PUBLIC HEALTH RESEARCH

The Impact of 2013 Haze on Emergency Department Utilizations for Acute Respiratory Diseases: A Retrospective Study

Mohd Azim Ab Manap,[1] Shamsuriani Md Jamal,[1] Hilwani Kaharuddin,[2] Husyairi Harunarasid,[1] Mazrura Sahani,[3] Talib Bin Latif[4], Nik Azlan Nik Muhamad[1*]

[1]Department of Emergency Medicine, Hospital Canselor Tuanku Muhriz, Universiti Kebangsaan Malaysia Kuala Lumpur Campus, Wilayah Persekutuan Kuala Lumpur, Malaysia.
[2]Ara Damansara Medical Centre, Shah Alam, Selangor, Malaysia.
[3]Program Kesihatan Persekitaran & Keselamatan Industri, Pusat Kajian Toksikologi & Risiko Kesihatan, FSK Universiti Kebangsaan Malaysia, UKM Bangi, Selangor, Malaysia.
[4]Department of Earth Sciences and Environment, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, UKM Bangi, Selangor, Malaysia.

**Corresponding; Email: nikazlanmuhamad@hotmail.com*

ABSTRACT

Introduction	Haze imposes a substantial health burden especially in Southeast Asia where occurrences are frequent. Reduction in air quality levels has resulted in an increase in healthcare utilization, especially to the front door of healthcare, the emergency department (ED). Data on ED utilization during haze period is lacking.
Methods	This was a retrospective study aimed to determine the association between haze and ED utilization of haze-related acute respiratory illnesses between April 2013 to September 2013. The study period was divided into haze/ non-haze period. Clinical data was collected from the registration book and patients' case notes. Environmental data was obtained from Institute of Environment and Development Universiti Kebangsaan Malaysia.
Results	Total number of patients presented to ED during the study was 32,661. Fifteen percent (n= 5177) presented with acute respiratory symptoms. Total Emergency Department visits during haze period reduced due to emergency declaration, hence reducing non-emergency visits. However, there was a significant increase in hospital admission (p=0.0015) and infective respiratory illnesses (p=0.001) during haze which correlates with increase air pollutant. Patients with chronic respiratory illnesses were more affected by haze (p = 0.001). PM10 and ozone were the main pollutant during the haze period.
Conclusions	Increasing pollutant levels from the haze significantly increases ED hospital admission. Evidence from this study can influence policymakers to prepare and allocate resources to hospitals in response to haze-related illnesses.
Keywords	Haze; Malaysia; Emergency; Respiratory illnesses; Pollutant

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INTRODUCTION

Haze results in disruption of visibility, clarity and transparency due to presence of fine suspended particles.[1,2] It is an aggregation of widely dispersed solid and liquid particles in the atmosphere, giving an opalescent appearance that subdues colors.[3] This has been an ongoing problem in Southeast Asia since 1991 which primarily results from open burning for agricultural activity in Sumatera and Borneo. Haze disperses transboundary air pollutants which frequently affects Malaysia.[2, 4, 5] In June 2013, Malaysia experienced one of the worst hazes which resulted in proclamation of emergency and school closure. Haze worsens during the South West monsoon due to its facilitation of pollutant dispersion to Malaysia.

Increased healthcare utilization directly proportionate to the intensity of the haze.[6] Health impacts were more pronounced on the respiratory system, resulting in acute exacerbation of bronchial asthma (AEBA), acute exacerbation of chronic obstructive pulmonary disease (AECOPD), acute bronchitis, pneumonia and bronchiolitis. Monthly inpatient and outpatient incidence were significantly higher ($p<0.05$) during haze periods. Mean and standard deviation (SD) on monthly incidence of acute respiratory illnesses per hospital were n=320 (650.1) during haze versus n=34 (16.5) during non-haze period.[7-12]

Two major components of haze consist of particulate matter (PM) which were liquid or solid suspension particles and gaseous pollutants such as ozone (O_3) and carbon monoxide (CO). Such components exert cytotoxic effect, macrophages modification and neutrophil phagocytosis on the lung parenchyma.[13] PM_{10}, which was particulate matter less than 10 microns in diameter was studied due to its specific increase during the haze period.[14] It included particles from vehicle emissions, manufacturing, power generation and agricultural burning. World Health Organization (WHO) defined haze episode as exhibiting a 24-hour PM_{10} value of more than 51 $\mu g/m^3$.[15,16] Carbon Monoxide (CO) is an air pollutant resulted from incomplete combustion of carbon-containing fuels such as gasoline, natural gas, oil, coal and woods. O_3 is formed in the troposphere through the reaction between reactive hydrocarbon (from combustion), UV light and NO_2.[17] Ozone (O_3) is a natural constituent in the stratosphere where it provides protection from ultraviolet radiation, which at ground level develops into a harmful pollutant.

Data regarding healthcare impact of haze towards the gatekeeper of a hospital, the emergency department (ED) in Malaysia is limited. ED was expected to endure the most during any environmental disasters, which involves a sudden influx of patients with acute medical conditions. Objective of this study was to investigate frequency and nature acute respiratory problems in the ED and correlate it with level of air pollution during haze and non-haze period of 2013. It was hypothesized that there was a significant increase in respiratory related illnesses during the haze period and this was directly correlated to levels of studied pollutants.

This study was done in Kuala Lumpur due to the urbanization of this area and the wide availability of Continuous Air Quality Monitoring (CAQM) stations. HCTM-UKM was chosen as the hospital of study due to its affiliation to research university, which brought available manpower in assisting this study. This study can prepare ED for future haze episodes or other respiratory related disasters by allocating appropriate resources and manpower.

METHODS

This study which was a retrospective chart review was performed at Emergency Department UKM Medical Centre (ED UKMMC) from 1st April 2013 to 30th September 2013. Cases were selected after reviewing ED admission logbook. Respiratory diseases were defined according to the International Classification of Diseases 10 (ICD-10) from the WHO guidelines and the following cases were eligible in this study: J00–J06 for acute upper respiratory infections, J09–J18 for influenza and pneumonia, J20–J22 for other acute lower respiratory infections, J30–J39 for other diseases of upper respiratory tract and J40–J47 for chronic lower respiratory diseases. Patients transferred from other hospitals and respiratory symptoms from recent travel (e.g. China, Middle East etc.) were excluded. Demographic data including age, gender and background respiratory illnesses were obtained from the log book. It was classified into age groups (0-12, 13-64, > 64 years old), gender (male and female), pre-existing respiratory illnesses (bronchial asthma, lung fibrosis and chronic obstructive airway disease) and etiology of the current diagnosis (infective or non-infective). Data was collected directly by the primary investigator.

Air quality data was received from the Institute of Environment and Development, Universiti Kebangsaan Malaysia (UKM) and Division of Air Quality, Department of Environment, Ministry of Natural Resources and Environment. Data on air pollutants and ecological factors were taken from CAQM stations surrounding UKMMC and UKM KL Campus.

Data on the ambient temperature, windspeed, and relative humidity levels were also collected since these factors influence air pollutants level. Unit measurement for air pollutants were in $\mu g/m^3$ parts per million (ppm). These parameters were collected in the day to day basis and grouped into monthly data to match the delay of approximately 2-4 weeks before respiratory symptoms starts to present.

Data analysis

Statistical analysis was performed to determine relation between air pollution with ED visits for respiratory symptoms. Data were analyzed using the Statistical Package for the Social Science (SPSS) version 21.0. Descriptive test was used to measures average, minimum, maximum, frequencies and percentages of level of pollution and patient demographic characteristics. Correlation test, t-test and chi-square test were employed to assess relation between air pollution and respiratory disease in patients in Kuala Lumpur.

Ethical consideration

The study obtained ethical approval from UKM Research Ethic Committee. No informed consent and intervention were required. Data collected from the patient's medical record did not influence the care management.

RESULTS

Distribution of samples

There was no significant difference in ED visit with acute respiratory symptoms during haze and non-haze period (p=0.054). Ward admissions significantly increases during haze period (p=0.015). Patents with pre-existing respiratory illnesses such as asthma, chronic obstructive airway diseases (COAD) and lung fibrosis attended ED more frequent during haze period (n=563) (Table 1)

Table 1 Emergency Department Characteristic

	Pre-Haze	Haze	Post Haze
Time period	April – May 2013	Jun – July 2013	August – Sept 2013
Total (n) patients in ED	11,233	10,947	10,481
(n) (%) patients with respiratory symptoms p=0.054	1820 (16.20%)	1698 (15.51%)	1659 (15.82%)
Age (years) (%)			
0-12	743 (40.8%)	595 (35.0%)	664 (40.0%)
13-64	725 (39.8%)	731 (43.1%)	681 (41.1%)
≥65	352 (19.3%)	372 (21.9%)	314 (18.9%)
Gender			
Male	1010 (55.5%)	908 (53.5%)	933 (56.2%)
Female	810 (44.5%)	790 (46.5%)	726 (43.8%)
Gender			
Infective	1621 (89.1%)	1421 (83.7%)	1476 (89%)
Non-infective	199 (10.9%)	277 (16.3%)	183 (11%)
Pre-existing respiratory illness p=0.01	502 (27.6%)	563 (33.2%)	482 (29.1%)
Disposition p=0.015			3
Admitted	318 (17.5%)	380 (22.4%)	60 (21.7%)
Discharged	1502 (82.5%)	1318 (77.6%)	1299 (78.3%)

Table 2 Air Quality data

	Pollutant	Pre-Haze	Haze	Post Haze	Interim target (IT) 2015
Mean Pollutant mcg/m^3	PM_{10}	39.77	70.46	48.44	
	CO	0.89	1.11	0.95	
	Ground O_3	161.46	126.23	120.50	
Maximum pollutant mcg/m^3	PM_{10}	57.00	319.00	124.00	150
	CO	1.44	2.94	1.62	10
	Ground O_3	296.00	294.00	235.00	120

PM_{10} Particulate Matter less than 10 mcg/m^3
CO Carbon monoxide
O_3 Ozone

Ministry of Natural Resources and Environment determined an interim target (IT) which is the limit of each pollutant in the measurement of micrograms/m^3 for the specific year. Daily concentration of PM_{10} increased during haze period. The maximum concentration of PM_{10} during haze was 319 mcg/m^3 in which IT-1 2015 level was 150mcg/m^3. The increase in PM_{10} levels during the haze was proportionate to the increase in number of ED visits among patients with pre-existing respiratory problems and increase in ward admission. However, there was a decrease in total ED attendance due to movement restriction implementation during haze. (Table 1 and Table 2).

DISCUSSION

There was a reduction in number of total ED visits (n=10947) during haze compared to pre-haze period (n=11233). This number was higher than post-haze period (n=10,481). This did not correlate with other studies where total ED visits increased during haze, mainly due to respiratory and cardiac presentation. [18-20] Possible factor resulting in reduction of ED visits were limited outdoor movement due to compliant to government movement restriction and the condition of haze. Limited outdoor movement also contributes to reduction in inappropriate ED attendance for non-emergency cases which was reported to be rampant in hospitals in Malaysia.[21] Redirection and re-triaging of non-emergency patients during disaster was another contributing factor.[22]

Despite reduced number of patients, hospital admission significantly increased by 5% during haze period. The increment was from n=318 (17.5%) in the pre-haze period to n=380 (22.4%) during the haze period. Numbers of admission slightly reduced to n=360 (21.7%) after the haze period. (Table 1). The increased number of hospital admission reflects the increase severity of the respiratory illnesses. The increase correlates with studies by Jaafar et al[23] where the average monthly admission for AEBA was 50 cases during a haze episode compared to 23 cases during non-haze periods. AECOPD also recorded a higher average monthly admission of 24 cases during haze compared to 11 during non-haze. A study reported by Ming et al[24] in the same hospital showed admission rates per week for respiratory cases were significantly different between the two groups with 27.6 ± 9.2 cases per week during the haze versus 15.7 ± 6.7 cases per week during the non-haze period ($p< 0.01$). The increase in the admission is no higher than two-fold which relates with current study. Possible factors causing lesser increment in ward admissions were limited beds, forcing transfer out to other facilities and premature discharged, or patient voluntary discharge (at own risk) with advice to return immediately if the symptoms worsened.

Infection such as pneumonia, acute pharyngitis and influenza were the major cause of respiratory symptoms for ED visit within the 6 months' study period. It can be due *Respiratory Syncitial Virus (RSV), Rhinoviruses and Coronaviruses*. Bacterial causes of respiratory infections are *Streptococcus pneumonia* and *Mycoplasma pneumonia.* Unexpectedly, number and percentage of infective etiology for ED visits during the haze period was significantly lower compared to the pre and post haze period. (Table 1) This was balanced with a higher non-infective cause for ED visits during haze period. However higher ward admission rates during haze reflects on more serious infective or non-infective etiology of disease that presents to the ED. Environmental epidemiology research in recent decades has shown that haze was associated with increased morbidity due to respiratory infections and risks of other diseases.[25] A study in China showed following an episode of an extreme haze, patients with respiratory diseases increased significantly and some developed severe pneumonia and death. The number of patient admissions for respiratory infection into the Infectious Diseases Department in Shanghai increased by more than 3-fold over 3 months. It was interesting to note that although haze increased the risk of respiratory infection, including H7N9, it was not directly associated in the proliferation of viruses. Combination of respiratory illness from the haze and increased incidence of acute respiratory infections such as H7N9 increased awareness and preparedness for Chinese Center for Disease Control and Prevention for any upcoming surge in respiratory illness.[26]

Airway hyper responsiveness was aggravated with the exposure to air pollutants such as PM_{10}, ground level ozone which increased especially during the haze period. Hence the cause of pre-existing respiratory illness such as bronchial asthma and COPD were more affected during this period. In this study, significant increment of patient with chronic respiratory illnesses visited ED during haze as compared to non-haze period. (Table 1) This correlates with the study by Jaafar et al,[23] whereby total inpatient cases (for both AEBA and AECOPD), the average number of monthly admissions was 74 compared to 34 during non-haze episodes. Average monthly outpatient cases were also higher during haze episodes (n=320) compared to non-haze episodes (n=146) $p<0.05$.

Other factor contributes to the developing acute respiratory symptoms during haze is advanced age. Elderly (age ≥65) were more affected during the haze period with increment in percentage of ED visit by 2% as compared to pre-haze period. Pre-existing morbidities such as hypertension, diabetes mellitus and heart diseases contribute to the ineffectiveness of defense mechanism towards infection and exposure to the air pollutants. Children

and older adults are more susceptible PM-induced effects because of physiological differences.[27]

The concentration level increased exceeded IT-1 (2015) during the period of haze which is the main contributory factor for acute respiratory symptoms. Some studies have established a "dose-dependent" relationship between haze exposure and respiratory symptoms, where higher Pollutant Standards Index (PSI) values are associated with more frequent respiratory symptoms.[28]

LIMITATION

The presentation at emergency department only does not reflect the total number of patients who suffered from respiratory illnesses in the population. A significant number of respiratory cases were directed to primary healthcare clinic which was also able to cater for acute respiratory illness. Collecting data from primary health clinic was not included in the study methodology.

CONCLUSION

In view of the stagnant number of ED visits throughout the haze period, rise in admissions reflects an increase in proportion of severe patients. Patients with background of chronic respiratory illnesses and elderly were more affected by the haze. Long term actions should be taken in joint with the neighboring countries to curb wildfires and further studies on economical health impact of haze can be undertaken.

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