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Health Impacts of Haze In Malaysia

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Smoke Haze Air Pollution

- Thick smoke-induced haze has enveloped SEA regions notably Malaysia, Singapore, Indonesia and Thailand and has occurred almost every year within the last few decades (Latif et al 2018).

- Landscape fires are common in Southeast Asian countries
  - Peatland, a type of wetland ≈ 300,000 km^2 in Indonesia and Malaysia – 56 million football fields.
  - Become prone to fire (especially dry season) because of draining/land clearing for agriculture

- Systematic reviews of forest fires have consistently demonstrated adverse health effects (Sastry 2000; Afroz *et al*. 2003, Sahani et al, 2014, Sulong et al. 2017).

- Chronic long-term effects of haze exposures are not well studied or established locally, more need to be done

Source: http://edition.cnn.com/2015/01/27/asia/asia-air-pollution-

Air Quality Trend in Malaysia, 1998-2016. (Latif et al 2018)

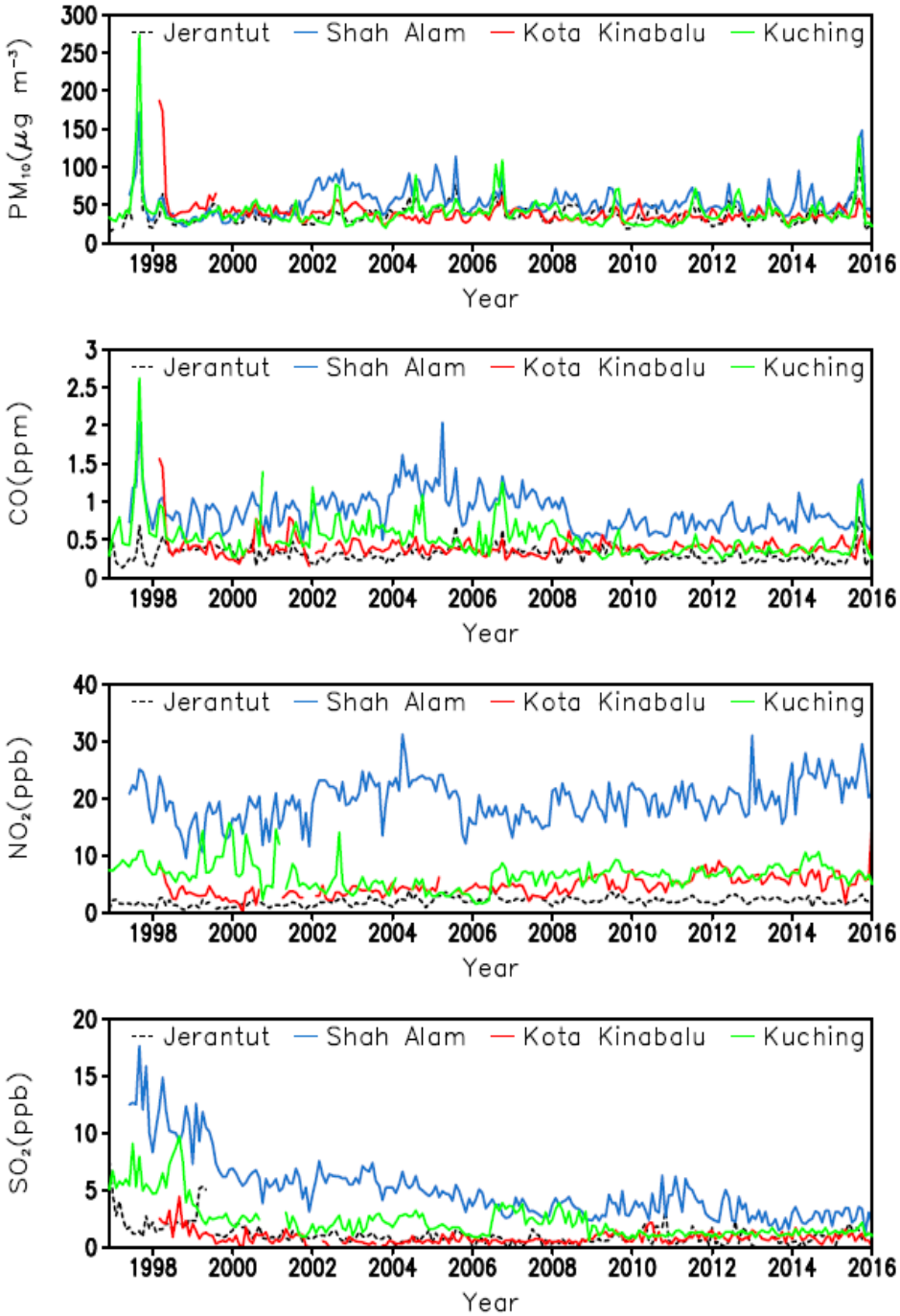
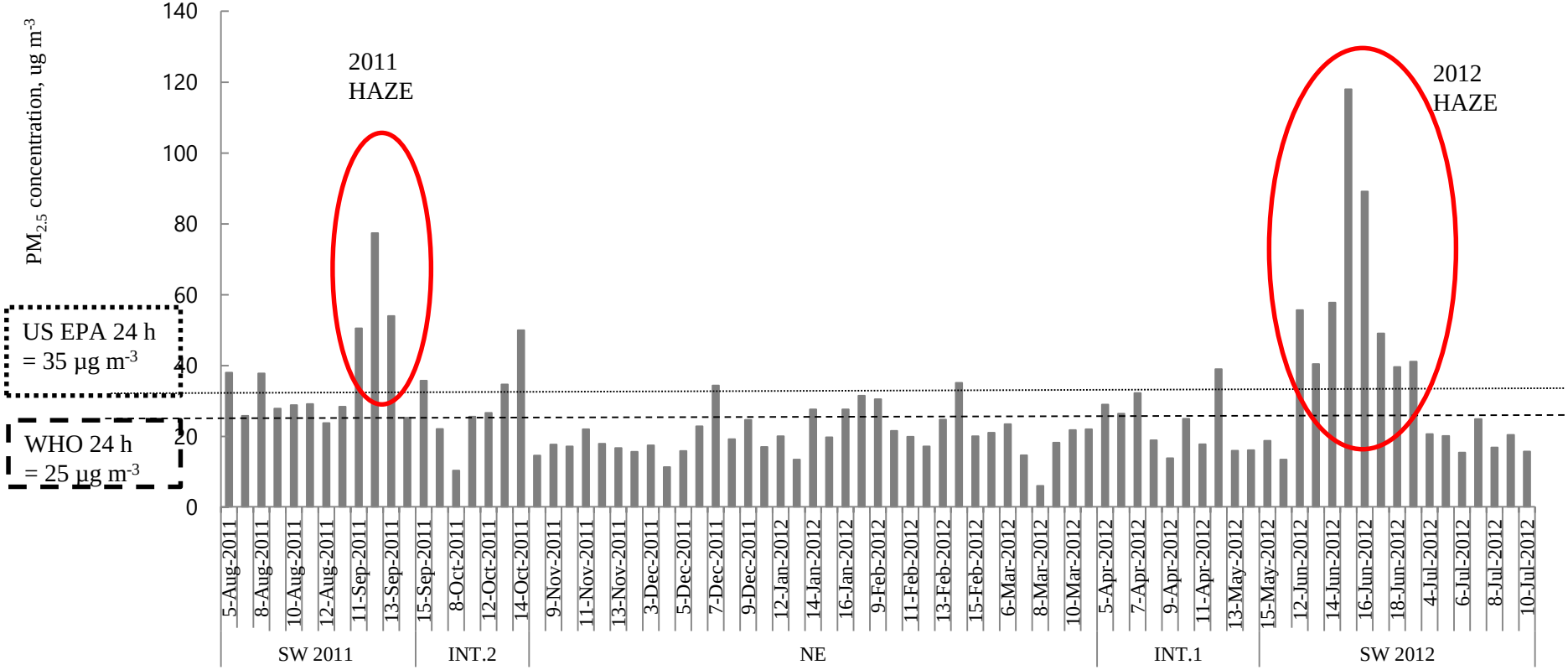


Fig. 1. Concentration trend of PM_{10}, CO, NO_2 and SO_2 in Shah Alam, Jerantut, Kota Kinabalu and Kuching from year 1997 to 2015.

Haze in Malaysia

$PM_{2.5}$: Petaling Jaya (2011-2012)



Amil et al. Seasonal variability of $PM_{2:5}$ composition and sources in the Klang Valley urban-industrial environment. *Atmospheric Chemistry and Physics* 16, 5357-5381, 2016.

Health effects of 1997 haze air pollution studies in Malaysia (ASM, 2016)

- The more common health symptoms following high exposure to air pollutants during the haze include throat irritation, coughing, difficulty in breathing, nasal congestion, sore eyes, cold attacks and chest pain (Mohd Shahwahid & Othman 1999).

- During the 1997 haze, Hospital Kuala Lumpur recorded a substantial increase in cases of upper respiratory tract infections, conjunctivitis, and asthma, with a 2-day delayed effect for asthma incidences, for example in June there were only 912 cases of asthma recorded in Selangor while in September, more than 5000 cases were recorded (Awang *et al.* 2000).

- Brauer and Hisham-Hashim (1998) investigated haze-related illnesses during the 1997 haze period (August – September) and reported significant increased in asthma and acute respiratory infections in Kuala Lumpur hospital.

- In Kuching, Sarawak, outpatient visits increased between 2 to 3 times during the peak 1997 haze period while respiratory disease outpatient visits to Kuala Lumpur General Hospital increased from 250 to 800 a day (WHO 1998).

Study Methodology

- Study design: a case cross-over
- Study location: Klang Valley region
- Study period: 2000-2007
- Mortality data from Stats Dept (ICD10) :
  - natural causes of mortality inclusive of respiratory mortality
- Air quality: DOE
  - Haze events: PM10>100ug/m3
    - 88 haze days and 2834 non-haze days

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A case-crossover analysis of forest fire haze events and mortality in Malaysia

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HIGHLIGHTS

- We modelled association of haze events and daily mortality using a case-crossover study design.
- Days with daily PM_{10} > 100 μg/m^3 were defined as haze events.
- Haze events were significantly associated with natural and respiratory mortality at various lags.
- Immediate effects of haze were particularly seen among males.
- Children and adult females mortalities were associated with delayed effects.

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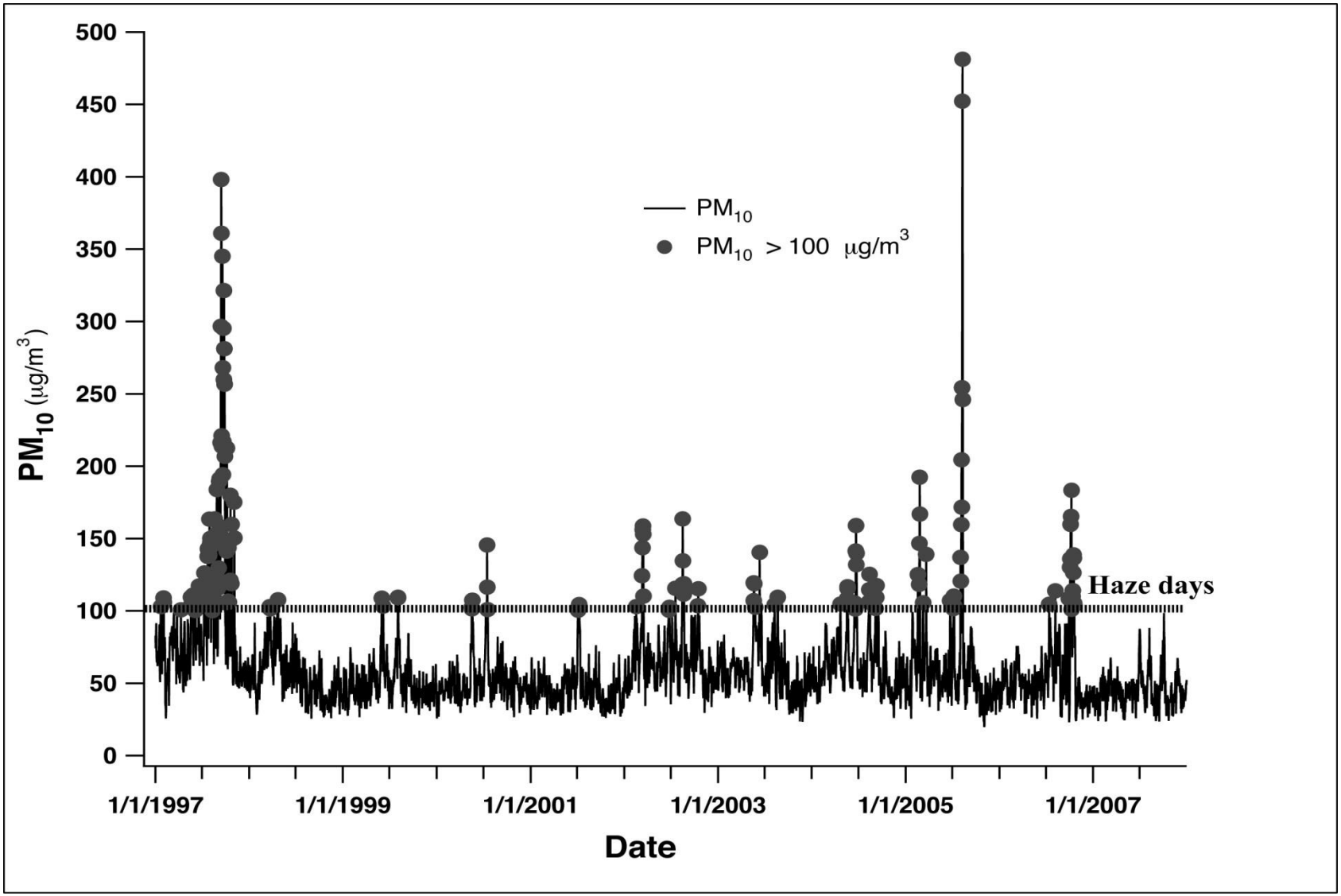
ABSTRACT

The Southeast Asian (SEA) haze events due to forest fires are recurrent and affect Malaysia, particularly the Klang Valley region. The aim of this study is to examine the risk of haze days due to biomass burning in Southeast Asia on daily mortality in the Klang Valley region between 2000 and 2007. We used a case-crossover study design to model the effect of haze based on PM_{10} concentration to the daily mortality. The time-stratified control sampling approach was used, adjusted for particulate matter (PM_{10}) concentrations, time trends and meteorological influences. Based on time series analysis of PM_{10} and backward trajectory analysis, haze days were defined when daily PM_{10} concentration exceeded 100 μg/m^3. The results showed a total of 88 haze days were identified in the Klang Valley region during the study period. A total of 126,822 cases of death were recorded for natural mortality where respiratory mortality represented 8.56% (N = 10,854). Haze events were found to be significantly associated with natural and respiratory mortality at various lags. For natural mortality, haze events at lagged 2 showed significant association with children less than 14 years old (Odd Ratio (OR) = 1.41; 95% Confidence Interval (CI) = 1.01–1.99). Respiratory mortality was significantly associated with haze events for all ages at lagged 0 (OR = 1.19; 95% CI = 1.02–1.40). Age-and-gender-specific analysis showed an incremental risk of respiratory mortality among all males and elderly males above 60 years old at lagged 0 (OR = 1.34; 95% CI = 1.09–1.64 and OR = 1.41; 95% CI = 1.09–1.84 respectively). Adult females aged 15–59 years old were

Daily average of PM concentration recorded in the Klang Valley region, Malaysia, between 1997 and 2007 (Sahani et al, 2014).

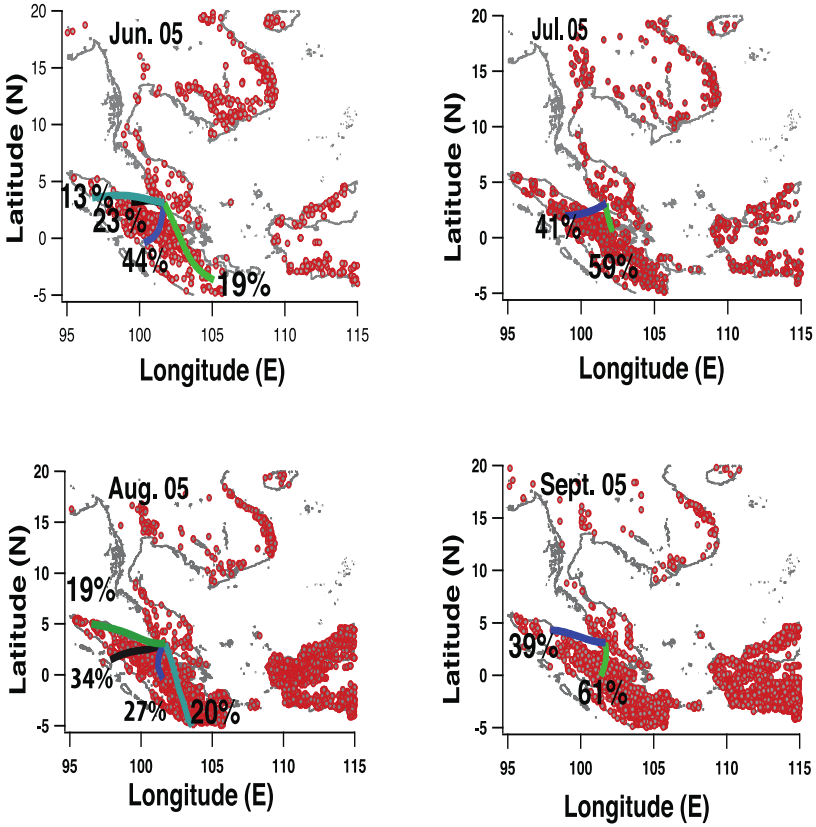


Haze definition in the case cross-over study design

- Haze events were defined using a cut-off of [PM_{10}] at 100 µg/m^3 and backward trajectory analyses.

- Densely spotted fire counts, particularly during June-September 2005, were reported.

- The results of the mean cluster of back trajectories demonstrated that the largest percentage of trajectories originated from the region of Sumatra and were then transported to the Klang Valley region of the Malaysia Peninsular.

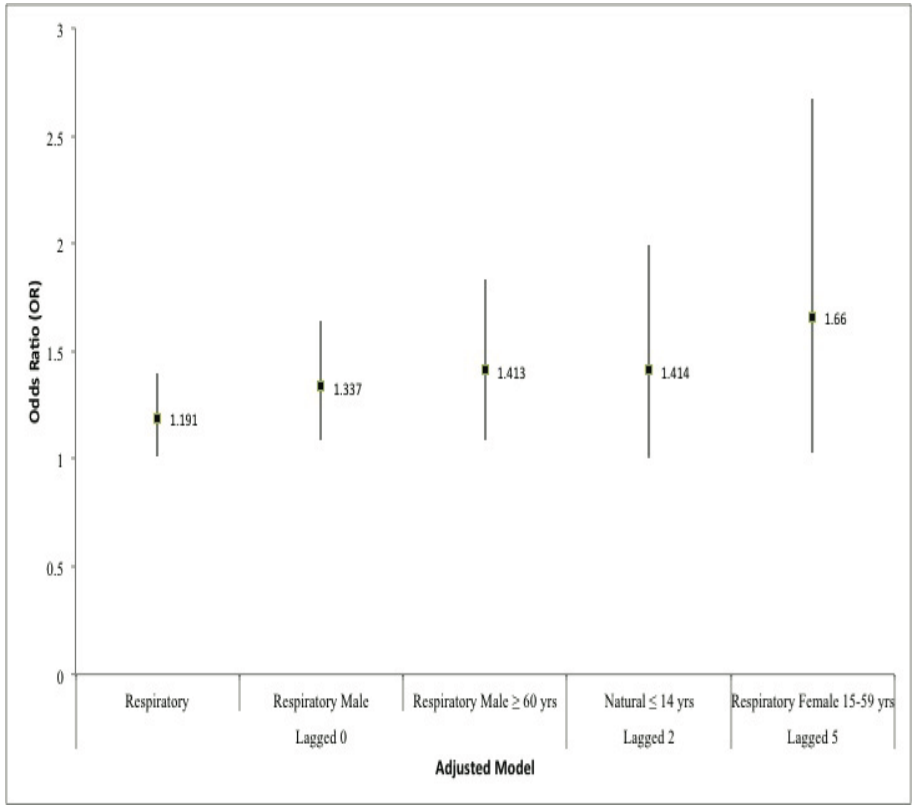


Haze episodes & mortality

- Significant 2-day delayed effect of haze event on all-cause mortality among children < 14 yrs old: OR = 1.41, 95%CI = 1.01–1.99).

- Immediate effects (lag 0) of haze on respiratory mortality
  - Elderly males> 60 years old (OR=1.41, 95% CI=1.09-1.84).
  - All resp : OR = 1.19, 95% CI = 1.02-1.40).

- Highest effect: delayed (lag 5):
  - respiratory among females 15-59 yrs old (OR=1.66, 95% CI=1.09-2.67)



Methodology

Cost-of-Illness(COI) approach

- to estimate the economic values of haze impact on health.
- Study location: Klang Valley region
- Study population: cardiovascular and respiratory diseases admission in 7 public hospitals
- Air quality data from the nearest DOE COQM stations
  - Intensity of haze variables
    - Hazy days: API > 100 or PM10 > 134 ug/ m3
- Economic valuation
  - Using panel data regression (OLS estimator)
  - $Z_i = f(H, RH_i, D\_Age, D\_Area)$
  - $AEV = *(1 + F)*\beta)*\Delta H*\Delta HD*POPN*UEV$

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Transboundary smoke haze pollution in Malaysia: Inpatient health impacts and economic valuation

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Smoke haze episodes in Malaysia

ABSTRACT

This study assessed the economic value of health impacts of transboundary smoke haze pollution in Kuala Lumpur and adjacent areas in the state of Selangor, Malaysia. Daily inpatient data from 2005, 2006, 2008, and 2009 for 14 haze-related illnesses were collected from four hospitals. On average, there were 19 hazy days each year during which the air pollution levels were within the Lower Moderate to Hazardous categories. No seasonal variation in inpatient cases was observed. A smoke haze occurrence was associated with an increase in inpatient cases by 2.4 per 10,000 populations each year, representing an increase of 31 percent from normal days. The average annual economic loss due to the inpatient health impact of haze was valued at MYR273,000 ($91,000 USD).

- This study has estimated annual loss of USD91,000 USD due to acute exposure to t smoke haze pollutions

- The figure is expected to go up if outpatient treatment, subsequent productivity loss, and shortage of hospital beds were considered.

- Othman & Shahwahid (1999) estimated
  - incremental cost of MYR5.02 million (~ USD1.5 mil) for treatment of haze-related diseases including self-medication and
  - MYR4.3 million for productivity losses (~USD1.3 mil.)

A Study on Burden of Disease from PM2.5 in Malaysia

This study was partially supported by a seeding grant from the Centre for Air quality and Research and Evaluation (CAR), Australia

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Aims of Study

- 1. Describe the pattern of haze (as measured by $PM_{2.5}$)
- 2. Quantify the burden of disease due to haze episodes in terms of mortality and the potential health benefits from reductions in haze.

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Research Methodology

1. Air pollution concentrations

- Daily aerosol optical depth (AOD) data for Malaysia at a 3km resolution for the period **2013 to 2015** was obtained from the MOD04 collection 6 dataset of the moderate resolution spectroradiometer (MODIS) satellite platform (Remer et al., 2013)

- Daily PM10 was obtained from DoE monitoring stations (53 stations) across al states n Malaysia for the period 2013-2015 and was averaged to weekly means that aligned with the AOD grid timesteps.

- Seasonal PM_{10} to $PM_{2.5}$ conversion factors were obtained for Malaysia from Amil et al. (2016) and applied to the PM_{10} grids to produce weekly interpolated $PM_{2.5}$ grids for Malaysia, which were then spatially aggregated to mean weekly $PM_{2.5}$ exposure values within each Malaysian state polygon.

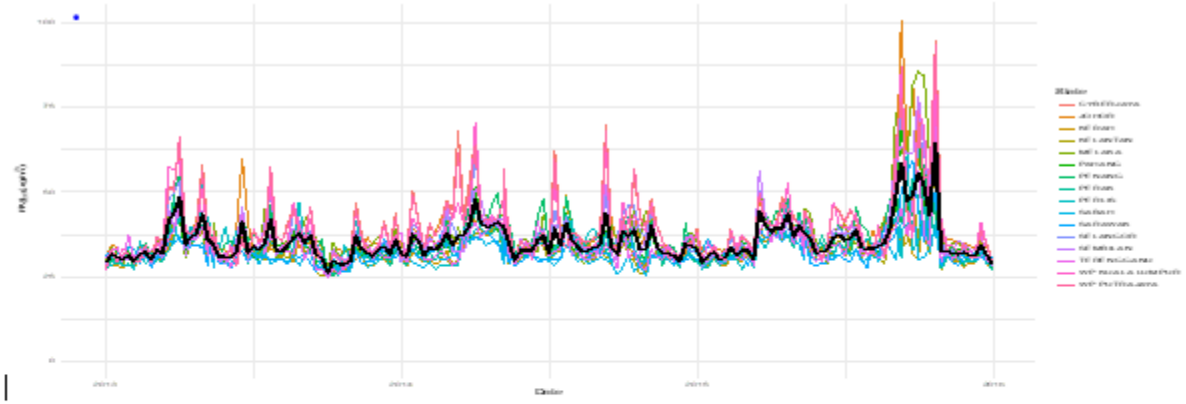

Figure 3.1 Time-series of weekly average $PM_{2.5}$, thick black line denotes weekly average of states

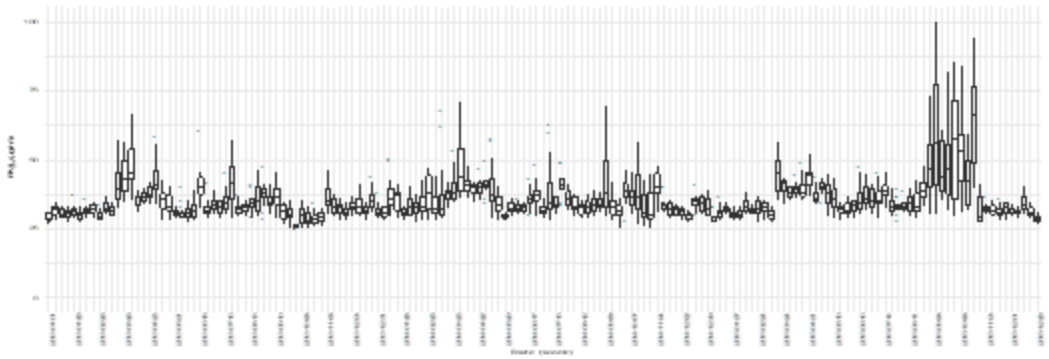

Figure 3.2 Time-series of weekly boxplots of average $PM_{2.5}$

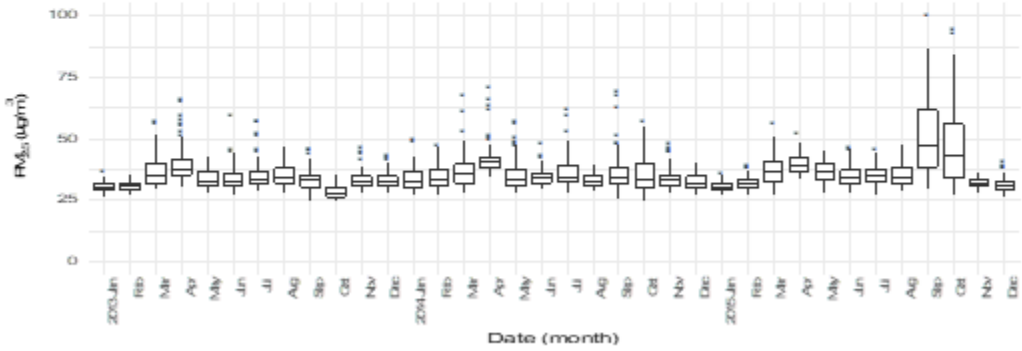

Figure 3.3 Time-series of monthly boxplots of average $PM_{2.5}$

2. Exposure attributable to haze event

- Changes in annual average $PM_{2.5}$ concentrations between the haze affected year (2015), and 2013 and 2014, have been assumed to be attributable to the haze event.

- In a sensitivity analysis, the annual average $PM_{2.5}$ conc in 2015 haze was calculated as the difference between the average $PM_{2.5}$ concentrations in the eight haze weeks of 2015 (September and October) and the average $PM_{2.5}$ concentrations in the eight weeks prior to the eight haze weeks.

- For each week and state during the haze period, $PM_{2.5}$ levels were compared to the state-level averages of the eight weeks preceding the haze period. Where haze-period $PM_{2.5}$ levels were higher, the increase was attributed to the haze event.

Table : Average $PM_{2.5}$ concentrations ($\mu g/m^3$) during the eight week haze period in 2015 and for the eight weeks preceding the haze period by State

State	Eight weeks before haze period	Eight weeks of the haze period	Difference between the two eight week periods	Annualised difference*	Non-haze period
Johor	36.47	66.69	30.22	4.64	35.76
Kedah	35.08	37.42	2.34	0.36	32.73
Kelantan	33.57	40.93	7.36	1.13	32.59
Melaka	36.27	71.44	35.17	5.40	35.84
Negeri Sembilan	36.90	63.33	26.44	4.06	35.18
Pahang	35.52	54.11	18.59	2.85	34.04
Penang	38.78	44.7	5.92	0.91	35.23
Perak	34.4	45.13	10.73	1.65	32.92
Perlis	35.38	40.25	4.86	0.75	33.51
Sabah	32.06	36.21	4.15	0.64	31.43
Sarawak	32.66	47.01	14.35	2.20	31.85
Selangor	35.4	58.16	22.76	3.49	35.65
Terengganu	33.78	46.67	12.89	1.98	33.53
WP Kuala Lumpur	36.41	60.72	24.31	3.73	37.24
WP Putrajaya	37.03	62.15	25.12	3.85	38.1

3. Population and health data

- Annual population estimates 2013-2015 by state obtained from the DOS, Msia.
- .
- Estimated annual counts of mortality (all-cause, circulatory (ICD10: I00-I99), respiratory diseases (ICD10: J00-J99) and external causes (ICD10: V01-Y98) were obtained.

- The state-level totals for 2013 and 2014 were used with population estimates to calculate state-level baseline incidence rates during the non-haze years

State	Malaysia Population All Ages 2015	Malaysia Population Aged 30+ yrs 2015	All-cause (all ages)	Natural cause (ages 30+ years)
Johor	3,610,300	1,713,900	5.061	9.539
Kedah	2,096,500	950,800	6.223	12.336
Kelantan	1,760,600	690,600	6.054	13.572
Melaka	889,000	407,200	5.482	10.737
Negri Sembilan	1,088,800	498,800	5.866	11.327
Pahang	1,607,900	708,200	5.204	10.456
Perak	2,466,900	1,185,700	6.790	10.283
Perlis	248,500	111,500	7.004	12.864
Penang	1,698,100	878,700	5.752	14.298
Sabah	3,720,500	1,440,400	2.803	6.293
Sarawak	2,701,500	1,223,400	4.318	8.577
Selangor	6,178,000	2,931,500	3.707	7.025
Terengganu	1,161,000	451,200	5.717	12.878
WP Kuala Lumpur	1,780,400	931,300	4.285	7.602
WP Labuan	95,100	42,200	2.801	5.638
WP Putrajaya	83,000	37,000	2.228	3.812
Overall	31,186,100	14,202,400	4.801	9.473

4. Health Burden Calculations

- We used the concentration response functions (CRFs) recommended in the Health Risks of Air Pollution in Europe project (HRAPIE) report. The CRFs were calculated for both short-term and long-term exposure to $PM_{2.5}$.

- For each state and each health outcome, the attributable number of health events due to haze exposure in 2015 was calculated as:

$$\textbf{Attributable } \boldsymbol{number} = \textbf{Baseline } \boldsymbol{incidence} \times \left(\boldsymbol{RR}^{(x-x_b)/10} - \mathbf{1}\right) \times \textbf{Population in 2015}$$

where

- RR is the relative risk per 10 μg/m^3 increase in $PM_{2.5}$ derived from epidemiological studies,
- x is the state-level annual average ambient levels of $PM_{2.5}$ in 2015, measured in μg/m^3, and
- x_b is the state-level baseline average ambient levels of $PM_{2.5}$ averaged over 2013 and 2014, measured in μg/m^3.

Results:

Table. Attributable number of health events due to haze in 2015.

State	Short-term exposure mortality (all-cause, all ages) N (95%CI)	Long-term exposure mortality (natural cause, aged 30+ years) N (95%CI)
Johor	108.4 (39.7, 176.8)	482.7 (313.1, 642.9)
Kedah	14.9 (5.5, 24.3)	66.2 (43.1, 87.9)
Kelantan	24.4 (9, 39.8)	106.2 (69.1, 141)
Melaka	30.5 (11.2, 49.7)	136.2 (88.3, 181.4)
Negeri Sembilan	33.6 (12.3, 54.8)	147.8 (95.9, 196.8)
Pahang	36.1 (13.3, 58.9)	158.7 (103.1, 211.1)
Penang	21.6 (7.9, 35.2)	98.9 (64.3, 131.3)
Perak	37.8 (13.9, 61.6)	170.1 (110.7, 225.9)
Perlis	1.3 (0.5, 2.2)	6 (3.9, 8)
Sabah	23.6 (8.7, 38.5)	101.4 (66, 134.7)
Sarawak	37 (13.6, 60.2)	164.6 (107, 218.8)
Selangor	67.6 (24.8, 110.1)	300.8 (195.6, 399.6)
Terengganu	17.8 (6.5, 29.1)	77.3 (50.3, 102.6)
WP Kuala Lumpur	28.2 (10.3, 46)	129.7 (84.3, 172.5)
WP Putrajaya	0.5 (0.2, 0.8)	1.8 (1.2, 2.4)
Total	**483.4 (177.3; 787.9)**	**2,148.5 (1,396.1; 2,856.8)**

Discussions

- We estimate that for short-term exposure effects of PM2.5, a total of 483.4 premature all-cause deaths (95% [CI]: 177.3, 787.9) in Malaysia could be attributable to the haze in 2015.
- In a sensitivity analysis, when we applied the long-term exposure risk estimates, the haze-related premature natural cause deaths in 2015 was **2,148.5 (95%CI: 1,396.1; 2,856.8).**
- In Malaysia, states with the greatest increase in $PM_{2.5}$ concentrations due to the 2015 haze as well as those with larger populations had the largest number of attributable deaths.
- This study showed that for the short-term exposure effects of $PM_{2.5}$, an underestimation of the actual number of deaths attributable to the 2015 haze. Longer durations of exposure are associated with an increased magnitude of health impact.
- This study has demonstrated the feasibility to use routinely collected air pollution, population and mortality data to calculate the burden of disease attributable to haze air pollution in Malaysia.

Current studies

- Trans-boundary haze air pollution and its associated toxicity in Malaysia.

- Risks of cardiovascular and respiratory hospitalisations from ambient air pollution in Klang Valley region, Malaysia
- (Wan Rozita WM[*], Mazrura S [**], Ahmad Faudzi Y[*], Nor Aini A[*], Zamtira S[*], Nurul I[*], Sohaya K[***], Md Khadzir SA[***], Khan Md FMohd TL)

- Risk of concentrations of major air pollutants on the prevalence of cardiovascular and respiratory diseases in urbanized area of Kuala Lumpur, Malaysia (under final review Ecotoxicology and Environmental Safety journal)

- Chemical Composition of Ambient Fine Particulates in Klang Valley region Malaysia: Source, Health Risk and Toxicity Assessment

- Cytotoxicity and DNA damage from the extract of fine particulates (PM2.5).

Future Studies

- Long term effects of ambient fine particles in Malaysia: A cohort study
- Health effects of air pollution on pregnancy outcomes in Malaysia

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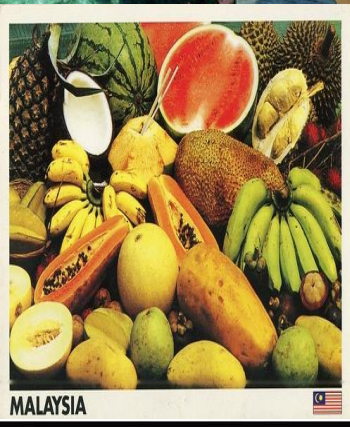

THANK YOU