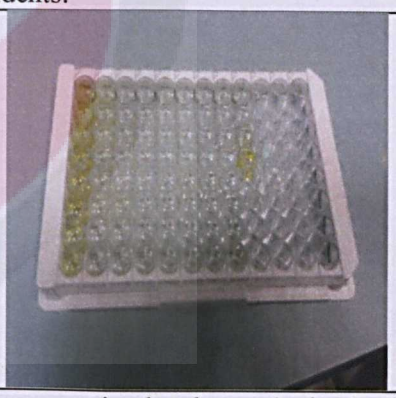
		2012				2013					
No	Activities	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1	Proposal preparations										
2	Presentation and Approval to proceed										
3	Pre Test Questionnaires										
4	Correction and preparation of questionnaires										
5	Questionnaire administration to respondents										
6	Familiarize and learn to use equipment										
7	PM2.5 measurement										
8	Work station assessment										
9	Data analysis										
10	Thesis writing										
11	Thesis presentation										

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APPENDIX 6

PHOTOGRAPH OF RESEARCH

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Respondents was required to answer IULTD questionnaire	Urine sample was collected.
	
Weight and height were measured using Seca scale.	Lung function test conducted for all respondents.
	
IL-6 in urine was analyzed using IL-6 ELISA kit.	IL-6 concentration level was obtained using 5-parameter curve fit through the point of graph.

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