ORIGINAL ARTICLE

THE MALAYSIA HAZE AND ITS HEALTH ECONOMIC IMPACT: A LITERATURE REVIEW

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ABSTRACT

Introduction: The transboundary smoke haze has become a major concern as it had a wide ranging impact in Southeast Asia from the aspect of public health to national economics. This review aims to synthesize available literature in epidemiology, economics and haze related studies to provide essential information for the valuation of health costs associated with haze in Malaysia. Methods: Evidence on health economic impact of haze was gathered by conducting a literature review and collecting information on the health effects of haze and the cost of it as well as the hospitalization cost from medical illnesses and hospital admissions due to haze. Articles were taken from those that were published from 1999 to 2016.Results: The 1997 Asian Haze episode has caused increasing trend of prematurity of mortality and respiratory problems and several series of haze later had caused increased number of hospitalization. The cost impact on hospital admission ranges from MYR1.8 million in 2005 to MYR118.9 million in 2013. During the 1997 haze, the incremental cost of illness (COI) was noted to be MYR 21million and it shot up to MYR 410 million during the 2013 haze. Conclusion: The haze gives a serious health effect to our country and our neighbours. These health effect has caused a significant health economy impact which include rise in hospital admission cost and medication, incremental cost of illness and extend to cost of medical-related leaves taken and lead to loss of income opportunities.

Keywords: *haze, health impact, hospitalization, air pollution and forest fire, particulate matter*

INTRODUCTION

In recent years, the transboundary smoke haze has become a major concern with regards to air pollution as it had a wide ranging impact in Southeast Asia from the view of public health to national economics (1). Haze is a transboundary pollution when its density and extent is so great at the source that it remains at measureable levels after crossing into another country's airspace (2). Since 1982, these haze pollution has become almost an annual occurrence in Southeast Asia, with the worst episodes being in the period of 1997–1998 and in 2006–2007 (3). However, the haze episode that occurred in 2015 was noted to be the worst after the 1997 Asian Haze (4).The haze affects the health of some 75 million people and the economies of six Southeast Asian nations; Indonesia, Malaysia, Singapore, Thailand, Brunei, and the Philippines (5).

In our local setting, the open biomass burning from Indonesia which produces transboundary smoke haze is an annual phenomenon that causes deterioration in the local air quality in Malaysia (6).The influence of wind cause these open biomass burning from our neighbours cross our borders and effect its people.However, there is small contribution of our local source that contribute to the haze condition. These local anthropogenic source came from the few burning hotspots occurred in our local area particularly in the paddy field and palm oil plantation (7). Other than that, domestic factors such as activity in industry, motor vehicle and open burning contributed to the worsening haze (8).

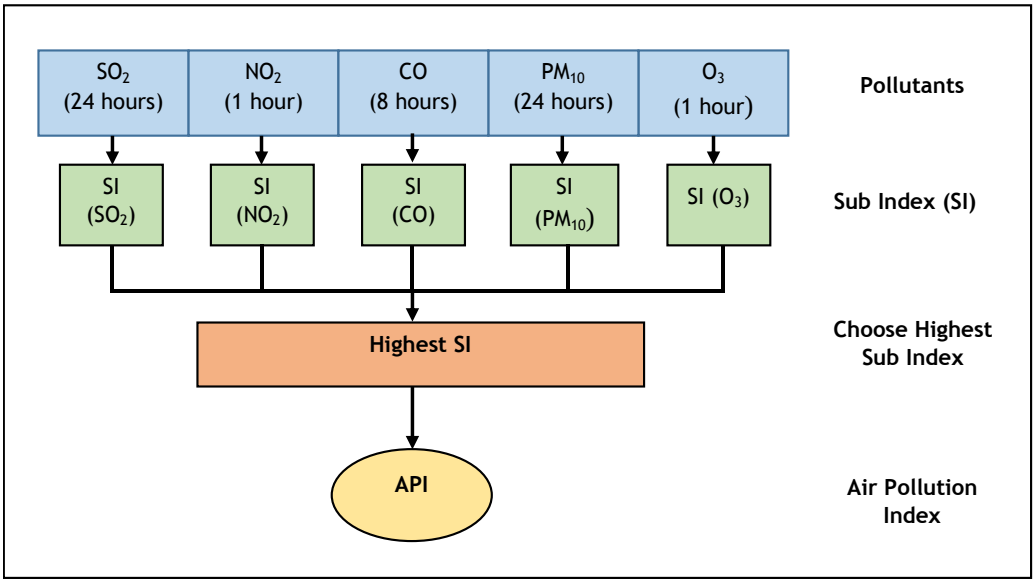
Haze is characterized by smog-like tiny suspended solid or liquid particles(9). Haze from biomass smoke contains a large and diverse number of chemical components that many also consider to have some health implications upon the general population. These include the particulate matter (PM), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) and ozone (O_3)(10). However, recent study showed that CO and O_3 were not listed as the chemical compounds found in haze (11). For most of the studies, PM is the major component of the haze and significantly contribute to it (9, 12).

Haze is defined as a pollution phenomenon characterized by deteriorated horizontal visibility of less than 10 km that is caused by fine particles suspended in the atmosphere (13). For Malaysia, the occurrence of haze is based on the level of certain air pollution or based on the Air Pollution Index (API). One of our recent and local study defined haze days as when daily particulate matter with size less than 10 μm(PM_{10}) concentration exceeded 100 μg/m^3(14). Another local study stated that haze episodes

were defined when the API level is at least within the Lower Moderate category level (API ≥ 76) (15). Thus, the true definition of haze is defined based on the measureable air pollutant that was recorded.

For Malaysia, the API is an indicator for the air quality status at any particular area. This API system closely follows the Pollutant Standard Index (PSI) of the United States Environmental Protection Agency (USEPA) and is mainly based on five major pollutants (PM_{10}, SO_2, NO_2, CO, and O_3) in the ambient air. Hourly values for PM_{10} and SO_2 are averaged over a 24-hour running period, with an 8-hour period for CO, while O_3 and NOx are read hourly before an hourly index is calculated with the use of sub-index functions for each pollutant. Then the highest index value recorded is then taken as the API for the hour. Normally, concentration of PM_{10} is the highest when compared to other pollutants and determines the API value (16). The API level will have its own health implication. Figure 1 showed the summary of calculating the API and Table 1 showing the API level and its implication to human health system.

Figure 1: Summary of calculating API as practiced by Department of Environment



Source: Department of Environment (DOE) (17).

Table 1 API level and its implication to human health system

API level	Descriptor
0-50	Good
51-100	Moderate
101-200	Unhealthy
201-300	Very unhealthy
>300	Hazardous

Source : Department of Environment (DOE) (17).

Regarding the particulate matter, its worth to mentioned about the difference of PM_{10} and the smaller particulate matter of less than 2.5 µm ($PM_{2.5}$). The $PM_{2.5}$ is a fraction from the PM_{10} that was being measured by the DOE for the API calculation as mentioned above. Recent study of haze have showed that these fine fraction of $PM_{2.5}$ was the dominant fraction during the haze days being a factor of 4–5 times higher than non-haze days compared with a 2 fold increase in the coarse fraction(18). It also noted that $PM_{2.5}$ cause more health effect as the smaller size of the particulate can reach deep to respiratory systems and effect cardiovascular system significantly (19). However, as the current practice of DOE only measured the PM_{10} for the API calculation, the haze effect that was discussed here is based on these current practises.

The haze has affected people in several aspects of life. There is significant effect of haze posing a health hazard to its citizen mainly the respiratory and cardiovascular illness as well as skin allergy(14). As to avoid these health problem and due to vision impaired, haze also cause social and productivity problem as school had to be closed and outdoor activity has to be reduced(20). The haze also affected the economy due to these various problem cause from haze which include the health cost incurred, reduce income from tourism activity and loss of income due to reduce productivity (21). Thus, there is the need to understand the seriousness effect of the haze.

Although the haze episode have become an annual occurrence in Malaysia, there still a lack of understanding the effect especially regarding its health economy impact. Further understanding about the effect of haze towards the health economy impact will help the policy maker to understand the seriousness of the effect of haze thus helping them in planning and strategizing their health system. It will help them in reorganize their resources so they can anticipate the health economy impact that was cause by occurrence of haze and help in better planning in managing the haze episodes in the future.

This review aims to synthesize available literature in epidemiology, economics and haze related studies to provide essential information for the valuation of health costs associated with haze in Malaysia. This paper will try to answer what is the haze health effect, the trend of the hospitalization cause by haze and the cost and its economy impact in our local setting.

METHODS

Database & sources

We searched three large databases covering health and medical literature which are Sage, Science Direct and ProQuest. As there is lack of local publication in those database, search were extended using the Goggle to get as much as possible data which includes local reports. Article and report were retrieved are those that were published from 1999 to 2017 to capture the 1997 Asian Haze and up to the recent haze episodes. Reference lists of all relevant studies were scanned to identify any further studies, and if these revealed that search terms had been missed, extra terms were added to the main database searches.

Search keywords and terms

Evidence on health economic impacts of haze was gathered by conducting a literature review and collecting information on the health effects of haze. In addition, the cost incurred by the health impacts as well as the hospitalization cost were analysed and special focus was on Malaysia. Our search of database used the following keywords *haze, health impact and hospitalization, cost of haze, air pollution, forest fire* and *particulate matter*.

Inclusion & exclusion criteria

To answer the research question of haze health effect, the trend of the hospitalization cause by haze and the cost and its economy impact in our local setting, studies of any relevant design were included if they presented original data, and included at least one analysis where the haze or air pollution is mention in the result. We excluded studies in which the authors did not mention the effect of haze in health or the economy impact.

Procedure

Titles and abstracts were screened for relevance, and full-text versions obtained where appropriate for assessment with reference to the inclusion and exclusion criteria; we were able to obtain full-text papers in all cases where required and it was not necessary to contact specific authors. For each study included, the following information was recorded based on prior beliefs about key aspects of study methodology and in order to summarise study quality: the haze episodes occurrence, the location of study, the health effect of the haze and cost involvement. Data were presented by explaining the health effect of haze, the trend of hospitalization in Malaysia cause by haze, the health economy impact of haze comparing with other countries and later health economy impact in our local setting.

RESULTS

Haze: the health effects

From the literature review, the health effect of the haze is shown based on the haze episodes that occurred. We extend our search to include the neighbouring countries that were affected by the haze. The health effect presented in Table 2 below includes effect to mortality and respiratory problems and symptoms and excluding the hospitalization that will be presented later. These cover eight studies where two (2) were using cross sectional design, 2 consists of mini-survey, and one each for report review, time series, case-crossover and case study.

Haze: the trend of hospitalization in Malaysia

We further explore the effect of haze towards the hospitalization in our Malaysia setting. Although studies were very limited to two studies, they have shown the increasing number of inpatient cases as shown in Table 3. Both had use cross-sectional design in in their studies.

Table 2: The health effect by the haze

Study	Location & haze episode	Study design	Health effect
Heil 2007 (22)	Indonesia 1997 Asian Haze	A report review	- 19,800 – 48,100 cases of premature mortality - 20 million people suffered respiratory problems
Mott et al 2005(23)	Kuching, Malaysia 1997 Asian Haze	Time series design	- No change on mortality - Increased in respiratory symptoms
Emmanuel 2000(24)	Singapore 1997 Asian Haze	Cross section design	- No change on mortality - 30% increase in respiratory symptoms in ED - 12% URTI - 19% asthma - 26% rhinitis
Othman &Shahwahid 1999(25)	Malaysia 1997 Asian Haze	Cross section design	- 1 unit of increased API measure is associated with 0.055 case of respiratory symptoms per 10,000 people
Phonboon et al 1999(26)	Thailand 1997 Asian Haze	Case study design	- 8.0% increase in respiratory symptoms in outpatient department. - 1ug/m^3 increase of monthly average PM_{10} is associated with 13 excess admissions of asthma
Sahaniet al 2014(14)	Malaysia 2000 to 2007 haze	Case-crossover	- Natural mortality OR 1.41 - Respiratory mortality OR1.19
Shahwahid 2016(27)	Malaysia 2013 haze	Mini survey	- Eye irritation (36.11%), coughing (37.50%), blurring of vision (23.61%), itchy throats (21.94%)
Ho et al 2014(28)	Indonesia 2013 Haze	Mini survey	- Throat discomfort (68.8%), nose discomfort (64.1%), eye discomfort (60.7%), headache (50.3%) and breathing difficulty (40.3%).

Table 3: Effect of the haze towards the hospitalization

Study	Location & haze episode	Health effect
Othman et al 2014(15)	Selangor & KL, haze in 2005, 2006, 2008 and 2009	- Increase of 1,707 inpatient cases - 2.4 per 10,000 of the population. - Increase of 142 cases monthly or 4.7 daily each year
Othman et al 2016 (29)	Selangor & KL, haze in 2005 and 2006	- Daily inpatient rates roses from 0.41 (normal days) to 0.53 (haze days), representing an increase of 90 cases (31%). - Mean number cases went up to 12 (33%) - Pneumonia, IHD,URTI, asthma and hypertensive disease represented about 63% - Asthma cases increased by 62% a 10-unit increase in PM_{10}, the number of daily inpatients in government hospital for every 10,000 will rise by 0.01.

Haze: health economy impact comparing with other countries

The cost impact on hospital admission due to haze world-wide range from USD148 million in Indonesia (30) to USD 253.8 million in China(31).To make a comparison with other neighbouring countries, we used the 1997 Asian haze to see the comparison cost involve in the hospitalization and outpatient of the diseases related to the haze. As we compare it with three different countries, the comparison was made using US Dollar as mention in each study to make the comparison easy as shown in Table 4.

Table 4: Health economic impact related to haze

Study	Location & haze episode	Health outcome studied	Cost in US Dollar
Othman & Shahwahid 1999(25)	Malaysia 1997 Asian Haze	Hospitalization	$0.6 million
		Outpatient	$1.8 million
Hon 1999(32)	Singapore 1997 Asian Haze	Hospitalization	$0.1-0.5 million
		Outpatient	$0.6-1.6 million
Ruitenbeek 1999(33)	Indonesia 1997 Asian Haze	Hospitalization	$385 million

Haze: health economy impact in our local setting

We then focus the studies that were done in Malaysia to see the health economic impact of haze. This study covering the hospital admission cost, the cost bear by the patient as well as other cost related. We maintain the currency use in these studies which is the MYR. Table 5 summarize the health economic outcome that were caused by haze by these three local studies.

Table 5: The health economic outcome by local studies

Study	Haze episode	Health outcome studied	MYR
Othman & Shahwahid 1999(25)	1997 Asian Haze	Incremental cost of Illness (COI)	MYR 9,562,466
		Incremental adjusted cost of illness or willingness to pay to avoid the illness (ACOI)	MYR I9,124,932
		Adjusted cost of illness covering outpatient and hospitalized cased	MYR21.02 million
		Per capita damage cost	MYR 104.72 which is 1.3% per capita income
Othman et al 2014(15)	2005 Haze	Hospital admission cost	MYR 1.8 million
		Average annual economic loss due to the inpatient health impact	MYR273,000
Shahwahid 2016 (27)	2013 Haze	Total cost of illnesses	MYR 410.6 million
		Cost of medical treatment and hospitalization	MYR 118.9 million
		Cost of medical-related leaves taken	MYR 202.8 million
		Reduced activity days	MYR 69.3 million
		Purchasing air pollution masks as protection	MYR 19.6 million
		Loss of income opportunities	MYR 958 million

Discussion

The health effect from haze as shown in Table 2, showed that although haze have become an annual occurrence in our country and regions, very limited study has been done to see the health effect of the haze. Thru massive and extend search of literature review, only 8 studies meet the requirement to be put in this table. These 8 studies consist of various study design and the accuracy of the result can be questionable. A mini survey has discrepancy in recall accuracy and the validity of a survey depends on the response rate (34). Design study using time series and case-crossover is better in giving the trend and measuring the risk of the hazard although it need more time and resources(35, 36). A cross sectional and case study are simpler studies to be done and can give the overview condition of certain population if the resources is limited (37). Thus, the design of the studies will weigh the finding.

The health effect of the haze can be difficult to compare as we based on different haze episodes. These haze episodes have different measurement of API for every haze episodes thus make it difficult to compare. However, if we used the

same haze episodes, we can make a relative comparison. For example, the 1997 Asian Haze which known to be the worse haze episodes in this region (15), have several studies based on the event. From this review, we noted that Indonesia sustain the worse health effect looking on the mortality aspects.

However, comparison is still difficult to measure as every study used different outcome for measuring. Some of the studies use mortality while some of the using symptoms. For the mortality, it is quite vague to say the mortality is the health effect of haze. Haze or air pollution have a significant effect on respiratory and cardiovascular mortality(38, 39). The mortality outcome that was measured here could be due other than these two group diseases and this mortality may not representing the true health effect on haze. In regards of the symptoms, these studies are more focus on respiratory symptoms. Recent studies have shown that PM which is the highest contribution of haze cause more health effect in cardiovascular system rather than respiratory system (40). Thus, the health effect may not be well presented in this study.

Looking on the effect of haze towards trend of hospitalization as shown in Table 3, again it showed very limited studies focus on this. Since these two studies describe their hospitalization trend on the same haze episode period, it is easier to compare. Both studies have managed to show the increasing trend of admission during the haze period. However, study by Othman et al 2014 has not specifically focus what type of disease admission they included in the study. This study take the whole admission and not focusing on certain diseases of respiratory and cardiovascular who have significant association with the air pollution as mention by other studies (41). For the study by Othman 2016, they did mention on respiratory admission cases but again left the other cases such as cardiovascular cases who known to have significant association with air pollution (42).

Comparing the health economy impact of haze with other countries, we used the 1997 Asian Haze and using US Dollar currency (as mentioned in their studies) to make it comparable as show in Table 4. Changing of the US Dollar currency to MYR may change the true cost that was measured in these studies. From this table we could say the health economy impact is divided to two big groups which are the hospitalization cost and outpatient cost. Here, we can clearly state that Indonesia suffered the highest effect as the cost hospitalization as they reach up to USD$ 385 million. The 1997 Asian Haze did effect the Indonesia badly as the emission came from the forest fire that was estimated involving 45,600 km2 of vegetation that burnt on the Indonesian islands Kalimantan and Sumatra (22). However, these studies did not cover the outpatient cost and the total cost of health economy impact could be much higher.

The other two studies that were done in Malaysia and Singapore did include the hospitalization cost as well as the outpatient cost. It was noted her that the outpatient cost are much higher the hospitalization cost. It is worth to mention here that comparison of the cost here is still need to be argue. These three countries has different health system where the Singapore health system is believed to be more advanced(43) thus the cost should be more. The health system of Indonesia at that time are said to be lower than Singapore and Malaysia (44)making the hospitalization cost is much lower. Therefore, there is vague line to argue in comparing the cost involve here.

When we focus the health economy impact of haze on our local studies as shown in Table 5, only three studies were found to be included here. It needs to be mentioned here that study by Othman et al in 1999 have explain their finding in both currencies which are the USD and MYR. Therefore, we can use the USD currency value to compare with studies done by other neighbouring countries as discussed earlier and using the MYR currency to be discussed with the other local studies here.

For these three local studies, they have used three different haze episodes which is the 1997 Asian Haze, the 2005 haze episode and the 2013 haze episode. They also used different measurement outcome making it quite difficult to compare with each other. However, there are certain measurements that can be discussed here. First, the incremental cost of illness (COI) was mentioned in the Othman & Shahwahid 1999 study and Shahwahid 2016 study. For the first study, the COI costing about MYR9.5 million which cover the whole Malaysia and excluding Kelantan, Terengganu and Pahang while the latter study gives a value of MYR 410.6 million for the whole Peninsular. This showed a huge increase of health economy impact of the haze. Another example is the hospital admission cost by Othman et al 2014 give a value of MYR 1.8 million while Shahwahid 2016 study give a value of MYR18.9 million. This again shows the increment of health economy impact of the haze.

The Shahwahid study also showed that haze have affected the health economy aspect in various ways. This include the cost of illness, cost of medical treatment and hospitalization, cost of medical-related leaves taken as well as purchasing air pollution mask as protection. It also affects the productivity as a whole when patient will loss the income opportunities when they are sick and effect the bigger economic

cost. This study really supports the argument on the seriousness of health effect of haze.

Conclusion

The haze has no doubt given as serious health effect not only to our country but also to our neighbouring countries. The repeating episodes of haze has cause the increasing health problem become unsolved and require more effort to manage this issue. These health effects has caused a significant health economy impact which include rise in hospital admission cost and medication, incremental cost of illness and extend to cost of medical-related leaves taken and lead to loss of income opportunities. As haze become annual occurrence, we should be ready in term of our health facilities, staff and other resources tomanage these health effect economy impact.

The extreme haze may result in a variety of other impacts (e.g. on tourism, business and transportation) all of which have significant social and economic cost. Taking these factors into account, the total damages due to haze are very substantial. Taking into account the significant impact of the haze on people's health, on health care resources, and on the Malaysia economy, it is recommended that serious discussion, planning and implementation for an international legislation should be drawn up to advocate neighbouring countries to strive harder for control of the haze sources that are occurring within their respective countries.

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