UNIVERSITI PUTRA MALAYSIA

EXPOSURE TO INDOOR AIR POLLUTANTS (PM10, CO2 AND CO) AND RESPIRATORY HEALTH AMONG LONG DISTANCE EXPRESS BUS DRIVERS

BY
MOHD FIRDAUS BIN OTHMAN

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ABSTRACT

EXPOSURE TO INDOOR AIR POLLUTANTS (PM_{10}, CO_2 AND CO) AND RESPIRATORY HEALTH AMONG LONG DISTANCE EXPRESS BUS DRIVERS

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Introduction: Previous studies have consistently found that exposure to indoor air pollutants is higher inside the building and also buses. However, there are limited studies have been conducted in Malaysia related to indoor air pollutant in long distance express buses. **Objective:** The objective of this study was to determine the exposure of indoor air pollutants (PM_{10}, CO_2 and CO) and respiratory health problem among long distance express bus drivers. **Methodology:** This cross sectional study was conducted among a total of 30 long distance express bus drivers and the entire respondent were male. Exposure of PM_{10} was measured using DustTrak Aerosol Monitor while CO_2 and CO were measured using Q-Trak IAQ Plus and all parameter were measured along the route where the average is 4 hours duration. The route is based at Kuala Lumpur and travelled to another region in peninsular Malaysia. A purposive sampling was used to select the respondents based on inclusive and exclusive criteria such aged 20 to 56 years old, at least 1 year working experience, no history of chronic lung disease, and non-smoking. Questionnaire adapted from American Thoracic Society (ATS) was used to collect information on respondent's socio-economic status, working history, and respiratory symptoms. Lung function test was performed after the participants arrived to their destination. **Results and Discussion:** Data collected showed that the mean concentration of PM_{10} (220.00±120.00μg/m^3), CO_2 (1085.50±460.98ppm), and CO (2.79±0.95ppm) which are acceptable level according to indoor air guidelines by ASHRAE. The number of passengers on the bus influenced the concentrations of elevated CO_2 inside buses. Chronic respiratory symptoms that were reported among drivers were phlegm (23.3%), cough (20.0%), wheezing (13.3%) and chest tightness (10.0%). Lung function result showed that there were 50% respondents had abnormality of FVC% predicted value and FEV_1% predicted value. **Conclusion:** Exposure to air pollutants over a long period of time and continuously while driving has potential to caused effect to drivers' respiratory health. Exposure to PM_{10} in air conditioned buses such as long distance express buses can increase the risk of respiratory illness and the reduction of lung function among bus drivers. Therefore control measures may need to improve in these situations.

Keywords: PM_{10}, CO_2, CO, Respiratory Symptoms, Lung Function, Bus Driver

ABSTRAK

PENDEDAHAN KEPADA PENCEMAR UDARA DALAMAN (PM_{10}, CO_2 DAN CO) DAN KESIHATAN RESPIRATORI DI KALANGAN PEMANDU BAS EKSPRES JARAK JAUH

MOHD FIRDAUS BIN OTHMAN

Pengenalan: Kajian terdahulu mendapati pendedahan kepada pencemar udara dalaman adalah tinggi di dalam bangunan dan juga di dalam bas. Walaubagaimanapun, kajian yang dijalankan di Malaysia berkaitan dengan pencemar udara dalaman di dalam bas ekspres jarak jauh terhad. **Objektif:** Tujuan kajian ini adalah untuk menentukan pendedahan pencemar udara dalaman (PM_{10}, CO_2 and CO) dan masalah simptom respiratori di kalangan pemandu bas ekspres jarak jauh. **Metodologi:** Kajian rentas ini melibatkan pada 30 orang pemandu bas ekspres yang kesemuanya adalah lelaki. Pendedahan PM_{10} diukur dengan menggunakan DustTrak Aerosol Monitor manakala CO_2 dan CO pula diukur dengan menggunakan Q-Trak IAQ Plus dan kesemua parameter ini diukur di sepanjang laluan iaitu selama 4 jam. Laluan bermula di Kuala Lumpur dan bergerak merentasi negeri-negeri lain dalam Semenanjung Malaysia. Kaedah persampelan bertujuan telah digunapakai untuk memilih responden berdasarkan kepada inklusif dan eksklusif kriteria seperti berumur antara 20-56 tahun, mempunyai sekurang-kurangnya setahun pengalaman bekerja, tidak mempunyai sejarah penyakit paru-paru kronik dan tidak merokok. Borang kaji selidik yang diadaptasi daripada American Thoracic Society (ATS) telah digunakan untuk mengumpul data berkaitan status sosio-ekonomi, sejarah bekerja dan simptom respiratori responden. Ujian fungsi paru-paru dilakukan selepas responden tiba ke destinasi. **Keputusan & Perbincangan:** Data yang dikumpul mendapati min kepekatan PM_{10} ($220.00 \pm 120.00 \mu g/m^3$), CO_2 (1085.50 ± 460.98ppm), dan CO (2.79 ± 0.95ppm) adalah di paras yang dibenarkan berdasarkan kepada garis panduan udara dalaman oleh ASHRAE. Bilangan penumpang di dalam bas mempengaruhi kepekatan CO_2 yang tinggi di dalam bas. Simptom respiratori kronik yang dilaporkan di kalangan pemandu bas adalah kahak (23.3%), batuk (20.0%), nafas berbunyi (13.3%) dan kesesakan dada (10.0%). Keputusan ujian fungsi paru-paru menunjukkan bahawa 50% daripada responden mempunyai ketidaknormalan nilai FVC% jangkaan dan nilai FEV_1% jangkaan. **Kesimpulan:** Pendedahan kepada pencemar udara dalam tempoh yang lama dan berterusan semasa memandu mempunyai kebarangkalian untuk mempengaruhi kesihatan respiratori pemandu bas. Pendedahan kepada PM_{10} di dalam bas berhawa dingin seperti bas ekspres jarak jauh boleh meningkatkan risiko penyakit respiratori dan penurunan fungsi paru-

paru di kalangan pemandu bas. Oleh itu, langkah kawalan diperlukan untuk memperbaiki situasi ini.

Kata Kunci: PM_{10}, CO_2, CO, Simptom Respiratori, Fungsi paru-paru, Pemandu Bas

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LIST OF ACRONYMS

<	Less than
>	More than
ACGIH	American Conference of Governmental Industrial Hygienists
ATS	American Thoracic Society
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
NIOSH	National Institute of Occupational Safety & Health
USEPA	United State Environmental Protection Agency
SPSS	Statistical Package of Social Science
WHO	World Health Organization
CO_2	Carbon Dioxide
CO	Carbon Monoxide
FEV_1	Forced Expiratory Volume in one second
FVC	Forced Vital Capacity
cm	Centimeter
kg	Kilogram
$\mu m/^3$	Micrometer per meter cube
ppm	Part per million

CHAPTER 1

INTRODUCTION

1.1 Background

Air pollution problem has becomes a major concern due to the overwhelming air pollution in environment which affected human's health in all around the world. The risk of acquiring health-related problems especially respiratory problems is increased as the result of frequent exposure to air contaminants.

The health hazards are caused by poor Indoor Air Quality (IAQ) that contained air contaminants such as volatile organic compounds, particulate matter, metal, toxic gaseous and airborne bacteria. These contaminants are generally formed by many electric power plants, automotive industry for transportation, other industrial processes, construction and agriculture (USEPA, 2010). It is for the reason that this study is undertaken to determine the status of lung function among long-distance bus drivers in Malaysia.

The city has seen a rapid growth in transportation demand, including its public transit system including taxis, buses, trains and many more. Vehicular usage has been increasing rapidly in combination with a booming growth in population (Kadiyala & Kumar, 2011). A vehicle cabin is an important microenvironment leading to passenger as well as drivers exposure to elevated levels of air pollutants, such as volatile organic compounds (VOCs), carbon monoxide (CO), carbon dioxide (CO_2) and particulate matter (PM) (Hsu & Huang, 2009).

Every day, the bus drivers were exposed to a mixture of air pollutant from the diesel exhaust particles during their work time (Ye, et al., 2000). Chronic respiratory symptoms that were reported among drivers in Klang Valley were phlegm (37.3%), breathlessness (31.8%), cough (25.9%) and wheezing (16.4%) (Zainuddin, et al., 2005). The prevalence of respiratory health for bus drivers shows that is 28% of them having cough and phlegm. Exposure to indoor air pollution lead to decrease of lung function and increase complain of respiratory symptoms (Juliana, et al., 2007).

This study assesses indoor air quality inside long distance express bus drivers' compartment in Kuala Lumpur. In this study, the air contaminants measured include Carbon Monoxide (CO), Carbon Dioxide (CO_2) and Particulate Matters (PM_{10}). Long distance express bus drivers spend more than 8 hours in the commuter every day and the concentration of the indoor air pollutants that been inhaled by the drivers might cause some health effects.

1.2 Problem Statement

Indoor air pollutants are possible in the modern home. Air pollutant levels in the home increase if not enough outdoor air is brought in to dilute emissions from indoor sources and to carry indoor air pollutants out of the home. In addition, high temperature and humidity levels can increase the concentration of some pollutants.

Although the interest in indoor air quality (IAQ) has been rising and many studies have been conducted, the numbers of studies focused on the indoor air of long distance express bus compartment are relatively small. According to Hsu & Huang (2009), air pollutants in long-distance buses have not been examined to date, and therefore need to be addressed. There are also no studies that are related to indoor air quality of long distance express bus compartment in Malaysia.

There are levels of in-vehicle pollutants inside buses have been reported largely from urban buses with stop-and-go driving patterns. In contrast to the buses in urban areas, long-distance buses are characterized by long travel time, high speed and long-time on highways. Additionally, highway traffic conditions and surroundings differ from those on local routes. Air pollutants in long-distance buses have not been examined to date, and therefore need to be addressed.

The recent field studies on the air quality in transportation compartment indicated that available field data is limited and care should be taken when comparing the results of different studies. According to Jones et al., (2006), measured PM_{10} and CO_2 level were significantly higher in air-conditioned buses. Due to the nature of the job, bus drivers are among the risk group being exposed to highly polluted air consisting of a mixture of air pollutants for about 8 hours without any personal protective equipment (Kavitha, et al., 2011).

Exposure to emissions from materials in passenger cabins found to be higher in new vehicles compared to older vehicles. These potentially adverse health effect are further complicated by the fact that any employees which spending more time ever indoors, up to 90% estimates by USEPA. The elevated indoor air pollutants concentrations can lead to the respiratory health problems and can be determined by symptoms experienced by bus drivers such as irritated eyes, nose, sinus or throat. Other symptoms are on the lower respiratory such as cough, tight chest, wheeze or difficulty in breathing (Juliana. J, et al., 2007).

In the indoor environment, people exhale Carbon Dioxide (CO_2), which contributes to CO_2 levels in the air. The level of CO_2 indoors depends upon the number of people present, how long an area has been occupied, the amount of outdoor fresh air entering the area, the size of the room or area, whether combustion by-products are contaminating the indoor air (e.g., idling vehicles near air intakes, leaky furnaces, tobacco smoke), the outdoor concentration (MDH, 2011). Working at

limited space of compartment such as inside vehicles can contribute to inhalation of PM_{10}, CO_2 and CO. For this reason, the concentration of PM_{10}, CO_2 and CO needs to be measured in order to maintain a good indoor air quality in bus drivers' compartment.

1.3 Study Justification

Public transportation system is used by many passengers in a tightly enclosed space; it can cause adverse impacts on health due to poor indoor air quality and a lack of appropriate ventilation. There are very limited studies that relate the exposure to indoor air pollutants and respiratory health among long distance bus drivers in Malaysia. Since the public transportation system is used by many passengers in a tightly enclosed space, it can cause adverse impacts on health due to poor indoor air quality and a lack of appropriate ventilation. Diesel engine exhausted and gasoline engine exhausted emitted a lot of hazardous pollutants such as particulate matters, carbon monoxide, nitrogen dioxide, volatile organic compounds and photo chemical oxidants.

It is common for people to report one or more of the following symptoms dryness and irritation of the eyes, nose, throat, and skin, headache, fatigue, shortness of coughing and sneezing, dizziness, etc. Some people may not be sensitive to indoor air quality problems in the early years of exposure but can become sensitized as exposure continues over time (CCOHS, 2011). If many people report similar

symptoms, or if all of the people reporting symptoms work in the same area of a couch, air quality should be suspected.

The aim of this study is to understand the effect on the indoor air pollutants inside long distance express buses. Besides that, this study aimed to strengthen the other study on association air pollutants and lung function among bus drivers. In the context of indoor air relationship inside vehicles, ventilation system is an important element where the system has to maintain the cycle of air inside vehicles in order to ensure that the fresh air is continuously been produced. This study can be preliminary study for long distance express buses related to exposure of indoor air pollutants inside buses and lung function of the drivers to future researcher.

Exposure to the indoor air pollutants inside buses will lead to adverse health effect including acute and chronic effects (Kavitha, Juliana, & Abdah, 2011). By conducting this research, effects of exposure to PM_{10}, CO_2 and CO among long distance express bus drivers' can be determined and documented through respiratory symptoms and lung function test. Hence, the data obtained from this study can be used as a reference for further study regarding IAQ for public transportation and to overcome the air quality problems by providing relevant control measures to ensure the safety, health and welfare of the workers.

1.4 Conceptual Framework

Figure 1.1 shows the conceptual framework of research study which will assist and guide researcher in implementing the study. The aim of this study is to determine the exposure to indoor air pollutants (PM_{10}, CO_2 and CO) and respiratory health among long distance express bus drivers.

From the framework, indoor air quality has become an important occupational health and safety issue. Indoor air quality can be divided into two which is indoor air quality in building and transportation. In this study, the indoor air quality conducted will focus on the transportation and the long distance express bus drivers are selected to be the study population. The parameters of indoor air quality are including particulate matters (PM_{10}, $PM_{2.5}$ and ultrafine), carbon monoxide (CO), carbon dioxide (CO_2), carbon monoxide (CO), mould, air temperature, humidity, air exchange rate, temperature humidity index and air velocity.

In this study, the parameters selected are carbon dioxide (CO_2), carbon monoxide (CO) and particulate matters (PM_{10}) because the exposure will lead to dryness and irritation of the eyes, nose, throat, and skin, headache, fatigue, shortness of breath, hypersensitivity and allergies, sinus congestion, coughing and sneezing, dizziness, and/or nausea (Canadian Centre for Occupational Health and Safety, 2011). Human body can be exposed to this air contaminant through direct contact to skin and inhalation.

This research will focus on the sign and symptoms shows after exposed to these air contaminants, where the exposure level to the air contaminants will be measured with TSI DustTrak 8520 Aerosol Monitor for particulate matter (PM_{10}) and TSI 8554 Q-Trak Plus for carbon dioxide ($CO_{2)}$ and carbon monoxide (CO).

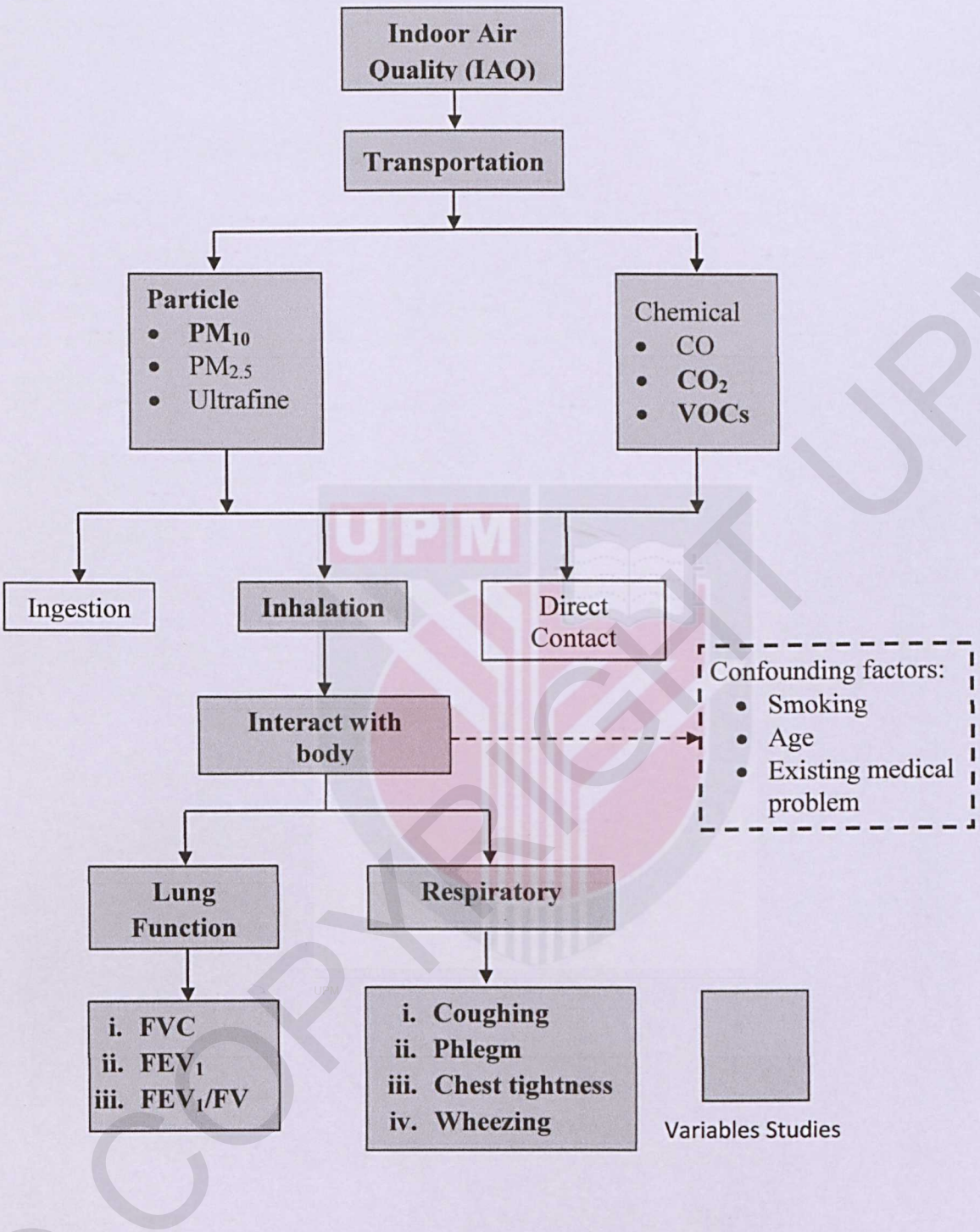

Figure 1.1: The conceptual framework of indoor air pollutants and respiratory health among long distance express bus drivers.

1.5 Definition of Term

1.5.1 Conceptual Definitions

a) Indoor Air Quality

Indoor air quality refers to the presence or absence of air pollutants in buildings. There are many sources that can contribute to indoor air quality. The presence of sources of indoor air pollutants such as tobacco smoke and radon, or by conditions that promote poor indoor air quality such as inadequate ventilation or moisture intrusion that can lead to mold growth, are used as indications of potential health effects (USEPA, 2010).

b) Indoor Air Pollutants (IAP)

Indoor air pollutants is the event where the outdoor or indoor contaminants enter the building that is inadequate with the pollution control despite otherwise normal or baseline rates of ventilation (USEPA, 2010).

c) Particulate Matter (PM_{10})

PM_{10} refer to particles with a diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of a human hair) (USEPA, 2008)

d) Carbon Dioxide (CO_2)

A colorless, odorless, nonpoisonous gas which results from fuel combustion and human activity indoors. Elevated levels of CO_2 indicate ineffective ventilation indoors. (USEPA, 2008)

e) Carbon Monoxide (CO)

Carbon monoxide is an odorless, colorless and toxic gas. At lower levels of exposure, CO causes mild effects that are often mistaken for the flu. These symptoms include headaches, dizziness, disorientation, nausea and fatigue. The effects of CO exposure can vary greatly from person to person depending on age, overall health and the concentration and length of exposure. (USEPA, 2008).

f) Respiratory symptoms

Respiratory tract symptoms can be defined as conditions that resulted from a disturbed respiratory system by various factors either internal or external factors. The examples of respiratory symptoms are cough, phlegm, episodes of cough and phlegm, wheezing, breathlessness, chest cold and chest illness.

g) Cough

Cough is a reaction or reflex which helps to keep things out of lungs and clears things that are not supposed to be in the lungs (ATS, 2011).

h) Phlegm

Phlegm or known as sputum production is the mucus coming from the lungs with the function to keep the breathing pathways moist (ATS, 2011).

i) Wheezing

Wheezing is a high-pitched whistling sound during breathing. It occurs when air flows through narrowed breathing tubes (MedlinePlus, 2010).

j) Breathlessness

Breathlessness refer to a feeling occurring when the lung changes from working in the way it was normally designed to work, to working differently. If the lung senses that it takes more work or effort to move air in and out of the lungs, a feeling of breathlessness will be experienced (ATS, 2011).

k) Forced Vital Capacity (FVC)

The maximum volume of air exhaled with maximally forced effort from a maximal inspiration (ATS, 2005).

l) Forced Expiratory Volume in One Second (FEV_1)

The maximum volume of air exhaled in the first second of a forced expiration from a position of full inspiration (ATS, 2005)

1.5.2 Operational Definition

a) Particulate Matter (PM_{10})

The exposure level of PM_{10} is measured by using DustTrak Aerosol Monitor for average 4 hours work duration. The instrument is attached near to the respondents.

b) Carbon Dioxide (CO_2)

The exposure level of CO_2 is measured by using Q-TRAK for average 4 hours work duration. The instrument is attached near to the respondents.

c) Carbon Monoxide (CO)

The exposure level of CO is measured by using Q-TRAK for average 4 hours work duration. The instrument is attached near to the respondents.

d) Respiratory symptoms

The occurrence and intensity of respiratory symptoms is evaluated using a modified questionnaire which developed from American Thoracic Society (ATS-DLD-78-A Adult Questionnaire). Symptoms evaluated are cough, phlegm, episodes of cough and phlegm, wheezing, and breathing difficulties.

e) Chronic Cough

Symptoms of chronic cough identified from the study questionnaire are based on the ATS (2011)

f) Chronic phlegm

Symptoms of chronic phlegm identified fro, the study questionnaire are based on the ATS (2011)

g) Forced Vital Capacity (FVC)

The FVC is measured using the spirometer (Spirolab II Model) and expressed in litres.

h) FEV_1

The FEV_1 is measured for the volume of air exhaled during the first second with spirometer (Spirolab II Model) and expresses litres.

i) FEV_1 % Predicted

Percentage value of measured FEV_1 divided with FEV_1 predicted of a respondent. FEV_1 % Predicted = (FEV_1 Measured / FEV_1 Predicted) x 100

j) FVC % Predicted

Percentage value of measured FVC divided with FVC predicted of a respondent. FVC % Predicted = (FVC Measured / FVC Predicted) x 100

1.6 Research Objective

1.6.1 General Objective

To determine the exposure to indoor air pollutants (PM_{10}, CO_2 and CO) and respiratory health among long distance express bus drivers.

1.6.2 Specific Objectives

The objectives of this research paper are:

1. To determine the socio-demographic and socio-economic of the bus drivers.
2. To measure the concentration of indoor air pollutants (PM_{10}, CO_2 and CO) in bus drivers compartment.
3. To determine the association between indoor air pollutants (PM_{10}, CO_2 and CO) and lung function test (FVC, FEV1, FVC% predicted and FEV1 % predicted) among bus drivers.
4. To determine the association between exposure to indoor air pollutants (PM_{10}, CO_2 and CO) and respiratory symptoms among bus drivers.
5. To determine the association between duration of exposure to indoor air pollutants (PM_{10}, CO_2 and CO) and lung function among bus drivers.

1.6.3 Study Hypothesis

The hypotheses for the research study are:

1. There is a significant association between indoor air pollutants (PM_{10}, CO_2 and CO) and lung function (FVC, FEV_1, FVC% predicted and FEV_1 % predicted) among bus drivers.
2. There is a significant association between exposure to indoor air pollutants (PM_{10}, CO_2 and CO) and respiratory symptoms among bus drivers.
3. There is a significant association between duration of exposure and lung function among bus drivers.

CHAPTER 2

LITERATURE REVIEW

2.1 Indoor Air Pollution

According to Petersen and Sabersky (1975), the space inside a vehicle can be categorized as an indoor environment of a vehicle where there is significantly different between indoor air pollutants inside building and indoor air pollutants inside vehicle due to their activities. Major contributing factor of indoor air pollution in vehicles is traffic air pollution from the vehicles emission itself. Accumulation of pollutants inside vehicles is more dangerous due to restricted of air movement.

Recent study found that bus drivers were exposed directly to traffic air pollutants inside buses such as $PM_{2.5}$, PM_{10}, VOCs and CO_2 and this traffic air pollution was generated caused by incomplete combustion of diesel and gasoline engine (Nurrul Fariza, 2006). According to Nurrul Fariza (2006), as well as Godlee and Walker (1992), emission from vehicles exhaust produce a lot of pollution

including particulate matters, nitrogen dioxide, carbon monoxide, benzene, sulfur dioxide and polyhydrocarbon that can impair human health when enter the human bloodstream through the nose, mouth, skin, and the digestive tract.

2.2 Vehicular Emission

Express buses can be classified as a heavy duty vehicle which is diesel highway heavy-duty vehicles under 14,000 pounds (USEPA, 2011). In a recent study, Vijayan (2007) said that older vehicles without good maintenance usually emitted more pollutants than newer ones.

Many studies have found that concentrations of CO, NOx, and fuel-related VOCs were significantly higher inside the vehicles than in the ambient air (Shikiya et al., 1989; Ptak and Fallon, 1994; Lawryk and Weisel, 1995; Solomon et al., 2001; Wargo et al., 2002). Shikiya et al. (1989) observed that the in-vehicle concentrations of emitted criteria pollutants such as CO and NOx could be two to four times those measured at fixed site monitors.

Several studies also observed high concentrations of toxic pollutants such as benzene and other aromatic VOCs within the vehicle microenvironments and estimated these pollutants to contribute 10 to 60 percent of a nonsmoker's total exposure (Chan et al., 1991; Weisel et al., 1992; Lawryk and Weisel, 1995). Chan (2003) in his study commented that the CO_2 level inside a fully occupied air-

conditioned bus could reach up to 10 times the outside concentration and also observed that better air exchange with the outdoor air resulted in lowered CO and CO_2 levels for a non-air conditioned bus.

The study also determined a strong dependence of the exposure level of CO_2 inside an air-conditioned vehicle to the number of passengers and not the driving environment. According to Vijayan (2007), relationship exists between the in-vehicle concentration of the pollutants and a number of variables such as classification of vehicles in the proximity, operating locations and vehicular conditions. Many pollutants emitted by vehicles that are dispersed on the roadways that eventually reach inside the bus microenvironment, but most studies have measured and reported only one or two pollutants over a long period.

Table 1.1: Pollutants from Vehicular Exhaust

Pollutants Emitted	Formation	Environmental significance/Health Risk
Carbon Monoxide (CO)	Incomplete combustion of carbon in fuel. Highest CO levels occur when the weather is very cold or at high elevations where there is less oxygen in the air to burn the fuel.	Reduces the oxygen carrying capacity of the blood
Carbon Dioxide (CO2)	Complete combustion product	Global warming and climate change
Volatile Organic Compounds (VOCs) – mainly from Hydrocarbons (HC)	Unburned or partially burned fuel is emitted from the engine as exhaust; leaks and evaporation	Potential carcinogens; react with nitrogen oxides in the presence of sunlight to form ozone; ozone component of smog, lung damage and respiratory problems.
Nitrogen Oxides (NOx)	Formed when the oxygen and nitrogen in the air react with each other during combustion at high temperature and excess oxygen (more than what is needed to burn the fuel)	Eye, nose, Throat irritation, Central nervous system damage, chronic respiratory problems. Precursors to secondary pollutant formation
Particulate Matter (PM)	Particulate matter from mobile sources is primarily $PM_{2.5}$. Direct emissions and secondary formation in atmosphere	Asthma; chronic respiratory problems; potential carcinogens; Visibility issues and haze

Source: Vijayan A. (2007) - Compiled from the USEPA

2.3 Particulate Matter (PM_{10})

Particulate matter is the term for solid or liquid particles found in the air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can be detected only with an electron microscope. Because particles originate from a variety of mobile and stationary sources (diesel trucks, woodstoves, power plants, etc.), their chemical and physical compositions vary widely. Particulate matter can be directly emitted or can be formed in the atmosphere when gaseous pollutants such as SO_2 and NO_x react to form fine particles (USEPA, 2010).

In Malaysia, the main source of particulate matter is automotive exhaust and heavy diesel engines, buses, and trucks contribute approximately 50% - 60% of the of the traffic emission in the urban areas. Workers involved in transportation industry were highly exposed to the particulate matter where the workplace is also site of exposure to the combustion derived PM_{10}. Moreover, air pollution due to the particulate matter inside the vehicles is relatively higher than the air pollution outside the vehicles (Kavitha M. et. al., 2010). Jones and Dean (2006) found that measured PM_{10} and CO_2 levels in air-conditioned buses were higher than non-air-conditioned buses.

According to Jones, Lam and Dean (2006), the efficiency of air filters in air-conditioned buses may not be sufficient to protect the respiratory health of drivers. Adverse health effects have been associated with the increase ambient PM_{10} globally

and the large fraction of combustion from the diesel engines ended up inside buses are particulate matters (PM_{10}, $PM_{2.5}$ and UFP), nitrogen dioxide, carbon monoxide and volatile organic compounds (VOCs) (Kavitha, Juliana, & Abdah, 2011).

Excessive levels of particulates can cause allergic reactions, such as dry eyes, contact lens problems, nose, throat, and skin irritation, coughing, sneezing, and respiratory difficulties (USEPA, 2010). Long term exposure to particulate matter for years is associated with elevated total, cardiovascular, and infant mortality. Respiratory symptoms, lung growth and function of the immune system are also affected (Nurrul Fariza, 2006).

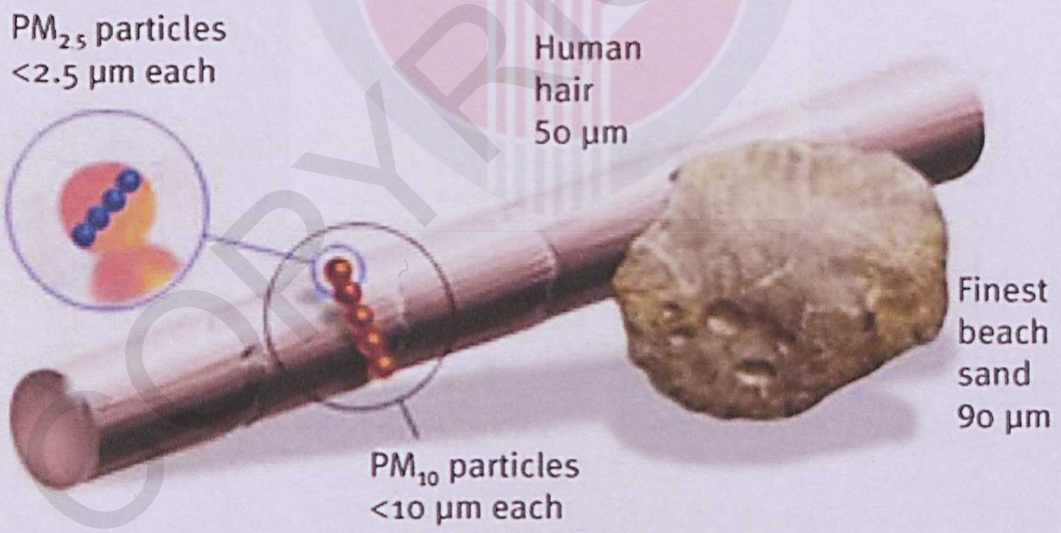

Figure 2.1: PM_{10} particle is less than 10 microns in diameter, or one-fifth of the diameter of human hair.

(Source: Environment New Zealand, 2012)

As showed in Figure 1.1, PM_{10} are easily inhaled and can be readily absorbed into the lungs. As a result, PM_{10} can cause significant health effects, particularly for the elderly and infants, people with asthma and other respiratory diseases, and sufferers of other chronic diseases, such as heart disease.

2.4 Carbon Dioxide (CO_2)

Carbon dioxide (CO_2) is a normal constituent of exhaled breath and the measurement of CO_2 concentrations can be used as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. Study of exposure to CO and CO_2 in different buses inside and outside using portable monitors showed that in-vehicle levels are 10 times higher compared to outdoors, and CO_2 levels were mainly influenced by passengers and not the driving environment (Kadiyala & Kumar, 2011). Zainuddin et al. (2005) found that elevated CO_2 concentrations were associated ($p < 0.05$) with the number of passengers on the bus.

Carbon dioxide (CO_2) is naturally present in the atmosphere at levels of approximately 0.035%. Short-term exposure to CO_2 at levels below 2% (20,000 parts per million or ppm) has not been reported to cause harmful effects. Higher concentrations can affect respiratory function and cause excitation followed by depression of the central nervous system. High concentrations of CO_2 can displace oxygen in the air, resulting in lower oxygen concentrations for breathing. Therefore,

effects of oxygen deficiency may be combined with effects of CO_2 toxicity (Canadian Centre for Occupational Health and Safety, 2011).

Carbon dioxide is a simple asphyxiant, and can also act as a respiratory irritant. However, although indoor to outdoor ratios of the gas are typically in the range 1-3 for most environments, exposure to an extremely high CO_2 concentration (above 30,000ppm or 54860 mg^{-3}) is required before significant health problems are likely. At moderate concentrations, CO_2 can cause feelings of stuffiness and discomfort (Korukçu & Kiliç, 2011). Respiration can be slightly affected at levels above 15,000ppm (27430mg^{-3}). Exposures above 30,000 ppm can lead to headaches, dizziness, and nausea (Minnesota Department of Health, 2011).

According to Zainuddin et al. (2005), they also found that more than 30% of respondents had at least one acute respiratory symptom such as blocked nose, runny nose and sore throat while driving due to exposure to CO_2 and CO. Chronic respiratory symptoms that were reported among drivers were phlegm (37.3%), breathlessness (31.8%), cough (25.9%) and wheezing (16.4%).

2.5 Carbon Monoxide (CO)

Carbon monoxide is an odorless, colorless and toxic gas. It is impossible to see, taste or smell the toxic fumes. At lower levels of exposure, CO causes mild effects that are often mistaken for the flu. These symptoms include headaches,

dizziness, disorientation, nausea and fatigue. The effects of CO exposure can vary greatly from person to person depending on age, overall health and the concentration and length of exposure. According to Nurrul Fariza (2006), 60% of all carbon monoxide emission was contributed by vehicle exhaust due to incomplete combustion of vehicle engine.

Exposure to carbon monoxide reduces the blood's ability to carry oxygen. The chemical is odourless and some of the symptoms of exposure are similar to those of common illnesses. This is particularly dangerous because carbon monoxide's deadly effects may not be recognized until it is too late to take action. Breathing of low levels of the chemical can cause fatigue and increase chest pain in people with chronic heart disease. Breathing of higher levels of carbon monoxide causes symptoms such as headaches, dizziness and weakness in healthy people.

Carbon monoxide also causes sleepiness, nausea, vomiting, confusion and disorientation. At very high levels it causes loss of consciousness and death. Poisoning may have irreversible sequelae (USEPA 2010). Figure 2.2 shows the mechanism of Carbon monoxide poisoning. Carbon monoxide poisoning occurs as carbon monoxide mixes and binds with hemoglobin in the blood to form carboxyhemoglobin (COHb). When carbon monoxide binds to hemoglobin, less oxygen gets transported to body tissues and vital organs such as the brain and heart. The bond between carbon monoxide and hemoglobin is approximately 250 times stronger than the bond between oxygen and hemoglobin (eMedicineHealth, 2012).

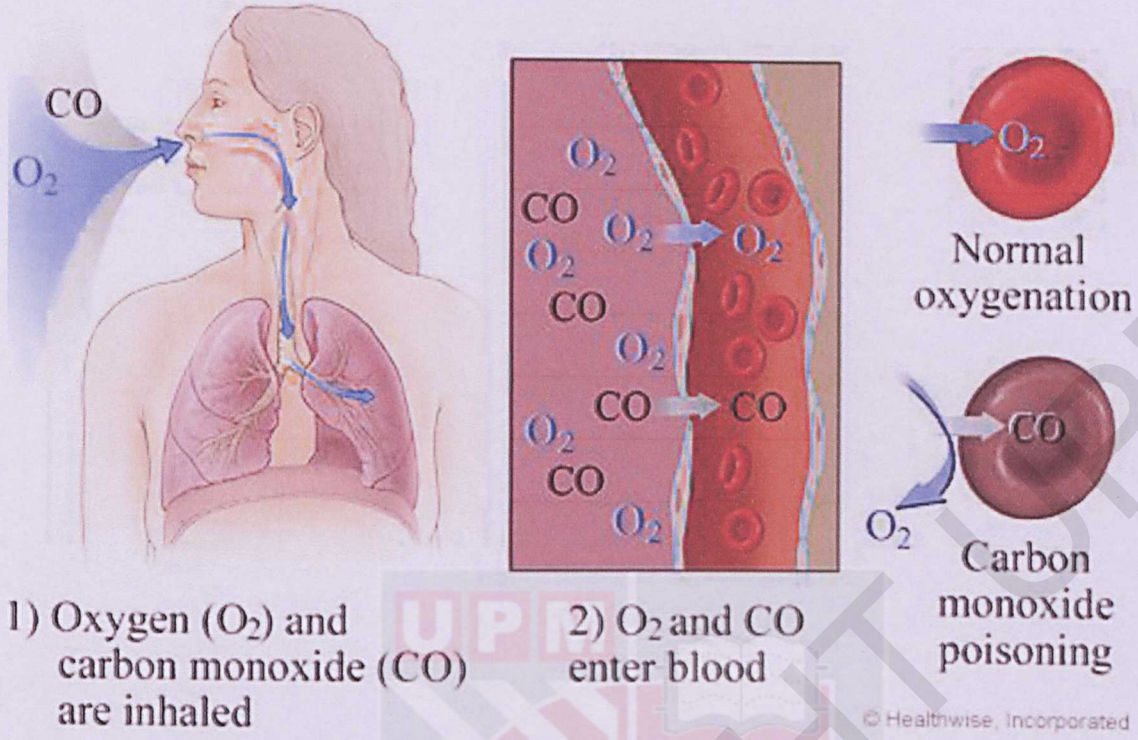

Figure 2.2: Carbon monoxide poisoning

(Source: eMedicineHealth, 2012)

Table 2.2: List of indoor air contaminants and the acceptable limits

INDOOR AIR POLLUTANTS	LIMIT/RANGE		REFERENCE
Particulate Matter (PM_{10})	$20\mu g/m^3$ (annual mean) $50\mu g/m^3$ (24-hours mean)		WHO
Carbon Dioxide (CO_2)	1000 ppm 1000 ppm 5000 (prolonged period) 35000 ppm (for 15 minutes)		NIOSH ASHRAE OSHA
Carbon Monoxide (CO)	8-hour TWA	1-hour TWA	
	50 ppm	-	OSHA
	35 ppm	-	NIOSH
	9 ppm	35 ppm	EPA
	9 ppm (peak)	-	ASHRAE
	25 ppm	-	ACGIH
	9 ppm	26 ppm	WHO

2.6 Lung Function

Spirometer or also known as lung function test is the most common of the Pulmonary Function Tests (PFTs). This test measures lung function, specifically the measurement of the amount (volume) and/or speed (flow) of air that can be inhaled and exhaled. This test is also helpful in assessing respiratory problems such as asthma, pulmonary fibrosis, cystic fibrosis and chronic obstructive pulmonary disease (COPD). Table 2.3 shows the abnormalities of lung function which consist of obstructive and restrictive disease, as stated by American Thoracic Society (1991).

Table 2.3 : Abnormality of Lung Function

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

(ATS, 2005)

Restrictive lung disease or the condition where a person cannot inhale normal volume of air can be detected by the measurement of lung volume. This disease may have been caused by bleeding or scratch in lung tissue or muscle tissue abnormal or bone in chest wall. The lung function test can also assist to detect early respiratory disease and measure the severity of lung problems that caused abnormal respiratory problems (Spengler et al., 2003). Indicator to determine restrictive defect is through vital capacity value and it present when the lung volume reduce to less than 80% of predicted levels.

CHAPTER 3

METHODOLOGY

3.1 Study Location

This study was conducted among long distance express bus drivers from most well-known bus company in Malaysia. This bus company provides transportation services for almost all regions in peninsular Malaysia. This study involved three express bus terminals which is Terminal Bersepadu Selatan (TBS), Puduraya Bus Terminal and Pekeliling Bus Terminal. This place has been chosen as based of routes before start traveling to another region.

Bus models used in this transportation company were Scania and Hino. However, all routes involved in this study used Scania model. Scania buses are low-emission Euro 3 engines; in 310 hp, 380 hp and 420 hp specifications. These engines exceed Malaysian emissions regulations requirements, and combines low noise levels that guarantees comfort for the driver and passengers alike. The difference

between Euro 1, the current Malaysian emission regulation, and Euro 3 corresponds to 72% reduction of particles and 38% reduction of nitrogen oxides (Scania Malaysia, 2008).

A coach is a type of bus, used for conveying passengers on excursions and on longer distance express coach scheduled transport between cities or even countries. Unlike buses designed for shorter journeys, coaches often have a luggage hold separate from the passenger cabin. These buses compartments are modern and air-conditioned. This study is conducted inside long distance express buses which travel from Kuala Lumpur to Johor Bahru, Kuantan, Kuala Terengganu, Butterworth, Kulim, Sik, Pendang, Alor Setar, and Arau which are almost all around peninsular Malaysia. After that, the bus returned to Kuala Lumpur. See Figure 3.2.

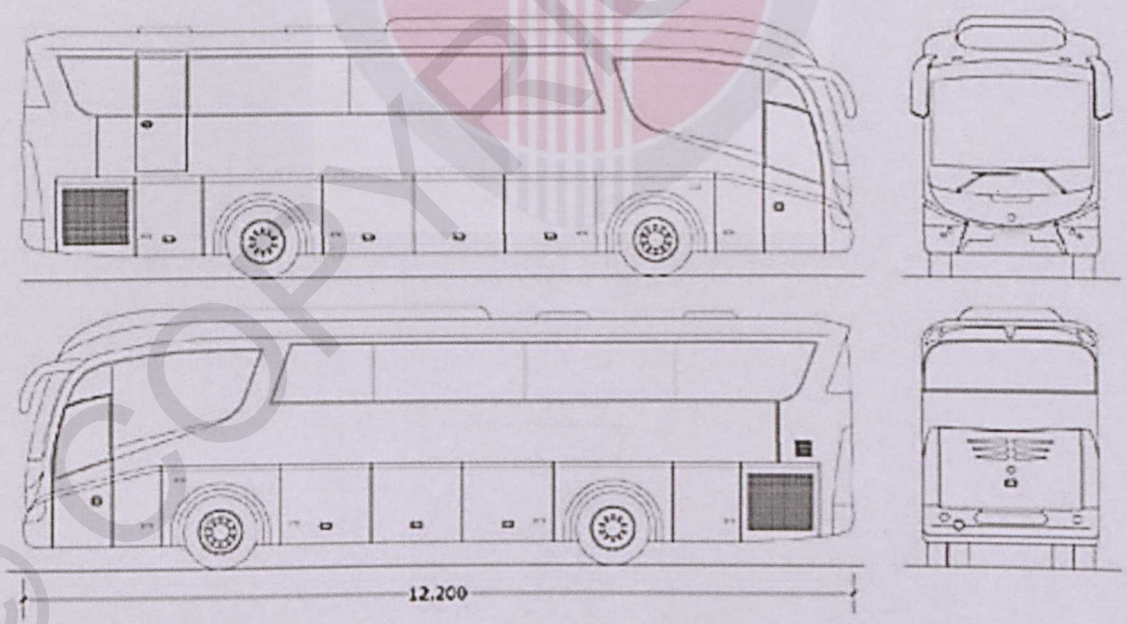

Figure 3.1: Scania Bus used by Bus Transportation Company

(Source: Scania Group)

Figure 3.2: Long distance express bus routes used in study

3.2 Study Design

A cross-sectional study design was used in this study as a complete assessment on indoor air quality inside express bus and measures the indoor air pollutants and also conducted the survey of the any respiratory health related to the air pollutant among the long distance express bus drivers.

3.3 Sampling

3.3.1 Study population

The study population for this study were all male bus driver in Bus Transportation Company who are exposed directly to indoor air pollutants (PM_{10}, CO_2 and CO) while working.

3.3.2 Sampling Frame

The sampling frame of this study is include all the drivers in the name lists that fulfilled the inclusion criteria obtained from the selected long distance express bus company manager.

3.4 Sample Size

The sample study consists of long distance express bus drivers who exposed to carbon dioxide, carbon monoxide and particulate matter in their work task and age between 20-56 years old. Below is the sample size calculation.

The sample size for this study is based on Kirkwood (2009). The formula used is as follows:

$$n = p\,(1 - p)/e^2$$

Where:

n = sample size

p = prevalence

e = standard error (0.05)

Based on Zainuddin et.al, (2005) the prevalence of chronic respiratory symptoms is 30%.

$= 0.3\,(1 - 0.3) / (0.05)^2$

$= 0.21 / 0.0025$

$= 84$

3.5 Instrumentation and Data Collection

3.5.1 Approval Letter

The letter used in this study is application letter, to get respondents to involve in this study and the other one is the approval letter from the Bus Transportation Company to approve their workers involves in this study.

3.5.2 Questionnaire

The questionnaire is used to get information from respondents. It consists of personal information such as socio-demographic, socio-economic, working history, exposure history, year of work, duration of work every day, and family history of disease. The questionnaires are distributed to respondents and they have to answer all questions as required. Interview session held to ensure the respondents understand what the researcher wants in the questionnaire.

3.5.3 Q-TRAK PLUS IAQ Monitor (Model 8554)

TSI 8554 Q-Trak Plus was used to measure the concentration level of CO_2 and CO inside long distance express bus. It has the sensor non-dispersive infrared (NDIR) and have detection limit 0 to 5,000 ppm. CO_2 is detected due to its natural properties; CO_2 molecules absorb light at specific wavelength of 4.26 μm. This

wavelength was in the infrared (IR) range. High concentrations of CO_2 molecules absorb more light than low concentration. The IR light was directly through the sensing chamber towards the detector. The detector had a filter in front of it which eliminates all light except the 4.26 μm wavelength that CO_2 molecules affect the amount of light reaching the detector.

The intensity of 4.26 μm light that reaches the detector was inversely related to the concentration of CO_2 in the sensing chamber. When the concentration of CO_2 in the chamber was zero, the detector will 'see' the full light intensity. As the concentration of CO_2 increases, the intensity of light striking the detector decreases. The exact relationship between the IR light and intensity and CO_2 concentration was determined when the instrument is calibrated using pure nitrogen (0 ppm CO_2) and a known concentration of CO_2 such as 1000 or 5000 ppm.

The concentration of CO_2 in this research was used as the ventilation measurement for the fresh air supply. The limit or range of CO_2 in ASHRAE Standard 62-2003 is not more than 700 ppm over outdoor ambient. The limit of ventilation for the fresh air regulate by ASHRAE Standard 62-2003 is 15 to 60 cubic feet minute (cfm)/person minimum depending on type of space. Levels of CO_2 higher than 1000 ppm indicate the poor indoor air quality.

The concentration of carbon monoxide can be detected using sensor type Electro-chemical and have range of detection 0 to 500 ppm. This instrument use the

principle of electrochemical wavelength same as the carbon dioxide detection. The standard limitation for the CO exposure indoor by WHO is 9 ppm in 8 hours time-weighted average (TWA) and 26 ppm in 1 hour TWA.

In this research, the Q-Trak will be located at the bus driver's compartment, near to the driver area where the sampling point is determined and the data downloaded from all the instruments have been set for measurement averaged to 4 hours for analysis. The Q-Trak was calibrated using specific method according to the gas parameter and using American Society Testing Material (ASTM) Standard 1999a, 1999b in D3162 Test Method for Carbon Dioxide in atmosphere (Using Nondispensive Infrared Spectometry).

Figure 3.3: TSI 8554 Q-Trak Plus

3.5.4 TSI DustTrak™ 8520 Aerosol Particulate Monitor

For the particulate matter, the model 8520 DustTrak Aerosol Monitor will be used in this study. It used 90° light scattering, laser diode. The TSI DustTrak has 0.001 to 100 mg/m3 (calibrated to respirable fraction of standard ISO 12103-1, A1 test dust). The TSI 8520 DustTrak Aerosol Monitor uses light scattering technology to determine mass concentration in real time.

An aerosol sample was drawn into the sensing chamber in a continuous stream. One section of the aerosol stream is illuminated with a small beam of laser light. Particle in the aerosol scatter light in all directions. A lens as 90° to both the aerosol stream and laser beam collects some of the scattered light and focuses it onto a photo detector. The TSI DustTrak monitors were zero checked regularly and the nozzles cleaned to obtain good quality data. In this research, the TSI DustTrak will be located at the bus driver's compartment, near to the driver area where the sampling point is determined and the data downloaded from all the instruments have been set for measurement averaged to 4 hours for analysis.

Figure 3.4 : TSI DustTrak 8520 Aerosol Monitor

3.5.5 SECA Body meter

SECA Body meter which will be used to measure the height of respondent. The respondent will be asked to take off his shoe and stand right on a wall where this equipment will be set up on it. Then the height of the respondent will be recorded by the assessor.

Figure 3.5 : SECA Bodymeter

3.4.7 SECA Weighing Scale

SECA weighing machine (Figure 3.2) will be used to measure the weight of the respondent in kilogram unit. The respondent will be asked to take off their shoes during the weighing process to avoid any bias in the measurement.

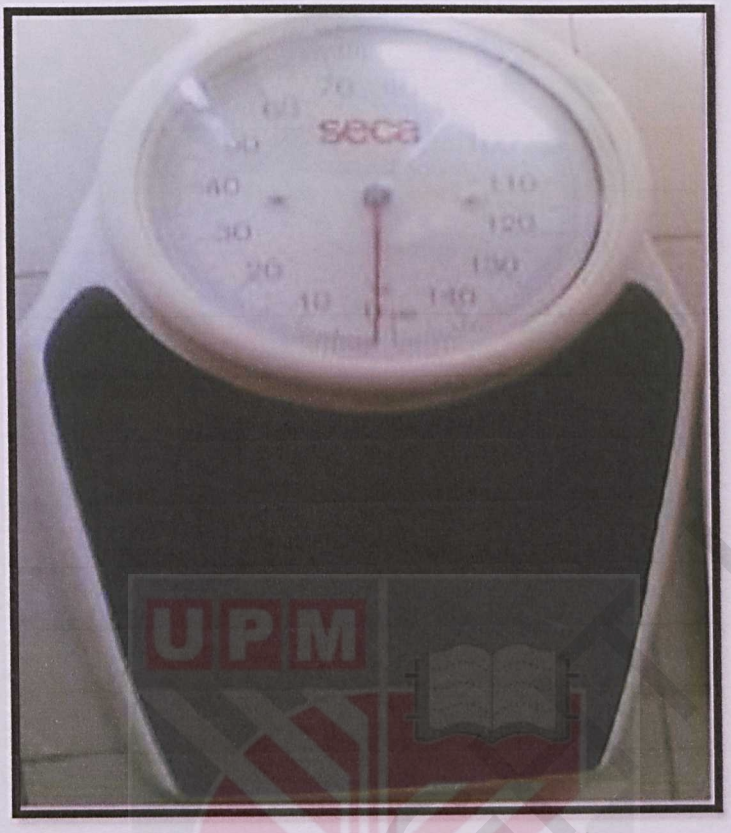

Figure 3.6 : SECA Weighing Scale

3.5.7 Spirometer and lung function test

The spirometer will be used to measure lung function parameter such as FVC, FEV_1 and FEV_1/FVC. The proper instruction to undergo lung function test is as follows; a respondent breathe into a mouthpiece on a device called a spirometer. At the same time, it makes a tracing of the rate at which the air leaves the lung. Diseases of airflow obstruction and of lung stiffening give characteristics tracings with spirometer. It measures the amount (volume) and/or speed (flow) of air that can be

inhaled and exhaled. The ATS recommends that the lung function test should not be conducted at temperature less than 17°C or more than 40 °C.

Figure 3.7 Chestgraph HI-101Spirometer

3.6 Data Collection Procedure

The application letter to run the research will be given to the Human Resource of selected long distance express bus before the research will be held. The name lists of the workers that involves in the indoor air pollutants in their work tasks will get from human resource. Questionnaire will be distributed to the respondents before they go to work to get the information about their personal details, working

background, socio-demographic, socio-economic, family history of disease and so on.

The PM_{10} was measured using the DustTrak™ 8520. The data was collected in real time in the sample location which is bus driver's compartment. The location was determined near to bus drivers' seat. Q-TRAK Model 8554 measures the most important parameters for IAQ studies and simultaneously measures carbon dioxide (CO_2), carbon monoxide (CO), temperature and humidity, all within a single probe.

There were three important variables in this study. For the CO_2 and CO detection, the TSI 8554 Q-Trak Plus was used. The concentrations of CO_2 and CO were measured simultaneously in the sampling location determined by the workstation using Q-Trak. For the particulate matter (PM_{10}), the TSI Model 8520 Dust Trak™ Aerosol Monitor were respectively used in this study. The DustTrak and Q-Trak were placed within the driving zone of the bus drivers and samples were taken when a steady level was achieved after about 5 minutes and the duration of the sampling measurement is averaged 4 hours due to nature of bus drivers.

Throughout the sampling, time, duration, traffic conditions, number of passengers and surrounding environment were recorded. Lung function test was performed after arrived to the destinations.

3.7 Data Analysis

All the data analysis will be analyse using the statistical analysis by performing SPSS 20.0 (Statistical Package for Social Science) and Microsoft Excel 2010 for Window Seven. Univariate analysis will be used to produce the raw and basic statistical data of respondent background information (descriptive analysis), like age, gender and basic laptop usage information. The data will be presented in the form of mean, maximum and minimum value. The specific objective will be determined by analysis the collected data using bivariate analysis. The level of significance was chosen as $p<0.05$ for all statistical tests. Unless otherwise stated, all data are expressed as the mean ± SD. Shapiro Wilk statistic was used to test the normality for all continuous variables while Chi-square test was used to determine the association between high and low level of concentration indoor air pollutants and respiratory symptoms and also lung function. Pearson correlation test was used to determine the association between duration of working with Bus Transportation Company and lung function.

3.8 Quality Control

To ensure that data collection will be reliable and valid, quality control on the instrument and procedure during data collection are as following:

1. Pre-test for questionnaire is conduct among 10% of same sample population but not the respondents to determine the understanding of questionnaire.
2. The calibration of all instruments was performed before and after takes the measurement during field work.
3. Before field works, questionnaire is re-checked after answered by respondents to avoid missing information and ensures accuracy.
4. Standard Operating Procedures (SOP) for every instrument used Spirometer, SECA Weight Scale and Body meter, DustTrak, and Q-Trak.

3.8 Ethical Consideration

This study will be held by consider some ethical issues that had set by Faculty of Medicine and Health Science, University Putra Malaysia.

1. The respondents will be given some explanation about the whole of the study activities involved.
2. The respondents will be given some explanation about the purpose of the air sampling taken before run the test.
3. The respondents will be given some explanation about the purpose of the test, the procedure taken, and also respondents' right in this study.

3.9 Study Limitation

Besides a strict compliance on measurements and data collection techniques in the study, the main limitations of the study were as follows:

1. The study design, cross sectional study design studies collect information on exposure and health status at the same time.
2. Limited studies on air pollution and respiratory health done locally especially regarding long distance buses. Within the constrain of limited baseline data references, it is difficult to discuss and to make comparison on the study result.
3. Confounding variables are very important in this study related to long term exposure to indoor air pollutants including health status, smoking habits, age and duration of exposure.

CHAPTER 4

STUDY RESULTS

4.1 Background and selection of respondent

This study was conducted among long distance express bus drivers from most well-known bus company in Malaysia. This bus company provides transportation services for almost all regions in peninsular Malaysia. This study involved three express bus terminals which is Terminal Bersepadu Selatan (TBS), Puduraya Bus Terminal and Pekeliling Bus Terminal. This place has been chosen as based of routes before start traveling to another region.

This study was conducted to determine the relationship between indoor air pollutants (PM_{10}, CO_2 and CO) and respiratory health among long distance express bus drivers. This study has been conducted on 30 long distance express bus drivers. Based

on the random sampling method, this study involved bus drivers who fulfilled the inclusive criteria which are male, age range between 20-56 years, no past history of chronic lung disease and at least 1 year experienced working as long distance express bus driver were selected.

4.2 Descriptive Analysis

4.2.1 Socio-demographic

Table 4.1 below shows the socio-demographic of long distance bus drivers. Shapiro-Wilk test was used to determine the normality of the data. As the result, the data for age, height, weight and working experiences are normally distributed. Hence, the mean and standard deviation of the respondents' age was 41.70 ± 7.80 years old and the range between 27 to 56 years old. The mean and standard deviation of the respondents' height was 166.43 ± 4.45 cm and the range was 157 to 180 cm. The mean and standard deviation of the respondents' weight was 64.73 ± 6.35 kg and the range between 48 to 80 years old. . The mean and standard deviation of the respondents' working experiences was 7.77 ± 6.16 years and the range between 1 to 26 years.

Table 4.1: Socio-demographic data of the respondents

Variables	Mean ± S.D	Range
Age (year)	41.70 ± 7.80	27 – 56
Height (cm)	166.43 ± 4.45	157 – 180
Weight (kg)	64.73 ± 6.35	48 - 80
Working experienced (year)	7.77 ± 6.16	1 - 26

N = 30

4.2.2 Indoor Air Pollutants Concentration

Table 4.2 showed the concentration of indoor air pollutants (PM_{10}, CO_2 and CO) in the express bus. From the data obtained, the concentration of particulate matter (PM_{10}) is 220.00±120.00µg/m3, carbon dioxide (CO_2) is 1085.50 ppm, and carbon monoxide (CO) is 2.79 ppm.

Table 4.2: The concentration of indoor air pollutants (PM_{10}, CO_2 and CO) in the express bus

Variables	Mean±SD	Range
Concentration of PM_{10} ($\mu g/m^3$)	220.00±120.00	10.00 – 410.00
Concentration of CO (ppm)	2.79±0.95	1.20 – 4.60
Concentration of CO_2 (ppm)	1085.50±460.98	466.00 – 2147.00

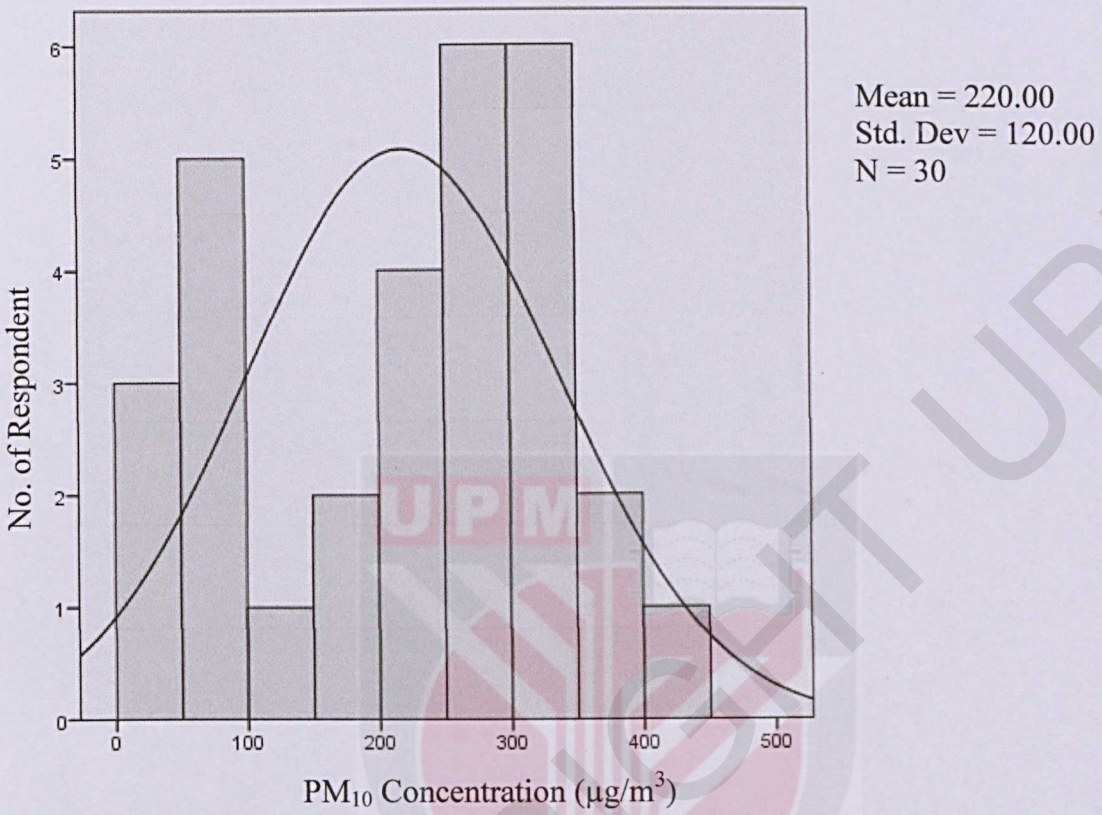

Figure 4.1: The distribution of PM_{10} concentration level among respondents

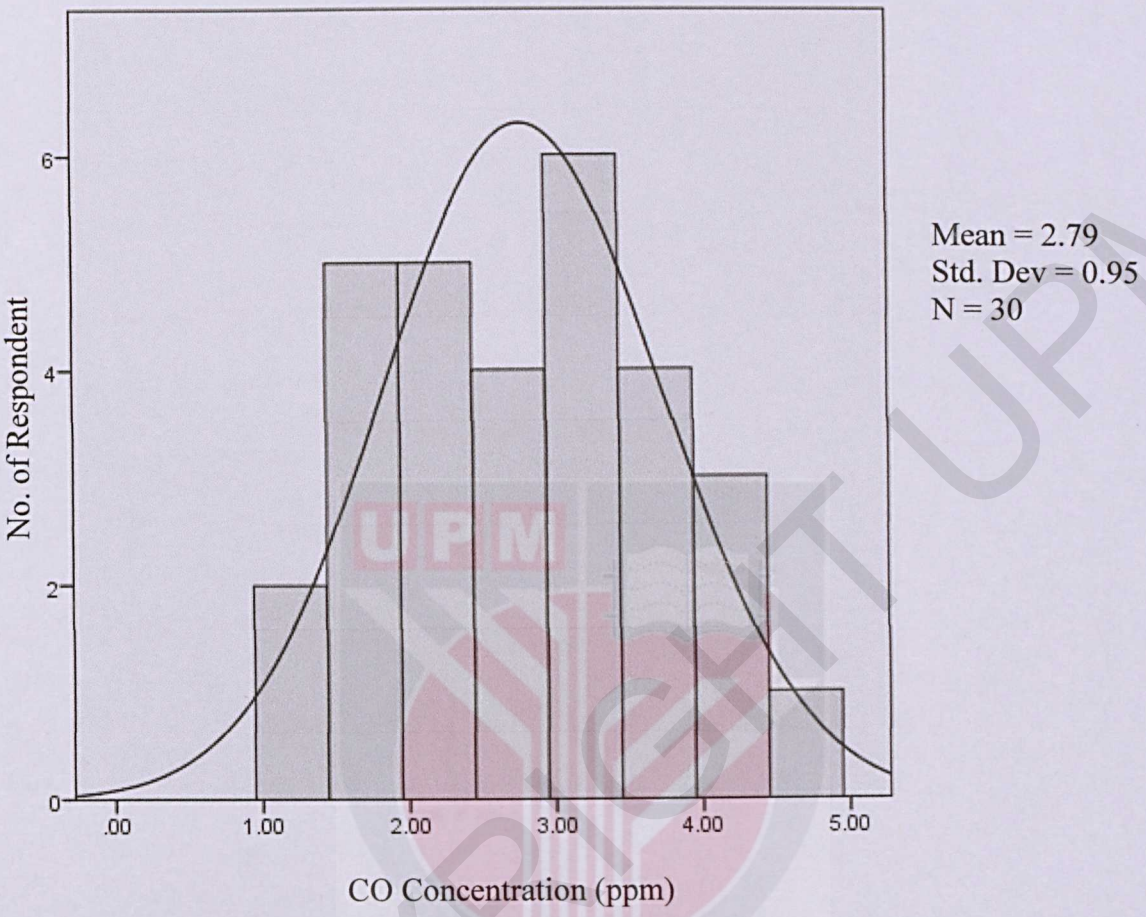

Figure 4.2: The distribution of CO_2 concentration level among respondents

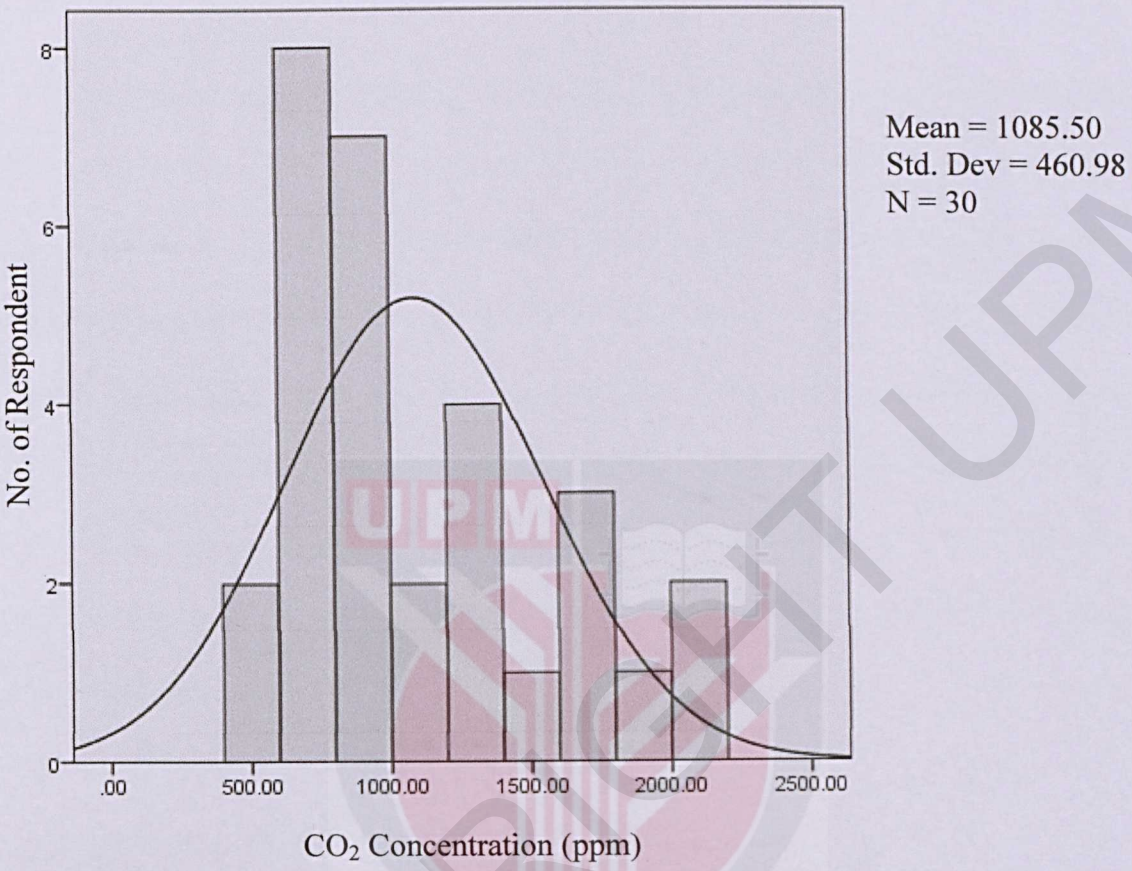

Figure 4.3: The distribution of CO_2 concentration level among respondents

4.2.3 Respiratory Health Symptoms

The modified questionnaire from the American Thoracic Society-Adult Questionnaire (ATS) was used to identify the prevalence of respiratory symptoms among respondents. There were 8 respiratory symptoms that have been studied in order to find its association with indoor air pollutants level. Table 4.3 showed the respiratory symptom that experienced by the respondents. The most common symptoms experienced by respondents were sore throat (43.3%), runny nose (33.3%), and blocked nose (26.7%). Table 4 showed the chronic respiratory symptoms that were reported among drivers were phlegm (23.3%), cough (20.0%), wheezing (13.3%) and chest tightness (10.0%).

Table 4.3 Respiratory health symptoms among respondents

Variables	Study group n (%)	
	Yes	No
Dry eye	17 (56.7)	13 (43.3)
Watery/itchy eye	12 (40.0)	18 (60.0)
Stuffy nose	8 (26.7)	22 (73.3)
Runny nose	10 (33.3)	20 (66.7)
Sore throat	13 (43.3)	17 (56.7)
Exhausted/ fatigue	23 (76.7)	7 (23.3)
Headache	9 (30.0)	21 (70.0)
Dry/itchy skin	6 (20.0)	24 (80.0)

N = 30

4.2.4 Lung Function Test

Lung function test was done to assess the respiratory health and impairment of bus drivers. By having this data, we can identify the association between indoor air pollutants concentration and respiratory symptoms experienced by respondents. Lung function test were performed after arrived to their destination to determine the reduction of lung function among respondents. Table 4.4(a) showed the FVC% predicted FEV_1% predicted and % FEV_1/FVC of lung function abnormalities and table 4.4(b) showed the prevalence of lung function abnormality.

Table 4.4(a): Lung function of respondents

Variables	Median(IQR)	Range
FVC% predicted	85.29(35.91)	17.00-123.00
FEV_1% predicted	99.57(44.10)	6.00-120.00
FEV_1/FVC%	109.09(18.25)	35.00-167.00

N=30

Table 4.4(b): Prevalence of Lung Function abnormality

Variables		Study Group N = 30	
		n	%
FVC% predicted	Abnormal	15	50.0
	Normal	15	50.0
FEV_1% predicted	Abnormal	15	50.0
	Normal	15	50.0
FEV_1/FVC%	Abnormal	14	46.7
	Normal	16	53.3

Abnormal <80%

Normal>80%

4.3 Bivariate Analysis

4.3.1 Association between levels of Indoor Air Pollutants Concentration (PM_{10}, CO_2 And CO) Respiratory Symptoms

The result from table 4.5(a) showed that there was non-significant increased risk of chronic cough (OR = 1.69, 95%CI = 0.26-11.07) for PM_{10} levels of concentration. Table 4.5(b) showed that there was non-significant increased risk of chest tightness (OR = 2.91, 95%CI = 0.23-36.16), wheezing (OR = 1.36, 95%CI = 0.17-11.23), blocked nose (OR = 1.44, 95%CI = 0.28-7.34), and runny nose (OR = 1.50, 95%CI = 0.33-6.92) for CO_2 levels of concentration. Table 4.5(c) showed that there was non-significant of respiratory symptom for CO levels of concentration.

Table 4.5(a): Association between level of PM_{10} concentration and respiratory symptoms

Variables	Exposure to PM_{10} n(%)		x^2	p	OR	95% CI
	High	Low				
Chronic Cough						
Yes	4(23.5)	2(15.4)	-	0.672[a]	1.692**	0.259-
No	13(76.5)	11(84.6)				11.065
Chronic Phlegm						
Yes	3(17.6)	4(30.8)	-	0.666[a]	0.482	
No	14(82.4)	9(69.2)				0.087-2.680
Chest tightness						
Yes	0(0.0)	3(23.1)	-	0.070[a]	0.370	
No	17(100)	10(76.9)				0.226-0.606
Wheezing						
Yes	2(11.8)	2(15.4)	-	1.000[a]	0.733	
No	15(88.2)	11(84.6)				0.089-6.041
Dry eye						
Yes	8(47.1)	9(69.2)	1.475	0.225	-	
No	9(59.2)	4(30.8)				-
Watery/itchy eye						
Yes	6(35.5)	6(46.2)	0.362	0.547	-	
No	11(64.7)	7(53.8)				-
Blocked nose						
Yes	4(23.5)	4(30.8)	-	0.698[a]	0.692	
No	13(76.5)	9(69.2)				0.136-3.518
Runny nose						
Yes	4(23.5)	6(46.2)	-	0.255[a]	0.359	
No	13(76.5)	7(53.8)				0.075-1.714
Sore throat						
Yes	7(41.2)	6(46.2)	0.074	0.785	-	
No	10(58.8)	7(53.8)				-
Exhausted/fatigue						
Yes	13(76.5)	10(76.9)	-	1.000[a]	0.975	
No	4(23.5)	3(23.1)				0.177-5.358
Headache						
Yes	4(23.5)	5(38.5)	-	0.433[a]	0.492	
No	13(76.5)	8(61.5)				0.101-2.396
Dry /itchy skin						
Yes	3(17.6)	3(23.1)	-	1.000[a]	0.714	
No	14(82.4)	10(76.9)				0.119-4.297

*significant at $p<0.05$, **OR significant >1 at 95% CI, [a] Fisher Exact Test, N = 30

Table 4.5(b): Association between level of CO_2 concentration and respiratory symptoms

Variables	Exposure to CO_2 n(%)		x^2	p	OR	95% CI
	High	Low				
Chronic Cough						
Yes	2(15.4)	4(23.5)	-	0.672[a]	0.591	0.090-3.864
No	11(84.6)	13(76.5)				
Chronic Phlegm						
Yes	3(23.1)	4(23.5)	-	1.000[a]	0.975	0.177-5.385
No	10(76.9)	13(76.5)				
Chest tightness						
Yes	2(15.4)	1(5.9)	-	0.565[a]	2.909**	0.234-36.164
No	11(84.6)	16(94.1)				
Wheezing						
Yes	2(15.4)	2(11.8)	-	1.000[a]	1.364**	0.166-11.233
No	11(84.6)	15(88.2)				
Dry eye						
Yes	7(53.8)	10(58.8)	0.074	0.785	-	-
No	6(46.2)	7(41.2)				
Watery/itchy eye						
Yes	5(38.5)	7(41.2)	0.023	0.880	-	-
No	8(61.5)	10(58.8)				
Blocked nose						
Yes	4(30.8)	4(23.5)	-	0.698[a]	1.444**	0.284-7.341
No	9(69.2)	13(76.5)				
Runny nose						
Yes	5(38.5)	5(29.4)	-	0.705[a]	1.500**	0.325-6.918
No	8(61.5)	12(70.6)				
Sore throat						
Yes	6(46.2)	7(41.2)	0.074	0.785	-	-
No	7(53.8)	10(58.8)				
Exhausted/fatigue						
Yes	9(69.2)	14(82.4)	-	0.666[a]	0.482	0.087-2.680
No	4(30.8)	3(17.6)				
Headache						
Yes	3(23.1)	6(35.3)	-	0.691[a]	0.550	0.108-2.805
No	10(76.9)	11(64.7)				
Dry /itchy skin						
Yes	3(23.1)	3(17.6)	-	1.000[a]	1.400**	0.233-8.421
No	10(76.9)	14(82.4)				

*significant at $p<0.05$, **OR significant >1 at 95% CI, [a]Fisher Exact Test, N = 30

Table 4.5(c): Association between level of CO concentration and respiratory symptoms

Variables	Exposure to CO n(%)		x^2	p	OR	95% CI
	High	Low				
Chronic Cough						
Yes	3(18.8)	3(21.4)	-	1.000[a]	0.846	0.141-5.070
No	13(81.2)	11(78.6)				
Chronic Phlegm						
Yes	3(18.8)	4(28.6)	-	0.675[a]	0.577	0.104-3.186
No	13(81.2)	10(71.4)				
Chest tightness						
Yes	1(6.3)	2(14.3)	-	0.586[a]	0.400	0.032-4.960
No	15(93.7)	12(85.7)				
Wheezing						
Yes	2(12.5)	2(14.3)	-	1.000[a]	0.857	0.104-7.043
No	14(87.5)	12(85.7)				
Dry eye						
Yes	8(50.0)	9(64.3)	0.621	0.431	-	-
No	8(50.0)	5(35.7)				
Watery/itchy eye						
Yes	5(31.3)	7(50.0)	1.094	0.296	-	-
No	11(68.7)	7(50.0)				
Blocked nose						
Yes	2(12.5)	6(42.9)	-	0.101[a]	0.190	0.031-1.177
No	14(87.5)	8(57.1)				
Runny nose						
Yes	3(18.8)	7(20.0)	-	0.122[a]	0.231	0.045-1.184
No	13(81.2)	7(50.0)				
Sore throat						
Yes	5(31.3)	8(57.1)	2.039	0.153	-	-
No	11(68.7)	6(42.9)				
Exhausted/fatigue						
Yes	12(75.0)	11(78.6)	-	1.000[a]	0.818	0.149-4.505
No	4(25.0)	3(21.4)				
Headache						
Yes	3(18.8)	6(42.9)	-	0.236[a]	0.308	0.060-1.589
No	13(81.2)	8(57.1)				
Dry /itchy skin						
Yes	2(12.5)	4(28.6)	-	0.378[a]	0.357	0.054-2.344
No	14(87.5)	10(71.4)				

*significant at $p<0.05$, **OR significant >1 at 95% CI, [a] Fisher Exact Test, N = 30

4.3.2 Association between levels of Indoor Air Pollutants Concentration (PM_{10}, CO_2 And CO) Lung Function

The result from table 4.6(a), the result showed that there is significant different between levels of PM_{10} concentration and FVC% predicted value while result from Table 4.6(b) and 4.6(c) showed that there were no significant between exposure CO_2 and CO levels of concentration.

Table 4.6(a): Association between level of PM_{10} concentration and lung function

Variables		Exposure of PM_{10} n(%)		x^2	p
		High	Low		
FVC% predicted	Abnormal	12(70.6)	3(23.1)	6.652	0.010*
	Normal	5(29.4)	10(76.9)		
FEV_1% predicted	Abnormal	10(58.8)	5(38.5)	1.231	0.269
	Normal	7(41.2)	8(61.5)		
FEV_1/FVC%	Abnormal	8(47.1)	6(46.2)	0.002	0.961
	Normal	9(52.9)	7(53.8)		

*significant at $p<0.05$
N = 30

Table 4.6(b): Association between level of CO_2 concentration and lung function

Variables		Exposure of CO_2 n(%)		x^2	p
		High	Low		
FVC% predicted	Abnormal	6(46.2)	9(52.9)	0.136	0.713
	Normal	7(53.8)	8(47.1)		
FEV_1% predicted	Abnormal	6(46.2)	9(52.9)	0.136	0.713
	Normal	7(53.8)	8(47.1)		
FEV_1/FVC%	Abnormal	6(46.2)	8(47.1)	0.002	0. 961
	Normal	7(53.8)	9(52.9)		

*significant at p<0.05
N = 30

Table 4.6(c): Association between level of CO concentration and lung function

Variables		Exposure of CO n(%)		x^2	p
		High	Low		
FVC% predicted	Abnormal	9(56.3)	6(42.9)	0.536	0.464
	Normal	7(43.7)	8(57.1)		
FEV_1% predicted	Abnormal	7(43.7)	8(57.1)	0.536	0.464
	Normal	9(56.3)	6(42.9)		
FEV_1/FVC%	Abnormal	7(43.7)	7(50.0)	0.117	0.732
	Normal	9(56.3)	7(50.0)		

*significant at p<0.05

4.3.3 Association between Working Duration (Years) and the Lung Function Parameters

From the normality test, it showed that the data was not normally distributed. Hence, Spearman's rho test was used to determine the correlation between working duration (years) and the lung function parameters among respondents. Table 4.7 showed that there were significant correlation between years of working duration with FVC predicted ($p = 0.016$) and FEV_1 predicted ($p = 0.013$).

Table 4.7: Correlation between Working Duration (Years) and the Lung Function Parameters among Respondents

Variables	Working Duration (Years)	
	Study group (N = 30)	
	r value	p value
FVC (litre/s)	-0.434	0.016*
FEV_1 (litre/s)	-0.450	0.013*
FVC % predicted	0.149	0.433
FEV_1 % predicted	0.235	0.212
FEV_1/FVC % predicted	0.266	0.156

*significant at $p<0.05$

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

5.1.1 Background and selection of respondents

This study involved 30 long distance express bus drivers who fulfilled the inclusion criteria from local transportation company which exposed to the indoor air pollutants inside air conditioned bus such as particulate matter (PM_{10}), carbon dioxide (CO_2) and carbon monoxide (CO). Due to limited time of conducting the study, only 30 respondents were volunteered to participate and fulfilled the inclusion criteria in this study.

5.1.2 Socio-demographic data

The respondents were selected by following the inclusive criterias such as age between 20 to 56 years old, experienced of driving long distance bus for at least 1 year, no history of chronic lung disease. From the result, the mean age of the

respondents is 41.70 ± 7.80 years old. Age was considered as an important factor in present study as to understand the susceptibility to air pollutant-induced lung disease. According to Sheldon (2000), factors such as age, weight and height are important factors that can influence the lung function parameters among the subject. Aging has been associated with various lung diseases due to human immunological function (Kavita et. al., 2010). The mean height for the study group was 166.43 ± 4.45 cm while on the other hand; the mean weight was 64.73 ± 6.35 kg among the study group. Height and weight were measured and has been identified as normal BMI. The mean for working experienced was 7.77 ± 6.16 years.

5.1.3 Indoor Air Pollutants Concentration

Table 4.2 showed the concentration of indoor air pollutants (PM_{10}, CO_2 and CO) in the express bus. From the data obtained, the concentration of particulate matter (PM_{10}) is 220.00±120.00µg/m3, carbon dioxide (CO_2) is 1085.50 ppm, and carbon monoxide (CO) is 2.79 ppm.

5.1.3.1 Particulate Matter (PM_{10})

The concentration levels of PM_{10} in the long distance buses were 220µg/m^3 which high compared to transit bus (196.17µg/m^3) done by Nurrul Fariza (2006) but there is no standard has been published regarding exposure of indoor air pollutants in transportation. Other studies in developing countries have reported the range of PM_{10}

values inside cars (65-14017μg/m^3), bus (125-184μg/m^3) and subway (55-7817μg/m^3) (Chan, Lau, Lee, et al. 2002).

5.1.3.2 Carbon Dioxide (CO_2)

From the data obtained, the concentration of CO_2 (1085.50 ppm) were high compared to study done by Nurrul Fariza (2006) in transit bus (669 ppm) but lower compared to study done by Jones, Lam and Dean (2005) in air conditioned bus in Hong Kong (2113.8 ppm). Concentration level of CO_2 inside air conditioned buses reflected the insufficient of ventilation inside the bus and also caused by the number of passenger inside buses.

5.1.3.3 Carbon Monoxide (CO)

The CO levels (2.79ppm) in the long-distance buses in this study were much lower than those obtained from urban buses in Athens, Greece (9.6 ppm, Duci et al., 2003, Hsu & Huang, 2009). According to Nurrul Fariza (2006), the CO level concentration inside transit bus was 5.77ppm which is higher than long distance express bus. Source of CO inside the buses were from the incomplete combustion that emitted by vehicles.

5.1.4 Respiratory Health Symptoms

Respiratory symptoms among the respondents were obtained by using American Thoracic Society Questionnaires (ATS, 1978). Eight respiratory symptoms being studied among the respondent but not all them were having the same respiratory symptoms. It is common for people to report one or more of the following symptoms dryness and irritation of the eyes, nose, throat, and skin, headache, fatigue, shortness of coughing and sneezing, dizziness, etc.

Some people may not be sensitive to indoor air quality problems in the early years of exposure but can become sensitized as exposure continues over time (Canadian Centre for Occupational Health and Safety, 2011). The most common symptoms experienced by respondents were sore throat (43.3%), runny nose (33.3%), and blocked nose (26.7%). Table 4.2.3 showed the chronic respiratory symptoms that were reported among drivers were phlegm (23.3%), cough (20.0%), wheezing (13.3%) and chest tightness (10.0%).

Compared to study done by Jones, Lam and Dean (2005), long distance express bus drivers experienced sore throat (11.1%), Runny nose (8.0%), chronic cough (7.7%) and chest tightness (6.7%). Zainuddin. Z (2005) found that transit bus drivers experienced phlegm (37.3%), chest tightness (31.8%), cough (25.9%), and wheezing (16.4%). According to Nurrul Fariza (2006), respiratory symptoms such as

cough is the indicator of airway irritant stimuli to air pollutants and it may occur early response to irritant receptor in the air way.

5.1.5 Lung Function Test

Lung function test is one of the indicators to determine whether the respondent experienced respiratory health problem. By having this data, we can identify the association between indoor air pollutants concentration. Lung function test were performed after arrived to their destination. Study from Nurrul Fariza found that the median and mean of drivers exposed to indoor air pollutants for FVC% predicted, FEV_1% predicted and FEV_1/FVC% predicted were lower compared to this study which is 78.4 ± 16.34, 82.4(31.12) and 105.7(23.9).

Table 4.2.4(a) showed the distribution of lung function among respondents. From the result, median and IQR of FVC% predicted, FEV_1% predicted and FEV_1/FVC% of lung function were 85.29(35.91), 99.57(44.10) and 109.09(18.25). Table 4.2.4(b) showed the prevalence of Lung Function abnormality. Normal FVC% predicted value and FEV_1% predicted value are 80%. FVC% predicted value and FEV1% predicted value below 80% are considered as abnormal. From the result, 50.0% was classified as abnormal for FVC% predicted value and FEV_1% predicted value while for FEV_1/FVC% predicted value was 46.7%. Study done by Nurrul Fariza (2006) found that the abnormalities in FVC% predicted and FEV1% predicted

were 50.9 percent and 49.1 which is near to the finding of this study but FEV1/FVC% predicted were lower high lower which is 9.4 percent.

5.1.6 Association between Concentration of Indoor Air Pollutants (PM_{10}, CO_2 And CO) Exposure and Respiratory Symptoms among Respondents

From the normality test, it showed that the data was normally distributed. Table 4.5(a) showed the high levels of PM_{10} concentration (≥220ppm) to respiratory symptoms and lower level of PM_{10} concentration (≤220ppm). From the result, it showed that there was non-significant increased risk of chronic cough (OR = 1.69, 95%CI = 0.26-11.07) for PM_{10} levels of concentration. Table 4.5(b) showed the high levels of CO_2 concentration (≥1085.50ppm) to respiratory symptoms and lower level of CO_2 concentration (≤1085.50ppm).

From the result, it showed that there was non-significant increased risk of chest tightness (OR = 2.90, 95%CI = 0.23-36.16), wheezing (OR = 1.36, 95%CI = 0.17-11.23), blocked nose (OR = 1.44, 95%CI = 0.28-7.34), and runny nose (OR = 1.50, 95%CI = 0.33-6.92) for CO_2 levels of concentration. Table 4.5(c) showed the high levels of CO concentration (≥2.79ppm) to respiratory symptoms and lower level of CO concentration (≤2.79ppm).

From the result, it showed there was non-significant of respiratory symptom for CO levels of concentration. There were no significant due to the small number of respondents in this study. Headache, dizziness, fatigue and dyspnea shows the occurrence of CO. Unintentional exposure to CO can be attributed to smoke inhalation from inadequately vented combustion appliances, and from vehicles and tobacco smoke.

Acute effects are due to the formation of carboxyhaemoglobin in the blood, which inhibits oxygen intake and caused difficulty of breathing or chest tightness (WHO, 2008). The ventilation system in closed buses may serve to concentrate CO_2 generated by passengers and other pollutants if the exchange of air is not effective. Exposure to CO_2 for long duration with high concentration caused a feeling of an inability to breathe (dyspnea), increased pulse rate, headache, and skin itchy.

The symptoms experienced by the respondent may due to the long-term exposures with lower concentration level. Zainuddin et. al., (2005) and Pope and Dockery (1999) found that there was association between lower respiratory symptoms, asthma, cough and reduction of lung function. Even though in this study showed that there is no significant, the respondents still have the risks of respiratory symptoms in long term.

5.1.7 Association between Concentration of Indoor Air Pollutants (PM_{10}, CO_2 And CO) Exposure and Lung Function Parameters among Respondents

From the normality test, it showed that the data was not normally distributed. Table 4.6(a) showed the high levels of PM_{10} concentration (≥220ppm) to lung function and lower level of PM_{10} concentration (≤220ppm). Table 4.6(b) showed the high levels of CO_2 concentration (≥1085.50ppm) to lung function and lower level of CO_2 concentration (≤1085.50ppm). Table 4.6(c) showed the high levels of CO concentration (≥2.79ppm) to respiratory symptoms and lower level of CO concentration (≤2.79ppm).

The result from table 4.3.2(a) showed that there is significant different between levels of PM_{10} concentration and FVC% predicted value ($p<0.01$). Table 4.6(b) and 4.6(c) showed that there was no significant different risk between levels of CO_2 and CO concentration. There were no significant due to the small number of respondents in this study. Exposure to low concentration of PM_{10} in long duration can caused impairment of lung function to the respondent.

Concentration level of PM_{10} ($220.00\pm120.00\mu g/m^3$) is considered as lower but it has potential of risk to develop chronic disease of lung function while exposure to CO_2 and CO does not have any correlation with lung function problems. The effects of indoor air pollutants to respiratory health depends on many factors such as level of pollutants exposures, duration of exposure, individual susceptibility level

and also their individual features such as age, gender, smoking habit, genetic and eating habit (Zainuddin et. al., 2005)

5.1.8 Association between Working Duration (Years) and the Lung Function Parameters among Respondents

Shapiro-Wilk test was used to determine the normality of the data. From the test, it showed that the data was not normally distributed and Spearman's rho test was used to determine the correlation between working duration (years) and the lung function parameters among respondents. Table 4.7 showed that the results were inverse significant correlation between working duration with FVC predicted ($p = 0.016$, $r = -0.434$) and FEV_1 predicted ($p = 0.013$, $r = -0.0450$) which indicated that duration of exposure to air pollutants also contributed to decreasing in lung function.

There is no correlation between working duration with FVC % predicted, FEV_1 % predicted and FEV1/FVC % predicted. According to Zainuddin (2005), lung function depended on health status, eating habit, smoking status and lifestyle. There is possibility that the respondents were exposed to indoor air pollutants for a long-term but practice the healthy life style and does not have lung function decline that is apparent.

5.2 Conclusion

This study reported that among 30 long distance bus drivers involved as the respondent. Common symptoms experienced by respondents were sore throat (43.3%), runny nose (33.3%), and blocked nose (26.7%). Chronic respiratory symptoms that were reported among bus drivers were phlegm (23.3%), cough (20.0%), wheezing (13.3%) and chest tightness (10.0%). Exposure to PM_{10} in air conditioned buses such as long distance express buses can increase the risk of respiratory illness and the reduction of lung function among bus drivers.

The respiratory concentrations of PM_{10}, CO_2 and CO were acceptable according to indoor air guidelines by ASHRAE. Exposure to air pollutants over a long period of time and continuously while driving has potential to cause chronic effect to the drivers' respiratory health. Therefore control measures may need to improve in these situations.

5.3 Recommendation

In order to reduce the risk of respiratory diseases among bus drivers, top management from this company need to take an action for example by doing preventive measure for maintenance of air condition of the buses to ensure that the system are in good condition. Exhaust of the buses should be check frequently to

identify whether there is leakage from the exhaust which can contribute to the accumulation of air pollutants inside buses through the air conditioner.

Housekeeping inside the buses should be done frequently to maintain the good condition. PVC carpet should not use for floor carpet inside buses to avoid deposition of particulate. Further research should be done which involve a large sample size and increase the number of pollutants parameter such as volatile organic compounds, nitrogen dioxide, particulate matter less than 2.5 μm ($PM_{2.5}$) and ozone.

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APPENDIX 1

APPENDIX 2

APPENDIX 3

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

PENERANGAN KEPADA PESERTA
TAJUK KAJIAN : PENDEDAHAN KEPADA PENCEMARAN UDARA DALAMAN (PM_{10}, CO_2 dan CO) DAN MASALAH PERNAFASAN DI KALANGAN PEMANDU BAS EKSPRES JARAK JAUH.
PENYELIDIK : MOHD FIRDAUS BIN OTHMAN

Terima kasih kerana membantu kami di dalam kajian ini.

Apakah kajian ini?

Kualiti udara dalaman (IAQ) yang baik diperlukan bagi persekitaran kerja dalaman yang sihat. Kualiti udara dalaman yang kurang baik boleh menyebabkan pelbagai masalah kesihatan jangka pendek dan jangka panjang. Masalah kesihatan yang biasanya dikaitkan dengan IAQ kurang baik termasuk tindak balas alahan, masalah pernafasan, kerengsaan mata, sinusitis, bronkitis dan pneumonia. Masalah IAQ berlaku di dalam bangunan yang dilengkapi sistem pengalihudaraan mekanikal dan penyaman udara (MVAC) termasuk unit pendingin udara pisah. Masalah IAQ boleh disebabkan oleh bahan cemar udara dalaman atau pengalihudaraan yang tidak mencukupi.

Pendedahan kepada pencemaran udara dalaman (PM_{10}, CO_2 dan CO) berhubungkait dengan fungsi pernafasan di mana ia dapat menghalang paru-paru dari beroperasi dengan baik kerana ianya dicemari dengan bedasing yang boleh menjejaskan kesihatan manusia. Kemasukan pencemar ini boleh berlaku disebabkan oleh sistem ventilasi dan pengudaraan yang tidak baik dan rosak.

Berdasarkan maklumat yang diperoleh dari kajian ini, beberapa usaha boleh dijalankan bagi mengawal pencemaran udara dalaman di ruang pemandu bas ekspres daripada melebihi had yang di tetapkan di dalam panduaan Kualiti Udara Dalaman dari JKKP. Antaranya adalah kawalan pencemaran udara yang boleh dipraktikkan iaitu melalui undang-undang, pendidikan dan teknikal.

Apakah tujuan kajian ini?

Kajian ini dijalankan adalah bertujuan untuk mengenalpasti hubungan di antara pendedahan kepada pencemaran udara dalaman (PM_{10}, CO_2 dan CO) dengan masalah pernafasan di kalangan pemandu .

Berapa ramai responden yang terpilih?

Responden akan dipilih dari kalangan pemandu bas ekspres jarak jauh yang terdedah kepada pencemaran udara dalaman (PM_{10}, CO_2 dan CO). Seramai 83 orang pekerja dan dipilih.

Apakah jenis ujian yang akan dilakukan?

Semua responden akan diberi borang soal selidik oleh pengkaji. Selain itu, bagi pekerja di ruang pemandu bas ekspres, kualiti udara yang disedut oleh setiap individu akan diukur menggunakan *TSI Dust Trak 8520 Aerosol Monitor* untuk *particulate matter (PM_{10})* dan *TSI 8554 Q-Trak Plus* untuk CO_2 dan CO .

Adakah bayaran dikenakan?

Pengkaji akan menanggung segala pembiayaan ujian yang akan dijalankan dan tiada sebarang bayaran dikenakan terhadap setiap responden.

APPENDIX 4

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

BORANG PENYERTAAN PESERTA

1. Saya,.....No.K/P.....bersetuju untuk menyertai kajian bertajuk "**PENDEDAHAN KEPADA PENCEMARAN UDARA DALAMAN (PM_{10}, CO_2 dan CO) DAN MASALAH PERNAFASAN PEMANDU BAS EKSPRES JARAK JAUH**".

2. Saya telah membaca dan memahami isi kandungan kajian berdasarkan apa yang telah dinyatakan di dalam **"PENERANGAN KEPADA PESERTA"** yang telah dilampirkan bersama surat kebenaran ini dan penerangan tambahan daripada penyelidik.

3. Saya faham bahawa kajian ini dijalankan untuk mengenalpasti kaitan di antara pendedahan pencemaran udara dalaman individu terhadap masalah pernafasan manusia.

4. Saya faham bahawa kajian ini mungkin akan melibatkan fizikal dan mental berdasarkan aktiviti pengutipan data yang dijalankan.

5. Saya faham bahawa segala maklumat yang diberikan dan segala keputusan yang saya perolehi adalah sulit dan hanya akan digunakan untuk tujuan penyelidikan dan rujukan penyelidik.

6. Saya juga faham bahawa maklumat ini boleh digunakan untuk penerbitan tetapi setiap individu tidak akan dinyatakan identitinya.

7. Saya faham bahawa saya mempunyai hak untuk menarik diri dan juga mempunyai hak untuk menarik semula keizinan pada bila-bila masa sekiranya perlu apabila merasa tidak selesa pada mana-mana ujian atau aktiviti yang dijalankan oleh penyelidik semasa kajian dijalankan dan tiada sebarang tindakan boleh dikenakan ke atas tindakan tersebut.

.....
(Tandatangan peserta)

Nama :.....
No. K/P :.....
Tarikh :.....

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Adakah maklumat dijamin sulit?

Semua maklumat yang diberikan oleh responden di dalam borang kaji selidik adalah dijamin sulit. Tiada huraian individu akan dibuat pada mana-mana bahagian di dalam kajian atau penerbitan.

Apakah hak anda?

Kajian ini melibatkan anda secara sukarela. Oleh itu, peserta mempunyai hak untuk menarik diri dari penyertaan dalam kajian ini pada bila-bila masa sekiranya peserta merasa tidak selesa untuk memberikan maklumat kepada pengkaji.

Apakah yang anda akan dapati?

Kajian ini akan menjelaskan samada pendedahan kepada pencemaran udara dalaman (PM_{10}, CO_2 dan CO) boleh mengakibatkan masalah kepada fungsi paru-paru atau tidak kepada pemandu bas ekspres jarak jauh yang terdedah. Andainya tahap pencemaran udara dalaman (PM_{10}, CO_2 dan CO) adalah tinggi dan memberi kesan kepada responden, maklumat kajian ini berguna untuk tindakan selanjutnya. Melalui hasil kajian tersebut, beberapa polisi boleh digubal atau dilaksanakan oleh pihak MARA LINER untuk meningkatkan taraf kesihatan pekerja. Melalui kajian ini juga, anda dapat menentukan samada anda mengalami masalah sistem pernafasan atau tidak tanpa dikenakan sebarang bayaran dan ianya berfaedah untuk anda.

Apakah yang harus anda lakukan?

Anda dikehendaki menandatangani borang penyertaan responden yang menyatakan minat anda untuk menyertai kajian ini. Ianya boleh dilakukan setelah anda membaca dan memahami isi kandungan penerangan ini. Borang penyertaan responden boleh dikembalikan kepada pengkaji sebelum temubual dan ujian yang akan dijalankan. Sekiranya anda mempunyai sebarang kemusykilan, pengkaji akan membantu untuk member maklumat yang selanjutnya.

Terima kasih atas kerjasama dan bantuan anda.

MOHD FIRDAUS BIN OTHMAN
Penyelidik
B. Sc. Kesihatan Persekitaran dan Pekerjaan
012 - 7058365

APPENDIX 5

FAKULTI PERUBATAN DAN SAINS KESIHATAN
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ISIKAN KOTAK KOSONG YANG DISEDIAKAN

BAHAGIAN A : DATA RESPONDEN

1. No. Responden : ☐☐☐☐ (isikan)

2. Nama :

3. Alamat :

4. No. Telefon :

5. Umur : ☐☐ tahun

6. Bangsa : Melayu ☐ Cina ☐ India ☐ Lain-lain ☐

   Jika lain-lain, nyatakan : ____________________

7. Tinggi : ☐☐☐ cm   8. Berat : ☐☐☐ kg

9. Status Perkahwinan : Bujang ☐ Berkahwin ☐ Duda ☐

10. Tahap pendidikan: Tidak bersekolah ☐ Sekolah rendah ☐ Tingkatan 3 ☐ Tingkatan 5 ☐ STPM/Diploma ☐

11. Adakah anda merokok? ☐ Ya ☐ Tidak

    Jika Ya, secara purata berapa batang dalam sehari? ☐☐☐ Batang

BAHAGIAN B : MAKLUMAT PEKERJAAN

B (i) : SEJARAH PEKERJAAN DAHULU

1. Sebelum berkerja di syarikat sekarang, pernahkah anda berkerja di tempat lain?

   Ya ☐ Tidak ☐

2. Adakah pekerjaan dahulu anda melibatkan pemanduan bas?

   Ya ☐ Tidak ☐

Jika **Ya**, sila nyatakan;		
Pekerjaan	Jumlah tahun bekerja	Anggaran jam memandu sehari bekerja
Jika **Tidak**, sila nyatakan;		

B (ii) : MAKLUMAT PEKERJAAN SEKARANG

3. Berapa lamakah anda telah bekerja sebagai pemandu bas di syarikat ini?

   ☐☐ Tahun

4. Adakah kerja anda sekarang mengikut syif?

   Ya ☐ Tidak ☐

5. Secara purata, berapa jam dalam sehari anda memandu bas?

   ☐☐ Jam

6. Secara purata, berapa jamkah anda bekerja di dalam bas dalam masa seminggu?

   ☐☐ Jam

7. Purata masa yang diperuntukkan untuk melengkapkan satu trip / perjalanan di dalam masa sehari?

☐☐ Jam

8. Secara purata, berapa tripkah yang anda perlu dilakukan dalam masa satu hari?

☐☐ Trip

9. Secara kebiasaannya, berapa lamakah anda dapat berehat selepas satu trip?

☐☐ Jam

10. Purata cuti dalam seminggu?

☐☐ Hari

BAHAGIAN C: MAKLUMAT TENTANG KESIHATAN

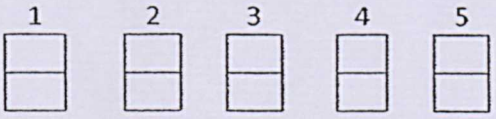
1. Sepanjang tempoh anda memandu bas, adakah anda mengalami gejala-gejala berikut lebih dari dua kali? Sila tandakan ☑ pada yang berkenaan.

Gejala	Tidak	Ya	Jika Ya, berapa kerapkah anda mengalami gejala tersebut? Sila bulatkan berdasarkan skala berikut: 1. Hampir setiap hari bekerja 2. 3-4 hari setiap seminggu 3. 1-2 hari setiap seminggu 4. Sekali bagi setiap 2-3 minggu 5. Sangat kurang	Adakah gejala tersebut hilang pada hari yang sama?	
				Ya	Tidak
i. Kekeringan mata			1 2 3 4 5		
ii. Mata berair / gatal			1 2 3 4 5		
iii. Hidung tersumbat			1 2 3 4 5		
iv. Hidung berair			1 2 3 4 5		
v. Sakit tekak			1 2 3 4 5		
vi. Letih / lesu			1 2 3 4 5		
vii. Sakit kepala			1 2 3 4 5		
viii. Kulit kering / gatal			1 2 3 4 5		

BAHAGIAN D: KESELESAAN DALAM KENDERAAN

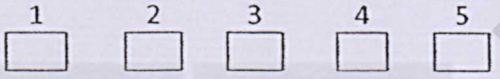
1. Sila tandakan di dalam kotak berkenaan keadaan yang sering anda alami bila memandu di dalam bas dengan menandakan pada skala yang diberikan.

A. *SUHU*



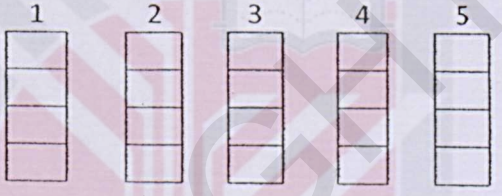
i. Selesa — Tidak selesa
ii. Terlalu panas — Terlalu sejuk

B. *PERGERAKAN UDARA*



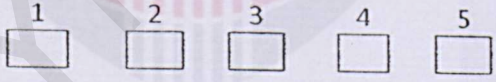
Terlalu tenang — Terlalu berangin

C. *KUALITI UDARA*



i. Kering — Lembab
ii. Segar — Pengap
iii. Tidak berbau — Berbau
iv. Secara keseluruhan memuaskan — Secara keseluruhan tidak memuaskan

2. Tandakan berikut berkenaan dengan tahap keselesaan di dalam bas



Secara keseluruhan memuaskan — Secara keseluruhan tidak memuaskan

BAHAGIAN E : SEJARAH PENYAKIT

1. Pernahkah anda mengalami masalah pernafasan? Ya ☐ Tidak ☐
2. Adakah anda mengalami penyakit ini?
   - i. Asma — Ya ☐ Tidak ☐
   - ii. Emfisema — Ya ☐ Tidak ☐
   - iii. Barah paru-paru — Ya ☐ Tidak ☐
   - iv. Bronkitis yang kronik — Ya ☐ Tidak ☐
   - iv. Lain-lain penyakit? _____
3. Adakah penyakit tersebut disahkan oleh doktor? Ya ☐ Tidak ☐
4. Batuk, Kahak, Kesesakan Nafas, Dan Nafas Berbunyi Batuk
   - i. Adakah anda selalu mengalami batuk? Ya ☐ Tidak ☐
   - ii. Berapa kalikah anda mengalami batuk dalam sehari? ☐☐ Kali sehari
   - iii. Adakah anda mengalami batuk pada waktu siang atau waktu malam? Ya ☐ Tidak ☐
   - iv. Adakah anda mengalami batuk semasa bangun daripada tidur atau di awal pagi? Ya ☐ Tidak ☐
   - v. Adakah anda mengalami batuk hampir setiap bulan untuk 3 bulan berturut-turut dalam setahun? Ya ☐ Tidak ☐
   - vi. Berapa lamakah anda mengalami masalah sebegini? ☐☐ Bulan/tahun
   - vii. Adakah anda mengikuti sebarang rawatan? Ya ☐ Tidak ☐
5. Kahak
   - i. Adakah anda selalu mengalami batuk berkahak? Ya ☐ Tidak ☐
   - ii. Adakah anda mengalami batuk berkahak pada waktu siang atau waktu malam? Ya ☐ Tidak ☐
   - iii. Adakah anda mengalami batuk berkahak semasa bangun daripada tidur atau di awal pagi? Ya ☐ Tidak ☐
   - iv. Adakah anda mengalami batuk 2 kali sehari atau 4 kali atau lebih dalam seminggu? Ya ☐ Tidak ☐
   - v. Adakah anda mengalami masalah batuk berkahak untuk 3 bulan atau lebih secara berturut-turut? Ya ☐ Tidak ☐

6. Kesesakan Nafas

i.	Adakah anda selalu mengalami kesesakan nafas atau dada apabila batuk?	Ya ☐	Tidak ☐
ii.	Adakah anda mengalami masalah ini ketika bekerja?	Ya ☐	Tidak ☐
iii.	Adakah anda mendapat rawatan doktor?	Ya ☐	Tidak ☐
iv.	Adakah anda telah menjalani unian X-ray?	Ya ☐	Tidak ☐

7. Nafas Berbunyi

i.	Pernahkah anda terasa nafas anda berbunyi seperti wisel?	Ya ☐	Tidak ☐
ii.	Berapa lamakah dada berbunyi ini berterusan?	☐☐	Bulan/tahun
iii.	Adakah anda mendapat rawatan doktor untuk masalah ini?	Ya ☐	Tidak ☐

SEKIAN,

TERIMA KASIH.