EFFECT OF AIR POLLUTION ON RESPIRATORY SYMPTOMS OF JUNIOR HIGH SCHOOL STUDENTS IN INDONESIA

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Abstract. In 1994, 16,187 junior high school students were surveyed in Jakarta and surrounding cities, Indonesia, to study the effect of air pollution on respiratory illnesses. Nitrogen dioxide (NO_2) was measured by the filter badge developed by Yanagisawa and Nishimura as a measure of air pollution. The average concentration of NO_2 is the highest in central Jakarta and Tangerang (22-30 ppb), the lowest in rural areas (5-11 ppb), and in other cities, 11-20 ppb. Self-administered questionnaires were given to the students in 29 schools to obtain respiratory symptoms of cough, phlegm and wheeze. A significant relationship was found in this study between NO_2 exposure levels and prevalence rates of cough, phlegm, and wheezing without cold, which were 27.7 to 38.7%, 15.0 to 21.9%, and 1.4 to 2.9%, respectively. Prevalence rates of persistent cough and persistent phlegm were 7.3 to 10.8% and 4.5 to 5.0% respectively. These rates were higher than those found by other researchers. This difference may be partly due to the survey methods. The more polluted, the higher the prevalence rate of respiratory symptoms.

INTRODUCTION

Toxicological and epidemiological studies have raised concern that exposure to nitrogen dioxide (NO_2) indoors and outdoors may increase the frequency and severity of respiratory ailments (Morrow, 1984; Samet *et al*, 1987; Samet and Utell, 1990; Nitta *et al*, 1993). Jakarta, the capital of Indonesia, and the surrounding cities of Bogor, Tangerang and Bekasi form the so called Jabotabek area. This is the most highly urbanized and industrialized area in Indonesia. The population of the area is expected to increase by the year 2,010 to 30 million people, against the current 20 million (Govt of Indonesia, 1994a). Previous studies have found automobile exhaust to be the main source of air pollution; automobile exhaust produces a mixture of volatile hydrocarbons, airborne particles, nitrogen oxides, and carbon monoxide. In 1982-1992, the total number of automobiles in Jakarta increased by 5.6% annually, road length grew 4% annually. The contribution of atmospheric NO_2 from automobiles in Jakarta was estimated to be 64-73% (Govt. of Indonesia, 1994b; Tri-Tugaswati *et al*, 1995).

This study was designed to assess the effects of air pollution on the respiratory health of junior high school students using an Indonesian version of the ATS-DLD questionnaire. To date, information on the exposure to and health effects of current air pollution in Indonesia is scarce, especially among children who are not occupationally exposed and do not smoke.

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SUBJECTS AND METHODS

Student area and the subjects

The survey was conducted in Jabotabek, an abbreviation of the conglomerate Jakarta, Bogor, Tangerang, and Bekasi; this area includes part of the province of West Java, and the rual area of Cianjur regency. Two areas in Jakarta, central and south Jakarta; a south area of south Jakarta, Depok; three cities surrounding Jakarta: Bogor, Tangerang and Bekasi; and a rural agricultural village also in West Java, Cianjur were selected as study areas (Fig 1). Cianjur regency, which does not appear in the figure, is located 40 km southeast of Bogor city.

The areas analyzed here were chosen to cover a range of locations with different degrees of air pollution in Western Java. Twenty-nine junior high schools from Jabotabek were selected; students in their second and third year of junior high school, aged 12-15 years were invited to participate in this

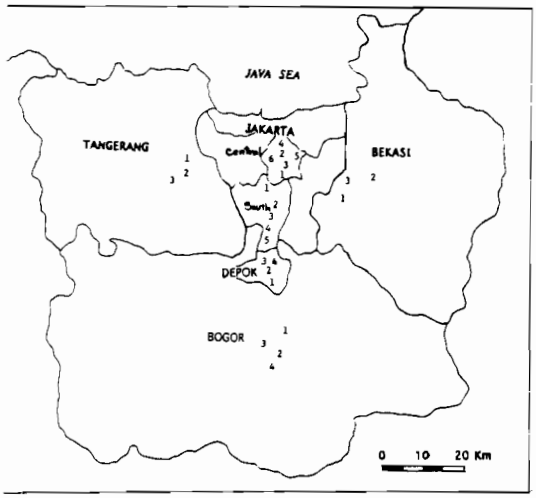

Fig 1–Map of Jabotabek areas and number of schools in the study areas.

study. Junior high school students were selected as subjects because they live within several kilometers of the schools; only a small percentage of them were smokers; and they gave the most reliable responses, probably due to a high rate of literacy. In this study 15,723 students participated from the Jabotabek area and 887 in the Cianjur regency.

NO_2 measurements

NO_2 concentration was measured in each school by the filter badge developed by Yanagisawa and Nishimura (1982). A badge was placed in each school yard for 24 hours on a shelf 1 or 2 meters from the ground. To obtain a reliable NO_2 concentration measurement in a given place, 24 hours sampling of NO_2 was done in two periods. The first period was conducted for 24 hours simultaneously with the respiratory questionnaire in October 1994. The second period was in April 1995 for 3 successive days. The first measurements in October 1994 and the average of second measurements in April 1995 were significantly correlated ($r = 0.84$, $N = 29$ pairs). The average of both periods of measurements was used in the analysis. Previous studies indicated that there was no significant difference between indoor and outdoor NO_2 concentrations in those areas (Tri-Tugaswati *et al*, 1995).

Questionnaire and data analysis

Self-administered questionnaires were given simultaneously in October 1994, to obtain demographic data and information about respiratory symptoms of cough, phlegm and wheeze.

The questionnaire used was derived from ATS-DLD (American Thoracic Society, Division of Lung Disease) for children (Ferris, 1978), but revised and simplified to become applicable for self-administration. This questionnaire was translated into Indonesian and abridged into 22 questions in two pages; however, it still included the original ATS-DLD key questions. The questionnaire was pre-tested, evaluated, and revised before distribution. Some medical terms such as tuberculosis and asthma were not well understood in the pre-test, and were substituted for more recognizable Indonesian terms.

It took 10 to 15 minutes to fill the questionnaires in a preliminary survey. Classroom teachers introduced and explained the objective of the study and questionnaires to the students, who filled the questionnaires in the classroom. Students in four schools of Cianjur regency were instructed not by the teacher but by one of the authors and her staff. Absent students on the day were not followed. The response rate was more than 95%.

The data were checked manually against the filled questionnaire result sheets after the recovery. Incompletely filled questionnaires were discarded (*ca* 5%).

Analysis was done by examining the nitrogen dioxide (NO_2) concentration and respiratory symptoms to see if an association existed. Our hypothesis was that high concentration of NO_2 in some highly polluted areas might increase chronic respiratory symptoms.

RESULTS

The average NO_2 measurements carried out in 29 schools in seven study areas are shown in Fig 2. Schools located in Central Jakarta (CJ) and Tangerang city (Ta) had generally higher concentrations of NO_2 in the air. Cianjur regency (Ci), the rural agricultural area had NO_2 levels substantially lower than those of the other areas. Except for one school in South Jakarta (SJ-1), NO_2 levels in Bekasi (Be), South Jakarta (SJ), Depok (De) and Bogor (Bo) were more equal. SJ-1 school is located in the border of Central and South Jakarta. Considering the SJ-1 location and the finding that the NO_2

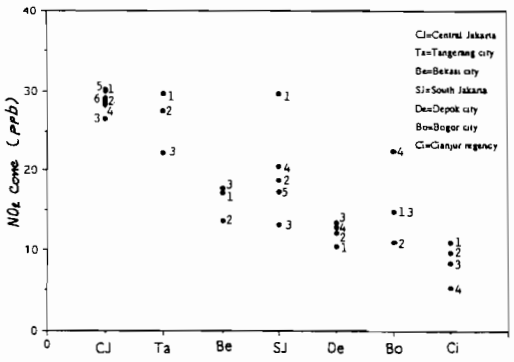

Fig 2–Average NO_2 concentration in each school in Jabotabek area and Cianjur area.

concentration there was as high as those in Central Jakarta's schools, SJ-1 was transfered into the CJ school group for further analysis.

Of the 16,610 questionnaires distributed through 29 junior high schools in Jabotabek areas and the Cianjur area, 15,816 (95.2%) were collected with 99% of the questionnaires completed. The characteristics of the students, sources of indoor pollution and possessions are described in Table 1. The mean age of the students was 14 years for both boy and girl students and the boy/girl ratio was almost 1 : 1. There were no differences in age between the students with respect to areas studied and more than 96% of students had lived in the same house for more than one year. For reasons yet unknown, the frequency of smokers in households from Bogor city was 9.9%, which was significantly higher than the 5.1 to 6.1% observed in the other areas.

A trend of higher prevalence of some reported respiratory symptoms characterized students living in the areas with higher NO_2 concentrations (Tables 2, 3). Jakarta (CJ and SJ) and Tangerang with higher NO_2 concentrations, had the highest prevalence rates of cough without cold, phlegm without cold, wheezing with or without cold, and asthma. Those living in Bekasi, Depok, and Bogor had similar values, while Cianjur the rural area had the lowest. The prevalence rates of other symptoms such as cough with cold, phlegm with cold and chest pain in Cianjur were higher than other areas studied: this was assumed to be due to other sources of air pollution or to infection.

To observe the exposure-response relationship, regressions for each school were plotted against the

Table 1

Sex, age, smokers, fuels for cooking, and some other backgound information in the student groups from Jabotabek areas and Cianjur area.

Characteristics of the student group	Ares						
	CJ	Ta	Be	SJ	De	Bo	Ci
Sex: boy	1,408	947	974	1,548	1,504	990	444
girl	1,432	1,432	1,071	1,516	1,512	977	432
Mean age, year	14.0	14.0	14.0	14.0	13.8	14.1	14.0
Smoker, %	5.1	5.5	5.3	6.1	6.0	9.9	5.3
Smoker(s) in the family, %	66.5	59.0	62.4	64.1	59.3	70.0	75.7
Fuel used for cooking (%):							
- Wood	0.7	1.7	1.3	2.4	1.3	5.2	25.4
- Kerosene	72.0	56.7	69.5	75.2	64.2	77.4	85.2
- LPG	35.9	46.6	37.8	25.5	45.6	22.5	11.3
- Electric	6.9	2.2	1.7	1.7	4.9	1.9	1.5
Possession (%):							
- Refrigerator	54.4	72.6	66.5	51.2	72.1	43.2	18.9
- Motor vehicles	48.1	63.3	46.8	42.2	46.9	33.7	25.1

CJ = Central Jakarta; Ta = Tangerang city; Be = Bekasi city; SJ = South Jakarta; De = Depok; Bo = Bogor city, Ci = Cianjur regency.

Table 2

Prevalence rates (in %) of respiratory symptoms by ATS-DLD questionnaire in the student groups in the seven study areas, October 1994.

Respiratory Symptoms	Prevalence rate (%)/area						
	CJ	Ta	Be	SJ	De	Bo	Ci
Cough with cold	56.7	59.3	59.8	55.0	60.8	56.3	72.4
Cough without cold	38.7	32.4	33.5	35.3	29.4	31.3	27.7
Persistent cough[a]	10.8	10.0	10.3	9.7	12.1	7.3	10.6
Phlegm with cold	53.8	58.4	60.0	50.1	61.7	59.1	61.2
Phlegm without cold	21.9	16.3	16.0	20.0	15.0	18.6	19.4
Persistent phlegm[b]	5.4	5.0	4.8	4.9	4.5	4.6	6.6
Persistent wheezing[c]	2.9	1.4	2.1	1.9	1.6	1.7	2.8
Chest illness	32.6	21.8	21.1	25.7	23.8	26.7	32.5
Chest illness with phlegm	10.2	7.4	6.7	7.1	7.9	8.3	10.8
Heavy cold with phlegm	9.5	8.0	7.9	8.2	7.0	7.0	10.7
Breathlessness	20.9	20.0	17.3	19.1	18.2	15.1	8.7
Breathlessness more than twice	11.7	10.2	9.1	9.9	10.1	7.5	4.9
Asthma	7.2	6.9	6.1	4.7	6.0	3.6	3.2

CJ = Central Jakarta; Ta = Tangerang city; Be = Bekasi city; SJ = South Jakarta; De = Depok; Bo = Bogor city and Ci = Cianjur regency

[a]'yes' in cough with cold, or 'yes' in cough without cold, and 'yes' in cough more than 4 days or more a week.

[b]'yes' in phlegm with cold or 'yes' in phlegm without cold, and 'yes' in phlegm more than 4 days or more a week.

[c]'yes' in wheezing with cold, 'yes' in wheezing without cold, and 'yes' in wheezing more than twice or more.

concentration of NO_2 measured in each school and the prevalences of respiratory symptoms of cough, phlegm and wheezing without cold (Fig 3). An increase in respiratory symptoms of cough without cold, phlegm without cold and wheezing without cold, with increasing of NO_2 concentration was found. Among those three symptoms, cough without cold appeared to be the best indicator for predicting the risk of the exposure with a regression coefficient (r) of 0.68 for total students. The other two symptoms, phlegm without cold and wheezing without cold showed weaker association: $r = 0.40$ and $r = 0.37$, respectively.

Prevalence rates of persistent cough, persistent phlegm, and persistent wheezing are shown with the mean concentration of NO_2 in Fig 4 and Table 4. The dose-response relationship of these persistent symptoms was weaker than that of symptoms without cold mentioned above in terms of coefficient of correlation and the slope of the regression line.

DISCUSSION

Central Jakarta is mainly characterized by the national and city government offices and other related service sectors. Commercial and trading areas are located in the southern part of Central Jakarta, along the main roads that serve as the main transportation axes of Jakarta. Residential areas of Jakarta are generally located in South Jakarta (SJ). Due to the rapid urbanization, newly developed residential areas are scattered over the suburbs in the southern (Depok, Bogor), western (Bekasi), and eastern (Tangerang) parts of Jakarta. Most of these areas are outside the territory of Jakarta Municipality. Central Jakarta, South Jakarta, Bogor city and Cianjur regency are relatively old established areas compared to Depok, Bekasi and Tangerang cities. Depok city, which is located in the northern part of Bogor city, has been developed as a residential area, while in Bekasi city and Tangerang city there are agglomerations of small to medium sized industries.

There are no data on emission inventory covering the whole of the Jabotabek region, but only for Jakarta (Govt. of Indonesia, 1993). The major sources of outdoor NO_2 in Jakarta come from traffic (73%), industry (16%), and domestic (~10%) ac-

Table 3

Concentration of NO_2 (in ppb) and prevalence rate (%) of cough without cold, phlegm without cold and wheezing without cold in each school in the seven study areas.

Area: School		Conc of NO_2 (ppb)	No. of students			Prevalence rates (in %)								
						Cough			Phlegm			Wheezing		
			T	B	G	T	B	G	T	B	G	T	B	G
C-Jakarta:														
School	1	29.9	916	469	447	36.2	34.3	38.2	17.8	23.0	12.3	8.5	11.2	5.6
	2	28.7	480	203	277	35.9	32.2	38.6	19.6	22.2	17.7	5.7	6.1	5.4
	3	26.5	312	148	164	42.1	35.8	47.9	20.2	20.9	19.5	8.7	11.6	6.1
	4	28.2	422	232	190	43.1	39.1	47.9	29.1	33.2	24.2	5.3	6.6	3.7
	5	30.1	434	230	204	40.6	37.8	43.6	27.2	32.2	21.6	9.6	11.1	7.9
	6	29.1	276	126	150	38.9	32.0	44.7	22.5	29.4	16.7	8.7	10.3	7.4
	7	29.7	580	298	282	35.9	38.9	32.6	21.9	28.9	14.5	6.1	8.9	3.2
Tangerang:														
School	1	29.7	1,074	487	560	32.4	31.0	33.6	16.1	20.2	12.6	6.0	4.7	4.7
	2	22.2	389	194	195	31.9	29.9	33.8	17.2	19.6	14.9	4.4	4.5	4.1
	3	27.5	571	266	305	32.9	32.7	33.1	16.1	21.4	11.5	3.0	3.0	1.7
Bekasi:														
School	1	17.8	790	380	410	32.8	29.8	35.7	14.9	19.7	10.4	4.2	5.1	3.5
	2	13.6	837	395	442	29.7	26.7	32.4	14.4	19.4	10.0	4.2	5.1	3.4
	3	17.8	418	199	219	42.1	39.2	44.7	21.3	29.6	13.7	5.0	8.0	2.3
S-Jakarta:														
School	1	18.8	559	300	259	36.3	37.0	35.5	16.8	19.0	14.3	7.2	9.4	4.7
	2	13.2	447	213	234	32.4	29.1	35.5	19.5	24.9	14.6	2.3	1.4	3.0
	3	20.6	830	415	415	33.6	34.0	33.3	18.8	25.3	12.3	7.4	10.0	4.9
	4	17.4	648	322	326	38.8	34.7	42.8	25.1	32.3	18.3	7.3	12.5	2.2
Depok:														
School	1	10.5	555	266	289	29.1	28.3	31.3	14.5	17.8	11.4	3.5	3.4	3.5
	2	12.2	994	502	492	26.2	25.0	27.4	14.9	20.3	9.4	4.9	5.0	4.7
	3	13.5	934	479	455	31.9	29.6	34.3	15.6	16.5	14.7	6.2	6.3	6.2
	4	12.9	532	256	276	31.0	30.9	31.2	14.5	19.1	10.1	5.3	7.9	2.9
Bogor:														
School	1	14.9	622	299	323	33.1	33.7	32.6	19.5	22.3	16.5	3.9	4.7	3.1
	2	11.0	616	312	304	33.1	31.3	34.9	20.8	24.7	16.9	2.9	3.2	2.7
	3	14.8	249	140	109	24.1	20.0	29.4	14.1	18.6	8.3	3.2	1.4	5.5
	4	22.5	479	238	241	30.3	29.0	31.5	17.1	24.4	10.0	3.6	4.3	2.9
Cianjur:														
School	1	11.0	730	371	358	28.3	24.4	32.4	19.6	25.3	13.7	3.0	3.0	3.1
	2	7.9	147	73	74	23.1	24.7	21.6	17.0	17.8	16.2	6.5	6.1	4.2

T = total students; B = boy; G = girl.
School group has been reorganized in this table.
School no. 7 in C-Jakarta is same as school no. 1 in S-Jakarta as appear in Fig 1 and Fig 2.
School no. 1, 2, 3 and 4 in S-Jakarta is same as school no. 2, 3, 4 and 5 in Fig 1 and Fig 2, respectively.

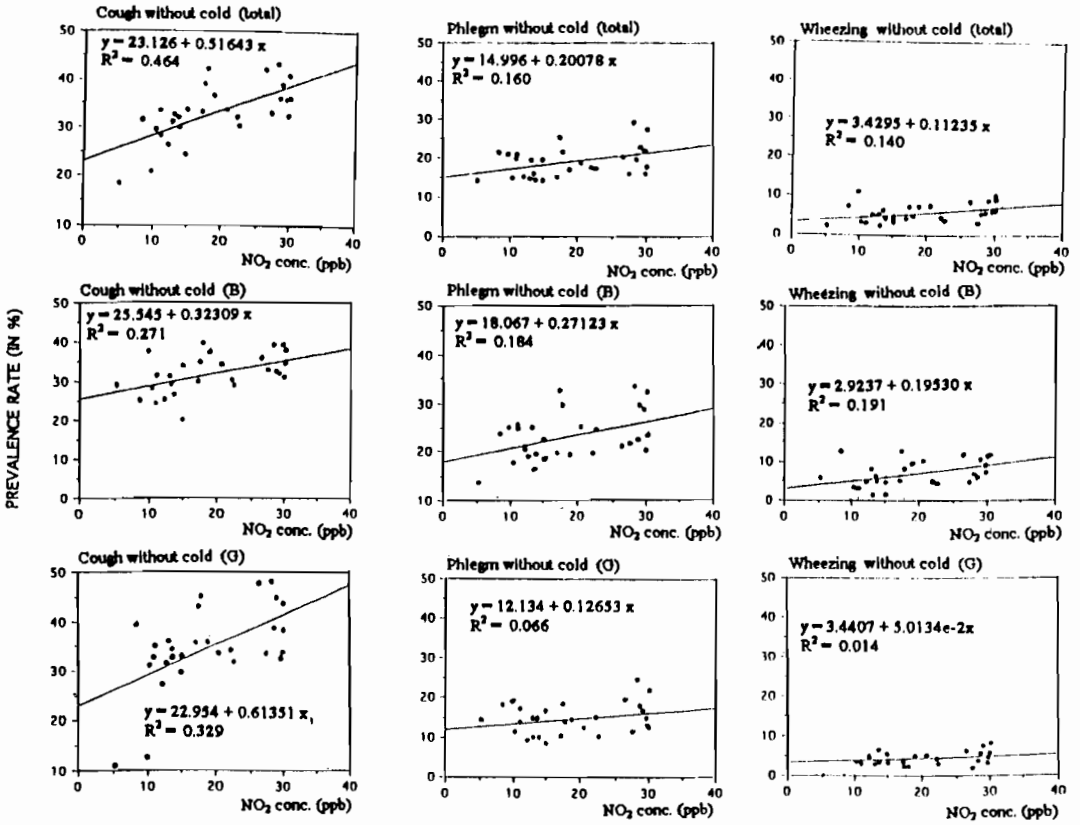

Fig 3–Prevalence rates (%) of cough without cold, phlegm without cold and wheezing without cold, versus NO_2 concentration in total (top line), boy (middle line) and girl (bottom line) students.

tivities. In general the spatial pattern of emissions closely follows that of traffic density except in subdistricts where industrial activity is substantial. The distribution of emissions is highest in the center of the city and decreases outwards towards Jakarta's boundary (Tri-Tugaswati *et al*, 1995) but with a subsidiary peak in the south of the city.

There has been no regular monitoring of air quality outside of Jakarta. A short study that has been done in Depok, Bogor, Tangerang and Bekasi (Tri-Tugaswati *et al*, 1995) showed that the concentration of NO_2 decreases further away from Jakarta, moving out in the suburbs until nearing those four cities.

A significant relationship was found in this study between NO_2 exposure levels and respiratory symptom rates of cough, phlegm and wheezing without cold. This association became stronger when Tangerang city and Bekasi city were excluded from the analysis, since the source of NO_2 in air in these two cities might be influenced also by industrial emissions.

Studies carried out in Israel (Goren *et al*, 1990; Goren and Hellman, 1988) found the frequency of reported respiratory symptoms among schoolchildren from the polluted area was higher than among children growing up in the non-polluted area. Tsunetoshi *et al* (1980) made a questionnaire survey of ATS-DLD in 1980 to 1984 for about 123,000 primary school children in 53 cities in Japan to know the health effect of nitrogen oxides. Annual average concentration of nitrogen oxides was the highest in Tokyo (36-46 ppb), the lowest in small cities (*ca* 10 ppb), and in most of the other cities it was 10-30 ppb. The prevalence rate of persistent cough ranged from 0.7 to 3.5%, and averaged in 1.8% in boys. The prevalence rate of persistent phlegm ranged from 0.1 to 2.7%, and averaged in 1.2% in boys. These rates are far lower than ours, which may be due to the response by their guard-

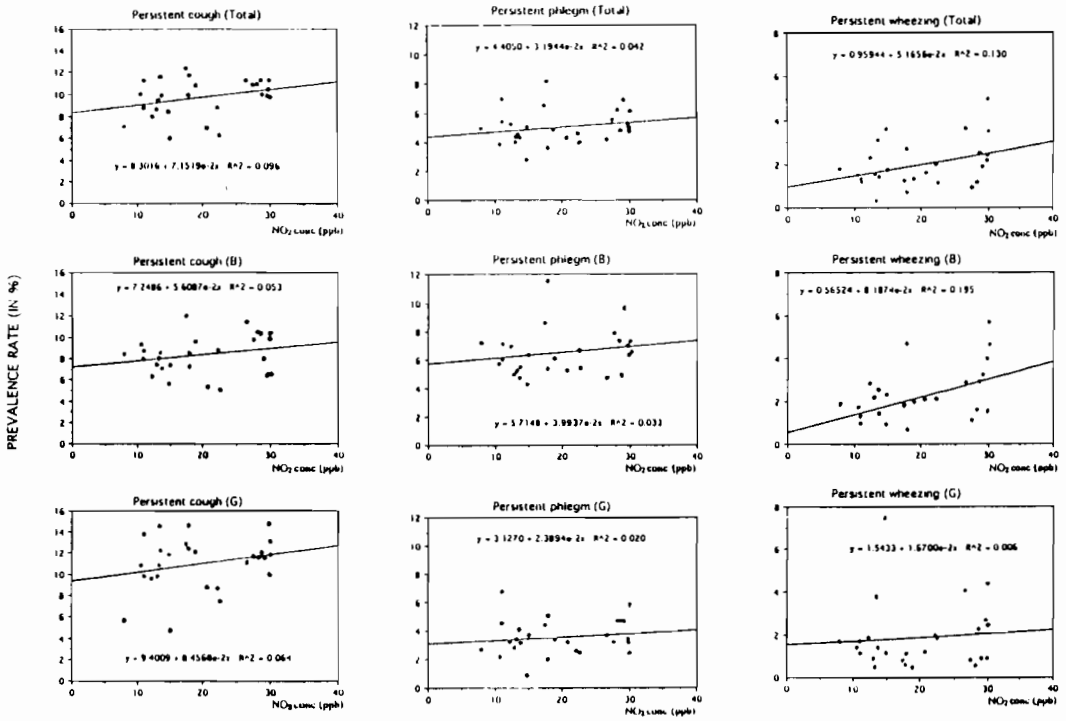

Fig 4–Prevalence rates (%) of persistent cough, persistent phlegm, and persistent wheezing,versus NO_2 concentration in total (top line), boy (middle line) and girl (bottom line) students.

ians' observation. Correlation coefficients between NO_2 concentration and the prevalence of persistent cough, phlegm, and asthma-like symptoms were mostly in the range 0.3 to 0.4%, which are higher than ours due to the wider range of NO_2 concentration and the larger number of subjects.

Other studies (Ono *et al*, 1990; Shimizu *et al*, 1987) carried out in Japan gave similar results. When we compare our results with findings from other studies (Nitta *et al*, 1993; Goren *et al*, 1990; Goren and Hellman, 1988; Tsunetoshi *et al*, 1980; Ono *et al*, 1990; Shimizu, 1987; Viege *et al*, 1991), our findings were 2-3 times higher than those found by other researchers. The difference may be due to the survey methods. In our study the students filled the questionnaire by themselves, while in other studies, questionnaires for children were filled by their parents. Self-administered ATS-DLD gave practically the same result as that using trained interviewers in adults (Nakadate, 1991).

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Table 4

Concentration of NO_2 (in ppb) and prevalence rate (%) in persistent cough, persistent phlegm and persistent wheezing in each school in the seven study areas.

Area: School		Conc of NO_2 (ppb)	No. of students			Prevalence rates (in %)								
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Depok:														
School	1	10.5	555	266	289	10.1	9.3	10.8	3.9	5.8	2.2	1.5	1.7	1.4
	2	12.2	994	502	492	8.0	6.4	9.6	5.2	7.0	3.3	2.3	2.8	1.9
	3	13.5	934	479	455	11.5	8.6	14.5	4.4	4.7	4.1	3.1	2.5	3.8
	4	12.9	532	256	276	8.7	7.5	9.8	4.0	5.1	2.9	1.5	2.2	0.9
Bogor:														
School	1	14.9	622	299	323	6.0	7.4	4.7	5.0	6.4	3.7	1.7	2.3	1.2
	2	11.0	616	312	304	8.9	8.0	9.9	5.4	6.1	4.6	1.2	1.3	1.2
	3	14.8	249	140	109	8.4	5.7	11.9	2.8	4.3	0.9	3.6	0.9	7.5
	4	22.5	479	238	241	6.3	5.1	7.5	4.0	5.5	2.5	1.1	0.0	1.9
Cianjur:														
School	1	11.0	730	371	358	11.3	8.9	13.8	6.9	7.1	6.8	1.3	1.0	1.7
	2	7.9	147	73	74	7.1	8.5	5.7	4.9	7.2	2.7	1.8	1.8	1.8

T = total students; B = boy; G = girl.
School group has been reorganized in this table.
School no. 7 in C-Jakarta is same as school no. 1 in S-Jakarta as appear in Fig 1, Fig 2.
School no. 1, 2, 3 and 4 in S-Jakarta is same as school no. 2, 3, 4 and 5 in Fig 1, Fig 2, respectively.

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