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Air Pollution and School Children Respiratory Diseases in Indonesia: A Cohort Study

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Air pollutant in Jakarta is a high risk factor for acute respiratory diseases to children. Objective of this study is to determine the effect of air pollution to respiratory diseases among elementary school children in Jakarta. The cohort comprises 392 school children from 25 elementary schools in Jakarta. An initial symptoms observation was carried out when the study began, and daily observations were performed over the 90 days of the study. The incidence rate of cough was found higher among children in low polluted area than those in high polluted area (11% and 4.9% respectively) but the incidence rates of sore throat, phlegm, and nasal were found no different between children in high and low polluted area. Having risk of sore throat found longer among children in low polluted area (survival time 7-8 days) than high polluted area (3-4 days). In contrast, having risk of cough found longer among children in high polluted area (survival time 8-9 days) than low polluted area (2-3 days). Similarly, having risk of phlegm and nasal found longer among children in low polluted area (survival time 4-5 days and 5-6 days) than high polluted area (3-4 days and 2-3 days) respectively. Air pollutants affected the risk of having sore throat, cough, phlegm, and nasal to elementary school children both in high and low polluted areas in Jakarta. It is suggested improvement of air quality monitoring, better quality for gasoline, reduce traffic congestion, and promote better public transports and green energy.

I. INTRODUCTION

Rapid economic development in Indonesia has created severe air pollution problems, particularly in its big cities. Jakarta id known as the most polluted mega-city after Mexico and Bangkok. Its major source of air pollution was emissions from transportation (Haryanto and Franklin, 2011). Diseases related to vehicular emissions and air pollution include acute respiratory infection, bronchial asthma, bronchitis, and eye and skin irritations was reported at 63 % of total visits to health care centres (Haryanto, 2009). It is believed that the lack of evidences from epidemiological studies, particularly the effects of air pollution to children's health, may affects to the lack of awareness of decision makers to develop appropriate strategy to protect Jakarta population from the exposure of air pollution. The objective of this study is to determine the effect of air pollution to respiratory diseases among elementary school children in Jakarta.

II. MATERIALS AND METHOD

A prospective cohort design was implemented. The study population was the 3rd and 4th grade children who attend schools in both high polluted area and low polluted area in Jakarta. High polluted area and low polluted area are selected based on the results of the Air Quality Monitoring 2000-2001 conducted by the Environmental Management Center – Ministry of Environment. High polluted area is indicated by its parameters of SO2 level of > 20 ppb, NO2 level of > 15 ppb, and NOx level of > 40 ppb on July-December 2001. The subdistricts are: Palmerah, Kalideres, Sawah Besar, Cilincing,

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and Tanjung Priok. Low polluted area is indicated by its parameters of SO2 level < 10 ppb, NO2 level of < 10 ppb, and NOx level of < 20 ppb on July-December 2001. The subdistricts are: Jagakarsa, Pasar Rebo, and Cipayung.

Assuming the respiratory illnesses among children is 35% in high polluted area with Confidence interval of 95% and power = 90%, and hypothesis children will have respiratory diseases in low polluted area is about half of those with respiratory illnesses in high polluted area, then the minimum cohort design sample size obtained is 131 children for each group (Lwanga and Lemeshow, 1998). By using cluster sampling method, we obtained 12 elementary schools in high polluted area and 13 elementary schools in low polluted area. Seven children of 3rd grader and another 7 children of 4th grader was randomly selected as subject at every single selected school. Therefore, 168 children from high polluted area and 182 children from low polluted area involved the study. A list of respiratory symptoms sheet was given to the class schoolteacher for collecting the daily data of the three months observation.

Consent forms were distributed to the children's parents through school principals at the selected schools prior to the study. Data for respiratory disease effects were collected daily by each classroom's teacher by using a set of respiratory disease symptoms form sheet within a total of 90 days of observation. Statistics analysis of life-table survival analysis, Kaplan-Meier, and log-rank test were performed by STATA software.

III. RESULT

Of the total 350 participants at baseline, 280 participants (80%) completed the study in 90 days involving 163 children (58.2%) schooling in low polluted area and 117 children (41.8%) in high polluted area. The characteristic demographics of school children were mostly comparable between groups, which is no statistical different for sex, age, school's grade, duration time to school, and location of home (Table 1). The transportation modes used to school and level of parents' education found significantly difference between the groups (p-value<0.05). In general, the baseline characteristic demographic distribution of participants in this study was quite similar.

Incidence rates of sore throat and phlegm found higher in high polluted area than low polluted area, 9.2% and 9.1% compared to 7.4% and 8.1% respectively (Table 2). Contrary, incidence rates of cough and nasal found lower in high polluted area than low polluted area, 4.9% and 8.7% compared to 11% and 12.2% respectively. These results reflected inconsistency of air pollution impacts to children's respiratory symptoms. In addition, the association between air pollution and respiratory symptoms are found mostly statistically no-different (p-values > 0.05). Cough is the only disease symptom that having significant different with higher incidence rate in low polluted area than high polluted area.

The incidence rate (IR) of sore throat found higher on children in high polluted area than low polluted area (9.2 and 7.4 respectively) but statistically no different. This result is also similar with the phlegm (9.1 and 8.1 respectively). In contrast, IR of cough and nasal are higher among children in low polluted area than high polluted area. The IR for cough found statistically different with p-value <0.05, whilst IR for nasal found no different among children in high and low polluted areas.

The survival time for all of the symptoms, except cough, are longer for those school children in low polluted area (7-8 days for sore throat, 4-5 days for phlegm, and 5-6 days for nasal) compared to those from high polluted area (3-4 days for sore throat, 3-4 days for phlegm, and 2-3 days for nasal). These indicate that the risk for having sore throat, phlegm, and nasal in low polluted area is higher than in high polluted area. For cough, the survival times of having symptom is higher in high polluted area (8-9 days) than low polluted area (3-4 days).

The data revealed the Hazard Ratios (HR) of sore throat is higher for children in high polluted area, meanwhile for cough, phlegm and nasal found the opposite results, higher among children in low polluted areas. The risk for having sore throat was 1.3 times higher among children in high polluted area than those in low polluted area.

The Kaplan Meier's estimation curve and calculation obtained a probability of life expectancy of a 3-day sore throat at high polluted area and 7 days in low polluted area in the 50th percentile or median life expectancy of a sore throat among children in Jakarta. For cough, an incidence rate of 4.9 and the median survival time of cough more than 5 times a

day, there was an estimated interval of 8 to 9 days in high polluted area, while in low polluted area obtained the incidence rate (11.0) and median survival time obtained an interval estimate of 3 to 4 days.

Table 1. Characteristic demographic distribution of school children by exposure groups

Characteristics of participants	Exposure Group (%)		p*
	Low polluted area (N = 163)	High polluted area (N = 117)	
Sex			
Male	53.4	48.7	0.47
Female	46.6	51.3	
Age			
8 year old	27.3	18.0	0.15
9 year old	46.0	47.4	
10 year old	26.7	34.5	
Transport to school			
Walk	59.5	67.5	0.002
Bike	3.1	17.1	
Motorbike	16.0	6.8	
Car/public transport	21.4	8.5	
School's grade			
3rd grader	47.9	53.0	0.39
4th grader	52.1	47.0	
Duration to school			
< 5 minute	16.6	15.4	0.28
5 – 15 minute	66.9	69.2	
16 – 30 minute	10.4	13.7	
> 30 minute	6.1	1.7	
Home location			
Main road	15.3	12.7	0.12
Cluster housing	14.8	22.6	
Kampong/Slum area	69.9	64.7	
Parent's education			
Junior high	12.9	17.1	0.001
Senior high	12.3	28.2	
Diploma/Bachelors	46.6	45.3	
Masters and higher	28.2	9.4	

* Pearson Chi-square

Table 2. Incidence Rates (IR) and Survival Analysis of Respiratory Diseases

Group	Number of incidence	Incidence Rate	Survival Time (days)	Hazard Ratio	P - value
Sore throat					
High polluted	122	9.2	3 – 4	1.3	0.21
Low polluted	115	7.4	7 – 8	1.0	
Cough					
High polluted	101	4.9	8 – 9	0.4	0.001
Low polluted	129	11.0	3 – 4	1.0	
Phlegm					
High polluted	98	9.1	3 – 4	0.9	0.70
Low polluted	139	8.1	4 – 5	1.0	
Nasal					
High polluted	56	8.7	2 – 3	0.6	0.13
Low polluted	123	12.2	5 – 6	1.0	

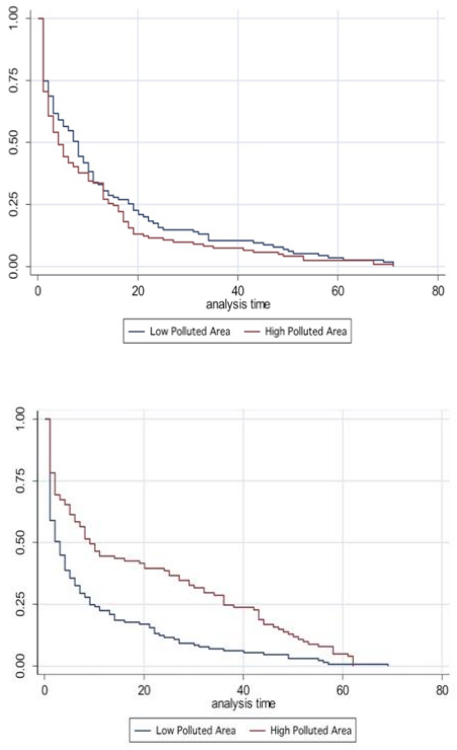

Figure 1. Graph of the Survival Time Difference of Sore throat and Cough. Low polluted area and High polluted area

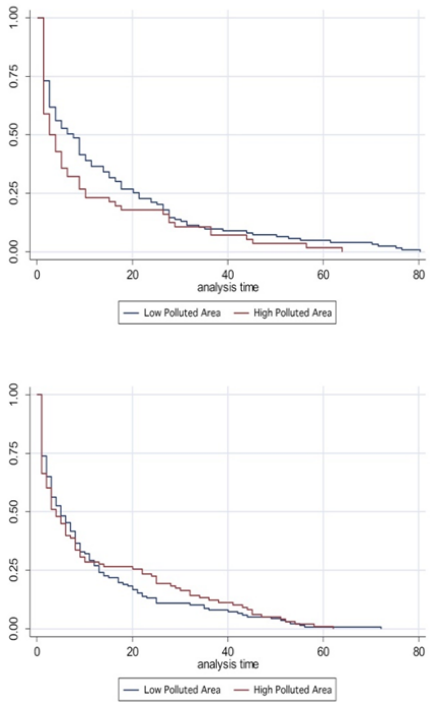

Figure 2. Graph of the Survival Time Difference of Phlegm and Nasal. Low polluted area and High polluted area.

The probability of life expectancy of 2 days phlegm in the high polluted area and 4 days in the low polluted area in the 50th percentile can be interpreted that half children in high polluted areas will survive having phlegm for 2 days from the beginning until the end of observation. Whereas half of the children in low polluted area will survive no experience phlegm for 4 days. It shows that children in low polluted area last longer to not experience phlegm compared to those in high polluted areas. Log-rank test result obtained p-value 0.53, meaning comparison of estimation result of life expectancy curve to not having a phlegm between exposures area showed insignificant result.

IV. DISCUSSION

Lorem The incidence rates of sore throat and phlegm are higher in high polluted areas than in low polluted areas. High IR of sore throat in high polluted areas was confirmed with a study among 6465 adults of UK, France, Poland, and Malaysia which found airborne pollution associated with 28% of throat discomfort in the last 12 months (Addey and Shephard, 2012). In Hong Kong, children's sore throat decreased when sulphur levels on fuel were reduced (Peter *et al.*, 1996). In Shanghai, exposure to vehicle emissions was linked with throat pain and chronic pharyngitis bus drivers/conductors/taxi drivers (Zhou *et al.*, 2001). Air pollutants indoor and outdoor, temperature and humidity, and hazardous or occupational irritants may also contribute to the incidence of sore throat as well as smoking, shouting, tracheal intubation, or concomitant illness (Renner *et al.*, 2012).

Incidence rate of children phlegm in this study found higher in high polluted area with no statistically different to the low polluted areas. It is similar with the finding of the NIEHS Sister Study 2003-2009 in USA involving 39,844 individuals where phlegm adjusted Odds Ratio = 1.07 associated with NO2 exposure (Hooper *et al.*, 2018). Other studies of the association between air pollutants and cough and phlegm include: a study conducted in 16 countries of Europe in 2000, involving 18277 adults, found the prevalence of cough or production of phlegm in the morning or during the day or night in the winter was 33% (Janson *et al.*, 2001); in Italy, a study in 9 areas with 18000 participants, prevalence of cough and phlegm on most days for as much as 3 months per year and for at least 2 successive years was 11.9% (Cerveri *et al.*, 2003); the study of association between daily changes in air pollution and in the respiratory health of children 7 to 12 year of age in winter of 1994 in Kuopio, Finland found positive association among children with cough symptoms (Timonen and Pekkanen, 1997); in Yorkshire United Kingdom, 4003 adults found experienced bouts or spasms of coughing in the previous 2 months with the prevalence of 12% (Ford *et al.*, 2006); cough lasting for > 8 weeks among 1087 participants in Guangzhou China reported a prevalence of 10.9% (Lai *et al.*, 2013); in 81 counties USA study with 5743 participants reported prevalence of cough on most days for ≥ 3 consecutive months per year was 9.3% (Coultas *et al.*, 2001); another study in USA involving 2397 participants in Seattle found prevalence of daily cough as often as 3 months out of the year was 7.2% (Carter *et al.*, 2006); and a study in Zaria, Nigeria, revealed an average respiratory illness phlegm incidence rate of 607 per 100,000 cases (Aliyu and Bota 2018).

For the nasal or runny nose, this study found that IR of children in high and low polluted areas about 9 and 12 respectively. The results are similar with studies conducted in

other countries. A cohort study among children living near major roads reported increased odds of runny nose (nasal) during the first year of life (Morgenstern *et al.,* 2007) and increased odds of sensitization during the first 8 years of life (Morgenstern *et al.*, 2008) (Bernstein, 2012). A Taiwan study among 32,143 school children found persistent exposure to NOX, CO, and SO2 affected the prevalence of allergic rhinitis (Hwang *et al*., 2006).

All of the statistical analyses provide evidences that the risk for having respiratory diseases among school children was no difference (except for cough) in low and high polluted areas. This may be happened because the air pollution exposures in both areas are quiet similar or getting worse in low polluted area. There is a big possibility that the air monitoring results in the year 2000-2001 has already changed in the year of the study in 2004.

V. CONCLUSION

Air pollutants affected the risk of having sore throat, cough, phlegm, and nasal to elementary school children both in high and low polluted areas in Jakarta. The probability of having those four respiratory symptoms is in the range of 2 to 9 days per episode. The results suggest improvement of air quality monitoring qualitatively and quantitatively, better quality for gasoline, reduce traffic congestion, and promote better public transports and green energy.

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