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The impact of haze on the adolescent's acute respiratory disease: A single institution study

Wan Fairos Wan Yaacob[1], Nor Suhana Mohamad Noor[1], Nor Ili Che A. Bakar[1], Nurulhuda Afisah Mat Zin[1], Fahisham Taib[2*]

[1]*Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Cawangan Kelantan, Kelantan, Malaysia*

[2]*Department of Pediatrics, School of Medical Sciences, Universiti Sains Malaysia, Kelantan, Malaysia*

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ABSTRACT

Objective: To examine the impact of haze in the reduction of peak expiratory flow rate (PEFR) reading and identify the risk factors affecting respiratory function due to haze.
Methods: This study was conducted during haze period among secondary school students in Kota Bharu. We analyzed data on a total of 126 secondary school children measuring the respiratory health and symptoms in October 2015 using standardized questionnaire and PEFR measurement. Clinical characteristics on the risk factor and prevalence of haze effect were explored. *Chi*-square test and independent sample *t*-test was used to investigate the relationship between risk factors and haze effect and logistic regression analysis for the odds of having haze effect.
Results: The findings revealed a significant reduction in PEFR reading of more than 15% from the expected PEFR values. It was also noted that the children with headache, cough, mucus and sore throat respiratory symptoms had consistently higher rates of respiratory illness of having haze effect compared to those who did not.
Conclusions: Student with haze effect documented much higher symptoms during haze especially female students. Symptoms such as headache, wheezing and mucus were noted among the normal secondary school children in Kota Bharu.

1. Introduction

Uncontrolled haze in Indonesia had started since the year 1983 and later recurred in the year 2015[1]. The worst documented episode was reported around year 1997 and 1998 as it had affected over 7.5 million people in six South East Asian countries involving Indonesia, Singapore, Thailand, Brunei, Philippines and Malaysia[2,3]. It was thought that air pollution which lead to haze phenomenon was as a result of fossil fuel combustion. This has significant risk for developing lung cancer[4]. The highest pollutant standards index in 2015 was at 189. The data was documented in Kuala Lumpur and Klang Valley and has been considered as unhealthy air quality. The worsening of haze pollutant standards index was due to wind flow pattern that has affected the region. The study on health-related haze effects, particularly in respiratory conditions, has been occasionally explored. Respiratory disease is one of the leading cause of childhood mortality in developing countries.

Several studies have reported significant relationship between air pollution and respiratory health in children and its association to asthmatic patients[5–9]. Several risk factors have been identified that contributed to the increment of haze effect on children's respiratory health, which were sociodemographic profiles, indoor environment and pollutants, and the presence of additional respiratory symptoms and diseases.

The aim of the study is to determine haze effect on a normal secondary school children's respiratory health by using peak expiratory flow rate (PEFR) measurement. We also aim to investigate risk factors associated with haze event. The study was done in an urban institution in Kota Bharu, the main and largely populated district in the state of Kelantan. PEFR is a crude way of measuring respiratory function by getting the participants to blow hard using a PEFR device. The readings were done during the day to avoid the influence of diurnal variation, personal effort, accurate technique and position. Haze effect is considered when there is a reduction of 15% of the reading from expected PEFR reading based on standardized

*Corresponding author: Fahisham Taib, Department of Paediatrics, School of Medical Sciences, Universiti Sains Malaysia, Kelantan, Malaysia.
E-mail: fahisham@gmail.com

The study protocol was performed according to the Helsinki declaration and approved by Ethical Committee of Universiti Sains Malaysia. Informed written consent was obtained from the parents and assents were taken from the students.

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nomogram, individual height and gender[10]. This is similar to expected value for diagnosing asthma.

2. Materials and methods

2.1. Study design

This was a cross sectional study that examined the effect of respiratory function following the haze event with the presence of other risk factors. The study was conducted into two stages. The first stage was related to the development of questionnaire and recruitment of participants. A total of 160 secondary school students from SMK Kota were given explanation and requested for consent from their parent and personal assent prior to enrollment. A total of 126 of them returned the consent and agreed for the involvement in the study. The questionnaire used was adopted from Bellia *et al.*, which was modified according to local context[11]. In the second stage, the students were given a questionnaire and explanation was given by the researcher prior to answering the questionnaire. Measurements on PEFR readings and basic anthropometry were taken by a medical doctor to ensure correct technique performed. The PEFR device used was the standard Wright scale similar to those performed in outpatient locally. Weight and height were taken and matched accordingly to calculate body mass index and expected PEFR value was matched using a nomogram value for PEFR. Students with preexisting chronic diseases were excluded from the study.

2.2. Measurements

PEFR reading was measured in liter/minute to acquire the volume of air and a person was performed during a forced exhalation breath. The participants were required to perform three PEFR measurements and the best PEFR value was recorded. Explanation and demonstration of correct techniques was done prior to the measurement. Measurement was done during the midday considering variability of PEFR reading. The technique was supervised by a medical doctor. The haze effect was measured as below:

Percentage difference of PEFR (%) = (Expected PEFR − Best PEFR)/(Expected PEFR) × 100

Calculation for PEFR variability measurement depended on the best PEFR for that day and its expected value. The expected value of PEFR was compared using a nomogram to acquire expected and normal value for the participants based on sex, age and height.

2.3. Questionnaires

The questionnaire used was divided into three parts, namely, sociodemographic, risk factors and symptoms assessment. The students were asked to complete the questionnaire by themselves with some guidance from the researchers. In sociodemographic part, the questions were related to personal details such as age, date of birth, gender, level of parent's education, parent's income and parent's smoking history. The second part was related to risk factors such as the understanding on asthma, smoking habit, allergic tendency and environmental influence. The last part which was related to symptoms developed during the haze like headache, nausea, cough, mucous, wheezing, itchiness, eyes problem, sore throat, hard breathing and chest pain.

2.4. Statistical analysis

Clinical characteristics on the risk factors and prevalence of haze effect were explored. To investigate the association between risk factors and haze effect, *Chi*-square test and independent sample *t*-test were used. Data were also analyzed using logistic regression analysis to compute the odds of having haze effect by using omnibus test, classification rate and Hosmer–Lemeshow test to check on model adequacy.

3. Results

There were 126 students who agreed to participate from 160 and this gave a response rate of 78.75%. Based on clinical parameter in Table 1 below, the mean age of the secondary student was (15.38 ± 1.68) years with a median of 16 years. The mean of height was (157.34 ± 8.30) cm with a median of 156.15 cm. The upper form students constituted the majority of the children with haze effect (61%) compared to lower form. The study also revealed 47 (77%) female students and 14 (11.11%) of the male student were categorized in the group of students with haze effect. Most of the students with haze effect were from middle and high socioeconomic group. Association between economic salaries had failed to reach any statistical significance finding. There was a significant association between haze effect and gender (*P* value = 0.000).

Table 1

Clinical characteristics of students with or without haze effect.

Clinical parameters		Student with haze effect (n = 61)	Student without haze effect (n = 65)	P value
Age (years)[a]		15.08 ± 1.74	15.66 ± 1.59	0.053*
Height (cm)[a]		156.10 ± 8.16	158.51 ± 8.33	0.104
School grade[b]	Lower form	24 (39)	16 (25)	0.076*
	Upper form	37 (61)	49 (75)	
Gender[b]	Female	47 (77)	30 (47)	0.000**
	Male	14 (23)	35 (53)	
Economic salary[b]	Lower income	11 (18)	13 (20)	0.597
	Middle income	25 (41)	31 (48)	
	High income	25 (41)	21 (32)	

*: Significant P value; **: P < 0.05.
a: Values were expressed as mean ± SD; b: Values were expressed as n (%).

Table 2 shows the mean fall in the percentage difference in PEFR measurement comparisons for 126 students from the age of 13–17 years old. A total of 61 (48.4%) of the students had a decline in PEFR measurement more than 15% when the difference between expected PEFR (based on standardized nomogram) and best PEFR reading were computed. The mean fall in percentage difference PEFR for student with haze effect was (28.85 ± 10.60) mL of standard deviation. While in the group without haze effect, the mean fall in percentage difference was (−4.03 ± 10.60) of standard deviation. Although about half of the studied group experienced a decline in their PEFR measurements, the mean difference in the fall between those with and without haze effect was highly significant.

Table 2

Mean fall of percentage difference of PEFR measurement for student with or without haze effect.

PEFR	Student with haze effect (n = 61)	Student without haze effect (n = 65)	P value
PEFR fall	61 (100)	30 (46.15)	0.000*
Fall of percentage difference[a]	28.85 ± 10.60	−4.03 ± 14.40	0.000*

*: Significant P value.
[a]: Values were expressed as mean ± SD.

Table 3 shows the exposure of indoor trigger for students with or without haze effect. The result found no association between all risk factors with haze effect since all the P value > 0.1.

The reported prevalence of respiratory symptoms were summarized in Table 4. Most of the symptoms were seen to be consistently higher rates in the group with haze effect than those without the effect.

The results of the logistic regression analysis was shown in Table 5. For gender, the odds ratio (OR) indicated that female students were about three times more likely to have haze affect (OR = 2.923) compared to male students. In terms of indoor housing environment, the OR for student's usage of aerosol factor indicated lower risk (OR = 0.4) of having haze effect compared to those who is not aerosol user. Among the symptoms documented during haze, having mucus and wheezing symptoms were significant increased during the haze. The symptom like having mucus was found to have nearly three times (OR = 2.697) more likely to have haze effect than the other group. The last significant contributing risk factor was wheezing symptoms. For wheezing symptoms, the OR (10.806) indicated that students having wheezing symptoms were about 11 times more likely to have haze effect than those without haze effect.

Table 3

Exposure of indoor trigger for students with or without haze effect. n (%).

Environment		Student with haze effect	Student without haze effect	P value
Parent's smoking history	Yes	32 (25.4)	29 (23.0)	0.615
	No	37 (29.4)	28 (22.2)	
Animal exposure	Yes	37 (29.4)	24 (19.0)	0.802
	No	38 (30.2)	27 (21.4)	
Carpet user	Yes	40 (31.7)	21 (16.7)	0.770
	No	41 (32.5)	24 (19.0)	
Aerosol user	Yes	42 (33.3)	19 (15.1)	0.535
	No	48 (38.1)	17 (13.5)	

Table 4

Prevalence of respiratory symptoms and diseases. n (%).

Respiratory symptom	Student with haze effect	Student without haze effect
Headache	42 (33.33)	25 (19.84)
Nausea	11 (8.73)	3 (2.38)
Cough	40 (31.75)	23 (18.25)
Mucus	37 (29.37)	23 (18.25)
Wheezing	15 (11.90)	2 (1.59)
Itchy	17 (13.49)	11 (8.73)
Eyes problem	9 (7.14)	5 (3.97)
Sore throat	26 (20.63)	18 (14.29)
Difficulty breathing	13 (10.32)	5 (3.96)
Chest pain	16 (12.70)	12 (9.52)

Table 5

OR (90% confidence intervals) for demography, environment and symptoms during the haze.

Category		OR (90% confidence intervals)
Demography	School grade	0.431 (0.173–1.075)
	Gender (female)	2.923 (1.173–7.282)*
	Economic salary (middle)	1.024 (0.338–3.105)
	Economic salary (high)	2.106 (0.639–6.945)
Environment	Parent's smoking history	0.796 (0.359–1.769)
	Animal exposure	0.882 (0.394–1.978)
	Carpet user	0.612 (0.264–1.419)
	Aerosol user	0.402 (0.169–0.955)*
Symptoms during haze	Headache	2.161 (0.829–5.632)
	Nausea	1.566 (0.327–7.493)
	Cough	2.451 (0.890–6.748)
	Mucus	2.697 (1.110–6.549)*
	Wheezing	10.806 (1.126–103.737)*
	Itchy	1.226 (0.436–3.447)
	Eyes problem	2.968 (0.889–9.915)
	Sore throat	0.821 (0.296–2.280)
	Hard breathing	1.424 (0.325–6.244)
	Chest pain	0.382 (0.124–1.175)

*Significant P value.

4. Discussion

The impact of haze during October 2015 somehow has caused various illnesses related to quality of air at that time. Previous study has focused on potential ill health effect on children with chronic respiratory diseases. Our study investigates a group of normal secondary school students through quantitative measurement using standardized questionnaire and individualized best PEFR value. Significant reduction in PEFR reading of more than 15% from expected values was seen in 61 students. PEFR measurement in the past was used as indirect marker of haze effect by measure according to asthma symptomatology[12,13]. Various air pollutants such as nitrogen dioxide, sulfur dioxide and particulate matters with other confounding factors such as cigarette smoke, indoor pollutants, open burning, motor vehicles combustion or industrial waste have a direct effect on the children's respiratory health[14,15,16–22]. This has worsened during the recent haze when particulate matter such as PM10 was at its peak.

Haze visibility was commonly associated with higher particle matter in the air[23,24]. Although air pollution index per se does not correlate with the presence of visible haze, perception of the public is rather different. The particles measured, such as PM10 or PM2.5, indicate the content of the haze and visibility of haze is directly related to the water vaporization on the particulate matter[25–27]. Deterioration in PEFR value was demonstrated even in normal population, which was indirectly linked to overall lung function. The factors which affect the respiratory health may be complex but there were a number of students which were not affected by haze. Explorative study should be done to ascertain factors which contributed to the protective effect from haze and air pollution especially in the general population. Longitudinal study should be planned to investigate the long term influence of haze towards population respiratory function. The PEFR use is mainly to have a crude reading of lung functionality. Sensitive measurement using spirometry is required to obtain a much accurate lung function measurement. Reduction in lung function due to haze hazard may pose risk for other cardiorespiratory problems such as cardiac event, bronchopneumonia, upper respiratory tract infection and asthma like bronchospasm.

The challenge of ensuring a reliable and accurate PEFR measurement with minimal bias can be achieved by correct technique of PEFR measurement. The reduction of PEFR reading may also be compounded with factors such as the presence of asthma like symptoms (wheezing, cough, mucus and breathing difficulty) which influenced the overall findings. Haze studied during this period was as a result from open burning after deforestation in Indonesia. Increased in hospital admission due to asthma attack was well documented in the previous studies[12,14]. However, potential long lasting effect from haze has yet to be investigated and evaluated. Most children have to change their lifestyle such as wearing of facemask and staying indoor to prevent the ill health effect of haze.

In our study, significant clinical characteristics documented were female students and those from the upper form who constituted the majority of the children with haze effect. We suspect that there were element of exposure difference of indoor and outdoor environment, position of classes at school, outdoor and indoor activities and undisclosed risk behaviors such as smoking, which affect the outcome. There were also contrasting findings that students who were from middle and high socio-economic group have been found to have a higher percentage of haze effect compared to the lower income group. This was different from previous study[28]. Most of the male students did not reveal smoking practice despite assurance that their information would be kept confidential. The students who exhibited symptoms related to respiratory illnesses such as headache, cough, mucus and sore throat would be higher in the group with haze effect compared to those who did not have the effect. These group of students reported or experienced much higher symptomology. Evaluation the indoor environmental factors showed no significantly association. The causal relationship to specific factors cannot be pointed out. This might be due to the limitation of this study, which did not consider the effect of individual heterogeneity of living area, type of accommodation and social circumstances of the involved students. Mapping of where they lived, whether in rural, urban or petrochemical area, might be important contribution to the final analysis.

There were some limitations of the study. The data collection was done during the end of haze event. We were not sure that whether days of haze exposure could affect the result. The measurement of PEFR should be done on daily basis to see the time sequel of the reading due to its variability. This is important to identify individual risk, variation and long term health sequalae. Serial data collection to establish optimal PEFR throughout the day should be the basis to prevent biased results. Our study did not possess information of the subjects involved such as serial best individual PEFR data prior to the commencement of the study. We utilized the expected PEFR from nomogram to guide the expected PEFR reading. This may not accurately reflect the true PEFR reading for each individual students. Lung function test should be the most reliable tool to achieve much accurate reading of lung function, however, the device itself could be costly, bulkier and operator dependent.

The study design can be improved by interventional study and the use of interrupted time series. Future research should explore the intrinsic and individualized factors to determine the potential risk or protective effect of haze. This is vital especially for the protection of high risk group in our population. Students should be advised on the use of preventive medicine and adequate preparation during haze period to avoid imminent risk of respiratory related illnesses. This preventive measure may be of help individually. Self-empowerment and self-protection programs are vital to ensure measures which are taken to avoid vicious cycle of health related issues following haze. Knowledge dissemination among the students is vital to improve their health and prevent long term complications from haze and air pollution in Malaysia.

Conflict of interest statement

The authors report no conflict of interest.

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