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AIR POLLUTION AND CARDIORESPIRATORY HOSPITALIZATION TRENDS BASED ON THE DAYS OF THE WEEK IN KLANG VALLEY, MALAYSIA

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Abstract
The days of the week have significantly more influence towards the trend of hospitalization whilst its relationship with air pollution is unclear. The aim of this paper is to describe the trend of air pollution and cardiorespiratory hospitalizations based on the days of the week trend. A study on time series design study was conducted based on daily basis from 2010 to 2015. Daily cardiorespiratory hospitalizations in a teaching hospital in Kuala Lumpur and concentrations of PM_{10}, CO, NO_2, SO_2, and O_3 were matched. Results showed that cardiorespiratory hospitalizations were lower on the weekend. CO, NO_2 and SO_2 have higher concentrations on weekdays, ozone has higher concentration on weekends whereas PM_{10} has no certain trend. Based on the day of a week, cardiorespiratory hospitalizations shared the same highest peak on Tuesday with PM_{10}. NO_2, SO_2 and CO. The findings support the association between hospitalization and air pollution.

Keywords: air pollution, trend of days, cardiovascular and respiratory hospitalizations, Kuala Lumpur

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1.0 Introduction

As the world progresses, air pollution has become a major problem that has to be faced, especially in developing countries. The relationship between air pollution and public health has gained increasing attention in the past decade (Zeng&Khondker 2016). The worsening air pollution towards health impact has become the centre of attention pertaining to short-term fluctuations and long-term levels of air pollution exposures, including particulate matter (PM), ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) (Bhaskaran et al. 2009).

Air pollution is defined as the presence of foreign substances in the air that affect the health and well-being of living beings (Amâncio&Nascimento 2012). It was noted to have significant effect of the hospitalization of cardiovascular and respiratory diseases (Arbex et al. 2007; Hod 2016). Air pollution have been long believe that it cause the hospitalization of respiratory diseases such as asthma (Ab Manan et al. 2017), Chronic Obstructive Pulmonary Disease (Hwang et al. 2017; Peacock et al. 2011), pneumonia (Harris et al. 2011) and bronchitis (Kurmi et al. 2010).

It is also believed that the air pollution can significantly affect the hospitalization of cardiovascular diseases such as stroke (Xiang et al. 2013), heart failure (Shah et al. 2013), arrhythmia (Link&Dockery 2010) and Ischaemic heart disease (Beckerman et al. 2012; Collart et al. 2017).

Cardiovascular and respiratory diseases are noted to be the top causes of hospitalization in Malaysia for the past few years (MOH 2017). Further understanding about the association of the air pollution and hospitalization will help the policy maker to understand the seriousness of the effect of air pollution thus helping them in planning and strategizing their health care system. It will help them in reorganizing their resources so they can anticipate the trend of hospitalization cases that was cause by the air pollution. The association of air pollution and the hospitalization was used to be presented by daily pattern although days of the week pattern have significantly more influence towards the trend of hospitalization as compared with other type of trend (Ito et al. 2011). Therefore, the aim of this paper is to describe the trend of air pollution and hospitalization of cardiovascular and respiratory diseases in Klang Valley Malaysia based on the days of the week trend and to see the association between them.

2.0 Method

2.1 Study location

Cheras was chosen for this study because it is located in the middle of the Klang Valley. The Klang Valley is regarded as a centre of industrial and development focus for Malaysia. Due to its location, it has undergone a rapid urbanization process, population development and rapid industrial activity that causes air quality disruption (Azmi et al. 2010). In addition, the area is also one of the areas affected by the haze episodes because of its location on the west coast of Peninsular Malaysia facing the open burning in Sumatra, Indonesia. Some previous haze episodes have shown that the Klang Valley area has become one of the worst affected areas in Malaysia. Its geographical position as well as weak wind movement limits the movement of air pollutants and causes the collection of air pollutants (DOE 2015).

In addition, Cheras is a highly populated with 400,000 population (Mahalingam 2016) had recorded the highest reading for an unhealthy day when compared with other urban areas in the Klang Valley (Noraishah&Farah 2015). It also has a university hospital that had served the surrounding community since 1998 and has a capacity of more than 1,000 beds. This hospital also is one of the few hospitals in Malaysia using the case-mix system where patients data were recorded in a systemic way based on the ICD-10. As one of the leading and biggest hospital in Klang Valley, it can act as proxy to the other hospital in these area.

2.2 Study design

This is a time series study that uses data from two sources, namely the hospitalization data and the air pollutant data. The review period comprises data that was extracted from 1st January 1 2010 to 31st December 2015. The 6-year period (2010-2015) was chosen due to the worsening air pollution in Malaysia in the past 6 years and the presence of epic haze during this period which contributes to air pollution.

Time series studies are epidemiological approaches used to collect well-defined data obtained through repeated measurement over time to determine statistical association between air pollutants and other environmental parameters of human health (Fung et al. 2003). Time series will be able to describe the trend and explanation for it, to measure the exposure-outcome association and its correlation; and for forecasting or predicting short term trends from previous pattern (Box et al. 2011).

2.3 Hospitalization data

The hospitalization data were obtained from the Health Information Unit of the hospital which is the gate keeper of patient's medical record. The cardiovascular and respiratory hospitalization data were given based on the case-mix system where all patients that were admitted in the hospital from 1st January 2010 to 31st December 2015 who was given a final diagnosis with the code I (for cardiovascular diseases) and J (for respiratory diseases) based on the ICD-10. Data were cleaned by only choosing only the disease that has related with the air quality parameters which are Ischaemic Heart Disease (I20-I25), Heart Failure (I46, I50-51), Stroke (I60-69), Arrhythmia (I47-49) and Embolism (I26-28, I74, I80-82) for the cardiovascular diseases. For the respiratory group, pneumonia (J12-J18), asthma (J45-46), Chronic Obstructive Pulmonary Disease (COPD) (J44) and bronchitis (J20-22, J40-43, and J47) were the diseases that had significant relationship with air pollution.

2.4 Air quality data

Air quality parameters were captured by the Cheras Continuous Air Quality Monitoring

(CAQM) station which undertaken by private company, Alam Sekitar Malaysia Sdn. Bhd. (ASMA). ASMA follows a stringent quality assurance and quality control procedures in reporting the data (Azmi et al. 2010). The CAQM station is an integrated ambient air quality monitoring system designed to monitor ambient air for specific pollutants. This is accomplished through the continuous operation of a number of ambient air analyzers and sensors. The data from these analyzers and sensors are recorded on a microcomputer-based data acquisition system (DAS) which also provides output control to the various analyzers and sensors. The data are then transferred to a central computer every hour for evaluation and reporting. The data for time series analysis (PM_{10}, CO, SO_2, NO_2 and O_3) was obtained from the Air Quality Division, Department of Environment (DOE) of Malaysia. The hospital and the CAQM location are shown in Figure.

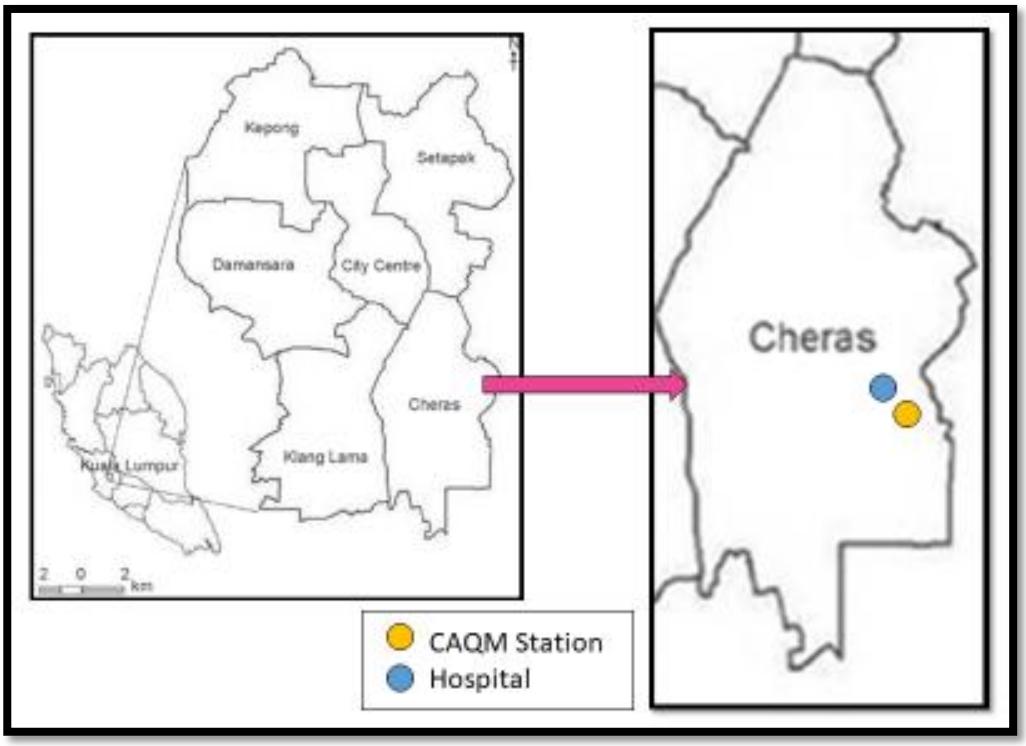

Figure 1: Location hospital and CAQM station in Cheras, Kuala Lumpur, Malaysia.

2.5 Data analysis

Both hospitalization and air pollutant data were the combined together and were arranged based on the date in SPSS datasheet. Data analysis were done using IBM SPSS 23 version.

2.6 Replacing Missing Value

In this study, linear interpolation method was used to handle the missing value in the air quality data. This method was chosen because it is a curve fitting method using linear polynomials to generate new data points within a discrete data set range. This is the most suitable method for time series study data that has a trend without seasonality (Xu et al. 2013) as data used in this study. This method can also provide data replacement values that take into account trends within a certain period of time using smoothing algorithms, which can differentiate disturbance signals in such data (Lepot et al. 2017). This method has been used in other time series studies using local data similar to this study (Mahiyuddin et al. 2013).

2.7 Trend analysis

The air quality data that was obtained was in the unit of ppm for CO, SO_2, NO_2 and O_3 while PM_{10} in µg/m^3. These parameters were then standardised to the same unit of (µg/m^3) based on US EPA Standard calculation. Days of the week were later add on the data according to the date of the study period. The study data were then presented based on the days of the week to see its relation with each other.

3.0 Results

3.1 Descriptive

For the 6 years period, the number of hospitalization of cardiovascular and respiratory diseases were noted to be increased by 2013 by slightly become lower by 2015. Cardiovascular has higher number of hospitalization as compared to the respiratory diseases for each year. Majority of the patient that were admitted for both cardiovascular and respiratory diseases were noted to be male in gender. The mean age group of cardiovascular diseases is between 53 to 64 years old whereas for respiratory diseases, the mean age group is 35 to 42 years old. Table 1 showed the number of hospitalization per year according to gender with the mean age group for the respiratory and cardiovascular disease group. The independent t-test also showed that female has a higher mean age in the respiratory group for every year as well as the during the total 6 years study duration. However, for the cardiovascular group, female has a higher mean age group only in the year 2015 and also in the total 6 years study duration period.

Table 2 showed the annual average air pollutant concentrations of PM_{10}, CO, NO_2, SO_2 and ozone. It is found that the average for PM_{10} increases annually and records the highest readings in 2012 and 2015. Some increment also were noted for the CO and ozone. ANOVA test that was done showed that there is a significance difference of mean for every year in each of the pollutant.

3.2 Trend of hospitalization

The number of hospitalization of cardiovascular and respiratory diseases based on the day of the week were shown in Figure 2 below. It was noted that the cardiovascular disease (CVS) has the highest peak on Tuesday (1998 cases). Respiratory diseases recorded highest cases on Wednesday (1331) followed by Tuesday (1326).

3.3 Trend of air quality parameters with the hospitalization

The air quality parameters were then presented separately as they have their own mean of concentration as shown in Figure 3-7. It was noted that CO, NO_2 and SO_2 have higher concentration on weekdays (Figure 4, 5 & 6) whereas ozone has higher concentration on weekends (Figure 7). PM_{10} has shown no certain trend (Figure 3).

It also shown here that cardiovascular shared the same highest peak with PM_{10} on Tuesday whereas CO, NO_2 and SO_2 also have higher peak on Tuesday although it is not their highest peak. Comparing it with the respiratory hospitalization trend, it shared a high peak on Tuesday with PM_{10}, CO, NO_2 and SO_2 although it is not the highest peak.

4.0 Discussion

This paper aims to describe the trend of air pollution and hospitalization of cardiovascular and respiratory diseases in Klang Valley Malaysia based on the days of the week trend and to see the association between them. The study showed that cardiovascular and respiratory cases have lower hospitalization on the weekend. This is strongly supported by other study (CIHI 2014; Hoh et al. 2010; Kostis et al. 2007). This may be because people avoid to be admitted over the weekend and expect a self-healing on the weekend. Patients often believe that enough rest can cause their pain or illness to diminish (Purdy 2010). Studies also have shown that patients are less comfortable getting treatment during their holidays or weekends (Ziebarth&Karlsson 2010).

They are more willing to use their work time to seek treatment that allows them to obtain a sick leave certificate on that day thus causing a higher hospitalization on weekdays. Moreover, most hospitals try to reduce the patient's hospitalization into the ward during the weekend, especially the unnecessary cases (Freemantle et al. 2012). This supports the low peak trend that was observed in Figure 1 for both groups of illness.

This study found CO, NO_2, and SO_2, shared a similar trend related with the weekdays and weekend, which is similar with the findings from other studies (Riga-Karandinos et al. 2006; Shi et al. 2009). This may be due to the use of more vehicles during working days causing more air pollutants to be released into the air. At weekends, people are more interested in being in the house and not using their vehicles. Also for families with more than one car to work separately on weekdays, the family only uses one vehicle only on weekends.

Table 1: Number of cardiovascular and respiratory hospitalization from 2010 to 2015

Year	Age (mean, s.d)	Age *			Gender		Total n (%)
		Male (mean,s.d.)	Female (mean,s.d.)	t-test	Male n (%)	Female n (%)	
2010							
Cardiovascular disease	53.62 (16.71)	53.06 (16.55)	54.97 (17.03)	-2.28	1364 (70.89)	560 (29.11)	1924 (100)
Respiratory disease	40.17 (32.51)	36.47 (33.84)	44.05 (30.60)	-4.02*	602 (51.23)	573 (48.77)	1175 (100)
2011							
Cardiovascular disease	58.08 (12.87)	58.10 (12.86)	58.05 (12.91)	0.69	1264 (72.56)	478 (27.44)	1742 (100)
Respiratory disease	35.32 (33.32)	33.32 (33.27)	37.82 (33.23)	-2.25*	618 (55.48)	496 (44.52)	1114 (100)
2012							
Cardiovascular disease	60.09 (11.51)	60.23 (11.50)	59.74 (11.54)	0.92	1584 (71.46)	633 (28.54)	2218 (100)
Respiratory disease	41.39 (32.24)	40.00 (32.39)	43.23 (31.70)	-2.00*	929 (56.96)	702 (43.04)	1631 (100)
2013							
Cardiovascular disease	62.22 (11.65)	62.35 (11.31)	62.00 (12.19)	0.74	1554 (62.01)	952 (37.99)	2506 (100)
Respiratory disease	43.91 (32.29)	41.34 (32.94)	47.07 (31.20)	-3.79*	1009 (55.20)	819 (44.80)	1828 (100)
2014							
Cardiovascular disease	64.61 (12.88)	64.44 (13.00)	64.85 (12.72)	-0.70	1118 (57.87)	814 (42.13)	1932 (100)
Respiratory disease	44.32 (32.81)	41.72 (33.08)	47.16 (32.31)	-3.27*	807 (52.17)	740 (47.83)	1547 (100)
2015							
Cardiovascular disease	61.94 (15.65)	60.15 (15.18)	64.51 (15.96)	-6.44*	1273 (58.91)	888 (41.09)	2161 (100)
Respiratory disease	42.12 (32.30)	40.31 (32.47)	44.41 (31.97)	-2.70*	1017 (55.94)	801 (44.06)	1818 (100)
TOTAL							
Cardiovascular	60.26 (14.02)	59.67 (13.88)	61.37 (14.21)	-6.47 *	8157 (65.35)	4325 (34.65)	12482 (100)
Respiratory	41.64 (32.63)	39.36 (33.06)	44.39 (31.91)	-7.35*	4982 (54.67)	4131 (45.33)	9113 (100)
Total					13139 (60.84)	8456 (39.16)	21595 (100)

Using independent t-test: * when p <0.05

Table 2: Mean concentration of air pollutants from 2010 to 2015

Air quality parameter ($\mu g/m^3$)	Year						p-value *
	2010	2011	2012	2013	2014	2015	
	Mean (s.d)						
PM_{10}	43.75 (10.35)	49.39 (14.75)	59.64 (19.09)	47.47 (25.78)	48.98 (26.88)	58.10 (26.87)	<0.005
CO	952.85 (279.19)	1017.86 (265.00)	909.47 (236.06)	941.53 (292.89)	948.76 (299.88)	1108.78 (541.20)	<0.005
NO_2	40.52 (9.00)	43.36 (9.90)	42.55 (10.02)	37.52 (8.70)	38.78 (10.27)	39.37 (10.98)	<0.005
SO_2	5.47 (2.47)	5.03 (3.16)	4.59 (2.79)	5.44 (3.18)	5.53 (2.97)	5.47 (2.74)	<0.005
Ozone	40.78 (16.30)	38.87 (14.74)	39.27 (14.43)	36.95 (14.50)	37.22 (17.43)	45.15 (15.65)	<0.005

*ANOVA test

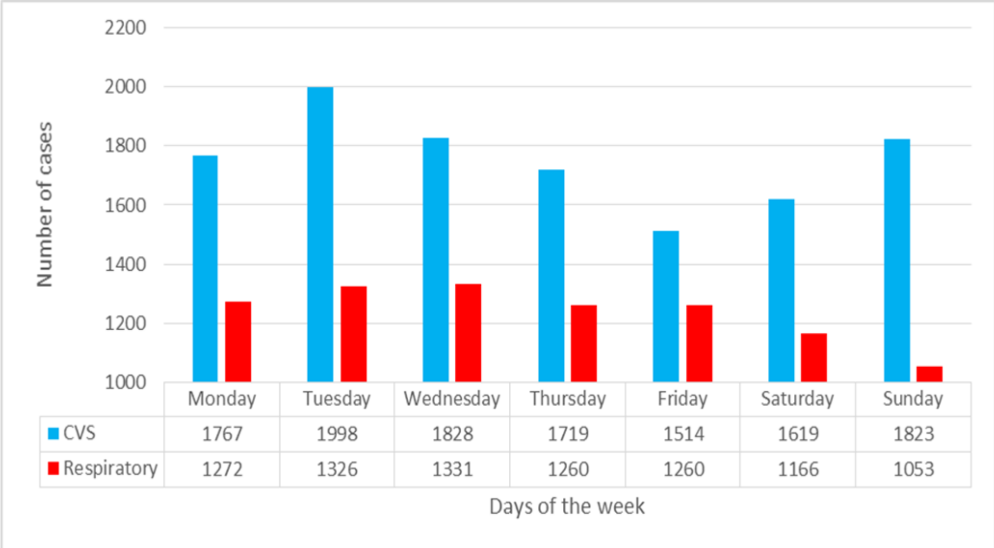

Figure 2: Trend of cardiovascular and respiratory hospitalization according to the days of the week

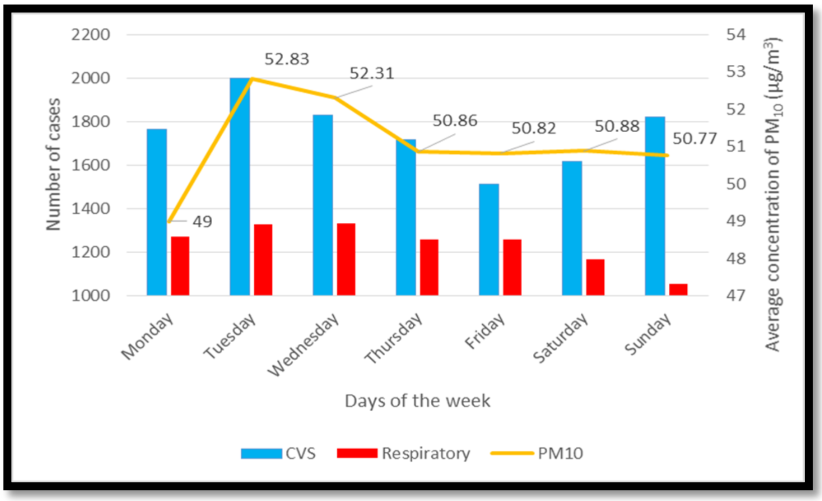

Figure 3: PM_{10} concentration comparing with the hospitalization

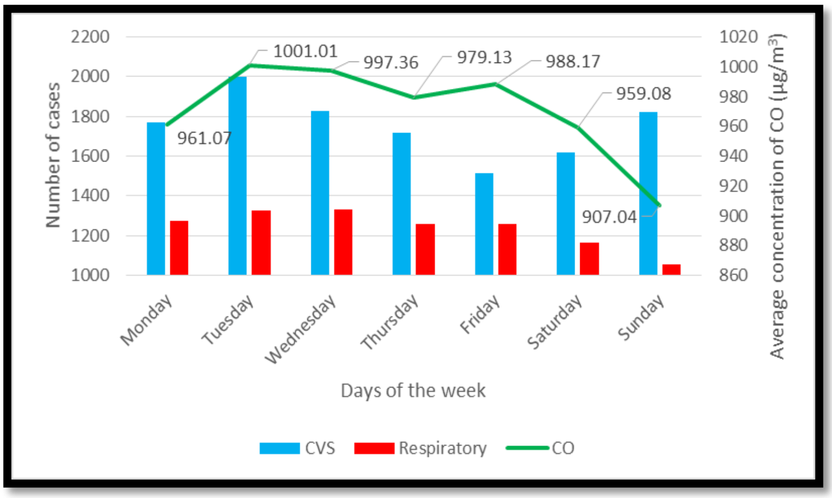

Figure 4: CO concentration comparing with the hospitalization

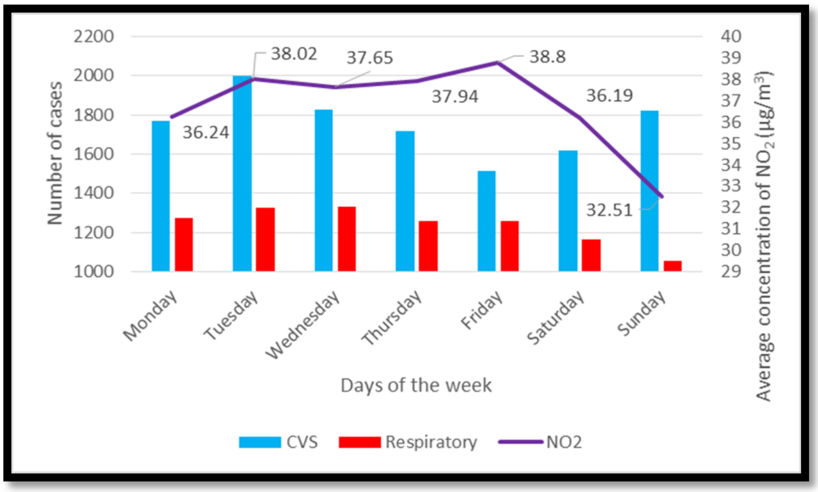

Figure 5: NO_2 concentration comparing with the hospitalization

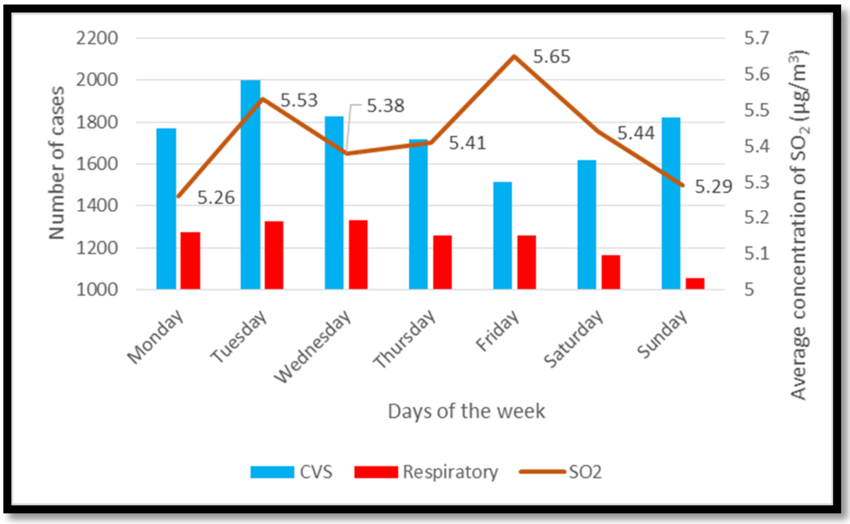

Figure 6: SO_2 concentration comparing with the hospitalization

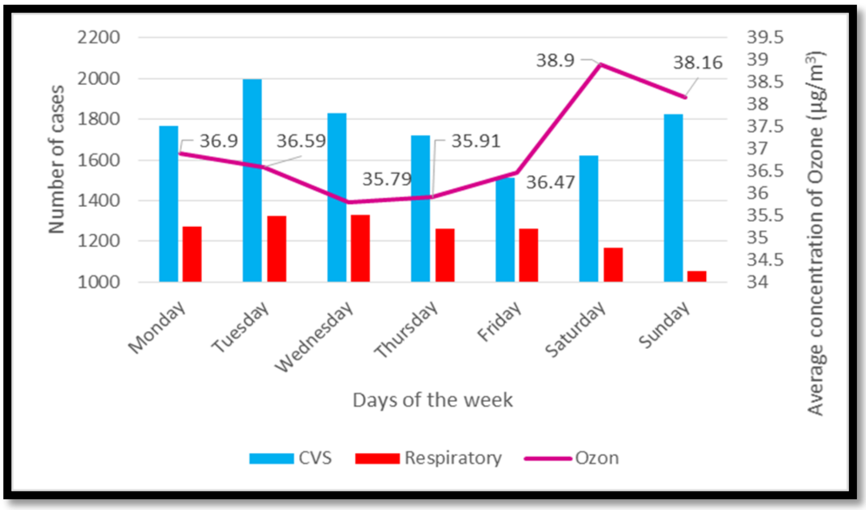

Figure 7: Ozone concentration comparing with the hospitalization

This causes the number of vehicles at the end to be less than working days (Ross et al. 2011). As these pollutants were much related with the fossil-fuel and biofuel consumption (Lu et al. 2010; Muralidharan et al. 2011; Skalska et al. 2010), the higher usage of mobile during weekdays cause a higher concentration of these pollutants The findings of this study are in line with other studies conducted earlier (Mohamed Bin Yehmed et al. 2016). This study found that ozone has different trends compared with other pollutants in which it reaches a higher mean concentration approaching the weekend. This can be explained by the condition called ozone weekend effect (OWE) as depicted in a study in China (Wang et al. 2014). Substances such as aerosols, volatile organic compounds (VOCs) and NOx have low concentrations over the weekend. This can increase UV radiation flux by dispersion and absorption, which leads to increased ozone production efficiency. Additionally, the lack of sunlight dispersion due to lower concentration of lower particles at the weekend results in better ozone formation which may contribute to this OWE (Qin et al. 2004).

This study found that PM_{10}, it has no specific trend based on the day of the week. However, this is contradict with a study done in London where it showed that PM had a lower concentration on weekend (Jones et al. 2008). This could probably due to the fact a higher proportion of the PM in that study area was contributed to the traffic which noted to be lower on weekend. For Malaysia and in this region, the PM_{10} is usually related to burning of forest and agriculture biomass, open burning and combustors (Simões Amaral et al. 2016).

Therefore, its concentration is based on import factor contributed by the transboundary haze thus days have very little influence on its trends.

This study found presence the relationship between PM_{10} and cardiovascular disease, similar with previous study (Martinelli et al. 2013). For PM_{10} it shares the same highest peak with the cardiovascular case on Tuesday. The PM_{10}, which has the lowest peak on Monday, is also supported by a low cardiovascular case admission on the same day although it is not the lowest value. This trend pattern illustrates or assumes that when PM_{10} has a higher average concentration, the admission of the ward for cardiovascular cases will also increase.

For SO_2 and NO_2, they share the highest peak that falls on Friday although each has its own trend. This is because of these pollutants, their main source is due to the same source as the burning of fossil fuels as discussed above (Geravandi et al. 2015). When comparing the pattern of cardiovascular hospitalization trends (which has Tuesday as the highest peak), both pollutants also have a higher peak on Tuesday although it is not the highest peak. The same situation is shared by CO which shares the same highest peak as cardiovascular hospitalization on Tuesday. Thus, it can be concluded that SO_2, NO_2 and CO have associated with cardiovascular disease as supported by previous studies (Atkinson et al. 2013; Shah et al. 2015).

Looking on the respiratory hospitalization trend with the air pollutants, it was noted that respiratory hospitalization had a high peak on Tuesdays and Wednesdays. For PM_{10}, CO, NO_2 and SO_2, they share the same high peak as respiratory trends on Tuesday. The trends for these four air pollutants almost resemble the respiratory hospitalization trend. Therefore, it can be concluded that these pollutants have an association with respiratory disease as supported by previous studies (Anderson et al. 2013; Barck et al. 2005; Chen et al. 2007).

However, this relationship is only based on the trend showed here and it needs to be statistically proven through further risk analysis. However, this study still provides a significant proof to support the relationship between hospitalization and air pollution.

Strength and limitation

One of the strength of this study is this study offered a different trend of air pollutants as its presented its finding based on the days of the week. Although the air pollutants pattern were always presented based on daily pattern to capture its seasonality, this study was able to be presented in this such way as the study area is known to be a non-seasonal area. It was also noted that days of the week have significantly more influence towards the trend of hospitalization as compared with other type of trend (Ito et al. 2011). Therefore, this study have given a significant contribution in understanding the pattern and trend of hospitalization and its relation with air pollutant.

This study finding also support the argument of the association between air pollutants and the cardiovascular and respiratory hospitalization. This study also focusing on the specific cardiovascular and respiratory disease that only related with air pollutants as compared with other time series studies that covered all the cardiovascular and respiratory that was admitted. Thus our finding were noted to be more valuable and precise in giving the relation of air pollutants and these admission.

While this study has contributed significantly and has its own strength, it still has some limitation. This study only confined to Cheras area as there is lack of hospital that were using the standardized diagnosis classification (ICD-10) within the last 3 years. Larger study areas are recommended but they require more time and additional resources. However, these finding still can act as proxy to other urban areas in Malaysia and can be used as a baseline study to enable national studies to be carried out which cover a wider area.

Conclusion

Source of the pollutants influence the days of the week trends of each pollutants. PM_{10}, NO_2, SO_2 and CO has a possible positive association with the cardiovascular and respiratory hospitalization. However, further analyses need to be done to prove the associations and later, estimating the risk. This study able to provides the proof to support the association between hospitalization and air pollution and contribute to existing knowledge regarding the trends of air pollution.

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