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# Air Quality-Related Human Health in an Urban Region. Case Study: State of Selangor, Malaysia.

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## Abstract

The urban region with high traffic volume and high density developments contributed to the decreasing of air quality. Air pollution is a major environmental risk to health and exposure to ambient air pollution has been associated with a series of adverse health effects including respiratory system. Previous scholars found a significant link between respiratory disease and air pollution. However, due to the limited study in the regional context, this study is needed to find the relationship between air quality and human health in the regional context, especially in Malaysia. As proven that distribution of air pollutants are influenced by the effects of wind and geographical factors (Sham, 1998). Therefore, air quality study should not focus on urban boundary only. The Air Pollution Index (API) data was obtained through a secondary source. For the health indication with the focuses on respiratory infections, a house to house questionnaire survey had been carried out. The self-reported health data (through questionnaire survey) was correlated to the air quality data (API). The research found that Acute Respiratory Infection (ARI) incidence was not clearly related to the air quality. However, the significant relationship between exposure to air pollution and respiratory health (ARI incidence) was established for 2 out of 5 study areas in Selangor State. Besides, respondents' perception of 'sense of clean air' was significantly correlated to ARI cases. It showed a relationship between air pollution exposure and environmental perception with respiratory health.

***Keywords:*** air quality, air-related health, environmental health, respiratory, urban region

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## Introduction

Clean air is paramount for human health and well-being, however, in the process of economic development, air quality deteriorated significantly and leads to air pollution. The driving forces of air pollution include economic development, urbanisation, energy consumption, transportation, and motorisation, as well as the increase in urban population (Chen & Kan, 2008). The Malaysian urban area especially the Klang Valley (Kuala Lumpur Federal Territory area and Selangor State) is experiencing rapid growth, but citizens may neglect one of the most important sources of human life which is the air. The urban region like Klang Valley (including Selangor state) with the high volume of traffic and high density developments contributed to the decreasing of urban air quality (Nurul Ashikin et al., 2014). Urban ambient air is more polluted than the overall atmosphere, due to the high density of human population and their activities in urban areas; it produces air pollutants with higher rate as compared to less-developed areas and natural environment (Ling et al., 2012). In relation to that, cities in developing countries are facing increasing environmental pollution from vehicle emissions, and from industries and domestic heating sources at a level that exceeds the capacity to disperse and dilute emissions to non-harmful exposure levels (UN, 2001).

Air pollution is a major environmental risk to health (WHO, 2014) and exposure to ambient air pollution has been associated with a series of adverse health effects (Chen & Kan, 2008). The health effects of air pollution ranging from subclinical effects, physiological changes in pulmonary functions and the cardiovascular system, to clinical symptoms, outpatient, and emergency room visits, hospital admissions and premature death (Chen & Kan, 2008). As stated by The World Health Organization (WHO), urban air pollution is a critical public health problem. Besides, the consequences of air pollution on public health are measured not only according to sickness and death but also including productivity lost and missed educational and other human development opportunities (UN, 2001). Furthermore, more than 2 million premature deaths each year can be attributed to the effects of urban outdoor air pollutant and indoor air pollutant (WHO, 2006).

As referred to Malaysian cases, a clear increasing trend in the number of unhealthy or hazardous days which increased from 11 days in 2001 to 67 days in 2005 at Kuala Lumpur (Ling et al., 2010). Other than that, in August 2012, air quality monitoring at Port Klang, Selangor showed the worst (unhealthy) Air Pollution Index of 118 due to the influenced of monsoon wind from Sumatra (DOE, 2012). Subsequently, Malaysia experienced short periods of severe haze episodes due to trans-boundary pollution from 15 to 27 June 2013 (DOE, 2014). Thus, several unhealthy days were recorded in Selangor especially during the dry period (DOE, 2014). Complementary to this, Environmental Quality Report (DOE, 2014) stated that the concentration of particulate matter ($PM_{10}$) in the urban area (Klang) was significantly higher compared to other suburban areas.

A number of researchers have proven the connection between air quality and its impact on human health. The epidemiology and laboratory studies demonstrated that ambient air pollutants (for example, PM, $O_3$, $SO_2$ and $NO_2$) contributed to various respiratory problems including bronchitis, emphysema, and asthma (Ling, 2011; Chen & Kan, 2008; WHO, 2014). While in Malaysia, Health Facts 2012 by Ministry of Health Malaysia (MoH, 2012) stated that, in 2011, diseases of the respiratory system are one of the principal causes of hospitalisation in MoH hospital with the percentage of 10.36%. However, there is an increasing in trend from 2011 to 2012. In the year 2012, among the ten principal causes of hospitalisation in MoH hospital is diseases of the respiratory system with 11.02%, which were second highest among all causes (MoH, 2013). On the other hand, one of the principal causes of death at MoH hospital in 2011 was also diseases of the respiratory system with the percentage of 19.48% (MoH, 2012). In the year 2012, diseases of the respiratory system were the second highest principal causes of death in MoH Hospitals with the percentage of 18.8% (MoH, 2013).

In addition, previous scholars found a significant link between respiratory disease and air pollution. In 2005 during haze episode, there was an increasing number of asthma cases, acute respiratory infection (ARI) and conjunctivitis cases in both West Malaysia and East Malaysia (Rafia et al., 2003; Norela et al., 2008). In 1997 the same scenario happened during haze in Selangor, asthma cases increased from 912 in June to more than 5,000 in September 1997. Moreover, the total number of ARI cases increased from about 6,000 to more than 30,000 during the same period (Rafia et al., 2003).

The adverse health effects associated with urban air pollution, which include respiratory morbidity, cardiovascular diseases, and mortality, have contributed to creating public awareness in this kind of pollution. Health risk evaluation and assessment have become important since these serve as the basis for any re-formulation or review of current air quality standards (Coils & Micallef, 1997).

The research gap to be filled in this research is the urban air quality level and human health at the regional level. Among previous researches made by other scholars, air quality study was made in localised area. For this study, the relationship between urban air quality and human health were determined in the regional context. As proven that distribution of air pollutants is influenced by the effects of the wind and geographical factors (Sham, 1988). Therefore, a study is needed to find the impact of air quality and human health in the regional context.

The aim of this study is to examine the relationship between human health and urban air quality in the urban region of Selangor State (part of Kuala Lumpur Conurbation / Klang Valley). At the end of this paper, researcher has concluded the research findings.

## 2. Materials and Methods

### *2.1 Area of Study*

The study focuses on the regional context of Selangor State. This is because air pollution is not localising in one area and affected by several factors such as geography and the wind; therefore, this study should not focus on one city only. As proven by Harrison (1999), some air pollutants can travel far away from the sources even at regional scale due to the long atmospheric lifetimes. Selangor as the most urbanised state in Malaysia was projected to have the population of 7.3 million in the year 2020 (JPBD, 2011). Approximately, 36 592.52 hectares of land (80%) has been classified for development. Selangor also is the largest urban region in Malaysia. In the year of 1991-2002 saturated land use of this state increase from 33 680 hectares to 127 591 hectares (JPBD, 2014). Even though development is good for the nation, the impact towards the environment especially urban air quality is worrying. Selangor is connected within districts, province and its surrounding area by highways (Federal Highway, MRR2, etc.) and railways (KTM, ERL).

As for this study, only five cities in Selangor chosen as the study area which are Petaling Jaya, Shah Alam, Banting, Kuala Selangor and Klang. It is because there are only five cities in Selangor which are equipped with Automatic Air Quality Monitoring Stations. Therefore, it is relevant to choose all the five (5) areas with Continuous Air Quality Monitoring Station (CAQM) as the case study in Selangor. As listed below is the list of schools with Continuous Air Quality Monitoring Stations (CAQM) provided by Department of Environment, thus the proximity areas become the areas of study (Figure 1):

i. Kolej *(College)* MARA Banting, Selangor
ii. Sekolah Menengah Sains *(Secondary School of Science)* Kuala Selangor, Kuala Selangor, Selangor

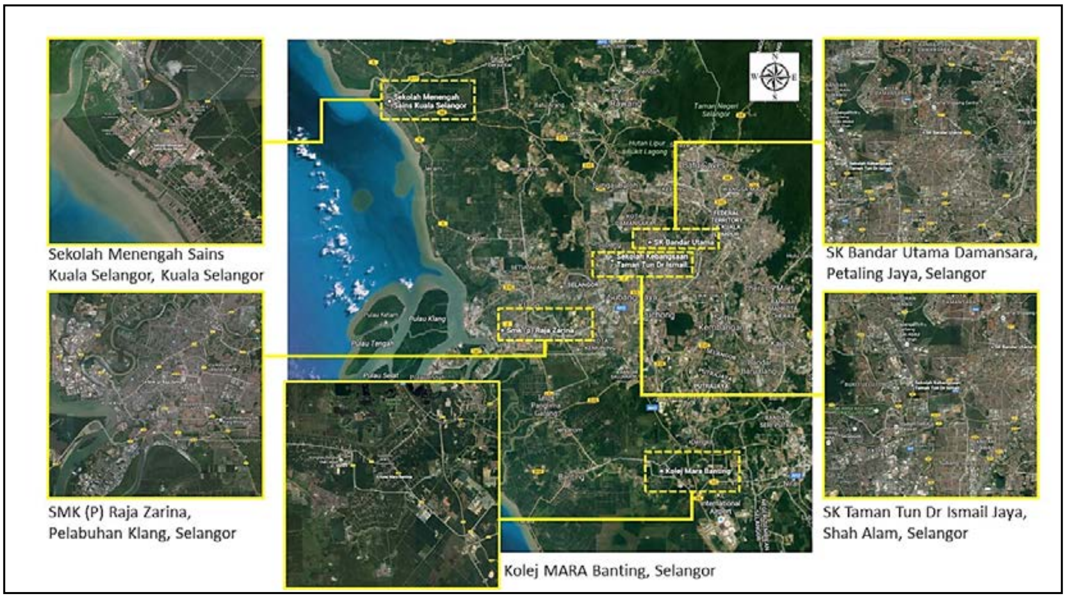


**Figure 1.** Location of Study Areas in Selangor State; Source: Google Earth (2015)

iii. Sekolah Menengah Kebangsaan (P) *(National Secondary Girl School)* Raja Zarina, Pelabuhan Klang *(Port Klang)*, Selangor
iv. Sekolah Kebangsaan *(National Primary School)* Bandar Utama Damansara, Petaling Jaya, Selangor
v. Sekolah Kebangsaan *(National Primary School)* Taman Tun Dr Ismail Jaya, Shah Alam, Selangor

*2.2 Methods of Data Collection and Analysis*

This study focuses on the ambient (outdoor) air quality of Selangor. The data of ambient air quality was obtained through secondary source as provided by Department of Environment Malaysia (DOE) which is the Air Pollution Index (API) data. Only five major pollutants used by Department of Environment Malaysia (DOE) in API calculation, which are Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2), Carbon Monoxide (CO), Particulate Matter with diameter 10 microns or less (PM10), and Ground-Level Ozone (O3).

While for human health, study focus only on the aspect of health effect that directly related to air quality with the focus on respiratory diseases. Air pollution contributes to the substantial worldwide burden of disease from acute lower respiratory infections and possibly tuberculosis (Laumbach & Kipen, 2012), this is because, respiratory system is sensitive to air pollution, due to lungs must bring in large quantities of air to supply sufficient oxygen to the blood system (Health Canada, 2013).

**Table 1.** Distribution of population and respondents in study areas

| CAQM Stations | Banting | Kuala Selangor | Klang | Petaling Jaya | Shah Alam | Total |
|---|---|---|---|---|---|---|
| Population in proximity CAQM Stations | 26 062 *(20.59%)* | 11 649 *(9.20%)* | 10 445 *(8.25%)* | 61 367 *(48.48%)* | 17 057 *(13.48%)* | 126 580 *(100%)* |
| No. of sampled respondents | 78 *(20.37%)* | 35 *(9.13%)* | 32 *(8.36%)* | 186 *(48.56%)* | 52 *(13.58%)* | 383 *(100%)* |

For the purpose of this study, human health indication focuses on respiratory infections, which are the acute respiratory infections (ARI) and chronic respiratory infections (CRI) as self-reported by respondents. In the indication of health, this analysis covers frequency of incidence, outpatient and hospitalisation cases due to ARI, and CRI during the study period.

ARI incidence was measured based on reported number of cases with ARI symptoms by respondents (self-reported), including a cough, nasal discharge, nasal block, sore throat, loss of voice and throat irritations for a duration fewer than 14 days per case (Ling, 2011). Frequency of ARI outpatient cases was measured based on self-reported (by respondents) statements of getting medical advice or treatment without hospitalisation due to ARI. Meanwhile, CRIs were measured based on respiratory infections more than 14 days. Number of outpatient cases for CRI was measured based on self-reported by respondents in getting medical advice or treatment without hospitalisation due to CRI. Frequency of hospitalisation cases for CRI was measured based on the self-reported number of days of hospitalisations due to CRI.

The health indicators calculated for two seasons (rainy and dry) and the transition seasons, from April 2013 until March 2014. The questionnaire was divided into two sections. Section A was designed to collect information on the socio-economic and general background of the respondents and to ascertain the exposure of the respondents to air pollution. This section covers the aspects of gender, marital status, age, education level, income range, sex, type of houses, occupation, etc. Also, included in the first section are the daily level of respondents’ exposure to air pollution, respondents’ perception towards cleanliness of air and clarification of respondent’ smoking habit. Section B designated based on the data requirements of air-related health indication. This study focuses on respiratory infections only. Subsequently, this section consisted of two sub-sections which were the ARI and CRI. From this section, respondent's history of respiratory infection (ARI & CRI) were measured according to the ARI incidence, CRI incidence, ARI outpatient visits, CRI hospitalisation, during April 2013 – May 2013, June 2013 – September 2013, October 2013, and November 2013 – March 2014.

About the questionnaire survey, the respondents were selected from each of the CAQM station proximity areas, covering five kilometres (5km) in radius, using a stratified random sampling procedure. The stratified sampling method ensured that respondents from the different type of houses are selected.

Based on the total number of residents live in five selected cities of Selangor (the study area) which was 126 580 residents, the total number of respondents identified for this study was 383 samples (with 95% confidence level and sampling error, 5%). Table 1 shows the number of respondents for the five areas in Selangor. In general, the survey covered general households with various socio-economic, demographic and pre-existing health backgrounds. The questionnaire survey was carried out from April to May 2014 by face-to-face interviews. Table 2 shows the general demographic characteristics of the sampled respondents. Information collected from the questionnaire, was used in relationship analysis for better understanding of the respondents' air-related health conditions and air quality. Statistical Package for Social Science (IBM SPSS Statistics Version 22) was used as the statistical analysis tool to calculate the indicators values and to find the relationship between air quality and health. Spearman rank correlation was used to determine whether there was a significant relationship between "ambient air quality and ARI", "duration exposed to polluted air and ARI", and "perception on the air cleanliness and ARI". The Spearman rank correlation was used because of normality test using the Kolmogorov-Smirnov method indicating that the frequency distributions of values for the variables were significantly different from the normal distribution. Therefore, the correlation analysis using the Spearman rank correlation method is the most appropriate method for this study.

## 3. Results and Discussion

### *3.1 Air Quality*

#### *Number of Good API days*

Distribution trend for the number of good API days for the period of January 2013 until March 2014 showed three peak periods. The good days were lesser during the dry season (June 2013 to July 2013) as compared to November and December 2013 (rainy season). Except for Kuala Selangor, the number of good API days for the remaining four areas slightly dropped in March 2013. In the period of February 2014 to March

**Table 2.** Background of respondents

| Variables | Percentage (%) |
|---|---|
| **Gender** | |
| Male | 46.7 |
| Female | 53.3 |
| **Age** | |
| 15-19 | 7.6 |
| 20-24 | 10.7 |
| 25-29 | 12.3 |
| 30-34 | 9.9 |
| 35-39 | 9.9 |
| 40-44 | 5.2 |
| 45-49 | 11.0 |
| 50-54 | 11.0 |
| 55-59 | 8.9 |
| 60-64 | 6.0 |
| 65-69 | 3.4 |
| 70-74 | 3.7 |
| 75++ | 0.5 |
| **Ethnic** | |
| Malay | 65.8 |
| Chinese | 20.9 |
| Indian | 12.5 |
| Others | 0.8 |
| **Smoking status** | |
| Active smoker | 21.7 |
| Ex-smoker | 2.1 |
| Passive smoker | 22.5 |
| Non-smoker | 53.7 |

2014, all five areas showed a significant drop in the number of good API days (Figure 2). The focus of the analysis is for the period of April 2013 to March 2014. However, for the purpose of discussion on the general trend of air quality for the study area, air quality for the period of January 2013 to March 2014 was used in this section was used in this section for a wider view of air quality trend. The number of good API drop in June 2013 to July 2013 (dry season) due to Malaysia experiencing short period of severe haze episodes due to trans-boundary pollution from 15 to 27 June 2013 where most part of Peninsular Malaysia adversely affected when the air quality deteriorated to unhealthy and hazardous levels (DOE, 2014).

For the dry weather during the transition period between February and March 2014, Peninsular Malaysia had experienced moderate haze episodes and worsened on 14 March 2014 as the API level increase to hazardous level with API more than 300 in two areas namely Klang and Banting, Selangor. November 2013 to December 2013 was a rainy season for Selangor, Malaysia with heavy rainfall, thus increase the number of good API days. This argument supported the study of Mkoma and Mjemah (2011), which is higher air pollutant concentration obtained during the dry season and the lowest during the rainy season. The same study by Mkoma and Mjemah (2011) stated that air pollutants are removed from the air through wet deposition process that occurs during rain, and larger or smaller particles can be removed sequentially during a single rain event.

Among the five study areas, Kuala Selangor can be categorised as the cleanest city. While Klang and Banting were the lowest in numbers of good API days during January 2013 to March 2014, refer Figure 2.

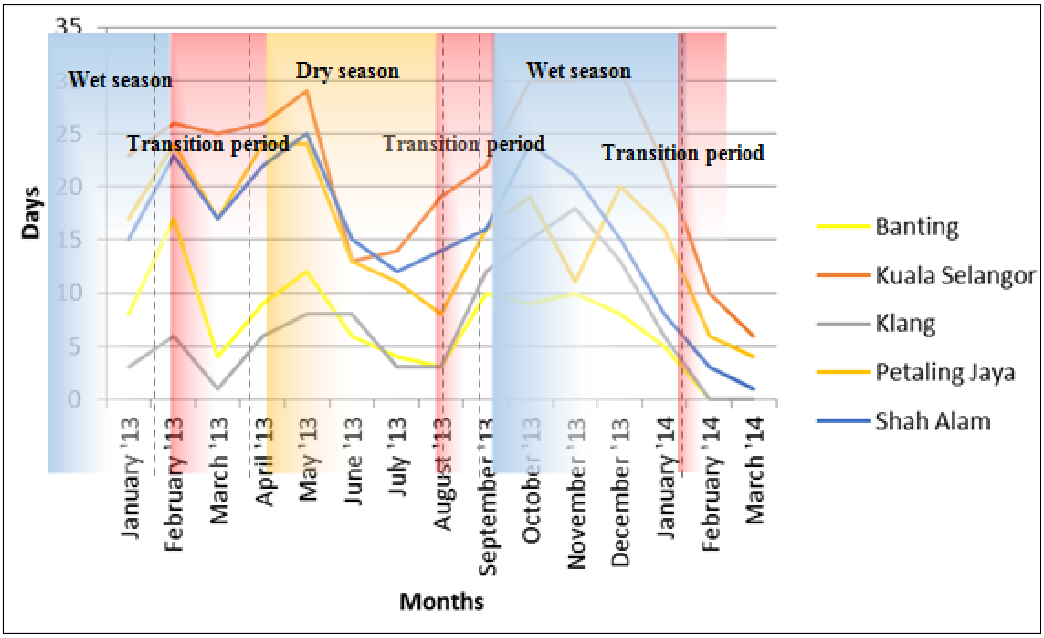


**Figure 2.** Monthly Good API Days, January 2013 - March 2014; Source: DOE (2015)

*Number of Unhealthy, Very Unhealthy & Hazardous API Days*

During the period of January 2013 to March 2014 (Figure 3), there were increasing numbers of unhealthy (API) days in Selangor. Looking at the trend of unhealthy, very unhealthy and hazardous API during the period, it shows two peak months of unhealthy API which were in June 2013 (during the dry season) and March 2014 (during the transition period), refers Figure 3, 4 and 5.

By comparing among the five areas, Banting was the most polluted area and Kuala Selangor was the cleanest area. This was based on the highest number of unhealthy days that were recorded in Banting whilst Kuala Selangor was recorded with the lowest number of unhealthy days. In addition, there was no hazardous API day recorded in Kuala Selangor throughout the study period (Figure 3, 4 and 5).

*API for the Five Study Areas*

Air pollution index (API) showed that the unhealthy days occurred in all the five (5) areas, especially in Banting, Klang, Petaling Jaya and Shah Alam (Table 3). According to the percentage of unhealthy days (including very unhealthy and hazardous), Banting was the most polluted (unhealthy) area with the highestpercentage of unhealthy days, followed by Shah Alam and Klang. Petaling Jaya was the second lowest in term of the percentage of unhealthy days and Kuala Selangor was the area with least pollution among all.

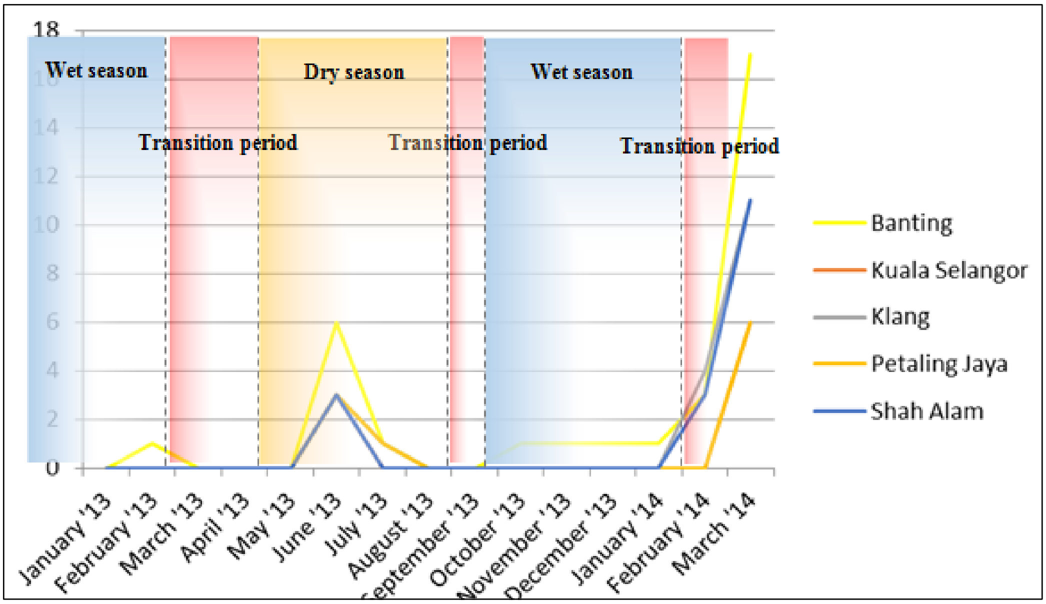


**Figure 3**. Monthly Unhealthy API January 2013-March 2014; Source: DOE (2015)

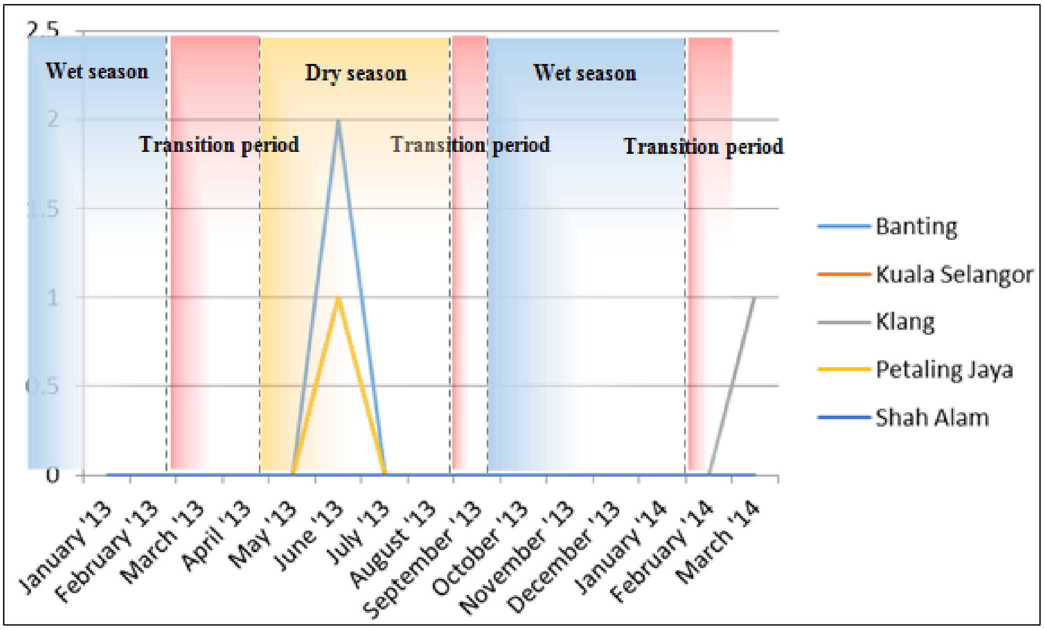


**Figure 4.** Monthly Very Unhealthy API January 2013 - March 2014; Source: DOE (2015)

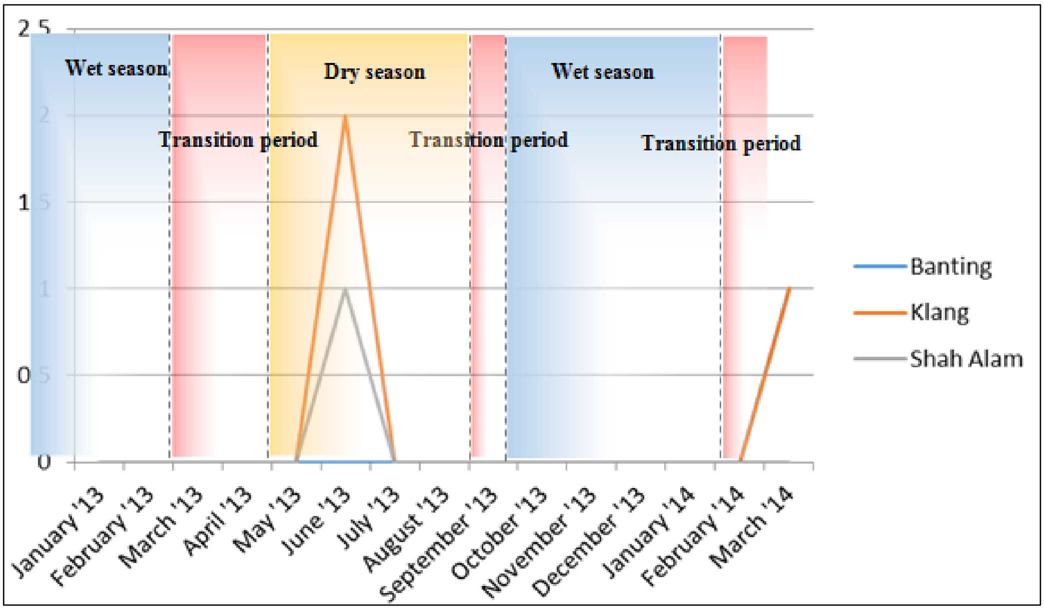


**Figure 5**. Monthly Hazardous API January 2013 - March 2014
Note: No hazardous day for Kuala Selangor and Petaling Jaya; Source: DOE (2015)

*API for the Different Seasons*

In order to reveal which season between dry and rainy season were more polluted, comparisons were made for air quality level between dry season of April 2013 to September 2013 and rainy season of October 2013 to March 2014 (Table 4). The results showed that dry season was more polluted than rainy season. This result supports the assumption that air pollution will be lower during the rainy season and higher during the dry season.

### *3.2 Respiratory Health*

*ARI Incidence and Outpatient Visit*

The highest rates of ARI incidence were reported during the period of November 2013 to March 2014 (wet season) (Table 5), even though it was during the rainy season where the number of good API days was relatively higher. Air quality analysis showed that study areas have a higher pollution level during the dry season, however, ARI incidence was slightly higher in the rainy season as compared to dry season. A study by Ling, et al. (2010) found that most areas in Kuala Lumpur had the highest ARI incidence during the rainy season, in contradiction with an assumption that respiratory cases should be higher during the dry season (higher air pollution level). However, the study by Siti Nur Afiqah (2013) showed that ARI incidence and hospitalisation due to ARI were high during the dry season.

In contrast, outpatient visit rate due to ARI was higher during the dry season. It is apparent that the analysis showed a lower rate of ARI outpatient visit in Petaling Jaya and no outpatient visit at all for Kuala Selangor (Table 6), thus Kuala Selangor is the healthiest area (as measured in ARI Outpatient as well as API) among the five study areas. Klang was the area with the highest percentage of ARI outpatient visit and the area was the third unhealthiest area (as measured in API) among the five areas (Table 3).

*CRI Incidence and Hospitalisation*

In line with the trend of the ARI incidence rates, the highest rates of CRI incidence as well as CRI Hospitalisation were also reported in the period of November 2013 to March 2014 (rainy season) as compared to the period of June 2013 to September 2013 (dry season) (Table 7 and 8). During the period of April 2013 until May 2013 and October 2013 (transition periods), there were no CRI incidence or hospitalisation in study areas.

**Table 3.** Percentage of Days for Each Level of API, April 2013 to March 2014

| Areas | % of days | | | | | Ranking of Healthiness |
|---|---|---|---|---|---|---|
| | Good (API 0-50) | Moderate (API 51-100) | Unhealthy (API 101-200) | Very Unhealthy (API 201-300) | Hazardous (API >300) | |
| K.Selangor | 61.76 | 22.86 | 1.76 | 0.00 | 0.00 | 1 |
| P. Jaya | 30.33 | 53.40 | 2.64 | 0.00 | 0.44 | 2 |
| Klang | 14.95 | 66.81 | 3.96 | 0.66 | 0.66 | 3 |
| Shah Alam | 27.03 | 54.29 | 5.27 | 0.22 | 0.22 | 4 |
| Banting | 15.38 | 63.29 | 7.69 | 0.00 | 0.66 | 5 |

Note: 1= The cleanest or healthiest area, 5=The most polluted area

Among the five (5) areas of study, Kuala Selangor was the healthiest area as measured in API. The area also healthiest as measured in CRI cases (incidence and hospitalisation), with no CRI cases in Kuala Selangor. Meanwhile, Banting was recorded as the area with the highest percentage of unhealthy days, however, the CRI rate for Banting was not the highest among the five (5). On the other hand, Shah Alam, the second highest percentage of unhealthy days recorded the highest percentage of CRI incidence and hospitalisations (Table 7 and 8).

### *3.3 Relationship between Ambient Air Quality (API) and ARI Incidences*

Prior to air quality analysis, Banting had the highest number of unhealthy days compared to other areas and followed by Shah Alam and Klang. However, the highest percentage of ARI cases was identified in Klang, followed by Kuala Selangor, Shah Alam and Banting. Kuala Selangor was identified with the lowest percentage of unhealthy days but ranked in number two with a higher percentage of ARI incidence. On the other hand, Petaling Jaya was identified with the lowest rate of ARI cases. In comparison, Banting with the highest percentage of unhealthy days was not the area with highest ARI incidence, refer Table 9.

However, by excluding Kuala Selangor in the comparison, it is apparent that Banting, Shah Alam and Klang were more polluted with higher ARI incidence (>100%). Meanwhile, Petaling Jaya was less polluted and lower ARI incidence (<90%). Kuala Selangor was not correlated by referring to the rank, this is because though the number of the unhealthy days was lowest, the percentage of ARIwas second highest. Table 9 shows the comparison between ARI

**Table 4.** Percentage of Days for Each Level API, April 2013-September 2013 and October 2013-March 2014

| CAQM Stations | Generalised Dry Season April 2013-September 2013 (%) | | | | | Generalised Wet Season October 2013-March 2014 (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Good | Moderate | Unhealthy | Very Unhealthy | Hazardous | Good | Moderate | Unhealthy | Very Unhealthy | Hazardous |
| Banting | 24.00 | 70.49 | 3.83 | 1.09 | 0.00 | 17.58 | 67.58 | 13.18 | 0.00 | 0.55 |
| K.Selangor | 67.21 | 29.50 | 1.64 | 0.55 | 0.00 | 70.88 | 25.27 | 3.29 | 0.00 | 0.00 |
| Klang | 21.86 | 71.04 | 2.73 | 0.55 | 1.09 | 28.57 | 60.44 | 8.24 | 0.55 | 0.55 |
| P. Jaya | 52.45 | 43.71 | 2.18 | 0.55 | 0.00 | 41.76 | 54.95 | 3.29 | 0.00 | 0.00 |
| Shah Alam | 56.83 | 38.79 | 1.64 | 0.00 | 0.55 | 39.56 | 52.74 | 7.69 | 0.00 | 0.00 |
| *Average* | *44.47* | *50.70* | *2.40* | *0.55* | *0.33* | *39.67* | *52.19* | *7.14* | *0.11* | *0.22* |

Note: Average is calculated based on the average number of days for five stations in study area.

incidence cases of each area with API ranking.

A past study conducted in town of Kanpur, India found that the more polluted the town the higher respiratory health among adults in the town (Brunekreef, 2010), the same study also found that bronchitis, wheeze, shortness of breath and airway obstruction were higher in men and women living in the more polluted town than less polluted town. In conjunction with that, a similar study was also conducted in three cities of China with different pollution level. The cities were Lanzhou, Wuhan and Guangzhou; and the outcome found respiratory infection was higher among parents in a more polluted city (Brunekreef, 2010).

Spearman correlation tests were made between the percentage of good API and percentage of unhealthy API

**Table 5.** ARI Incidence in Study Area, April 2013 - March 2014

| CAQM Stations | April ’13–May ‘13 (Transition period) | June ’13-Sept ‘13 (Dry season) | October ‘13 (Transition period) | Nov ’13-March ‘14 (Wet season) | Total | Health Ranking |
|---|---|---|---|---|---|---|
| *Petaling Jaya* | | | | | | |
| Percentage of cases | 3.2% | 40.3% | 1.6% | 40.9% | 86% | 1 |
| Rate | 323 | 4032 | 161 | 4086 | 8602 | |
| Total respondents | 186 | 186 | 186 | 186 | 744 | |
| *Banting* | | | | | | |
| Percentage of cases | 3.8% | 47.4% | 3.8% | 51.3% | 106.3% | 2 |
| Rate | 400 | 4743 | 384 | 5128 | 10655 | |
| Total respondents | 78 | 78 | 78 | 78 | 312 | |
| *Shah Alam* | | | | | | |
| Percentage of cases | 1.9% | 53.8% | 5.8% | 46.2% | 107.7% | 3 |
| Rate | 192 | 5384 | 577 | 4615 | 10768 | |
| Total respondents | 52 | 52 | 52 | 52 | 208 | |
| *Kuala Selangor* | | | | | | |
| Percentage of cases | 0.0% | 57.1% | 0.0% | 62.9% | 120% | 4 |
| Rate | 0 | 5714 | 0 | 6285 | 11999 | |
| Total respondents | 35 | 35 | 35 | 35 | 140 | |
| *Klang* | | | | | | |
| Percentage of cases | 3.1% | 56.2% | 3.1% | 59.4% | 121.8% | 5 |
| Rate | 313 | 5625 | 312 | 5937 | 12187 | |
| Total respondents | 32 | 32 | 32 | 32 | 128 | |

Note: Rate is calculated based on number of cases ÷ total number of respondents × 10 000. Percentage is calculated based on number of cases ÷ total number of respondents × 100. Ranking most healthy to most unhealthy in the rank of 1 to 5.

**Table 6.** *ARI Outpatient, April 2013 - March 2014*

| CAQM Stations | April ’13– May ’13 (Transition period) | June ’13- Sept ’13 (Dry season) | October ’13 (Transition period) | Nov ’13- March ’14 (Wet season) | Total | Health Ranking |
|---|---|---|---|---|---|---|
| *Kuala Selangor* | | | | | | |
| Percentage of cases | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 1 |
| Rate | 0 | 0 | 0 | 0 | 0 | |
| Total respondents | 35 | 35 | 35 | 35 | 140 | |
| *Banting* | | | | | | |
| Percentage of cases | 0.0% | 1.3% | 0.0% | 0.0% | 1.3% | 2 |
| Rate | 0 | 128 | 0 | 0 | 128 | |
| Total respondents | 78 | 78 | 78 | 78 | 312 | |
| *Petaling Jaya* | | | | | | |
| Percentage of cases | 0.0% | 0.5% | 0.0% | 1.1% | 1.6% | 3 |
| Rate | 0 | 0 | 0 | 108 | 108 | |
| Total respondents | 186 | 186 | 186 | 186 | 744 | |
| *Shah Alam* | | | | | | |
| Percentage of cases | 0.0% | 1.9% | 0.0% | 0.0% | 1.9% | 4 |
| Rate | 0 | 192 | 0 | 0 | 192 | |
| Total respondents | 52 | 52 | 52 | 52 | 208 | |
| *Klang* | | | | | | |
| Percentage of cases | 0.0% | 0.0% | 0.0% | 3.1% | 3.1% | 5 |
| Rate | 0 | 0 | 0 | 313 | 313 | |
| Total respondents | 32 | 32 | 32 | 32 | 128 | |

Note: Rate is calculated based on number of cases ÷ total number of respondents × 10 000. Percentage is calculated based on number of cases ÷ total number of respondents × 100. Ranking most healthy to most unhealthy in the rank of 1 to 5.

days with rates of ARI incidence throughout the study period (4 seasons) to analyse the relationship. The purpose of this analysis is to determine whether there is a statistically significant relationship between air quality (measured in API)and ARI incidence (health effect). Earlier, by using comparison table (Table 9), the relationship between these two variables was not clear enough. The correlation analysis by using the Spearman correlation is an appropriate way to find the relationship in this study. It is because the data of ARI and API violated the normal distribution requirement for Pearson correlation.

The results showed that there was a strong and positive relationship between rates of ARI incidence and percentage of unhealthy API days during the transition period of October 2013, with the correlation coefficient of 0.900 and significant at 0.05 level among the five (5) study areas (Table 10). However, during the dry and wet seasons, the correlation of ARI and unhealthy API indicates a negative and weak relationship with the correlation coefficient of -0.400 and -0.300 and not significant even at 0.1 level. Meanwhile, the correlation between good API and ARI incidence were not significant at all seasons (whole period of study). This data shows weak relationship between ambient air quality and ARI incidence, according to Ling (2011), there was possibility of a stronger influence from air pollution in traffic areas (roads) and work places, to human health (ARI cases) as compared to the influence of ambient air pollution to human health. Relevant to this, respondents might have exposed to other sources of air pollution such as traffic areas, factories, construction, during travel time and others. Thus, exposure to air pollution was significantly correlated to ARI cases in this study, refer Table 12.

*3.4 Relationship between Ambient Air Quality (API) and CRI*

This analysis was made to determine the relationship between rates of CRI and percentage of unhealthy API days in the five study areas. Spearman correlation test revealed a positive but weak relationship with the correlation coefficient of 0.300. The significant level was at 0.624 which indicates not statistically significant correlation (Table 11). Therefore, this study can conclude that percentage of unhealthy days poses not a significant relationship with CRI incidence rates among the five areas of study.

*3.5 Relationship between Exposure to Air Pollution and ARI*

The purpose of this analysis is to examine whether there is a significant relationship between duration of time spent in polluted air areas (exposure to air pollution measured in hours per week) and ARI incidence cases of respondents for the study area. Using the Spearman correlation method, the relationship analysis were carried out separately for every area. Analysis revealed that there was a significant and weak positive relationship between duration exposed to polluted air and ARI incidence cases throughout the study period for Klang and Shah Alam (Table 12). For Shah Alam, even the correlation coefficient was 0.296 but the weak correlation was significant at 0.033 that indicates statistically significant at 0.05 level.

**Table 7**: CRI Incidence in Study Area April 2013 - March 2014

| CAQM Stations | April '13– May '13 | June '13- Sept '13 | October '13 | Nov '13- March '14 | Total | Health Ranking |
|---|---|---|---|---|---|---|
| *Kuala Selangor* | | | | | | |
| Percentage of cases | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 1 |
| Rate | 0 | 0 | 0 | 0 | 0 | |
| Total respondents | 35 | 35 | 35 | 35 | 140 | |
| *Petaling Jaya* | | | | | | |
| Percentage of cases | 0.0% | 1.6% | 0.0% | 1.6% | 3.2% | 2 |
| Rate | 0 | 161 | 0 | 161 | 322 | |
| Total respondents | 186 | 186 | 186 | 186 | 744 | |
| *Banting* | | | | | | |
| Percentage of cases | 0.0% | 1.3% | 0.0% | 2.6% | 3.9% | 3 |
| Rate | 0 | 128 | 0 | 256 | 384 | |
| Total respondents | 78 | 78 | 78 | 78 | 312 | |
| *Klang* | | | | | | |
| Percentage of cases | 0.0% | 0.0% | 0.0% | 6.2% | 6.2% | 4 |
| Rate | 0 | 0 | 0 | 625 | 625 | |
| Total respondents | 32 | 32 | 32 | 32 | 128 | |
| *Shah Alam* | | | | | | |
| Percentage of cases | 0.0% | 5.8% | 0.0% | 5.8% | 11.6% | 5 |
| Rate | 0 | 577 | 0 | 577 | 1154 | |
| Total respondents | 52 | 52 | 52 | 52 | 208 | |

Note: Rate is calculated based on number of cases ÷ total number of respondents × 10 000. Percentage is calculated based on number of cases ÷ total number of respondents × 100. Ranking most healthy to most unhealthy in the rank of 1 to 5.

Meanwhile, Klang also showed significant correlation but at 0.10 level. In other three (3) areas, the analysis showed weak correlation and not significant even at 0.10 level (Table 12). It showed that the factor of exposure to air pollution by respondents were significantly correlated to ARI incidence cases for 2 out of 5 study areas.

**Table 8.** CRI Hospitalisations April 2013 - March 2014

| CAQM Stations | April '13– May '13 | June '13- Sept '13 | October '13 | Nov '13- March '14 | Total | Health Ranking |
|---|---|---|---|---|---|---|
| *Kuala Selangor* | | | | | | |
| Percentage of cases | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 1 |
| Rate | 0 | 0 | 0 | 0 | 0 | |
| Total respondents | 35 | 35 | 35 | 35 | 140 | |
| *Petaling Jaya* | | | | | | |
| Percentage of cases | 0.0% | 0.5% | 0.0% | 0.5% | 1.0% | 2 |
| Rate | 0 | 54 | 0 | 54 | 108 | |
| Total respondents | 186 | 186 | 186 | 186 | 744 | |
| *Banting* | | | | | | |
| Percentage of cases | 0.0% | 1.3% | 0.0% | 0.0% | 1.3% | 3 |
| Rate | 0 | 128 | 0 | 0 | 128 | |
| Total respondents | 78 | 78 | 78 | 78 | 312 | |
| *Klang* | | | | | | |
| Percentage of cases | 0.0% | 0.0% | 0.0% | 3.1% | 3.1% | 4 |
| Rate | 0 | 0 | 0 | 313 | 313 | |
| Total respondents | 32 | 32 | 32 | 32 | 128 | |
| *Shah Alam* | | | | | | |
| Percentage of cases | 0.0% | 1.9% | 0.0% | 1.9% | 3.8% | 5 |
| Rate | 0 | 192 | 0 | 192 | 384 | |
| Total respondents | 52 | 52 | 52 | 52 | 208 | |

Note: Rate is calculated based on number of cases ÷ total number of respondents × 10 000. Percentage is calculated based on number of cases ÷ total number of respondents × 100. Ranking most healthy to most unhealthy in the rank of 1 to 5.

**Table 9.** Comparison between Air Quality and ARI Incidence

| Ranking based on API | % of API unhealthy days | % of API good days | CAQM stations | ARI incidence (/100) | Ranking based ARI |
|---|---|---|---|---|---|
| 1 | 8.35% | 15.38% | Banting | 106.3% | 4 |
| 2 | 5.71% | 27.03% | Shah Alam | 107.7% | 3 |
| 3 | 5.28% | 14.95% | Klang | 121.8% | 1 |
| 4 | 3.08% | 30.33% | Petaling Jaya | 86.0% | 5 |
| 5 | 1.76% | 61.76% | Kuala Selangor | 120.0% | 2 |

Note: Percentage of unhealthy days based from number of unhealthy, very unhealthy and hazardous days. 1= Most unhealthy; 5= Most health.

**Table 10**. Spearman Correlation between ARI Incidence Rates and API among Five Study Areas

| Spearman Correlation | | ARI Incidence April '13 – May '13 | ARI Incidence June '13 – Sept '13 | ARI Incidence Oct '13 | ARI Incidence Nov - '13 March '14 |
|---|---|---|---|---|---|
| Good (API) Days | Correlation Coefficient | -0.500 | 0.100 | -0.600 | 0.000 |
| | Sig. (2-tailed) | 0.391 | 0.873 | 0.285 | 1.000 |
| | N | 5 | 5 | 5 | 5 |
| Unhealthy (API) Days | Correlation Coefficient | 0.600 | -0.400 | 0.900* | -0.300 |
| | Sig. (2-tailed) | 0.285 | 0.505 | 0.037 | 0.624 |
| | N | 5 | 5 | 5 | 5 |

*Correlation is significant at the 0.05 level (2-tailed).

**Table 11.** Relationship of CRI with Unhealthy Days

| Spearman Correlation | | |
|---|---|---|
| Unhealthy days with CRI Cases | Correlation Coefficient | 0.300 |
| | Sig. (2-tailed) | 0.624 |
| | N | 5 |

*3.6 Relationship between Sense of Clean Air and ARI*

According to Dicenso (2016), human body responds to the way we think, feel and act, thus poor emotional health or negative feelings weaken human body's immune system, making more likely to get colds and other infections. Therefore, correlation test was done to determine the relationship between respondents 'sense of clean air' in their area and ARI incidence cases. The sense of clean air among respondents for all the study areas was shown in Table 13.

Analysis of 383 respondents revealed the relationship between senses of clean air among respondents and the number of the ARI incidence occurred in the study area (as a whole). The variable of the sense of clean air is presented in Likert scale. Spearman correlation method is the most appropriate method for this analysis due to the type of data is 'non-parametric'. The results showed that there was a weak and positive relationship with a correlation coefficient of 0.264 that significant at 0.01 level. It showed the correlation was statistically significant between the sense of clean air and frequencies of ARI incidence throughout the study period, refer Table 14. This analysis demonstrated that human perception of air quality is significantly correlated to ARI cases.Considering the findings, it can be concluded that there are potential influences of environmental perception on human health.

## 4. Conclusion

The air quality in the study area was more polluted in the period of May to July 2013 which was the dry season, compared to the period of December 2013 to February 2014 which was the rainy season. This study believes that more rainfall during the wet season leads to better air quality by reducing the concentration of air pollutants. However, Peninsular Malaysia experienced a short period of haze in March 2014 that results in deteriorated of air quality to unhealthy for a little while.

For the relationship between air quality (API) and respiratory health, it is found that ARI incidence (self-reported by respondents) was not clearly related to the air quality. However, the correlation between ARI cases and API data (number of unhealthy API days) was only significant in October 2013 and not significant for another period among the five areas. Thus, it shows that there were other factors affecting human health such as food, behaviour, genetic, etc.

In contrast, the significant relationship between exposure to air pollution and respiratory health (ARI incidence) was established for 2 out of 5 study areas, which were Shah Alam and Klang. For Petaling Jaya, Kuala Selangor, and Banting the correlation shows a weak and not significant relationship. Besides, respondents' perception of 'sense of clean air' was significantly correlated to ARI cases in the study area. It showed a relationship between environmental perception and human health.

**Table 12**. Relationship between duration of Time Spent in Air Polluted Areas and Number of ARI Incidence among Respondents

| Spearman Correlation between duration exposed to polluted air with ARI incidence throughout the study period | | |
|---|---|---|
| Banting | Correlation Coefficient | -0.130 |
| | Sig. (2-tailed) | 0.256 |
| | N | 78 |
| Kuala Selangor | Correlation Coefficient | 0.042 |
| | Sig. (2-tailed) | 0.809 |
| | N | 35 |
| Klang | Correlation Coefficient | 0.325** |
| | Sig. (2-tailed) | 0.070 |
| | N | 32 |
| Petaling Jaya | Correlation Coefficient | 0.106 |
| | Sig. (2-tailed) | 0.151 |
| | N | 186 |
| Shah Alam | Correlation Coefficient | 0.296* |
| | Sig. (2-tailed) | 0.033 |
| | N | 52 |

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.10 level (2-tailed).

**Table 13.** Sense of Clean Air among Respondents

| Sense of Clean Air | Respondents (%) |
|---|---|
| Feel the air is clean | 84.9 |
| Feel the air is polluted | 15.1 |
| Total | 100.0 |

**Table 14.** Correlation between Sense of Clean Air and ARI

| Spearman Correlation | | |
|---|---|---|
| Sense of clean air and ARI incidence | Correlation Coefficient | 0.264** |
| | Sig. (2-tailed) | 0.000 |
| | N | 383 |

**. Correlation is significant at the 0.01 level (2-tailed).

Based on the findings, it is recommended that air quality should be improved for healthier community in the urban region. The concern should not only to be put on the quality of ambient air but also all the buildings and spaces. It is because the study had shown a significant correlation between exposure to air pollution and respiratory health. In addition, the monitoring of air quality should not only focus on the ambient air quality but also all the pollution sources such as construction area and traffic area. Scheduled or continuous monitoring of air quality at potential pollution areas is crucial for healthier urban dwellers.

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