Respirology (2000) **5**, 169–174

GENERAL LECTURE

Impact of haze from forest fire to respiratory health: Indonesian experience

TJANDRA YOGA ADITAMA

Pulmonology Department, Faculty of Medicine, University of Indonesia, Persahabatan General Hospital, Jakarta, Indonesia

Impact of haze from forest fire to respiratory health: Indonesian experience
ADITAMA TY. *Respirology* 2000; **5**: 169–174
Objective: This paper will describe the impact on the human lung of haze from forest fires in Indonesia based on data collected from different provinces.
Methodology: Data were collected from personal reports from pulmonologists working in the area as well as from province/district health offices and hospitals.
Results: These data show that there was a significant impact of haze to the human lung. There was a significant increase in respiratory conditions, lung function complaints and other related impacts.
Conclusion: Further studies, especially cohort studies, should be undertaken so that the long-term impact of pollution from forest fires can be known.

Key words: forest fire, Indonesia, lung condition, lungs, pollution.

INTRODUCTION

In the past 20 years forest fires influenced by climate variability and rapid demographic changes have become a major problem adversely affecting the sustainable management of tropical forest. Hazards to human health, the destruction of valuable forest resources and biodiversity, accidents and difficulties for land, water and air transportation, the disruption to the lives and livelihoods of millions of people and the far-reaching negative impact on several sectors of the economy, have all been widely reported. This problem is not only confined to Southeast Asia but is present in many other parts of the world.[1]

In 1997–98, catastrophic fires swept across all three of the world's major forest types (tropical, temperate, and boreal) on five continents. An estimated 5.3 million ha burned in Indonesia, 1.5 million ha in Central America, and 1.3 million ha in Brazil, totalling an area the size of Maine. Smoke from more than 13 400 fires in Mexico and 18 000 fires in Central America even fouled the air of the southern USA. Fire also burned across Africa, North America, and the Russian Far East, and brought tremendous human and ecological cost.[2]

Large-scale forest fires have occurred in Indonesia periodically at the interval of long and severe droughts associated with the El Nino phenomenon. Forest fires bring about huge economic losses and devastation of ecosystem. Haze harms public health and disturbs air transportation in neighbouring countries. Control of forest fire and smoke is given the highest priority among the policies of the Government of Indonesia.

In Indonesia, catastrophic forest fires affected an estimated 75 million people throughout Southeast Asia.[2] Haze and smoke closed airports, schools and hospitals, and kept millions indoors as air pollution rose to hazardous levels. People in search of treatment for respiratory, eye, and skin ailments overwhelmed medical clinics.

The fires of Indonesia also exacted a heavy economic toll; $4.4 billion throughout Southeast Asia according to estimates by the World Wide Fund for Nature and the Economy and Environment Programme for Southeast Asia. This amount exceeds the combined economic damages assessed for the Exxon Valdez oil spill and the Bhopal chemical incident. The damages included over $1.2 billion in short-term health cost, $1.4 billion in forest ecosystem services, $1.2 billion in timber and other forest products, and $0.5 billion in agriculture. In addition, the fires destroyed future potential revenues from timber and other forest resources.

Correspondence: Tjandra Yoga Aditama, Pulmonology Department, Faculty of Medicine, University of Indonesia, Persahabatan General Hospital, Jakarta, Indonesia.

Presented at the 4th APSR Workshop. This Workshop was held at the 39th Annual Meeting of Japan Respiratory Society, Yokohama City, March, 1999.

SCOPE OF THE PROBLEM

The biggest forest fires in Indonesia first occurred in 1982. Over 3.5 million ha of forest and young coal in East Kalimantan burned during that time. The biggest fires that occurred in 1994 had burned about 160 000 ha forest in Kalimantan and Sumatera, while in 1997 about 165 000 ha of forest caught fire over 12 provinces, namely Riau, North Sumatera, Jambi, Bengkulu, four provinces in Kalimantan, Maluku and Irian Jaya. It was estimated that total of 121 626 ha of forest had been burned; 730.5 ha of food crops and horticulture were burned in South Kalimantan, Central Kalimantan, South Sumatera and Riau consisting of 209 ha of rice crops, 1.5 ha of second crops and 520 of horticulture. A total of 96.693 ha of forest was burned consisting of 10 552.30 ha of protected forests, 70 259.20 ha of productive forests and 34.75 ha of other natural forests. Timber and plantation estates suffered an estimated loss of Ro.45.7 billion.[3]

A total of 1037 flights were cancelled at 11 airports in Sumatera and 2027 other flights at 12 airports in Kalimantan. There was a decrease in income originating from the airline business, plane passengers, landing fees, and the directing and parking of airplanes.[3]

Fires in Indonesia have left air pollutants, particularly biomass sources particulate, far in excess of World Health Organization guidelines. Chemical pollutant such as SO_2, NOX and O_3 invaluable fine particulate are very dangerous to human health. The air quality monitoring data were produced by many other different institutions and efforts have been made to collect data on air quality levels during the peak period from various institutions. Following the Indonesian Ministry of Environmental guidelines, pollutant standard index (PSI) has been used as a standard calculation of the pollutant index. The results of air quality monitoring in areas close to fire spots have found that levels of air pollutant parameters in those areas are much higher (four- to eightfold), far exceeding the normal values, resulting in significant health impacts. Data collected through active surveillance from September to November 1997 in eight provinces has shown increased levels of the incidence of bronchial asthma and acute respiratory infection (ARI). Among 12 360 000 people affected by haze, there were approximately 1 802 340 cases of bronchial asthma, bronchitis and ARI observed (data from Indonesian Central Bureau of Statistics, 1997).[3,4]

It is well known that the haze from forest fires consists of SO_2, NOX, O_3, CO, and total suspended particulate (TSP). All of these components are risks to health. A report from several provinces revealed that TSP was found elevated as compared to the limit threshold, such as in West Sumatra (5–10 times), Riau (0.8–7 times), South Sumatra (3.5–8 times), West Kalimantan (0.5–7.3 times) and Central Kalimantan (0.5–15 times). The limit threshold was as high as 260 $\mu g/m^3$.[3,4]

Directorate General CDC and EH-MOH[4,5] Indonesia reported the air quality monitoring data collected from Provincial Health Offices.

North Sumatera

The peak period occurred in the first week of October 1997. The TSP value was more than three times that of the standard, while other particles were below standard. Since October 1997 for all particles monitored, the result was below standard, even though no report was sent to Ministry of Health.

West Sumatera

The peak period occurred at the second week of October 1997. The TSP value was more than 10 times the standard, while NOX was more than 2.5 times in the last week of September 1997. There was no report after that.

Riau

The peak period occurred in the last week of September 1997. The TSP value was more than seven times the standard. In the last November 1997 TSP was still twice more than the standard. There was no report since December 1997.

Bengkulu

The peak period occurred in the last week of October 1997. The TSP value was still below standard, while CO was slightly above standard. There was no report since December 1997.

South Sumatera

The peak period occurred in the first week of October 1997. The TSP value was more than eight times the standard, while NOX was slightly above the standard. There was no report after that.

Jambi

The peak period occurred in the second week of October 1997. The TSP value was more than 15 times above standard, while other particles, such as NOX, were below standard. There was no report after that. To collect better information on air quality a team consisting of JICA and PUSARPEDAL (Center for Environmental Laboratories) State Ministry of Environmental had measured five air quality parameters in Jambi between on 29 March and 16 April 1997. One of the parameters (PM_{10}) was found to be above standard. BAPEDAL's data showed that on 3 and 5 October 1997 the TSP level was around 1.126–1.707, PM_{10} around 1214–1864 p.p.m. and PSI was above 500. The level of SO_2 was 0.01 p.p.m., NO_2 was 0.004–0.02 p.p.m., CO 20 p.p.m. and O_3 0.03–0.06 p.p.m.

West Kalimantan

The peak period occurred in the last week of September 1997. The TSP value was more than seven times. At the end of October 1997 the TSP value was still twice above the standard. There was no report after November 1997.

Central Kalimantan

The peak period for TSP value and CO value occurred at the end of October 1997. The TSP value was more than 15 times the standard, while CO was more than eight times. The peak period for other particles occurred at the first week of October 1997, such as SO_2 and NOS were more than four times the standard. At the end of October 1997, the TSP value was still above standard, more than 12.6 times. There was no report after November 1997. Field monitoring for five parameters conducted by JICA and PUSARPEDAL on 10–15 November 1997 found that PM_{10} value was still above standard.

South Kalimantan

The peak period for TSP and CO value occurred at the last week of September 1997. The TSP value close to four times the standard and CO value close to 15 times. Then the peak period for CO occurred on the first week of October 1997 close to 29 times the standard. There was no report since the second week of October 1997. At the end of October 1997 the TSP value was still above standard, about 12.6 times. There was no report since November 1997.

East Kalimantan

The peak period for CO value occurred at the second week of October 1997; more than 2.6 times the standard and the peak period for other parameters occurred at the third week of October, such as TSP value which was more than 1.3 times, while other parameters were below standard. At the end of October 1997 the TSP value was still above standard, more than 1.3 times. There was no report after that.

During this particular condition it was reported by Ministry of Health that there was an elevated number of cases of respiratory diseases in Pontianak, West Kalimantan, such as upper respiratory tract infection (URI) and asthma, while the numbers of skin and eye diseases did not significantly change.

There were very limited data and information for air quality at the central level from the two provinces of Maluku and Irian Jaya which also suffered from forest fires. Since December 1997 there were no more reports from any of the provinces. It was thought that the forest fire had been stopped, but at the beginning of February 1998 forest fire started again in East Kalimantan, central Kalimantan and Maluku for quite some time.

According to the results of the investigation of the haze in Indonesia by Obayashi and Ismail (EMC),[6] various substances that would be harmful for human health were detected.

As for the five basic items, PM_{10} (particulate matter whose diameter is under 10 μm) was shown to be as high as nearly 1600 μg/m^3 at the maximum of daily average. This value is more than six times as high as the environment standard in Indonesia, whose value is 260 μg/m^3 at the index of TSP (Total Particulate Matter (TPM)).

As a result of the analysis of 17 substances among polycyclic aromatic hydrocarbons (PAH) in the particulate matter, the concentration of each substance in Jambi is between 2.7 times and 65.4 times as high as that in the Environmental Management Center (EMC), which is located in Jakarta. Concentration of benzo(a)pyrene, which is one of the most toxic substances among PAH, was 15 times as high as that in EMC.

As a result of the analysis of the gaseous components, the following were found.

It is suggested that photochemical reaction is promoted in the ambient air because the concentration of acetone $(C_3H_6O)_5$, which is one of the major photochemical reaction products from hydrocarbons, was high.

Organic sulfur compounds such as dimethyl sulfide (DMS) was detected in high concentration. Dimethyl sulfide is supposed to be generated as a result of the combustion of peat lay. Dimethyl sulfide is oxidized into methansulfonic acid (CH_3SO_3H) and sulfuric acid (H_2SO_4), the latter of which is related to acid deposition.

Methyl halides, which is said to destroy the ozone layer, showed a high concentration.

Heil –(SMCP-GT2)[7] reported that as a consequence of the spreading and intensifying forest and land fires in Indonesia, air pollution levels in Kalimantan, Sumatra, Irian Jaya and Sulawesi increased significantly from July 1997 onwards, peaked during the second half of September until the end of October and decreased to background levels by mid November with the onset of the monsoon rain.

Most affected by the haze were Central Kalimantan and Jambi, southern east Sumatera, where peak particle concentrations of 4000 μg/m^3 TPM (as daily average) were recorded. Those locations were downwind from dense, emission-intense peat fire clusters in the coastal areas as wind predominately originated from the south in Kalimantan and south-west in eastern Sumatera, respectively. In most other locations, peak values between 2000 and 2500 μg/m^3 TPM were measured from resulting local fires and medium to long range contributions from more distant sources. Relatively less affected were East Kalimantan and the south-eastern and nothern parts of Sumatera where particle concentrations remained below 800 μg/m^3 TPM. Those areas were only tangentially impacted by the smoke trajectories or local fire sources. In all locations, particle concentration showed high daily fluctuations which reflected the interdependencies with the spatial and temporal variations of fire locations as well as wind conditions.

Daily mean horizontal visibility was below 3 km for at least 50 days. The time series of the particle development, based on the fragmentary data-set at hand, indicate that in three locations in Kalimantan and four locations in Sumatra, particle concentrations were above 626 μg/m^3 TPM for 1 month. Particle concentration (TPM) above this value is categorized as hazardous, according to the US-EPA PSI-system. Taking into consideration the fine particle-dominated character of the haze with an estimated ratio of PM_{10} (particulate matter smaller than 10 μm diameter) to TPM of 80–90%, the number of days categorized as hazardous.

RESPIRATORY IMPACT

The most significant immediate health impact of the haze disaster observed in the affected areas in Indonesia are ARI, bronchial asthma, diarrhoea, eye irritation, and skin disease. Data during September 1997 to June 1998 were compared with the values from 1995 and 1996. Generally, ARI cases were still below the average in some provinces. In South Kalimantan province the number of ARI cases increased by 1.8 times, South of Sumatera increased by 3.8 times, while in other provinces a significant increase occurred in October to November 1997. The number of ARI cases decreased significantly in parallel with the decrease of forest fire incidence.

Details of health impact during haze disaster as reported by DGCDC-EH-MOH[4,5] in eight provinces are shown in Tables 1 and 2.

Another survey was conducted by team from the Indonesian Association of Pulmonologist East Java branch. They performed a survey at the city of Samarinda (highly polluted area; NOX 140.30 μg/m^3 and TSP 438.56 μg/m^3) and Bontang (relatively low polluted area; NOX 36.52 μg/m^3 and TSP 198.91 μg/m^3) in central Kalimantan, which examined 127 high school students. They found that there were no statistically significant differences on the prevalence of bronchitis and bronchial asthma and the lung function parameter of forced expiratory volume in 1 s (FEV_1). There were significant differences in forced vital capacity and PFR in the male population. Seven out of nine samples who had obstructive changes got a positive test of bronchial hyperactivity. They also found that there were restrictive pulmonary function changes in their samples, even though it was not statistically significant (Djoko Imam Santoso, unpubl. data, 1998).

Another team of the Indonesian Association of Pulmonologists conducted a survey at Palembang (South Sumatera) and Jambi. The TSP level at Palembang between 25 September to 4 October 1997 was around 1.047–4.86 mg/m^3, NOX was 0.03–0.11 p.p.m. and SO_2 was 0.00–0.19 p.p.m. They examined 212 patients, 158 of whom (74.5%) had no prior history of respiratory problems. For those who had no prior history of respiratory problems, 81% had complaints of cough, 24% dyspnoea and 19% had complaints of phlegm. In contrast, from those who had a prior history of respiratory problems, 83% had complaints of cough, 72% dyspnoea and 29.6% had a complaint of wheeze (Indonesian Association of Pulmonology, unpubl. data, 1998).

A report from the Provincial Health Office Jambi showed that there was an increase of 51% on respiratory diseases in that area during haze period. Bronchial asthma was also one of the main complaints of respiratory diseases in patients treated at Jambi and Palembang, which constituted approximately three-quarters (78%) of cases treated. On the whole, 70% of respiratory patients had a worsening of symptoms during the haze period. Mortality data from the pulmonary ward of the Jambi hospital showed that there was an increased mortality rate two to four times that of the previous months. The cause of death in these patients was mainly respiratory failure in advanced tuberculosis patients, severe chronic bronchitis, severe pneumonia and lung cancer.

The data compiled from the present study are presented in Tables 3, 4 and 5. Table 6 shows the immediate impact felt by eight members of the medical doctor team after being exposed for 10–12 h to the haze in the forest fire area.

Table 1 Health impact during haze disaster in eight provinces in Indonesia: September–November 1997

Province	No. population risk	No. cases			
		Death	Asthma	Bronchitis	ARI
Riau	1 701 000	75	41 028	7 995	199 107
West Sumatera	2 411 000	106	58 164	11 332	282 087
Jambi	1 478 000	65	35 650	6 947	172 926
South Sumatera	2 355 000	104	56 803	11 069	275 535
West Kalimantan	1 478 000	74	44 574	8 686	216 216
Central Kalimantan	716 000	29	17 574	3 366	83 772
South Kalimantan	1 733 000	69	41 800	8 145	202 716
East Kalimantan	118 000	5	2 846	555	13 806
Total	12 360 000	527	298 125	58 095	1 446 120

DG CDC & EH, MOH Indonesia.

Table 2 Estimated health and social impact during haze disaster in eight provinces in Indonesia: September–November 1997

Province	No. population risk	No. cases			
		Limited activities (days)	Outpatient (no. visitor)	Inpatient (no. cases)	Loss of working (day(s))
Riau	1 701 000	654 885	5 018	2 177	336 670
West Sumatera	2 411 000	928 235	7 112	3 086	477 197
Jambi	1 478 000	569 030	4 360	1 892	292 533
South Sumatera	2 355 000	906 675	6 948	3 015	466 114
West Kalimantan	1 478 000	711 480	5 452	2 366	365 765
Central Kalimantan	716 000	275 660	2 112	917	141 714
South Kalimantan	1 733 000	667 205	5 112	2 218	343 004
East Kalimantan	118 000	45 430	348	151	23 355
Total	12 360 000	4 758 600	36 462	15 822	2 446 352

DG CDC & EH, MOH Indonesia.

Table 3 Outpatient diseases pulmonary clinic disease pattern: Jambi General Hospital

Disease	No. cases	%
Tuberculosis	197	27.5
Bronchial asthma	172	24.6
Bronchitis	153	21.9
Bronchiectasis	135	19.3
COPD	16	2.3

Table 4 Inpatient diseases pattern: Jambi General Hospital

Disease	No. cases	%
Bronchial asthma	39	56
Tuberculosis	16	24
COPD	2	3
Pneumonia	2	3

Table 5 Health centre's diseases pattern: Palembang

Age group	Disease					Total
	Irritation	Acute respiratory infection	Acute bronchitis	Bronchial asthma	Tuberculosis	
Infection	—	3 (1.4%)	—	—	—	3 (1.4%)
Under 5 and children	21 (9.9%)	26 (21.17%)	3 (1.4%)	12 (5.7%)	—	82 (38.7%)
Adult	25 (11.7%)	28 (13.2%)	25 (1.8%)	27 (12.7%)	2 (0.9%)	107 (50.5%)
Elderly	3 (11.4%)	4 (1.4%)	7 (3.3%)	6 (2.8%)	—	20 (9.4%)
Total	49	81	35	45	2	212

Table 6 Symptoms of eight medical doctors after 10–12 h exposure to haze

Symptom	Number	%
Eye irritation	8	100
Throat irritation	3	37.5
Cough	3	37.5
Headache	2	25
Cold sweat	1	12.5

Medical experts of the Japan Disaster Relief (JDR) Team conducted field surveys aiming to assess the living environmental and health effects on the people affected by the haze in Indonesia. They found that cases of conjunctivitis, bronchial asthma and pneumonia have been increasing in hospital visits and admissions in the affected areas, and might be increasing in its severity. They found, through community survey, that people had developed many symptoms of respiratory and digestive problems within 1 month of the haze. People with poor respiratory function were also detected. The elderly and young children were suspected to be more vulnerable to this hazard (Japan Disaster Relief Team, unpubl. data, 1997).

CONTROL ACTIVITIES

Management of haze disasters is the responsibility of a number of Ministries with the State Minister of Social Welfare as coordinator. The National Policy in haze management for the health sector is to increase

the available medical emergency services and to increase the provision of environmental health, diseases surveillance and health education services.

Management of haze disaster for each health administrative level is divided into pre-disaster, disaster and post-disaster response phases. The activities in pre-disaster phase include preparation or guidelines, placement of respiratory drugs and reinforcing local health facilities and identification of areas for possible evacuation. The activities during disaster include distribution of masks, medicines, air purifiers, air monitoring equipment and health education materials, 24 h medical services, support of the evacuation areas with sanitation facilities, monitoring of ambient air quality, surveillance of diseases. In the post-disaster phase activities include regulatory measures to control land clearing activities in sensitive areas, stocking of emergency supplies and equipment, establishing air quality monitoring and warning systems and follow-up research and review.

Health professional associations such as Indonesia Medical Association, Indonesian Pulmonologist Association, and Environmental Health, and their members participated and were involved in developing guidelines, health education and providing health services in affected areas.

Indonesian Association of Pulmonologists were involved in various activities, for example: (i) developing guidelines for medical doctors handling cases with respiratory problems due to haze from forest fire; (ii) sending a health team to affected areas in Jambi and Central Kalimantan; (iii) conducting a small scale survey on the impact of haze to respiratory health; and (iv) developing a proposal for cohort study on long-term respiratory health impact of haze disaster.

The world's forests play a critical role in maintaining a habitable climate on earth and providing ecological services required for sustainable development. Stoner mentioned that forests hold 80% of all the carbon stored in vegetation and 40% of the carbon contained in soil.[2] They also are vital in maintaining stable hydrologic and oxygen cycles globally. Despite their importance, however, vast stretches of forest are literally going up in smoke. From 1850 to 1980, 13% of the carbon stored in the planet's vegetation was released into the atmosphere by human-induced land-use changes. When released the carbon becomes carbon dioxide, a leading greenhouse gas. Although forests located at the mid and northern latitudes are now rebounding and adding to the world's carbon stores, the rapid loss of tropical forests, particularly through fire, are offsetting these gains. Tropical deforestation now accounts for the largest amount of carbon emitted into the atmosphere from non-fossil fuel sources. Forest fires, in particular, are a major agent of deforestation, and they create untold human, environmental, and economic cost. Addressing global climate change and promoting environmentally sustainable development, therefore, requires a long-term solution to conserve the world's forests, particularly through fire prevention and management.

REFERENCES

1 Goldammer JG. *An Overview of International Guidelines: Itto Guidelines on Forest Fire Management*. Presented on International Cross-Sectoral Forum on South East Asia Forest Fire Management, Jakarta, December 7–8, 1998.
2 Stoner B. *Forest Fires Global Climate Change, USAID*. Presented on International Cross-Sectoral Forum on South East Asia Forest Fire Management, Jakarta, December 7–8, 1998.
3 Tjandra Yoga Aditama. *The Impact of Forest Fire to Respiratory Health*. IDI Press, Jakarta, 1998 (in Indonesian).
4 DGCDC-MOH. *Haze Disaster and Health Impact in Indonesia*. Presented on Biregional Workshop on Health of Haze-Related Air Pollution, Kuala Lumpur. 1–4 June, 1998.
5 Nukman A. *Role of Health Sector to Prevent Adverse Health Impact of Haze in Indonesia*. Presented on International Cross-Sectoral Forum on South East Asia Forest Fire Management, Jakarta, December 7–8, 1998.
6 Obayashi S, Ismail TS. *Haze Pollution and Its Effects*. Presented on International Cross-Sectoral Forum on South East Asia Forest Fire Management, Jakarta, December 7–8, 1998.
7 Heil GDA. *Impacts of Large Scale Forest and Land Fires in Indonesia on Regional Air Pollution*. Presented on International Cross-Sectoral Forum on South East Asia Forest Fire Management, Jakarta, December 7–8, 1998.