Traffic-related Air Pollution (TRAP), Air Quality Perception and Respiratory Health Symptoms of Active Commuters in a University Outdoor Environment

M F Zakaria¹, E Ezani¹*, N Hassan², N A Ramli¹, and M I A Wahab³

¹Department of Environmental and Occupational Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Serdang 43400 Selangor, Malaysia
²Department of Human and Societal Wellbeing, Faculty of Social Sciences and Humanities, Universiti Kebangsaan Malaysia, Bangi 43600 Selangor, Malaysia
³Department of Diagnostic and Applied Health Sciences, Faculty of Health Sciences, Jalan Raja Muda Abdul Aziz 50300 Kuala Lumpur, Malaysia

*Corresponding author’s email: elianiezani@upm.edu.my

Abstract. Air quality plays significant role in human’s health and wellbeing. Vehicle exhaust emissions may lead to health risks especially people who are actively commute. This study aims to examine the association between traffic-related air pollution, perception on traffic pollution and respiratory health symptoms among pedestrian and cyclists in a university campus located in Selangor, Malaysia. A self-administered questionnaire was used to collect data on sociodemographic, air quality perception and respiratory health symptoms among university students (N=180). Air pollutants (PM₁₀, PM₂.₅ and ozone(O³)) were measured during rush hour (morning, afternoon and evening) simultaneously with traffic count nearby campus roadsides. The average levels of PM₁₀ (83.8 µg/m³), PM₂.₅ (48.9 µg/m³) and O³ (314.9 µg/m³) were higher during rush hour measurements. 51.1% participants agreed that high number of old and private vehicles were the major contributor of air pollution. There were significant associations between each level of traffic-related air pollutants and air quality perception and respiratory health symptoms (p<0.05). This study suggests preventive measures for the university management to control traffic-related air pollution in the campus areas.

1. Introduction
Air pollution has recently received greater attention due to its detrimental effects to human health. Malaysia has recorded about 26.3 million vehicles registered by end of year 2015 compared to 20.1 million in 2010, an increase of almost 6.2 million vehicles [1]. This traffic congestion may increase vehicle emissions that contribute to outdoor air pollution especially in urban areas [2]. Traffic-related air pollution is a major contributor to outdoor air pollution in urban settings, producing significant amounts of carbon dioxide (CO₂), particulate matter (PM), ozone (O₃), nitrogen dioxide (NO₂), carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs) [2].

Outdoor air pollution has adverse health effects on active commuters, especially pedestrian and cyclists worldwide. Nonetheless, study into this phenomenon in Malaysia is rather limited. A study found out that Port Klang, Malaysia suffered from highest PM₁₀ concentration as there was heavy traffic congestion due to active industrial activities. People who were living and working in that area were...
exposed to high traffic pollution levels [3]. Another study observed from monitoring stations in the Klang Valley, Malaysia had found higher levels of PM$_{10}$, CO, NO$_2$ and SO$_2$ with the effects of traffic congestion [4]. Biomass burning activities and ultra violet radiation from sunlight also contributed significantly to high concentrations of PM$_{10}$ and ozone particularly from the tropics region. United States Environmental Protection Act (USEPA) classifies particle pollution mainly into two different sizes based on their predicted penetration capacity into the lung; coarse particulate matter (PM$_{10}$) and fine particulate matter (PM$_{2.5}$). Coarse particulate matter is a particle with an aerodynamic diameter of 10 µm whereas fine particulate matter with an aerodynamic diameter of 2.5 µm [5]. This type of particulate airborne will be deposited into head region of the airway when inhaled due to its bigger size compared to fine particulate matter which will be deposited further into the tracheobronchial region [6].

The pollutant is generally emitted from vehicle components such as brakes and tires as well as suspension of road dust in urban areas [7].

Active transport could be generalized as any forms of movement that was based on human energy including walking, cycling, scootering, skateboarding, rollerblading and also the use public transport [8]. Promoting these activities in the community may increase their physical activity, decrease pollution level and the impacts, and change the number of accidents. Active travel may cause people having the highest exposure to air pollution as they are directly inhaled the pollutants. A study in the United States had found active travelers were moderately exposed to particulate concentrations especially on major roads whereby pedestrian mostly used passages around activity center such as along main transportation roads which caused them to have high exposure to the pollutants [9]. However, no such studies yet on active travelers’ exposure being conducted in Malaysia. In addition, study on short-term exposure to diesel emissions from transport emissions may cause hypersensitive allergies and asthma-like symptoms [10]. The anthropogenic sources primarily come from the automobile exhaust the ambient air pollutants comprise of carcinogenic and mutagenic compounds and lead to possible health risk among the population especially individuals who are active in outdoor. Clearly, outdoor air pollution threatens human health and wellbeing in many ways. Our health can deteriorate when the air quality is poor.

Thus, preventive measures are urgently needed in order to overcome the health effects of air pollution.

Human perception plays a fundamental role on people’s response to preventive measures [11]. People’s behaviors and responses to preventive measures depends on the way they perceive environmental stimuli, therefore to protect public health through adaptation measures it is significant to consider people’s perception and behavioral changes. The sense of air quality varies among groups and individuals [12]. Our study examines traffic-related air quality perception among active commuters in an outdoor university campus environment. This study on perception suggests improvement of transportation system in the campus and reducing personal’s risk to adverse health effects.

The aim of this study is to examine traffic-related air pollution, perception on air quality and respiratory health symptoms among university students who were actively walking and cycling within campus in one university in Malaysia. The study included measurements of PM$_{10}$, PM$_{2.5}$ and ozone in different traffic rush hour (i.e. morning, afternoon and evening) at three selected roadsides used frequently by the students. Our study also included measurements on perception air quality and respiratory health symptoms. To the best of our knowledge, this study is the first attempt to examine traffic-related air pollution measurements were taken in the morning, afternoon and evening alongside traffic count survey to examine the temporal relationship between period of rush hour and traffic volume.

2. Methodology

Measurements of traffic-related air pollutants (PM$_{10}$, PM$_{2.5}$ and ozone) were conducted between February and March 2018 at three sampling sites in South Campus in a University (Figure 1). For the same period that the sampling was conducted, a self-administered questionnaire used to collect data on sociodemographic, air quality perception and respiratory health symptoms. The questionnaire was distributed to first-and second-year undergraduate students who were actively cycling and walking from their residential college to attend the class at the academic zones in North Campus. Additionally, traffic-related air pollution measurements were taken in the morning, afternoon and evening alongside traffic count survey to examine the temporal relationship between period of rush hour and traffic volume.
2.1. Study location
The South Campus is part of institutional area sited at southern of University main campus in Serdang, Selangor. This campus is located approximately 28 km southeast from central Kuala Lumpur within the region of Klang Valley and District of Hulu Langat. The roads within the campus can be very crowded with local traffics of daily vehicular movements during peak hours due to its location nearby the main road which connected to academic zones at North campus, student’s residential colleges and student health clinic.

2.2. Air sampling
Static ambient measurements for PM$_{10}$, PM$_{2.5}$ and ozone were carried out using Dustrak Aerosol Monitor 8532 (TSI Inc, Shoreview, MN), Sidepak Personal Monitor AM520 (TSI Inc, Shoreview, MN) and Aeroqual Series 500 (Aeroqual, Auckland, NZ) respectively. These real-time monitors were placed on the bench at the height of ~1.1 m elevation above the ground at each sampling point (JA1, JA2 and JU). All measurements were logged to record 5-min average concentrations at three different rush hour morning (7.00 am - 8.00 am), afternoon (1.00 pm - 2.00 pm) and evening (5.00 pm – 6.00 pm). To record day-to-day and rush hour differences in background concentrations, the monitoring at a reference site was conducted for 30 minutes before and after rush hour measurements.

![Sampling locations and reference site at Jalan Alpha 1 (JA1), Jalan Alpha 2 (JA2) and Jalan Universiti (JU) at South Campus. (Source: Google Earth).](image)

2.3. Subject recruitment
A total of 180 participants were involved in an online survey study. The sample size was calculated using the 2 proportions formula giving a minimum sample size 180 after considering the design effect and 20% of non-response rate [13]. Simple random sampling was used. Participants were invited to participate in the study via social media, including WhatsApp and Facebook. Participants were selected based on specific inclusion criteria; (1) actively cycling or walking within campus; (2) age between 19 and 22; (3) first and second year of study; (4) and living in residential colleges within the sampling points (JA1, JA2 and JU). Those with previous history of respiratory illnesses were excluded.
2.3.1. Questionnaire. The questionnaire was adapted and modified from several studies [14, 15, 16]. It consisted of four sections; i) background characteristics of the respondents (7 items), covering questions on sociodemographic, residential information and environmental tobacco smoke; ii) transportation mode (3 items); iii) air quality perception (3 sub-section with 9 items) and iv) respiratory health symptoms among respondents (6 items). The questionnaire was prepared in Malay and English language and underwent a back-to-back translation to ensure that it suggests similar meaning.

2.4. Traffic survey
To assess contribution of main sources of traffic pollutants, a survey of traffic volume by vehicle type was conducted simultaneously with the measurements of PM$_{10}$, PM$_{2.5}$ and ozone. The manual classified count method used to quantify the traffic volume [17]. The variables were categorized into five categories; motorcycles, cars and taxis, buses, light good vehicles and also heavy good vehicles.

2.5. Quality control
All sampling instruments (Dust Trak, Sidepak and Aeroqual) were calibrated by the manufacturer. The sensors were switched on and leave for 10 minutes to ensure it was in a good condition and eliminate any possible errors of data. A pre-test on the questionnaire was held to ensure its comprehensibility. The reliability analysis of each section of the questions showed Cronbach Alpha of 0.7.

2.6. Data analysis
Descriptive analysis was computed for each pollutant concentrations measured in different rush hour using Microsoft Excel 2016. The analysis was including frequencies, percentage, mean, median, interquartile range and standard deviation for sociodemographic, air quality perception and level of traffic-related air pollutants. The data collected from questionnaire were analysed using IBM Statistical Package for the Social Sciences (SPSS), version 22.0. Chi square test was undertaken to measure association between the categorical independent variables and health effects. Level of significance was set at 0.05.

2.7. Ethical approval
Ethics approval was obtained from the University Ethic Committee for Research Involving Human Subjects with the reference number of JKEUPM-2017-197. Informed consent was attached with the questionnaire and distributed to all participants. The anonymity of the participants was maintained at all times.

3. Results

3.1. Traffic-related Air Pollution and Traffic Count
The full list of three traffic-related air pollutants (PM$_{10}$, PM$_{2.5}$ and ozone) we quantified at three sampling points shown in Table 1. Measurements at three rush hours (morning, afternoon and evening) were also shown below. The sampling campaign was conducted between February and March 2018. This has resulted in 41 sampling counts with 15 number of measurements were conducted during morning, 14 in the afternoon and 12 in the evening rush hour. Measurements of PM$_{10}$, PM$_{2.5}$ and ozone made at JA2 and JU were higher than JA1. This is because the location of JA2-JU is located at intersection with high density of traffic and may contribute to high concentrations of particulate matter (PM) compared to JA1.

Concentration levels of PM$_{10}$ (average morning max±SD= 87.7±18.2 µg/m$^3$, average afternoon max±SD= 77.8±26.1 µg/m$^3$) and PM$_{2.5}$ (average morning max±SD= 44.1±12.7 µg/m$^3$, average afternoon max±SD= 49.0±13.1µg/m$^3$) were highest during morning and afternoon rush hour. This suggests the airborne particulate pollutants concentrations were coincided with each other and originated from the source. In contrast, ozone levels were found highest during afternoon and evening rush hour.
Table 1. Mean and standard deviation of PM$_{10}$, PM$_{2.5}$ and ozone for three periods of rush hour measured at roadsides within South Campus during 1-h measurement.

| Location                  | Rush hour | PM$_{10}$ Mean (SD) (µg/m$^3$) | PM$_{2.5}$ Mean (SD) (µg/m$^3$) | Ozone Mean (SD) (µg/m$^3$) |
|---------------------------|-----------|--------------------------------|--------------------------------|-----------------------------|
| Jalan Alpha 1 (JA1)       | Morning   | 72.4 (30.3)                    | 34.1 (9.7)                     | 22.8 (8.1)                  |
|                           | Afternoon | 58.3 (36.3)                    | 25.7 (21.1)                    | 194.3 (171.7)               |
|                           | Evening   | 39.3 (36.5)                    | 21.6 (21.6)                    | 159.0 (165.6)               |
| Jalan Alpha 2 (JA2)       | Morning   | 83.8 (18.2)                    | 49.0 (13.1)                    | 31.4 (8.8)                  |
|                           | Afternoon | 70.6 (35.6)                    | 35.9 (17.1)                    | 303.0 (234.1)               |
|                           | Evening   | 53.0 (36.9)                    | 26.8 (17.4)                    | 315.0 (137.8)               |
| Jalan Universiti (JU)     | Morning   | 76.5 (26.9)                    | 40.7 (14.12)                   | 21.8 (4.9)                  |
|                           | Afternoon | 77.8 (26.1)                    | 44.1 (12.7)                    | 127.5 (78.3)                |
|                           | Evening   | 38.8 (27.9)                    | 43.5 (72.3)                    | 180.5 (147.4)               |

Table 2. Traffic count of different type of vehicles within sampling sites located at South Campus area between February and March 2018.

| Sampling site | Total | Motorcycles | Cars and taxis | Buses | LGV | HGV |
|---------------|-------|-------------|----------------|-------|-----|-----|
| Jalan Alpha 1 (JA1) | 2299 | 881         | 1286           | 91    | 41  | 0   |
| Jalan Alpha 2 (JA2) | 2760 | 1190        | 1526           | 2     | 39  | 3   |
| Jalan Universiti (JU) | 2886 | 1338        | 1507           | 3     | 37  | 1   |

3.2. Surveys on traffic-related air pollution perception

3.2.1. Socio demographic. A total of 184 questionnaires being answered, 4 were excluded due to incomplete questionnaire returned, giving the response rate 100%. Table 3 shows characteristics of participants by first-and second year undergraduates during the questionnaire surveys. Majority of participants were 21 to 22 years old, Malay ethnic, female students and second-hand smokers. There was equal number of respondents who were cycling and walking from their residential colleges at South Campus to academic zones at North Campus using JA1, JA2 and JU.
Table 3. Participants’ demographic information.

| Characteristics | Pedestrian (n=90) | Cyclist (n=90) |
|-----------------|-------------------|---------------|
| Age (years old) |                   |               |
| 19 - 20         | 43                | 44            |
| 21 - 22         | 46                | 46            |
| > 22            | 1                 | 0             |
| Gender          |                   |               |
| Male            | 29                | 43            |
| Female          | 61                | 47            |
| Ethnicity       |                   |               |
| Malay           | 72                | 45            |
| Chinese         | 9                 | 25            |
| Indian          | 5                 | 15            |
| Others          | 4                 | 5             |
| Year of study   |                   |               |
| First year      | 42                | 44            |
| Second year     | 48                | 46            |
| Smoking         |                   |               |
| Yes             | 5                 | 3             |
| No              | 85                | 87            |
| Second-hand smokers |             |               |
| Yes             | 13                | 12            |
| No              | 77                | 78            |

3.2.2. Perception on traffic pollution. The survey covers; student’s perception on the air quality in the campus area, sources of traffic pollution and the strategies to mitigate air pollution. Among the 180 respondents, 89 (49.4%) of respondents believed that air quality of university campus area was better compared to six months ago, while 48 (26.7%) believed that air quality was worse since six months ago. The air quality rating is presented in Figure 2.
As shown in Figure 3, majority (83.4%) of the participants agreed that the problem of traffic pollution was 'old vehicles' in campus area. They also agreed that 'too many private vehicles' (51.1%) also contributed to traffic pollution. Moreover, participants did not agree that (68.9%) 'traffic congestion' and (81.1%) 'diesel vehicles' automatically influenced the vehicles emission significantly impacted the level of traffic pollution.

Participants were also asked of their perceptions on how to mitigate traffic pollution, Figure 4 shows that highest percentage of respondents (73.3%) agreed that by improving of pedestrian and cyclists’ lane facilities would be one of the measures to reduce air pollution. Majority of respondents agreed that carpooling (68.9%), reducing number of private vehicles (66.7%) and also walking and cycling to class (66.1%) will decrease the level of air pollution in the campus area.
3.3. Association TRAP with air quality perception and respiratory health symptoms

To associate traffic-related air pollutants with air quality perception, all pollutants measured were categorized based on their median value and divided by low and high. This test only involved those who perceived air quality as poor (n=60) and good (n=77). Table 4 shows the association between traffic-related air pollutants and air quality perception among students who were cycling and walking within study locations. The Pearson’s chi square test results show a significant association between all pollutants (PM$_{10}$, PM$_{2.5}$, and ozone) with air quality perception among respondents as (p= 0.001, 95% CI= 3.877-46.347), (p= 0.001, 95% CI= 3.877-46.347) and (p= 0.011, 95% CI= 0.188-0.811) respectively.

Table 4. Association between traffic-related air pollutions with air quality perception among respondents using Pearson’s chi-square test (N=137).

| Air Pollutant | Poor Air Quality (n=48) | Good Air Quality (n=89) | $\chi^2$ value | p value | 95% CI       |
|---------------|-------------------------|-------------------------|----------------|---------|--------------|
| PM$_{2.5}$    |                         |                         |                |         |              |
| High          | 45                      | 47                      | 23.196         | 0.001*  | 3.877-46.347|
| Low           | 3                       | 42                      | 23.196         | 0.001*  | 3.877-46.347|
| PM$_{10}$     |                         |                         |                |         |              |
| High          | 45                      | 47                      | 23.196         | 0.001*  | 3.877-46.347|
| Low           | 3                       | 42                      | 23.196         | 0.001*  | 3.877-46.347|
| Ozone         |                         |                         |                |         |              |
| High          | 24                      | 64                      | 6.516          | 0.011*  | 0.188-0.811 |
| Low           | 24                      | 25                      | 6.516          | 0.011*  | 0.188-0.811 |

Further analysis was done to determine an association between traffic-related air pollutions exposure with respiratory health symptoms among the active travellers by using the median value each measured air pollutant. The results were shown in Table 5. There is a significant association between high level of PM$_{2.5}$ and PM$_{10}$ with five respiratory health symptoms which are wheezing (p= 0.000, 95% CI= 0.021-
0.107), chest tightness (p= 0.000, 95% CI= 0.052-0.225), shortness of breath (p=0.000, 95% CI= 0.060-0.340), coughing (p= 0.000, PR= 0.158, 95% CI= 0.079-0.315) and phlegm (p=0.006, 95% CI= 0.0163-0.748). A significant association between was also observed with high level of ozone and five respiratory health symptoms; wheezing (p= 0.002, 95% CI= 1.464-5.541), chest tightness (p= 0.000, 95% CI=2.141-8.354), shortness of breath (p= 0.001, 95% CI= 1.557-6.283), phlegm (p= 0.041, 95% CI=1.029-4.299) and breathing difficulties (p= 0.039, 95% CI= 0.252-0.972).

Table 5. The association between exposure of (a) PM$_{2.5}$, (b) PM$_{10}$ and (c) ozone with respiratory health symptoms among respondents using Pearson’s chi-square test (N=180).

| (a) Respiratory Symptoms | PM$_{2.5}$ (High) Number | PM$_{2.5}$ (Low) Number | $\chi^2$ value | p value | 95% CI |
|--------------------------|--------------------------|-------------------------|----------------|---------|--------|
| Wheezing                 |                          |                         |                |         |        |
| Yes                      | 74                       | 9                       | 68.297         | 0.001*  | 0.021-0.107 |
| No                       | 27                       | 70                      |                |         |        |
| Chest Tightness          |                          |                         |                |         |        |
| Yes                      | 63                       | 12                      | 40.607         | 0.001*  | 0.052-0.225 |
| No                       | 38                       | 67                      |                |         |        |
| Shortness of Breath      |                          |                         |                |         |        |
| Yes                      | 41                       | 7                       | 22.826         | 0.001*  | 0.060-0.340 |
| No                       | 60                       | 72                      |                |         |        |
| Coughing                 |                          |                         |                |         |        |
| Yes                      | 85                       | 36                      | 29.458         | 0.001*  | 0.079-0.315 |
| No                       | 16                       | 43                      |                |         |        |
| Phlegm                   |                          |                         |                |         |        |
| Yes                      | 32                       | 11                      | 7.689          | 0.006*  | 0.163-0.748 |
| No                       | 69                       | 68                      |                |         |        |
| Breathing Difficulties   |                          |                         |                |         |        |
| Yes                      | 34                       | 21                      | 1.047          | 0.306   | 0.733-2.679 |
| No                       | 67                       | 58                      |                |         |        |
| (b) Respiratory Symptoms | PM$_{10}$ (High) Number | PM$_{10}$ (Low) Number | $\chi^2$ value | p value | 95% CI |
| Wheezing                 |                          |                         |                |         |        |
| Yes                      | 74                       | 9                       | 68.297         | 0.001*  | 0.021-0.107 |
| No                       | 27                       | 70                      |                |         |        |
| Chest Tightness          |                          |                         |                |         |        |
| Yes                      | 63                       | 12                      | 40.607         | 0.001*  | 0.052-0.225 |
| No                       | 38                       | 67                      |                |         |        |
| Shortness of Breath      |                          |                         |                |         |        |
### Respiratory Symptoms

| Symptoms       | Yes | No  | χ² value | p value | 95% CI       |
|----------------|-----|-----|----------|---------|--------------|
| Coughing       | 41  | 60  | 22.826   | 0.001*  | 0.060-0.340  |
| Phlegm         | 85  | 16  | 29.458   | 0.001*  | 0.079-0.315  |
| Breathing      | 32  | 69  | 7.689    | 0.006*  | 0.163-0.748  |
| Difficulties   | 34  | 67  | 1.047    | 0.306   | 0.733-2.679  |

(e) Respiratory Symptoms

| Symptoms       | Yes | No  | χ² value | p value | 95% CI       |
|----------------|-----|-----|----------|---------|--------------|
| Ozone (High)   | 49  | 78  | 9.838    | 0.002*  | 1.464-5.541  |
| Ozone (Low)    | 34  | 19  | 18.356   | <0.001* | 2.141-8.354  |
| Coughing       | 25  | 102 | 10.751   | <0.001* | 1.557-6.283  |
| Phlegm         | 25  | 102 | 4.912    | 0.041*  | 1.029-4.299  |
| Breathing      | 33  | 94  | 4.248    | 0.039*  | 0.252-0.972  |

*significant at p<0.05

4. Discussion

Traffic related air pollution was measured in three different locations in a university campus. Average concentrations of PM$_{10}$, PM$_{2.5}$ and ozone were used to differentiate levels of air pollution during rush hour i.e. morning, afternoon and evening. A set of validated questionnaires was also distributed to first- and second year undergraduates who were actively commute to academic zones from his/her residential colleges either cycling or walking. This was to investigate traffic-related air pollution perception and
respiratory health effects. Pearson chi-square was applied to explore traffic-related air pollutants levels and association between perception and health condition.

In general, levels of particulate air pollutants (PM$_{10}$ and PM$_{2.5}$) were higher during morning and afternoon and in turn corresponded with high number of traffic count at three sampling points (JA1, JA2 and JU). This suggests ambient sources may drive from exhaust emissions from vehicles including private cars, taxis and buses that passed by the roadsides. PM measurements were found higher at near roadsides in which may influence by density of road networks and distance from emission sources [8]. The spatial patterns between traffic pollutants were similar although the levels of spatial variability were diverges [8]. Ozone levels were recorded highest during afternoon and evening measurements. Ozone measurements were the lowest in the morning. This corresponds to the solar intensity and oxidation process of precursor pollutants emitted into the atmosphere (NO$_x$) during early morning hour. The levels of ozone will accumulate and increasing during midday and evening peak.

Our study explored traffic-related air pollution on university student’s perception. Majority of the participants (83.4%) agreed that air pollution was motor vehicles. This is in line with study conducted in Kuala Lumpur city centre in which the main source of air pollution was from traffic emissions [18]. Our results also agreed with a study on air quality perception in the United Kingdom, in which majority of their respondents perceived automobiles as the main source of air pollution [19]. In contrast, a study on air quality perception Kuwait found that people identified air pollution to be the fifth most important consequence of traffic congestion out of eight possible consequences [20]. Majority of our respondents agreed to suggest that car pool, improving facilities of pedestrian and cyclists’ lane, reduced the number of private vehicles and also walking and cycling to the academic zones as control measures to reduce air pollution in campus area. This suggesting the role of practical everyday experience that may influence on how people perceived the quality of air especially to the active commuters.

Most studies have highlighted that the real-world experience of the respondents including the smells of pollutants and what they have seen were the major influence for their perception on the air pollution levels [19, 21]. Similar study also conducted whereby all respondents were randomly chose to answer their perception and awareness on traffic pollution [18]. However, not much work has been done to study how human perception correlates with physical measurements of pollution and their experience as cyclist or pedestrian. Our study has found a significant association between air quality perception with air pollutants (PM$_{10}$, PM$_{2.5}$ and ozone) (p<0.05). This has in line with observations made by researchers in China which found the levels of ozone and visibility were more correlated with perceived air quality [14]. People who were actively commuted are easily exposed to traffic emissions and might harm their health outcome. Respiratory diseases including asthma may affect pedestrian and cyclist during their active travel. Our study found levels of PM$_{10}$, PM$_{2.5}$ and ozone measured have significant associated with respiratory symptoms (wheezing, shortness of breath, coughing and phlegm) among students.

We have identified several study limitations. Our study was conducted through cross-sectional design, therefore we cannot predict whether certain variables precedes the other. It is also noted that our study used limited number of sample size; air monitoring exercise and participants. Our study adopted self-reported on respiratory symptoms, therefore recall bias might arise among respondent. Non-invasive health measurement such as lung function test should be included in the future studies. Due to short duration of the project we were unable to perform the assessment and validation of three portable real-time monitors (i.e Dustrak, Sidepak and Aeroqual S500) prior to our sampling campaign. However, this type of sampling exercise is important to examine outdoor exposure assessment in a representative campus area environment. Additional meteorological measurements such as relative humidity, temperature and wind speed should take into account for future research.

5. Conclusion
Our findings have revealed a significant association between air pollution concentrations and air quality perception among students who actively commute within the university campus area. It reveals that respiratory health symptoms are affected by exposure to traffic related air pollution. Most of participants
strongly agreed to policies and strategies in reducing air pollution in the university campus. For instances, reducing the number of private vehicles, carpooling, improving facilities for pedestrian and cyclists and sustaining healthy lifestyle in the campus. Therefore, these strategies should be taken into consideration by the university management in formulating policies, measures to mitigate outdoor air pollution by reducing traffic-related air pollution exposure to active commuters within the campus area.

References

[1] Road Transport Department Malaysia 2017 Transport Statistic Malaysia p 6
[2] Health Effects Institute 2010 Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects Special Report 17 p 2
[3] Mohamad ND, Ash’aari ZH and Othman M 2015 Preliminary Assessment of Air Pollutant Sources Identification at Selected Monitoring Stations in Klang Valley, Malaysia Procedia Environmental Sciences 30 p 121–126
[4] Azmi ZF, Latif MT, Ismail AS, Juneng L and Jemain AZ 2010 Trend and status of air quality at three different monitoring stations in the Klang Valley, Malaysia Air Quality, Atmosphere and Health 3(1) p 53-64
[5] United States Environmental Protection (USEPA) 2016 [accessed online: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM]
[6] Brown JS, Gordon T, Price O and Asgharian B 2013 Thoracic and respirable particle definitions for human health risk assessment. Particle and Fibre Toxicology 10 p 1-12
[7] Kim H, Kabir E, and Kabir S 2015 A review on the human health impact of airborne particulate matter Environment International 74 p 136–143
[8] Lorimer SW and Marshall S 2015 Beyond walking and cycling: scoping small-wheel modes Proceedings of the Institution of Civil Engineers p 1-10
[9] Hankey S and Marshall JD 2017 Urban Form, Air Pollution, and Health Curr Environ Health Rep. 4(4) p 491-503
[10] Donaldson K, Gilmour MI and MacNee W 2000 Asthma and PM(10) Respiratory Research 1(1) p 12-5
[11] Pantavou K, Lykoudis S and Psiloglou B 2017 Air quality perception of pedestrians in an urban outdoor Mediterranean environment: A field survey approach Science of the Total Environment 574 p 663–670
[12] Van Kamp I, Leidelmiejer K and Marsman G 2003 Urban environmental quality and human well-being towards a conceptual framework and demarcation of concepts vol 65 pp 5–18
[13] Lwanga S and Lemeshow S 1991 Sample size determination in health studies: a practical manual (England: World Health Organization)
[14] Liao X, Tu H, Maddock JE, Fan S, Lan G, Wu Y, Yuan ZK, Lu Y 2015 Residents’ perception of air quality, pollution sources, and air pollution control in Nanchang, China Atmospheric Pollution Research 6 p 835-41
[15] Deguène S, Ségalas C, Pédrono G, Mesbah M 2012 A new air quality perception scale for global assessment of air pollution health effects. Risk Analysis: An International Journal 32 pp 2043-2054
[16] International Union against Tuberculosis and Lung Diseases (IUALTD) 2001 The international journal of tuberculosis and lung disease The official journal of the International Union against Tuberculosis and Lung Disease 5 p 213-215
[17] Zheng P and Mike M 2012 An investigation on the manual traffic count accuracy Procedia-Social and Behavioral Sciences 43 p 226-231
[18] Shafie SH and Mahmud M 2017 Public perception on traffic pollution in federal territory of Kuala Lumpur, Malaysia Planning Malaysia Journal 15 pp 105-114
[19] Howel D, Moffatt S, Bush J, Dunn CE, Prince H 2003 Public views on the links between air pollution and health in Northeast England Environmental Research 91 p 163-71
[20] Koushki PA, Ali MA, Chandrasekhar BP, Al-Sarawi M 2002 Exposure to noise inside transit buses in Kuwait: Measurements and passenger attitudes Transport Reviews 22 p 295-308
[21] Bickerstaff K and Walker G 2001 Public understandings of air pollution: the ‘localisation’ of environmental risk Global Environmental Change 11 p 133-145

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