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Allergy to Air Pollution and Frequency of Asthmatic Attacks among Asthmatic Primary School Children

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Abstract: A cross-sectional comparative study was conducted on asthmatic primary school children in 3 areas in Kuala Lumpur and Selangor in Malaysia. The main objective was to study the relationship between air pollutants and frequency of asthmatic attacks. A total of 207 asthmatic children comprising of 87 from the urban, 67 from the industrial and another 53 from the rural areas were involved. Only asthmatic children diagnosed by medical professionals were selected with reference to the medical records provided by the school. These 2nd to 5th grade students had written consent from their parents. A modified ISAAC Questionnaire was completed by the parents. Continuous ambient air pollutants data was obtained from the Department of Environment. The prevalence of asthma was higher in urban and industrial children. In 2008, the annual mean PM_{10} in the industrial areas (64.9 μg/m^3) was slightly higher than the Malaysian Ambient Air Quality Guideline. SO_2 was significantly higher in the industrial area (0.003ppm), while CO (1.31ppm) and NO_2 (0.03 ppm) were higher in the urban area. Significant association between the prevalence of respiratory symptoms with locations found. Urban children have more respiratory symptoms such as difficulty in breathing, (p=0.01) chest tightness, (p=0.047) and wheezing (p=0.029). Allergy symptoms such as skin rashes, nasal symptoms and watery eyes and nose were also higher among urban children. Results showed that PEF variability and allergy to pollen significantly influenced the frequency of asthmatic attacks while higher fathers' education was a protective factor. Urban and industrial asthmatic children were at greater risk of getting more frequent asthmatic attack due to allergy to high levels of air pollutants in the form of particulates such as pollen, or chemical content and gases which affect the PEF variability leading to asthmatic attacks.

Key words: Asthma prevalence・School children・Air pollutant・Pollen

INTRODUCTION

Air pollution remains a serious problem in cities throughout the world, particularly in developing countries. It is estimated that a quarter of the world population is exposed to unhealthy concentrations of air pollutants. Children are particularly at risk due to the immaturity of their respiratory organ systems [1] The association between air pollutants exposure and respiratory morbidity has been recognized since the early part of this century, in relation to the disastrous smog episodes in the Meuse Valley (Belgium,1930), Donora (Pennsylvania, USA, 1948) and London (UK,1952) [2].

Children and infants are among the most susceptible and vulnerable populations to many of the air pollutants because of their immature respiratory system [3] The different composition of air pollutants, the dose and time of exposure and the fact that humans are usually exposed to pollutant mixtures than to a single substance can lead to a diversity of effects on human health [4-6].

Asthma is a common condition that gives rise to considerable morbidity and mortality. Its prevalence is increasing and a local study found 13.8% of primary school children in Kuala Lumpur to be asthmatic [7]. One of the problems in childhood asthma is that the diagnosis is frequently missed. A study by Zailina *et al.* [8] found there was a significant difference between

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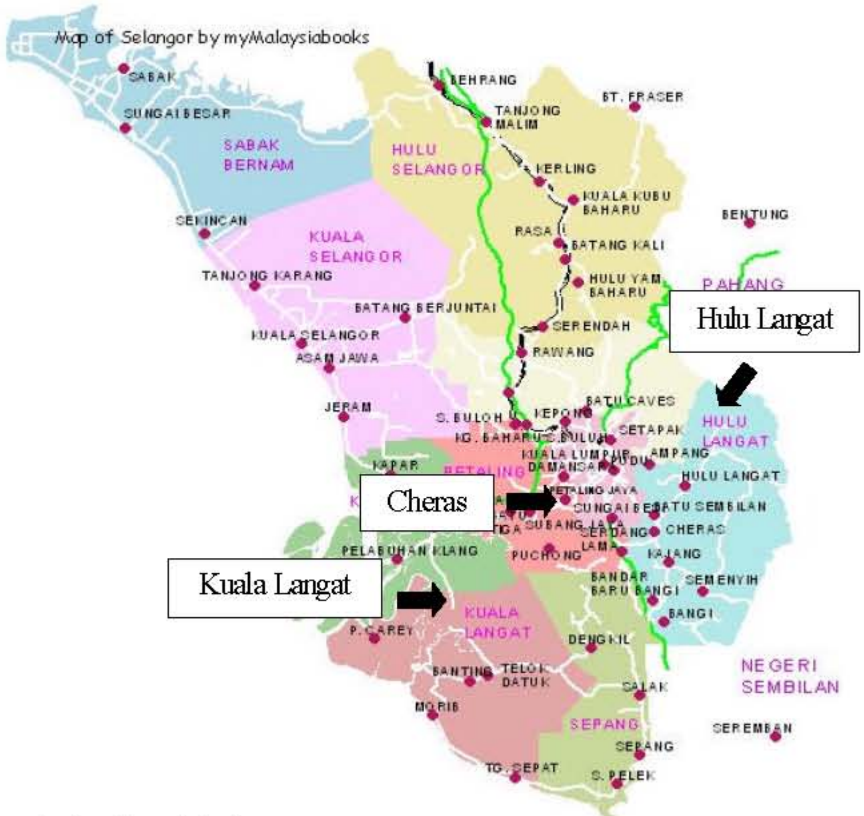

Fig. 1: Map shows the location of study
Source: http://www.mymalaysiabooks.com/maps/selangor1.jpg

the lung functions of asthmatic children in the urban and rural areas and significant correlations between the frequency of asthma attacks and air pollution among the asthmatic children living in the urban areas.

MATERIALS AND METHODS

Study Design: This is a cross sectional comparative study conducted in the Federal territory of Kuala Lumpur and the state of Selangor. Schools from Cheras and Petaling represented the urban areas; schools from Klang represented the industrial areas and schools from Hulu Langat and Kuala Langat represented the rural areas.

Study Sample: Grade A classified National Primary Schools with more than 1000 students from the Federal Territory and Selangor lists were obtained from the Ministry of Health webpage. The areas were then categorized as urban, industrial and rural. The schools located in the 3 areas were listed. The schools were then purposively sampled based on their distance of less than 5km radius from the ASMA Sdn Bhd air monitoring station. Two to three primary schools were selected from each of the 3 areas. Permission was obtained from the Malaysian Ministry of Education, at the Federal, State and Districts' education offices. Schools in Cheras and Petaling Jaya represented the urban areas; schools in Klang represented industrial areas and schools in Hulu Langat and Kuala Langat represented the rural areas.

From the schools selected, the students' medical records were referred to screen for medically diagnosed asthmatic children. Only those with written consent from their parents were included in the study. These children were from the age of 8-11 years old (Standard 1-5), with the exception of year 6 students as they are in an examination class and to be disturbed. There was no selection criteria based on gender, however, only Malay students were selected as respondents as there were no other ethnic group in the rural areas except the Malay ethnic group.

Questionnaire: A standardized set of questionnaire from the International Study of Asthma and Allergies in Childhood (ISAAC) was translated from English to Malay with some modifications, was used in the study. It comprises questions on asthma, allergies and respiratory symptoms. For the reliability test, a pilot study was conducted on 10 percent of the sample size at one of the schools in Selangor [9].

The questionnaire was divided into 5 sections; Section A consisted of general and demographic information. Information on respondents' respiratory as well as allergy symptoms and the determination of prevalence were in Section B. Section C consisted of questions on asthma and allergic conditions as well as the family history of asthma. Information on this section enabled the researcher to determine the potential risk factors associated with asthma together with their conditions. Section D included questionnaires on the indoor and outdoor environment. The information was important to assess the potential environmental factors which may contribute to the severity of asthma among respondents. Section E, captured information on their children's food intake and also current symptoms in the last 3 months. The parents were required to fill up the information on the questionnaire brought back by the respondents.

Pre-test of the questionnaires was also carried out among the urban and rural parents to ensure that the questionnaires were easily understood especially for the rural parents. The results from the pre-test were used to rephrase some of the questions for better understanding.

Peak Expiratory Flow Reading: The peak expiratory flow is commonly used in clinical research for respiratory problem such as asthma and chronic obstructive pulmonary disease (COPD). Peak expiratory flow was measured using a peak flow meter Mini Weight Model AFS CE 0120. In this study, peak expiratory flow readings were taken before and after school on Monday, Wednesday and Friday with 3 readings for each measurement. The best reading was then selected. Instruction was given to all children on how to blow into peak flow meter. They were asked to stand up straight and hold the peak flow meter horizontally. The mouthpiece was held between the teeth and over the tongue, with lips sealed around it. The children were then instructed to blow as hard and as quickly as possible. The readings were then recorded. PEF variability was calculated by the researchers as follows:

$$\frac{\text{Highest PEF - Lowest PEF}}{\text{Highest PEF}} \text{X} 100$$

Fig. 2: Formula for calculating the PEF variability. (Reddel *et al* 1995., Ellman *et al* 1997)

Then, the PEF variability results were grouped into three categories, which are <20% as low, 20-30% as medium and >30% as high as referred to in the National Asthma Education and Prevention Program [10].

Measurement of Ambient Air Pollutants: Daily data on the ambient air concentration for PM_{10}, carbon monoxide (CO), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2), were obtained from fixed stations located within 5km radius from the selected school in the urban and industrial areas. The data were provided by the Air Quality Section, Department of Environment. Twenty-four hour air pollutant concentrations were recorded. For the rural areas, since there was no ASMA station, measurements of ambient air were conducted by using the air sampling pump with standard method from NIOSH Manual of Analytical Method (NMAM) for respirable particulate, NO_2 and SO_2.

Data Analysis: Frequencies of asthmatic attacks were categorized into 3 categories in the questionnaire, which made up of: no attack, 1-3 episodes and 4 to 12 episodes in the last 12 months. Asthma attacks are characterized by airway inflammation, which restricts airflow. An exacerbation is an increase in the severity of the disease symptoms of a disease or symptoms of a disease. The cause of an asthmatic attack may vary among individual. Some individuals have stable asthma or did not have any attacks for weeks or months and then suddenly develop an episode of acute asthma attacks. Asthmatic individuals react differently to various factors and develop an attack from several triggering agents [11].

Logistic regression analysis was performed to select the significant influencing risk factors associated with the frequency of asthmatic attacks. The dependent variables were categorized as follows: (0=No), (1=Yes) for allergy reaction to pollen, food and mold, (0=Low) (1=High), for father's education, (0=Urban) (1=Rural),(2=Industrial) for location of study, (0=>1000m) (1=500 to 1000m) (2=100 to 500m) for location of respondents' house from the main road. The PM_{10} concentrations and PEF variability were analyzed as continuous data.

RESULTS

Table 1 shows the anthropometric data and socio-economic information of respondents. Significance differences were shown in the education years and income of respondents. Urban parents had higher educational attainment and household income than rural parents.

Table 1: Information on anthropometric and social economic status

	Urban	Industrial	Rural		
Variable	Mean (SD)	Mean (SD)	Mean (SD)	F	p
Age (yr)	9.69	9.84	9.58	0.78	0.46
	(1.13)	(1.08)	(1.10)		
BMI	18.74	17.88	17.26	1.94	0.15
	(4.66)	(4.54)	(2.85)		
Father Formal education (yr)	10.97	10.51	9.53	5.20	0.006**
	(11.46)	(4.98)	(3.38)		
Mother Formal education (yr)					
	10.09	10.72	9.96	5.11	0.007**
Household income (RM)	(10.97)	(1.99)	(2.34)		
	3703.99	2286.04	1919.39	10.39	0.001***
	(2887.06)	(2314.46)	(1986.14)		

***Significant at p=0.001

**Significant at p=0.01

Table 2: Prevalence of asthmatic children from school medical record in the selected schools for the areas

Area	Numbers of student having asthma (n)	Total numbers of students (n)	Prevalence rate (%)
Urban	172	3002	5.70
Industrial	91	1745	5.20
Rural	64	1379	4.60

Table 3: Average daily the air pollutant concentrations during the study period

Variables	Days (N)	Temp/C°Mean (SD)	Mean (SD)	Median (IQR)	Min	Max
Urban						
PM_{10}($\mu g/m^3$)	365		48.69(12.06)	48.168(15.33)	20.667	84
SO^2 (ppm)	365	26.94	0.002 (0.001)	0.002 (0.001)	0.000	0.011
CO (ppm)	365	(0.64)	1.31 (0.40)	1.25 (0.51)	0.436	2.958
NO^2 (ppm)	365		0.03 (0.01)	0.03 (0.01)	0.000	0.052
Industrial						
PM_{10}($\mu g/m^3$)	365		64.92(22.75)	60.72(22.51)	20.625	170.250
SO^2 (ppm)	365	26.62	0.03 (0.002)	0.004 (0.002)	0.000	0.012
CO (ppm)	365	(1.15)	0.87(0.46)	0.82 (0.47)	0.000	5.151
NO^2 (ppm)	365		0.02 (0.01)	0.004 (0.01)	0.000	0.042
Rural						
PM_{10}($\mu g/m^3$)	10	26.75	23.46(15.17)	22.18(26.28)	0.368	42.44
CO (ppm)	10	(0.64)	0.68 (0.19)	0.625 (0.468)	0.000	1.030
NO^2 (ppm)	3		0.01 (0.19)	0.000 (0.020)	0.000	0.030

Table 4: Comparison of annual ambient air pollutions within areas

Variables	Area v/s area	Mean difference	p
PM_{10}	Urban /Industrial	15.99	<0.001***
	Urban/Rural	25.13	<0.001***
	Industrial/Rural	41.12	<0.001***
Sulfur dioxide	Urban /Industrial	15.13	<0.001***
Carbon monoxide	Urban /Industrial	0.43	<0.001***
	Urban/Rural	0.62	<0.001***
	Industrial/Rural	0.19	0.342
Nitrogen dioxide	Urban /Industrial	0.01	<0.001***
	Urban/Rural	0.02	<0.001***
	Industrial/Rural	0.01	<0.001***

***Significant at p=0.001

Table 5: Association between respiratory diseases and symptoms among respondents by locations

	Urban (n=87)	Industrial (n=67)	Rural (n=53)		
Variable	Yes (%)	Yes (%)	Yes (%)	χ^2	p
Difficulty in breathing	88.51	74.63	67.92	9.34	0.009*
Cough	66.67	68.66	58.45	1.49	0.475
Chest tightness	43.68	34.33	33.96	9.66	0.047*
Breathlessness	42.53	31.34	30.19	8.16	0.086
Wheezing	48.28	29.85	35.85	12.01	0.029*
Skin rashes	66.67	35.82	24.53	13.49	<0.001***
Nasal symptoms	64.36	62.69	45.28	7.44	0.078*
Itchy watery eyes and nose	49.43	37.31	13.21	20.19	<0.001***
Eczema	26.44	29.85	20.75	6.83	0.339

***Significant at $p\leq 0.001$

*Significant at $p\leq 0.05$

Table 6: Risk Factors Influencing the Frequency of Asthmatic Attack Among Respondents

Risk factor		OR[b]	(95% CI)	p
Location of study	Rural	1[a]	0.730-7.773	0.150
	Urban	2.38	0.706-8.473	0.159
	Industrial	2.45		
Location of respondents	<1000m	1[a]		
house from the main road	500m-1000m	1.61	0.432-5.596	0.480
	100m-500m	1.82	0.444-7.437	0.406
PM_{10}		1.02	0.992-1.050	0.156
CO		1.33	0.308-5.771	0.701
PEF variability		1.18	1.175-3.543	0.011*
Allergy reactions				
Allergy to pollen	No	1[a]		
	Yes	3.29	1.416-7.623	0.006*
Allergy to food	No	1[a]		
	Yes	2.42	1.039-5.651	0.041*
Allergy to moldy objects	No	1[a]		
	Yes	3.23	1.393-7.501	0.006*
Family	Low	1[a]		
Father's education	High	0.33	0.141-0.767	0.010*

[b]Adjusted for age and gender

[a] Reference category

*Significant at p=0.05

Table 7: Risk Factors Influencing the Frequency of Asthmatic Attack among Respondents

Risk factors	B	(95% CI)	OR[b]	p
Constant	2.730		0.065	0.001
PEF variability	0.673	1.115-3.442	1.959	0.019*
Allergy to pollen	0.905	1.054-5.800	2.472	0.038*
Fathers' education	-1.132	0.134-0.774	0.322	0.011*

[b] Adjusted for age and gender

*Significant at p=0.05

N=207

R^2=0.154, OR significant >1 at 95% CI

Ln (frequency of asthmatic attack) = 2.730 + 0.673 (PEF variability) + 0.905 (allergic to pollen) - 1.132 (father's education)

Prevalence of Asthma from School Medical Records: The response rates among rural children were 83%, industrial 74% and urban 51%. The numbers of students with asthma for selected schools in urban area were 172, followed by 91 in industrial and 64 in rural. Based on Table 2, urban area showed the highest prevalence rate of asthma followed by industrial and rural areas.

Ambient Air: The average daily concentrations of air pollution in the three areas are shown in Table 3. There were significant differences in all pollutants between the areas. PM_{10} and SO_2 were highest in industrial area while CO and NO_2 were highest in urban (Table 4). Rural areas showed a lower level of pollutants as compared to urban and industrial areas. The PM_{10} concentrations were significantly different between urban and rural area and also between industrial and rural area respectively. For SO_2 there were significance differences between the 3 areas. Carbon monoxide concentrations also showed a significant difference between industrial with urban and urban with rural areas.

Table 5 shows there was an association between the prevalence of respiratory and allergic symptoms such as difficulty in breathing, chest tightness, wheezing, skin rashes and itchy watery eyes and nose among respondents by location. Higher prevalence of symptoms was shown among urban children followed by industrial and rural children.

Table 6 and 7 show risk factors which influenced the frequency of asthmatic attack among respondents. From the logistic regression model, significant risk factors which contributed to the frequency of asthmatic attacks were PEF variability, allergy to pollen and fathers' education levels.

DISCUSSION

Results showed a significant difference in the parents' education years among the study groups. Parents from urban area acquired higher educational background compared to industrial and rural, in which the majority have only Malaysian Certificate of Education (MCE) qualification. Therefore, the monthly incomes of urban parents were also significantly higher than the industrial and rural parents. Majority of the parents from urban and industrial area were in the government or private sector while parents from rural areas were mostly self-employed in the agricultural sector.

In our study we found that the prevalence of asthma were high among urban children (5.7%), followed by industrial (5.2%) and rural children (4.6%). In a cross-sectional study [7] among 7 to 12 years old primary school children, the prevalence of asthma was 13.8% among children in Kuala Lumpur. Another local study [12] found that the prevalence of asthma was 9.4% among the Kelantanese school children. Findings from this study may not be consistent with the present prevalence of asthma due to firstly, the prevalence of asthma obtained in this study may not accurately reflect that the populations of 7 to 12 years old school children in the 3 areas, due to the fact that the source of data for asthma was from the school medical records. Asthma is usually associated with widespread but variable airflow limitation that is partly reversible either spontaneously or with treatment. The inflammation also causes an associated increase in airway responsiveness to a various stimuli [13]. The school medical record might not be updated because they were created when the children were admitted to school in Year One at the age of 7 years old. Moreover, some children may develop asthma at later age.

Study on the prevalence of asthma among primary school children in Baghdad found that asthma prevalence and severe asthma symptoms decreased steadily with an increasing age [14]. Improvement can be made by conducting a screening program in school to identify students with asthma or other health problem annually.

However, findings from this study were consistent with a study [15], where the prevalence of asthma was high among urban preschoolers. The increase in urban asthma prevalence and morbidity among children and adults is associated with urban living. In addition, studies have also demonstrated that hospitalization and mortality rates of asthma in United States were high in urban area [16].

Epidemiological evidence in support of these findings showed that localized pollution mixtures when emitted from different sources were associated with differential prevalences of asthma [17] at different polluted industrial areas in East Germany. Furthermore, the International Study of Asthma and Allergies in Childhood (ISAAC) [16] and the European Community Respiratory Health Survey (ECRHS) [18] reported that, considerable geographic variations and the difference in environmental pollution results in different asthma and allergy prevalence within and also across the country.

Annual mean PM_{10} and SO_2 concentrations were highest in the industrial area. The mean PM_{10} concentrations in the industrial and urban areas were 64.922μm/m^3 and 48.687μg/m^3 respectively. The PM_{10} concentrations in the industrial areas of Klang exceeded the Malaysian Ambient Air Quality Guideline which is 50μm/m^3 annually. A French study found that increasing levels of outdoor PM_{10}, O_3 and SO_2 were significantly associated with higher rates of childhood asthma and rhinitis [19].

Most studies of the health effects of outdoor air pollution have dealt with respiratory health issues. Many of the studies have involved children and most of these studies have linked higher rates of asthma and other respiratory problems to higher outdoor air levels of priority pollutants such as PM_{10}, NO_2, SO_2 and CO. Many of these air pollutants can worsen childhood asthma at relatively modest concentrations. The mean PM_{10}, SO_2 and O_3 concentrations were well below US EPA standards [20].

In the urban area, source of PM_{10} exposure was from road traffic and also from the demolition of construction site. The PM_{10} concentrations may be generated by the handling, loading and unloading dusty material. In this study, construction site in urban area can be shown in the area with less than 10km radius from the schools. Modification and improvement on some of the school structure may also influence the concentration of dust particles in the air. This activity can be shown in three of urban schools, in which the additional classroom is needed due to the increasing number of students. Construction work on the improvement of roads and highway present in urban area, might contribute to the high concentrations of particulate matter in the air.

In rural area, the PM_{10} concentration was the lowest, with the mean concentration of 35.654μg/m^3, during the 10 days monitoring for each school. Sulfur dioxide was highest in the industrial area followed by the urban area. The mean SO_2 concentration was 0.003ppm and 0.002ppm for industrial and urban areas, respectively. This can be due to the industrial activities in the industrial area. Industrial zone are in the West and North of Port Klang from which Port Klang had been gazetted as an industrial area in Selangor.

In addition, emissions from factory might influence the SO_2 concentrations in the industrial area. Referring to Malaysian Ambient Air Quality Guideline, annual average for SO_2 is 0.04ppm. However, SO_2 concentrations in urban and industrial areas were below the permissible limit. In addition report by Department of Environment Malaysia, for the year 2000 to 2008, also showed the annual average of SO_2 remained below the guideline.

For CO and NO_2, the average concentration was highest in urban area. This is due to the high volume of road traffic. CO was formed in the process of incomplete combustion of organic substances including fuels. Mobile source of air pollutants include automobiles, trucks, buses, ships and trains. Traffic related exposure to fraction of particulate matter and CO have come under scrutiny.

Several epidemiologic studies had proven that living near roads with high level of car traffic is associated with impaired respiratory health due to the road traffic. Traffic gaseous and particulate emissions are the main contributor to air pollution in most urban settings. Our results show urban asthmatic children experienced higher symptoms followed by industrial and rural children. There was an association between respiratory and allergy symptoms with locations among respondents (Table 5).

Results from this study showed that urban asthmatic children experienced higher symptoms followed by industrial and rural children. Respiratory symptoms in this study were classified into difficulty in breathing, chest tightness, wheezing, cough and breathlessness. Asthma symptoms such as skin rashes, nasal symptom, itchy watery eyes and nose and eczema were investigated.

There was an association between the respiratory and allergy symptoms with locations among respondents (Table 5). Children who lived in a highly polluted area have shown a higher prevalence of respiratory symptoms compared to less polluted areas.

In this study, percentage of urban children experienced difficulty in breathing was 88.5%. Chest tightness was also highest among urban children (43.7%), followed by 34.3% in the industrial and 34.0% in the rural children. However for chronic cough, the highest was among the industrial children with a prevalence of 66.7%, followed by urban children (66.7%) and rural children (58.5%). Numerous local studies have repeatedly found an association between the presence of acute respiratory symptoms and short term reduction of pulmonary function with exposure to particulate matter [20-22]. Beside these, another local study [23], also found that among asthmatic children, symptoms such as wheezing and whistling, nasal symptoms and itchy watery eyes were significantly higher among urban asthmatic children. According to a study by Jonathan *et al.* (2004), majority of asthmatic children were reported having wheezing and tightness in the chest. Findings showed that household size, body mass index and environmental tobacco smoke were positively associated with severity of respiratory symptoms.

Results showed a significant results for PEF variability (OR=1.18, p=0.011), father's education (OR=0.330, p=0.010) and allergic to pollen, food and mold (OR=3.290, p=0.006) (OR=2.423, p=0.0420) and (OR=3.232, p=0.010) respectively. Adjusting for confounders was carried out for age and gender. Next, to obtain a regression model, all the significant values were tested again in order to select the most influencing factors associated with frequency of asthmatic attack by using backward stepwise methods. Results confirmed that PEF variability, allergic to pollen and level of father's education fit the regression model.

Peak expiratory flow (PEF) is the maximal flow that can be measured after a forceful expiration from total lung capacity (TLC). It is a useful parameter to monitor airway obstruction, assess it severity and variation and evaluate the effects of treatment. Peak expiratory flow can be used to define and assess the severity of asthma in epidemiology which usually were recorded for two weeks period with two or more measurements in one day. For asthmatic children, it was found that the morning PEF decreased by 0.27% and 0.31% in urban area and suburban areas, respectively, with the $10\mu g/m^3$ increase of PM_{10} in the daily mean [24-26].

Socioeconomic factors within asthmatic children should be considered when designing a personalized management plan. The description of the family background characteristics showed that children with the lower parent's educational level had a lower socio economic status. According to Warschburger *et al.* [27], current treatment approach of asthmatic patients does not rely only on the use of medications to control acute exacerbations of asthma and chronic inflammation, but also on the education level of the patient and parents.

Parents' quality of life were significantly associated with asthma severity of the children, in accordance to the results of [27]. In our study, a higher parent's educational level was protective factor for the frequency of asthmatic attacks reflecting on the proper management and awareness of asthma.

Many children do not receive comprehensive asthma treatment which includes management of allergies and information on how to avoid allergens. Lower reported allergy testing might indicate lower access to medical care among middle-income families who are ineligible for public programs and do not have the income to access higher quality health care. In this study allergic to pollen showed significant association with asthma severity among respondents. Allergy to pollen refers to some anemophilous plants whose pollen walls contain specific proteins causing hypersensitivity for sensitive individuals [28-30].

Study conducted by Jianan, et. al., [31] illustrated that the pollinosis incidence in developed urban areas is higher than in undeveloped rural areas. A series of studies have demonstrated that increase in pollen amount is associated with increase in temperature. Thus urban and industrial areas had a greater amount of pollen in the air as compared to rural areas. Besides that, three atmospheric pollutants, particulate matter, NOx and ozone from traffic pollution deserve consideration as the most possible causes of the increase in amount of pollen which may affect human health especially among the vulnerable group [32].

CONCLUSION

Results showed that the prevalence of asthma was high in urban areas. The pollutant levels were high in the urban and industrial areas. Prevalence of respiratory and allergy symptoms were significantly associated with the school locations. Fom the logistic regression model, risk factors which significantly influence the frequency of asthmatic attack were pollen and PEF variability. The urban and industrial asthmatic children have greater risk of getting frequent asthmatic attacks due to higher air pollutant levels in the form of particulate with pollen or chemical content which then affects the PEF variability leading to attacks.

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