Effect of Ambient Particulate Matter 2.5 Micrometer (PM$_{2.5}$) to Prevalence of Impaired Lung Function and Asthma in Tangerang and Makassar

Efek Ambien Partikel Debu 2,5 Mikrometer (PM$_{2.5}$) terhadap Prevalensi Gangguan Fungsi Paru dan Asma di Tangerang dan Makassar

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Abstract

Particulate matter 2.5 micrometer (PM$_{2.5}$) emission increased with increasing number of urban population as a result of increasing number of motor vehicles for their daily transportation. This study aimed to determine the level of impaired lung function and asthma and its relation to ambient levels of PM$_{2.5}$ among migrant communities in Tangerang and Makassar and socioeconomic conditions. A cross-sectional design was implemented by involving 4,250 and 2,900 respondents in Tangerang and Makassar respectively on April to September 2010. Cluster sampling approach was applied. PM$_{2.5}$ ambient measurements in each city were based on the coordinates of 40 global positioning system locations. The PM$_{2.5}$ levels found higher in the morning than afternoon in both cities, with average about six folds of WHO guideline of 35 mg/m^3. Asthma prevalence was found similar in both cities (1.3%) and impaired lung function prevalence in Makassar was higher (24%) than Tangerang (21%). Data showed there was no association between PM$_{2.5}$ levels to the prevalence of asthma and impaired lung function in both cities. The study confirmed that exposure to PM$_{2.5}$ is associated with prevalence of asthma and impaired lung function and provided evidence showed that the effect of air pollution was modified by certain living environment characteristics. These findings suggest the improvement of housing ventilations and larger space of living room for better oxygen circulation.
Keywords: Ambient PM$_{2.5}$, asthma, impaired lung function

Abstrak

Emisi partikel debu 2,5 mikrometer (PM$_{2.5}$) meningkat dengan bertambahnya jumlah penduduk kota akibat peningkatan angka kendaraan bermotor sebagai transportasi penduduk sehari-hari. Penelitian ini bertujuan untuk mengetahui tingkat gangguan fungsi paru dan asma serta hubungannya dengan kadar ambien PM$_{2.5}$ pada masyarakat migran di Tangerang dan Makassar dan kondisi sosial ekonomi. Desain potong lintang digunakan dengan melibatkan 4.250 dan 2.900 responden di Tangerang dan Makassar pada bulan April sampai September 2010. Pendekatan *cluster sampling* diterapkan. Pengukuran ambien PM$_{2.5}$ di masing-masing kota berdasarkan koordinat 40 lokasi *Global Positioning System* (GPS). Kadar PM$_{2.5}$ ditemukan lebih tinggi pada pagi hari dibandingkan siang hari di kedua kota tersebut dengan rata-rata enam kali lipat dari pedoman World Health Organization (WHO) 35 mg/m^3. Prevalensi asma ditemukan sama pada kedua kota (1,3%) dan prevalensi gangguan fungsi paru di Makassar lebih tinggi (24%) dibandingkan di Tangerang (21%). Data menunjukkan bahwa tidak terdapat hubungan antara kadar PM$_{2.5}$ terhadap prevalensi asma dan gangguan fungsi paru di kedua kota. Penelitian ini menguatkan bahwa pajanan PM$_{2.5}$ berkaitan dengan prevalensi asma dan gangguan fungsi paru serta bukti yang diberikan menunjukkan bahwa efek polusi udara diubah oleh karakteristik lingkungan tertentu. Temuan ini menyarankan adanya perbaikan ventilasi rumah dan ruang tamu yang lebih luas untuk sirkulasi oksigen yang lebih baik.
Kata kunci: Ambient PM$_{2.5}$, asma, gangguan fungsi paru

Introduction

In Indonesia, the rate of migration from village to city has increased during 1970 to 1980 because of the presence of increasing economic activities and industries in cities.[1-3] In general, an increase of the average income among people who migrate to the cities has become an attraction for many villagers to migrate to the city.[4] In the city, they then have to work as formal sector workers, as

students, but not the least of those who work in informal sector or become illegal workers with low pay.

To make the dreams come true, the workers have to work hard and be willing to live in a very limited condition in an unhealthy environment.[5] Therefore, this study concerned on lung function prevalence and asthma incidence among migrant communities in Tangerang and Makassar and its relation to levels of ambient dust particulate matter 2.5 ($PM_{2.5}$) micrometer and socioeconomic conditions of the migrants (analysis of spatial epidemiology). $PM_{2.5}$ is particulate with a diameter of less than 2.5 micrometer. $PM_{2.5}$ generated from combustion processes including exhaust fumes from motor vehicles, is also generated from chemical reactions between various gases, such as sulfur dioxide, nitrogen oxides and volatile organic compounds (VOCs). Health effects caused by inhaling air containing high concentrations of $PM_{2.5}$ include premature death, increased respiratory symptoms and diseases, chronic bronchitis, and decreased lung function, especially in asthmatics.

Some studies indicated that in general, urban population were exposed to ambient $PM_{2.5}$ originating from motor vehicle fumes. $PM_{2.5}$ emissions will increase with the increasing urban population, where the increase in population resulted the increasing number of motor vehicles in urban areas to accommodate needs of the urban population's activities. Tangerang and Makassar were selected as the focus in this study because migrants were at large numbers in these two cities. Although the scope of study was not large enough to represent a nationally representative sample, both cities were considered representing various conditions of migrants in Indonesia. Based on geographical aspect, settlements can be divided into two groups, namely (1) Western Indonesia, including Sumatera, Java, Bali, and (2) Eastern Indonesia, including other parts of Indonesia. Therefore, Tangerang would represent Indonesia to the western and Makassar would represent the eastern. This study aimed to determine relation between $PM_{2.5}$ pollution levels, socioeconomic status, and demographics with lung function prevalence and asthma incidence in Tangerang and Makassar.

Method

This study used cross-sectional design in which the measurements of $PM_{2.5}$ concentration levels according to the spatial coordinates and impaired lung function with a spirometer, and asthma incidence among migrants were taken at the same period of time. The study was conducted in Tangerang and Makassar to provide an overview with consideration of the movement of settlers in the territory of Western and Eastern Indonesia on April to September 2010. This study involved four trained $PM_{2.5}$ concentration data collectors in each city

and a total of 75 trained fresh graduate enumerators in both cities. Descriptive statistics and Pearson chi-square were performed in the analysis.

The study is nested to the study of Rural-Urban Migration in Indonesia (RUMiI), a multiyear study conducted by the Australian National University and University of Gadjah Mada since 2008. The RUMiI has the aim to observe the activities of the labor market and welfare of individuals for the migrants who came from the village and to measure the health status of migrants who move from villages to cities and compared them with those who have long lived in the city. Study populations were immigrants and local residents. Random cluster sampling was used to select the sample. The clusters were determined by 40 coordinates of global positioning system (GPS) from the entire area of the cities. A total of 4,250 migrants and local residents in Tangerang and 2,900 migrants and local residents in Makassar were randomly selected according to method of census blocks in each city.

Results

Of the total of 4,250 respondents in Tangerang and 2,900 respondents in Makassar, the proportions of their characteristics were mostly similar including sex, religion, marital status, education, age, height, weight, systolic and diastolic blood pressure, blood tension, perception on health status, and smoking behavior. In Tangerang, the race was dominated by Javanese (37%) and Sundanese (33%), while in Makassar by Bugis (31%).

In general, concentration of ambient $PM_{2.5}$ was found higher in Makassar (average means of 0.28 mg/m^3) than in Tangerang (average means of 0.15 mg/m^3). The data revealed that the one hour morning measurements were 0.23 mg/m^3 in Tangerang and 0.31 mg/m^3 in Makassar. Meanwhile, the one hour afternoon measurements were 0.19 mg/m^3 in Tangerang and 0.26 mg/m^3 in Makassar (Table 1).

The asthma prevalence was found similar between those respondents living in Tangerang and Makassar by 1.3%. While for impaired lung function, the prevalence of those respondents living in Makassar was found higher (24%) than those respondents living in Tangerang (21%) (Table 2).

In Tangerang, the data revealed that there was no relation between asthma prevalence and all variables of demographic characteristics of respondents (p value > 0.05). Meanwhile, the prevalence of impaired lung function was significantly related to marital status, age, height, systolic and diastolic blood pressures (p value < 0.05). In Makassar, the prevalence of asthma was statistically related to religion, marital status, age, systolic blood pressure, health perception and smoking. While

Table 1. Distribution of Ambient PM$_{2.5}$ at 40 Coordinates

PM$_{2.5}$ (mg/m^3)	Tangerang					Makassar				
	N	Min	Max	Mean	Std. Deviasi	N	Min	Max	Mean	Std. Deviasi
Average	40	0.04	0.71	0.21	0.15	40	0.18	0.42	0.28	0.07
Morning	40	0.06	0.53	0.23	0.13	40	0.18	0.56	0.31	0.09
Afternoon	40	0.02	1.09	0.19	0.25	40	0.16	0.41	0.26	0.08

Table 2. Distribution of Asthma Prevalence and Impaired Lung Function

Variable	Category	Tangerang		Makassar	
		n (4250)	%	n (2900)	%
Disease					
Asthma	Yes	54	13	37	13
	No	2362	55.6	1708	58.9
Lung function	Abnormal	881	20.7	699	24.1
	Normal	185	4.4	128	4.4

Table 3. The p Value of the Relation of Demographic Characteristics of Respondents to the Prevalence of Lung Function and Asthma Prevalence

Characteristics	Tangerang		Makassar	
	Lung Function	Asthma	Lung Function	Asthma
Sex	0.14	0.27	0.00	0.62
Religion	0.38	0.85	0.97	0.03
Ethnic	0.59	0.08	0.57	0.24
Marital status	0.00	0.93	0.07	0.02
Age	0.00	0.19	0.00	0.00
Height	0.00	0.63	0.22	0.07
Weight	0.22	0.15	0.04	0.37
Systolic	0.02	0.33	0.58	0.02
Diastolic	0.03	0.09	0.46	0.25
Pulse	0.70	0.78	0.51	0.74
Health perception	0.23	0.44	0.47	0.00
Diarrhea	0.34	0.14	0.32	0.46
Smoking	0.44	0.48	0.02	0.03

Table 4. The Relation of PM$_{2.5}$ Ambient Exposure to Prevalence of Lung Function and Asthma Prevalence

PM$_{2.5}$ Concentration		Lung Function	Asthma
		p Value	p Value
Average	Tangerang	0.88	0.53
	Makassar	0.85	0.75
Morning	Tangerang	0.52	0.97
	Makassar	0.63	0.77
Afternoon	Tangerang	0.61	0.46
	Makassar	0.89	0.79

the prevalence of impaired lung function was statistically associated with sex, age, and weight (Table 3).

The data revealed that there was no any statistically relation between PM$_{2.5}$ ambient exposure and asthma prevalence both in Tangerang and Makassar (p value > 0.05). The PM$_{2.5}$ ambient exposure was also not related to the incidence of lung function in both cities (p value > 0.05) (Table 4).

Discussion

The theoretical approaches of environmental epidemiology were the closest way to explain the absence of a relation of PM$_{2.5}$ ambient concentration with the incidence of lung function and asthma prevalence in Tangerang and Makassar. Environmental epidemiology has three key components, namely the person, place, and time. The 'person' in this study was the general population with all ages. The 'place' was the presence of respondents and the measurement of PM$_{2.5}$ to be taken. Then the PM$_{2.5}$ was measured when the respondents were interviewed and exposure by the 'time'.[6] Biological evidence has been established for plausible mechanisms between PM$_{2.5}$ and mortality, such as increased system inflammation and lower lung function among others.[7-9] The demographic characteristics of respondents in Jakarta and Makassar were quite similar, although in Tangerang more dominated by the Javanese and Sundanese, then by Bugis in Makassar.

Proportion of sex, religion, marital status, age, health condition and smoking habit were relatively equal. However, by involving all ages as respondents in this study, there were random in different places with different times in accordance with respondents' respective activities. They could be in the house, such as toddler groups, children and housewives. They could also be at the office, schools and on the streets or outside. Thus, the possibility of contact with PM$_{2.5}$ ambient exposure was also be very random.

The ambient exposure PM$_{2.5}$ in Tangerang and Makassar was evenly distributed throughout the city locations with very high concentrations, which was about 6 – 8 times higher than the WHO recommended limit values in 2008 (0.035 mg/m^3). The mean concentration of ambient PM$_{2.5}$ exposure in Tangerang was 0.21 mg/m^3 and 0.28 mg/m^3 in Makassar. Judging from the measurements of 40 points coordinate, there was a possibility that could not depict the actual levels of exposure concentration to the respondents, given such a vast area of Tangerang and Makassar, so that could have been 40 measuring points too few to represent areas of the cities. In addition, measurements made in the outside air also did not necessarily represent all of the air inhaled by the respondents because respondents could have spent much time in the house or room than outside. It also included

whether the respondent was in the location of the measurement of exposure or not. Some other studies suggested similar consideration when this study analyzed the short-term exposures, in which the need to ensure the relevance of the monitoring data and sufficient population for power has limited analysis to larger cities, and hence exurbs, smaller cities, and rural areas were not generally represented in the literature. This might compromise the generalizability of the results. In addition, there was spatial variability in $PM_{2.5}$ concentrations within cities that time series studies generally had not taken into account, introducing exposure measurement error.[10-11]

Asthma incidence was associated with proximity to primary roads with an odds ratio (OR) = 0.97 (95% CI = 0.94, 0.99) for a 1 km increase in distance using conditional logistic regression, implying that asthma incidence was less likely as the distance between the residence and a primary road increases. Similar relation and effect sizes were found using polychotomous conditional logistic regression.[12] Meanwhile, the other studies showed the opposite findings. The numerous multi- and single-city studies evaluated reported consistent positive associations with respiratory emergency department (ED) visits and hospital admissions for chronic obstructive pulmonary disease (COPD), asthma, and respiratory infection in study areas with mean 24-hour average $PM_{2.5}$ concentrations ranging from 6.1 – 22 μg/m^3. However, associations for asthma were imprecise and not consistently positive when limiting analysis to children.[13]

While the various characteristics of the respondents, namely gender, religion, ethnicity, marital status, age, height, weight, systolic blood pressure, diastolic blood pressure, pulse rate, perception of health conditions, experience to diarrhea, and smoking, which is in general, was not significantly related to the incidence of lung function and asthma prevalence. It is clear that the various characteristics of the respondents did not contribute to the incidence of lung function and prevalence of asthma in this study.

Conclusion

There are some evidences that migrants value living environment less than non-migrants. Living environment condition such as air pollution does affect the health status of both migrants and non-migrants. Both migrants and non-migrants are aware of the status of their health condition. Most likely migrants' utility of a quality living environment is lower than their urban (non-migrant) counterparts.

These findings suggest the improvement of housing ventilations and larger space of living room to get better oxygen circulation. Other more relevant and closer factors to the prevalence of impaired lung function and asthma need to be explored using causal-effect relationship study design in further study.

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