CHAPTER IV

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Demographic and Risk Factor Characteristics

Lung function was measured in 872 (99.3%) of the sampling 878 Bangkok children aged 10-15 years, for 2 (0.2%) children showed major signs of upper respiratory tract infections and 4 (0.4%) children refused to participate in the study. After evaluating the flow-volume curves applied to the criteria of ATS, data from 844 (96%) children were acceptable for further analyses. Among them 722 (82%) completed respiratory questionnaire. Table 4.1 showed the demographic and risk factor characteristics of the 722 children in each study group. Sixty percent of the ATS-DLD questionnaire was completed by mothers. There were 354 boys and 368 girls, and 37% of them had lived in their areas more than ten years.

Table 4.1 Demographic and risk factor characteristics of children included in analysis, Thailand, 2004 (n=722)

Parameter	Children included in the analysis[a]							
	HR		HG		MR		C	
	Elementary student (n=79)	Junior high school student (n=73)	Elementary student (n=111)	Junior high school student (n=96)	Elementary student (n=60)	Junior high school student (n=90)	Elementary student (n=110)	Junior high school student (n=103)
Mother responder, n (%)	44 (55.7)	39 (53.4)	60 (54.1)	65 (67.7)	29 (48.3)	65 (72.2)	68 (61.8)	66 (64.1)
Boys, n (%)	39 (49.4)	27 (37)	59 (53.2)	55 (57.3)	27 (45)	39 (43.3)	57 (51.8)	51 (49.5)
Mean age ± SD[b] (years)	10.6 ± 0.9	13.7 ± 1	10.3 ± 0.9	13.4 ± 1	10.5 ± 0.9	13.5 ± 1	10.6 ± 1	13.6 ± 0.9
Born in Bangkok, n (%)	68 (86.1)	53 (72.6)	92 (82.9)	89 (92.7)	46 (76.7)	76 (84.4)	98 (89.1)	87 (84.5)
Residential area, n (%)								
Urban	77 (97.5)	70 (95.9)	111 (100)	95 (99)	58 (96.7)	90 (100)	108 (98.2)	102 (99)
Suburban	2 (2.5)	3 (4.1)	0	1 (1)	2 (3.3)	0	2 (1.8)	1 (1)
Rural	0	0	0	0	0	0	0	0
Residential years, n (%)								
0-5	20 (25.3)	31 (42.5)	32 (28.8)	24 (25)	19 (31.7)	28 (31.1)	33 (30)	29 (28.2)
6-10	32 (40.5)	21 (28.8)	44 (39.6)	22 (22.9)	22 (36.7)	26 (28.9)	33 (30)	39 (37.9)
>10	27 (34.2)	21 (28.8)	35 (31.5)	50 (52.1)	19 (31.7)	36 (40)	44 (40)	35 (34)

a: HR = High-polluted roadside area; HG = High-polluted general area; MR = Moderate-polluted roadside area; C = Control area; Elementary student = Year 4-6; Junior high school student = Year 1-3.

b: Standard deviation.

Table 4.1 Demographic and risk factor characteristics of children included in analysis, Thailand, 2004 (n=722) (cont.)

Parameter	Children included in the analysis[a]							
	HR		HG		MR		C	
	Elementary student (n=79)	Junior high school student (n=73)	Elementary student (n=111)	Junior high school student (n=96)	Elementary student (n=60)	Junior high school student (n=90)	Elementary student (n=110)	Junior high school student (n=103)
Home size: room, n (%)								
1	32 (40.5)	29 (39.7)	41 (36.9)	23 (24)	21 (35)	27 (30)	19 (17.3)	23 (22.3)
2-5	36 (45.5)	33 (45.2)	61 (54.9)	66 (68.8)	31 (51.8)	56 (62.1)	84 (76.4)	71 (69)
>5	1 (1.3)	8 (11)	4 (3.6)	5 (5.2)	1 (1.7)	2 (2.2)	6 (5.4)	4 (3.9)
Family members, n (%)								
1-5	62 (78.4)	44 (60.3)	73 (65.7)	60 (62.4)	29 (48.4)	51 (56.7)	79 (71.8)	74 (71.8)
6-10	8 (10.2)	22 (30.2)	24 (21.6)	26 (27.1)	22 (36.7)	29 (32.1)	27 (24.4)	24 (23.3)
>10	4 (5.1)	6 (8.4)	10 (9)	7 (7.1)	3 (5)	4 (4.4)	3 (2.7)	2 (2)
Parental smoking habits, n (%)								
Neither smokes	51 (64.6)	42 (57.5)	70 (63.1)	65 (67.7)	35 (58.3)	54 (60)	84 (76.4)	69 (67)
Father only smokes	23 (29.1)	26 (35.6)	33 (29.7)	28 (29.2)	16 (26.7)	33 (36.7)	25 (22.7)	29 (28.2)
Mother only smokes	3 (3.8)	2 (2.7)	5 (4.5)	1 (1)	1 (1.7)	3 (3.3)	0	2 (1.9)
Both smoke	2 (2.5)	3 (4.1)	3 (2.7)	2 (2.1)	8 (13.3)	0	1 (0.9)	3 (2.9)

a: HR = High-polluted roadside area; HG = High-polluted general area; MR = Moderate-polluted roadside area; C = Control area; Elementary student = Year 4-6; Junior high school student = Year 1-3.

b: Standard deviation.

Table 4.1 Demographic and risk factor characteristics of children included in analysis, Thailand, 2004 (n=722) (cont.)

Parameter	Children included in the analysis[a]							
	HR		HG		MR		C	
	Elementary student (n=79)	Junior high school student (n=73)	Elementary student (n=111)	Junior high school student (n=96)	Elementary student (n=60)	Junior high school student (n=90)	Elementary student (n=110)	Junior high school student (n=103)
Use of air conditioners, n (%)	8 (10.1)	20 (27.4)	22 (19.8)	36 (37.5)	9 (15)	26 (28.9)	60 (54.5)	48 (46.6)
Domestic pets, n (%)	20 (25.3)	25 (34.2)	42 (37.8)	34 (35.4)	18 (30)	33 (36.7)	33 (30)	35 (34)
History of allergic diseases, n (%)	15 (19)	18 (24.7)	25 (22.5)	21 (21.9)	7 (11.7)	17 (18.9)	26 (23.6)	24 (23.3)

a: HR = High-polluted roadside area; HG = High-polluted general area; MR = Moderate-polluted roadside area; C = Control area; Elementary student = Year 4-6; Junior high school student = Year 1-3.

b: Standard deviation.

Home size referred to the number of rooms in a household. The highest percentage of home size was 2-5 rooms and approximately 80% of family members were less than 6 persons. This reflected as the majority of the urban middle class family. 65.1% of neither smokes but only 34.9% of father or mother or both smokes reported parental smoking habits. Use of air conditioners (31.7%) reporting less than no use (68.3%) and the lower percentage of having domestic pets (33.2%) than have not (66.8%). Children have history of allergic diseases (8.3%), whereas 91.7% have not.

In elementary and junior high school students, number of mother responder did not differ significantly in each area. Number of boys in junior high school students in HR area was lower significantly than those in HG area.

4.1.2 Respiratory Symptoms

The prevalence is measured existing cases of disease at a particular time. For example:

Elementary student		HG	C	Total
Chronic bronchitis	Yes	9 (8.1%)	1 (0.9%)	10
	No	102 (91.9%)	109 (99.1%)	211
	Total	111 (100%)	110 (100%)	221

Prevalence of chronic bronchitis among schoolchildren in HG area:

$$= \frac{9 \text{ children with chronic bronchitis}}{111 \text{ schoolchildren}} \times 100 = 8.1\%$$

Any of respiratory symptoms of individual and symptoms basis among schoolchildren in the study areas was shown in Table 4.2 – Table 4.5.

Table 4.2 Any of respiratory symptoms among schoolchildren in HR area

Area	Elementary student (n=79)		Junior high school student (n=73)	
	Case	Respiratory symptoms[a]	Case	Respiratory symptoms[a]
HR	1	C	1	D
	2	D	2	D
	3	C	3	BA
	4	CB, P	4	CB, D, C, P
	5	D, C	5	BA
	6	BA	6	C
	7	D	7	D
	8	CB, P	8	C
	9	D	9	D
	10	C	10	CB, BA, D, C, P
			11	D
			12	D
			13	C
			14	BA
			15	CB, D, C, P
			16	D
Total	Individual basis = 10	Symptoms basis = 13	Individual basis = 16	Symptoms basis = 26

a: CB = Chronic bronchitis; BA = Bronchial asthma; D = Dyspnea and wheezing; C = Persistent cough; P = Persistent phlegm.

Table 4.3 Any of respiratory symptoms among schoolchildren in HG area

Area	Elementary student (n=111)		Junior high school student (n=96)	
	Case	Respiratory symptoms[a]	Case	Respiratory symptoms[a]
HG	1	CB, P	1	D
	2	D	2	C
	3	CB, C, P	3	D
	4	CB, C, P	4	BA
	5	C	5	D
	6	D	6	D
	7	BA, D	7	D
	8	C	8	D
	9	CB, P	9	D
	10	CB, P	10	CB, P
	11	CB, P	11	D
	12	CB, C, P	12	D
	13	BA, C	13	C
	14	BA	14	CB, P
	15	CB, P	15	D
	16	CB, BA, C, P	16	D
	17	C, P	17	D
	18	C	18	D
			19	D
			20	D
			21	D
			22	D
			23	CB, P
Total	Individual basis = 18	Symptoms basis = 35	Individual basis = 23	Symptoms basis = 26

a: CB = Chronic bronchitis; BA = Bronchial asthma; D = Dyspnea and wheezing; C = Persistent cough; P = Persistent phlegm.

Table 4.4 Any of respiratory symptoms among schoolchildren in MR area

Area	Elementary student (n=60)		Junior high school student (n=90)	
	Case	Respiratory symptoms[a]	Case	Respiratory symptoms[a]
MR	1	CB, P	1	D
	2	P	2	BA
	3	BA, P	3	D
	4	D	4	C
	5	C	5	D
	6	D	6	BA, C
			7	P
			8	BA
			9	C
			10	CB, D, C, P
			11	C
			12	CB, P
			13	BA
Total	Individual basis = 6	Symptoms basis = 8	Individual basis = 13	Symptoms basis = 18

a: CB = Chronic bronchitis; BA = Bronchial asthma; D = Dyspnea and wheezing; C = Persistent cough; P = Persistent phlegm.

Table 4.5 Any of respiratory symptoms among schoolchildren in C area

Area	Elementary student (n=110)		Junior high school student (n=103)	
	Case	Respiratory symptoms[a]	Case	Respiratory symptoms[a]
C	1	BA	1	C
	2	CB, C, P	2	C
	3	D, P	3	D
	4	BA	4	CB, D, P
	5	D, C	5	D
	6	CB, P	6	CB, C, P
	7	BA	7	CB, P
Total	Individual basis = 7	Symptoms basis = 12	Individual basis = 7	Symptoms basis = 12

a: CB = Chronic bronchitis; BA = Bronchial asthma; D = Dyspnea and wheezing; C = Persistent cough; P = Persistent phlegm.

The prevalence of respiratory symptoms was higher for chronic bronchitis, bronchial asthma, dyspnea and wheezing, persistent cough, and persistent phlegm in the HR, HG, and MR area than in the C area (dyspnea and wheezing in junior high school students in HR and HG area $p<0.01$). The prevalence of chronic bronchitis, persistent cough, and persistent phlegm were higher significantly in elementary students in HG area compared to those in C area ($p<0.05$). Significantly higher prevalence of any one of the respiratory symptoms of individual basis was observed junior high school students in HR and HG areas ($p<0.01$) and elementary students in HG area ($p<0.05$) compared to those in C area. There was not differed significant in bronchial asthma (Table 4.7).

4.1.3 Impaired Lung Function

The percentage of impaired lung function in junior high school students who live in HR, HG, and MR area was higher significantly than in the C area ($p<0.01$). The lung function defect in schoolchildren such as mild obstruction, mild restrictive, moderate restrictive, mixed obstruction and restrictive, small airway obstruction or restrictive were shown in Table 4.6. The prevalence of respiratory symptoms and impaired lung function of children was shown in Table 4.7.

Table 4.6 Lung function defect in schoolchildren, Thailand (n=722)

Impaired lung function	Children included in the analysis[a]							
	HR		HG		MR		C	
	Elementary student (n=79)	Junior high school student (n=73)	Elementary student (n=111)	Junior high school student (n=96)	Elementary student (n=60)	Junior high school student (n=90)	Elementary student (n=110)	Junior high school student (n=103)
Mild obstruction, n (%)	1 (1.3)	2 (2.7)	2 (1.8)	4 (4.2)	0	4 (4.4)	5 (4.5)	3 (2.9)
Mild restrictive, n (%)	16 (20.3)	31 (42.5)	27 (24.3)	26 (27.1)	13 (21.7)	26 (28.9)	26 (23.6)	24 (23.3)
Moderate restrictive, n (%)	0	2 (2.7)	2 (1.8)	2 (2.1)	1 (1.7)	0	3 (2.7)	3 (2.9)
Mixed obstruction and restrictive, n (%)	1 (1.3)	1 (1.4)	1 (0.9)	1 (1)	2 (3.3)	0	1 (0.9)	0
Small airway obstruction or restrictive, n (%)	4 (5.1)	1 (1.4)	2 (1.8)	2 (2.1)	0	2 (2.2)	3 (2.7)	4 (3.9)

a: HR = High-polluted roadside area; HG = High-polluted general area; MR = Moderate-polluted roadside area; C = Control area.

Table 4.7 Number and prevalence (%) of respiratory symptoms and impaired lung function in schoolchildren, Thailand (n=722)

Area[a] (Total number)		Impaired lung function[b]	NSRD[c]			PCP[d]			Any one of the respiratory symptoms[e]	
			Chronic bronchitis	Bronchial asthma	Dyspnea and wheezing	Persistent cough	Persistent phlegm	Both of PCP	Individual basis	Symptoms basis
HR	E (79)	22 (28.9)	2 (2.5)	1 (1.3)	4 (5.1)	4 (5.1)	2 (2.5)	0	10 (13)	13 (16)
	J (73)	37 (56.1)**	3 (4.1)	4 (5.5)	10 (13.7)**	6 (8.2)*	3 (4.1)	3 (4.1)	16 (22)**	26 (36)**
HG	E (111)	34 (31.5)	9 (8.1)*	4 (3.6)	3 (2.7)	9 (8.1)*	10 (9)*	5 (4.5)	18 (16)*	35 (32)**
	J (96)	35 (37.2)	3 (3.1)	1 (1)	17 (17.7)**	2 (2.1)	3 (3.1)	0	23 (24)**	26 (27)*
MR	E (60)	16 (27.6)	1 (1.7)	1 (1.7)	2 (3.3)	1 (1.7)	3 (5)	0	6 (10)	8 (13)
	J (90)	32 (37.7)	2 (2.2)	4 (4.4)	4 (4.4)	5 (5.6)	3 (3.3)	1 (1.1)	13 (14)	18 (20)
C	E (110)	38 (34.9)	1 (0.9)	3 (2.7)	2 (1.8)	1 (0.9)	1 (0.9)	0	7 (6.4)	12 (11)
	J (103)	34 (34)	3 (2.9)	1 (1)	1 (0.9)	3 (2.9)	3 (2.9)	1 (1)	7 (6.8)	12 (12)

a: HR = High-polluted roadside area; HG = High-polluted general area; MR = Moderate-polluted roadside area; C = Control area; E = Elementary student; J = Junior high school student.

b: Results from spirometry test; Obstructive ventilatory defect (FEV_1 less than 80% predicted), restrictive ventilatory defect (FVC less than 80% predicted), mixed obstruction and restrictive (FEV_1 and FVC less than 80% predicted), and small airway obstruction or restrictive (MMEF less than 65% predicted).

c: Non-specific respiratory disease, results from ATS-DLD questionnaire.

d: Persistent cough and phlegm, results from ATS-DLD questionnaire.

e: Results from ATS-DLD questionnaire.

*$p<.05$, **$p<.01$ by chi-square test compared with control.

4.1.4 Confounding Factors

Confounding is the technical term for finding an association for the wrong reason. Previous study suggests that the presence of domestic pets increases the prevalence of respiratory symptoms in asthmatic children (Chew *et* al., 1997). Moreover, Hosein *et* al., 1989 reported that girls who were exposed to the emissions from indoor pollution have chance to more phlegm, dyspnea and wheeze. This study adjusted confounding factors that may affect the result such as questionnaire responder, gender, age, residential years, home size, family members, parental smoking habits, use of air conditioners, having domestic pets, and location areas. Staying indoors, in a tightly closed house that has a filter on the air conditioners and loss to inspect or change filter often, it can increase exposure to particles. All furred and feathered pets can cause an asthma reaction in sensitive individuals. Also other confounding factor that important for health status of children is socio-economic status (SES). Home size and family member as surrogate for socio-economic status was included in the regression model in the Table 4.8.

The results of the multiple logistic regression analyses were shown in Table 4.8. To evaluate the significant factors on any of respiratory symptoms or impaired lung function, independent variables of responder of ATS-DLD, gender, age, residential years, home size, family members, parental smoking habits, use of air conditioners, domestic pets, and residential areas were included in this model.

In children who live in HR and HG areas, the prevalence of respiratory symptoms increased significantly compared to those living in control area. Family members slightly increased significantly the prevalence of respiratory symptoms and age slightly increased significantly the risk of impaired lung functions. Residential areas and family members were associated with prevalence of respiratory symptoms and age was associated with impaired lung function significantly, whereas those factors of responder of ATS-DLD, gender, residential years, home size, parental smoking habits, use of air conditioners, domestic pets were not associated.

Table 4.8 Multiple logistic regression analyses for the association between independent variables, any of respiratory symptoms and impaired lung function among schoolchildren in Bangkok

Independent variables	Children (n=722)	
	Any of respiratory symptoms OR (95% CI)[a]	Impaired lung function OR (95% CI)[a]
Responder of ATS-DLD	0.63 (0.39, 1.01)	1.05 (0.77, 1.44)
Gender	0.77 (0.49, 1.21)	1.07 (0.78, 1.46)
Age	1.06 (0.94, 1.20)	1.18 (1.08, 1.28)
Residential years	0.97 (0.92, 1.02)	0.99 (0.96, 1.02)
Home size	0.95 (0.78, 1.16)	0.95 (0.83, 1.10)
Family members	1.16 (1.04, 1.29)	0.94 (0.86, 1.03)
Parental smoking habits	0.96 (0.61, 1.52)	0.92 (0.66, 1.27)
Use of air conditioners	0.78 (0.47, 1.28)	1.06 (0.74, 1.51)
Domestic pets	0.85 (0.53, 1.37)	1.14 (0.81, 1.60)
Area[b]		
HR	2.44 (1.21, 4.93)	1.41 (0.89, 2.22)
HG	2.60 (1.38, 4.91)	1.08 (0.71, 1.64)
MR	1.57 (0.76, 3.25)	0.99 (0.63, 1.57)

a: OR: odds ratio, CI: confidence interval.

b: HR = High-polluted roadside area; HG = High-polluted general area; MR = Moderate-polluted roadside area.

4.1.5 Only Mother Responder

Mothers were more likely to report a symptom or illness than were other questionnaire respondents. Mothers close to children more than other respondents. However they can give detail in symptoms of children reliable. Restricted only to the children whose mother completed the ATS-DLD questionnaires (n=436), family members increased significantly the prevalence of respiratory symptoms (OR=1.20, CI: 1.05-1.37) and age slightly increased significantly the risk of impaired lung functions (OR=1.19, CI: 1.07-1.34) (Table 4.9).

Table 4.9 Multiple logistic regression analyses only mother responder

	Children (n=436)	
Independent variables	Any of respiratory symptoms OR (95% CI)[a]	Impaired lung function OR (95% CI)[a]
Gender	0.94 (0.54, 1.63)	0.85 (0.56, 1.28)
Age	1.01 (0.87, 1.17)	1.19 (1.07, 1.34)
Residential years	0.96 (0.91, 1.02)	0.99 (0.95, 1.03)
Home size	0.84 (0.65, 1.08)	0.95 (0.79, 1.15)
Family members	1.20 (1.05, 1.37)	0.89 (0.81, 1.00)
Parental smoking habits	1.01 (0.58, 1.77)	0.87 (0.57, 1.33)
Use of air conditioners	0.84 (0.46, 1.55)	1.07 (0.67, 1.70)
Domestic pets	0.89 (0.50, 1.60)	1.08 (0.69, 1.67)
Area[b]		
HR	1.78 (0.78, 4.07)	1.57 (0.86, 2.87)
HG	1.84 (0.89, 3.81)	1.12 (0.65, 1.92)
MR	1.15 (0.49, 2.65)	0.96 (0.54, 1.74)

a: OR: odds ratio, CI: confidence interval.

b: HR = High-polluted roadside area; HG = High-polluted general area; MR = Moderate-polluted roadside area.

4.1.6 CO level

Ninety-one schoolchildren were sampling for performed alveolar CO concentrations. The result showed all of them were non-smoker and low level of alveolar CO concentrations. The alveolar CO level in schoolchildren was shown in Table 4.10.

Table 4.10 Alveolar CO concentrations in Bangkok schoolchildren (n=56).

Level	Area[a]			
	HR (n=11)	HG (n=43)	MR (n=7)	C (n=30)
0-6 ppm	11	43	7	30
7-10 ppm	-	-	-	-
11-20 ppm	-	-	-	-
20^{+} ppm	-	-	-	-

a: HR = High-polluted roadside area; HG = High-polluted general area; MR = Moderate-polluted roadside area; C = Control area.

4.1.7 Urban versus Rural

Two elementary schools and two junior high schools from HG and C area were chosen as an urban area. One elementary school and one junior high school were chosen at purpose in Ayutthaya as a rural area. The respiratory symptoms screening instruments were modified from the respiratory questionnaires ATS-DLD-78-C which used to survey schoolchildren from 10 to 15 years old. The questions included information on the following: where the children lived, respiratory symptoms, and family history of respiratory disease, the parent's level of education, when any respiratory diseases began, whether the symptoms had improved or still persisted, and when the symptoms had improved. The questionnaires used self-reporting by the children and their parents and questionnaires were not included if all answers were not completed.

In Bangkok, returned questionnaires totaled 420 from 440 schoolchildren and in Ayutthaya 173 questionnaires were returned from 208 schoolchildren. In Bangkok, the 420 children consisted of 222 males and 198 females and in Ayutthaya the 173 children consisted of 105 males and 68 females (Table 4.11).

Table 4.11 Demographic data of Ayutthaya schoolchildren (n=173)

Parameter	Ayutthaya	
	Elementary student (n=74)	Junior high school student (n=99)
Mother responder, n (%)	54 (73)	63 (63.6)
Boys, n (%)	32 (43.2)	73 (73.7)
Mean age ± SD[a] (years)	10.6 ± 0.9	13.5 ± 0.9
Born in Ayutthaya, n (%)	68 (91.9)	87 (87.9)
Residential area, n (%)		
Urban	0	0
Suburban	0	0
Rural	74 (100)	99 (100)
Residential years, n (%)		
0-5	22 (29.7)	22 (22.2)
6-10	21 (28.4)	25 (25.3)
>10	31 (41.9)	52 (52.5)
Home size: room, n (%)		
1	18 (24.3)	3 (3)
2-5	50 (67.7)	84 (84.8)
>5	5 (6.8)	7 (7.1)
Family members, n (%)		
1-5	52 (70.3)	62 (62.7)
6-10	16 (21.7)	31 (31.2)
>10	5 (6.9)	1 (1)
Parental smoking habits, n (%)		
Neither smokes	55 (74.3)	75 (75.8)
Father only smokes	18 (24.3)	23 (23.2)
Mother only smokes	0	1 (1)
Both smoke	1 (1.4)	0
Use of air conditioners, n (%)	27 (36.5)	50 (50.5)
Domestic pets, n (%)	45 (60.8)	54 (54.5)
History of allergic diseases, n (%)	18 (24.3)	26 (26.3)

a: Standard deviation.

In Bangkok, the prevalence of chronic bronchitis was 3.8%, of bronchial asthma 2.1%, of dyspnea and wheezing 5.5%, of persistent cough 3.6%, of persistent phlegm 4.1%, both of PCP 1.4%, any one of the respiratory symptoms 13.1%, and impaired lung function 33.6%. In Ayutthaya, the prevalence of chronic bronchitis was 0.6%, of bronchial asthma 2.3%, of dyspnea and wheezing 2.3%, of persistent cough 1.2%, of persistent phlegm 0.6 %, any one of the respiratory symptoms 5.8%, and impaired lung function 23.7% (Table 4.12). The prevalence of persistent phlegm, any one of the respiratory symptoms, and impaired lung function was thus higher significantly in Bangkok than in Ayutthaya (Table 4.13).

Table 4.12 Impaired lung function in Ayutthaya schoolchildren

Impaired lung function	Ayutthaya	
	Elementary student (n=74)	Junior high school student (n=99)
Mild obstruction, n (%)	1 (1.4)	4 (4)
Mild restrictive, n (%)	8 (10.8)	19 (19.2)
Moderate restrictive, n (%)	1 (1.4)	3 (3)
Mixed obstruction and restrictive, n (%)	1 (1.4)	0
Small airway obstruction or restrictive, n (%)	4 (5.4)	0

Table 4.13 Respiratory health data of study subjects from Bangkok and Ayutthaya

Variable[a]	Bangkok[b] (n=420)	Ayutthaya (n=173)	*p*-value
Boys, n (%)	222 (52.8)	105 (60.7)	0.098
Respiratory symptoms, n (%)			
- Chronic bronchitis	16 (3.8)	1 (0.6)	0.061
- Bronchial asthma	9 (2.1)	4 (2.3)	1.000
- Dyspnea and wheezing	23 (5.5)	4 (2.3)	0.143
- Persistent cough	15 (3.6)	2 (1.2)	0.183
- Persistent phlegm	17 (4.1)	1 (0.6)	0.048*
- Both of PCP	6 (1.4)	0	0.259
- Any one of the respiratory symptoms	55 (13.1)	10 (5.8)	0.014*
Impaired lung function, n (%)	141 (33.6)	41 (23.7)	0.023*

a: PCP = Persistent cough and phlegm

b: Bangkok = HG and C area.

*$p<.05$ by chi-square test compared with Ayutthaya.

The study also collected data on the concentration of air pollutants in the 2 areas over a 1-year period from January to December 2004 from the Thailand PCD and compared the average annual concentrations of various pollutants in each area as indicator of air pollution. The Wilcoxon signed-rank test was used to evaluate any comparison. The annual concentrations of SO_2 and NO_2 were higher in Bangkok (5.42 ± 2.59 and 22.77 ± 10.39 ppb) than in Ayutthaya (3.99 ± 1.69 and 11.43 ± 5.77 ppb). In contrast, the annual concentration of PM_{10} and O_3 was higher in Ayutthaya (73.72 ± 34.77 μg/m^3 and 26.78 ± 23.14 ppb) than Bangkok (57.09 ± 25.68 μg/m^3 and 17.34 ± 19.37 ppb). Interestingly, these differences were statistically significant ($p<0.001$) (Table 4.14).

Table 4.14 Comparison of atmospheric pollutant levels (mean ± standard deviation) in Bangkok and Ayutthaya

Pollutant[a]	Bangkok[b]	Ayutthaya	Standard	p-value
PM_{10}-24 hr ($\mu g/m^3$)	57.09 ± 25.68	73.72 ± 34.77	120	0.000**
CO-1 hr (ppm)	0.65 ± 0.32	0.67 ± 0.33	30	0.006*
CO-8 hr (ppm)	0.65 ± 0.25	0.67 ± 0.29	9	0.001*
SO_2-1 hr (ppb)	5.42 ± 2.59	3.99 ± 1.69	300	0.000**
NO_2-1 hr (ppb)	22.77 ± 10.39	11.43 ± 5.77	170	0.000**
O_3-1 hr (ppb)	17.34 ± 19.37	26.78 ± 23.14	100	0.000**

a: PM_{10} = Particulate matter diameter less than 10 microns; CO = Carbon monoxide; SO_2 = Sulfur dioxide; NO_2 = Nitrogen dioxide; O_3 = Ozone.

b: Bangkok = HG and C area.

*$p<.01$, **$p<.001$ by Wilcoxon signed-rank test.

4.1.8 Non-Response Analysis

From the total 1,086, 191 children were excluded from this study. Among them 27 children were not completed the questionnaire (2 children showed major signs of upper respiratory tract infections, 3 children refused to spirometry test, and 22 children were not acceptable spirogram). There were 13 boys and 14 girls, and 52% of them had lived in their areas less than ten years. There were no statistical differences between non-response and response groups in gender, residential years, use of air conditioners, and having domestic pets. For the other 164, non-response analysis could not be performed. They did not return the respiratory questionnaire, which reasons were unknown.

4.2 Discussions

There was no significant difference in the mean value of PM_{10} between HR and HG, however, original concern was the health effect of air pollution from major streets in Bangkok where pollutant concentrations have been high and frequently exceeded the ambient air quality standards for TSP and PM_{10}. Furthermore, these areas have difference in other air pollutants such as carbon monoxide and ozone. There may be some difference in respiratory health, due to different characteristic of air pollution between roadside and general site. Firstly, a lot of Thai children living in shop houses, which are in close proximity to the street, it is also necessary to assess the respiratory health where those are exposed. Secondly, this study assesses children who live in general site refers to residential, commercial, industrial and mixed areas that can represent impacts to general population.

The children living in highly polluted areas (HR, HG) would possibly indicate higher prevalence of respiratory symptoms and impaired lung function than those living in moderately (MR) and less polluted area (C). In this study, this study categorized the children into eight groups based on area, school type, roadside and general ambient monitoring stations and have found that children living in high-polluted area suffered more frequently with respiratory symptoms and decreased lung functions compared to children who live in less polluted area. Junior high school students in HR area were demonstrated the greatest impaired lung functions. Both elementary and junior high school students in HR and HG area were illustrated the higher prevalence of respiratory symptoms compared to children in the other groups. It is obvious that air pollution affects more on children living long terms in highly polluted area of Bangkok than on children who live in low polluted area. There were differences in associations between pollutants and respiratory symptoms for elementary students and junior high school students. In high-polluted area, the prevalence of any one of respiratory symptoms in junior high school students was higher than elementary students. These may be because junior high school students living longer term in their polluted areas than elementary students.

There may be children of younger ages had sensitive to these respiratory symptoms. The small airways of young children can be significantly narrowed by inflammation and mucus, making breathing difficult. These children breathe rapidly and may develop a high-pitched noise heard on breathing out or wheezing (Merck, 2006). These groups correspond with both biological development and the type of care those families. Also, this study confirmed the observation after controlling for other risk factors. There seemed greater effects of air pollution on the respiratory symptoms and lung function in schoolchildren compared to adults as having shown in other cities (Abbey *et al.*, 1998; Bascom *et al.*, 1996a; Bascom *et al.*, 1996b; Dockery *et al.*, 1991; Dockery *et al.*, 1994; Duanping *et al.*, 2004; Osunsanya *et al.*, 2001; Peter *et al.*, 1999a; Peters *et al.*, 1999b; Peters *et al.*, 1997; Pope *et al.*, 1995; Roemer *et al.*, 1998b; Seaton *et al.*, 1995; and Tager *et al.*, 1999). This study also suggested that children who live in highly polluted area were susceptible to adverse health effects.

Children were performed lung function tests in the seated position and without nose clip. ATS guidelines (ATS, 1995) suggest that subjects can be tested either seated or standing and a report from school-age children who were tested with and without nose clips found no systematic effect on FEV_1 or FVC (Chavasse *et al.*, 2003). After the flow-volume curve examinations, this study found the high proportion of valid tests. Therefore, the lung function tests were performed satisfactory. There may be an area differences in the proportion of time for the children spending outdoors. Outdoor pollutants may affect them more if they stayed outdoors longer. According to the population density, Bangkok Metropolitan Administration has divided the city into three zones, inner, middle, and outer zone, according to the population density basic. Khlong Chan Housing Community Station as control site, located in middle zone and HR and HG located in inner zone. The results revealed the association between site conditions and the health effects. The prevalence of respiratory symptoms was higher among children living in HR and HG than children in the other groups. This study assumed that children in control area, in middle zone, low population density, had more chance to play outdoors than those living in busy streets in inner areas. Thus without considering the difference in playing outdoors, there may be even larger difference in the effect of air pollution among the area.

Lung function tests are displayed in real-time so can encourage children effort; judge test quality and make sure tests are performed properly. The technicians were trained to follow carefully the standardized technique of recording FEV_1 and FVC to reach maximum validity and minimum variability in these recordings. The present testing procedure followed the standardized guidelines of the ATS with regard to equipment, maneuvers and measurements, as well as acceptability and reproducibility criteria (ATS, 1995). But the ATS guideline was written for adult patients. FEV_1 and FVC were chosen as the main parameters since these variables are the most widely used measures of ventilatory function, and FEV_1 is the most reproducible lung function variable. The technicians motivated the children to breathe in maximally and to deliver maximal force from the beginning to the very end of the exhalation. Furthermore, the children were trained individually before the actual test session to inhale and exhale completely. Children may rebel against such instructions and in such cases that these criteria should be relaxed if this is only means of obtaining results.

In addition, there may be other potential confounders such as unaccounted differences in socioeconomic variables. Lenthe *et al.*, 2004 showed that socioeconomic status affected health conditions. However most of the parents of the children in this study were regarded in the middle class and inclusion of the variables of air conditioners use, home size, family members, and respondents of the questionnaire in the multiple logistic regression analyses may adjust the remaining effect of SES. In addition, the prevalence of some respiratory symptoms, such as chronic bronchitis, dyspnea and wheezing, persistent cough and phlegm may be associated with residential area, which may in turn be associated with low SES. This could lead to a confounding bias if children with low SES were likely living near busy streets. Therefore, if poorer families are unable to afford to live in cleaner areas and as a result their children's respiratory health suffers, this would suggest that PM_{10} is one potential mechanism by which SES affects health. Family members were associated significantly with prevalence of respiratory symptoms. People with weakened immune systems can be especially susceptible to more severe complications, such as bronchial infections (Abatement Technologies, 2006). There may be any family member suffer from allergies, asthma or other respiratory problems. In addition, they may have immune system problems or illness and smoke in their houses.

Furthermore, questionnaire respondent was classified into two categories: mother response = 1, father and other household member = 0. Overall, in more than half of the households (60.4%), mothers were the questionnaire respondents. After adjusted other factors in regression model, the odds ratio to 0.63 (0.39-1.01) for mother respond on the questionnaire. Normally, mothers were more likely to report a symptom or illness than were other questionnaire respondents (Zhang *et al.*, 2002). However, this study found mother or father or other were not associated significantly with reporting the prevalence of any of respiratory symptoms. Nature of Thai people likes to take care of their children and to be very familiar. Some children may live with father only or with family senior relatives, because their parents were very busy at work. It is possible that mother or father or the other be equal in raising their children and can give reliable symptoms details.

Previous studies found a statistically significant association between particulate matter and chronic respiratory symptoms in non-smoking California residents (Abbey *et al.*, 1993; Abbey *et al.*, 1995a; and Abbey *et al.*, 1995b) and on children in Europe (Roemer *et al.*, 1993; and Roemer *et al.*, 1998a). A few researchers indicated that weak significant associations between lung function and particulate air pollution. No associations were found between pollutant concentrations and any of the pulmonary function measures considered such as FVC, FEV_1, $FEV_{0.75}$, and MMEF (Dockery *et al.*, 1989). The effect of air pollution on lung function in children and youths ages 6-24 years was examined. Forced vital capacity, forced expiratory volume at 1 sec, and peak expiratory flow all showed statistically significant ($p<0.05$) negative correlations with annual concentrations of total suspended particulates, nitrogen dioxide, and ozone (Schwartz, 1989). Lung function testing is often unreliable in young children. However, lung function test is still tool for predictive respiratory health (Dassen *et al.*, 1986; Delfino *et al.*, 2004; Dockery *et al.*, 1982; Eigen *et al.*, 2001; Hoek *et al.*, 1993; Jalaludin *et al.*, 2000; Neuberger *et al.*, 2002; Nystad *et al.*, 2002; Pekkanen *et al.*, 1997; Vedal *et al.*, 1987; and Wang *et al.*, 1993).

The study population was limited to children attending schools located within 2 km of these monitoring stations. Families of children who participate in this study are middle class and also their schools are governmental school. In Thailand, richer people like to study in schools, which are famous and private school. Children also spend more time in school than in any indoor environment other than the home. Because of these outdoor particles, like outdoor gases, readily enter the air indoors where children spend most of their time. Most of them live close to their schools. Monitoring stations located near the schools are also likely to be near the students' homes, thus providing good surrogates for both school and home exposure. There are advantages in the exposure information in this study.

For other air pollutants, Saenghirunvattana *et al.*, 2000 reported that carboxyhemoglobin, methemoglobin, and sulfhemoglobin level among Bangkok residents were decreased during period 1995-2000. Moreover, Aekplakorn *et al.*, 2003a and Aekplakorn *et al.*, 2003b indicated that at the low ambient air pollution concentrations observed, particulate matter rather than SO_2 was associated with acute daily respiratory symptoms in children. In 2004, there were 102 out of 58,081 observations (0.18 percent) of hourly ambient O_3 concentrations exceeding the ambient air quality standards of 100 ppb, mostly in the general areas downwind from the center of Bangkok. There was no violation of standard of SO_2, NO_2, and CO concentrations was observed both in the general areas and at the roadside areas of Bangkok (Table 2.1 and 2.2). Carbon monoxide reacts very rapidly with hemoglobin in the blood, preventing uptake and transport of oxygen which different target organ unlike particulate matter. It is possible that gaseous pollutants including O_3, SO_2, NO_2, and CO may not affect to respiratory system of Bangkok population. In addition, gaseous pollutants often are present in the atmosphere at the same time as are particles. It is not always possible to clearly differentiate between the healths effects of the gases, the particles, and possibly the combination of particles and gases. This complexity presents a tremendous challenge to the scientific community and to public in trying to understand how inhaled particles affect human health.

The short-term effect of particulate air pollution on the respiratory morbidity of children has been the subject of considerable investigations over the past decade (Linn *et al.*, 1996; Romieu *et al.*, 2002; Schwartz *et al.*, 1994; and Vedal *et al.*, 1998). Prolonged high levels of exposure to the particles of low toxicity may in the end produce the same damage as low-level exposure to a very toxic particle for a short period. On the other hand, large population can only be surveilled by air monitoring stations and not by personal air samplers. Therefore, previous epidemiological studies were used the same air monitoring data, which are used for air quality standards.

Prior study reported airborne fine particles of $PM_{2.5\text{-}10}$ and $PM_{2.5}$ in Ayutthaya during March 24 to 27, 1999. They found PM_{10} concentrations in Ayutthaya are lower than the Thailand standard of 120 $\mu g/m^3$ (74 $\mu g/m^3$ in the day time and 89 $\mu g/m^3$ in the night time). $PM_{2.5}$ in Ayutthaya was quite low both day and night and varied between 47 and 54 $\mu g/m^3$, lower than the U.S. EPA standard of 65 $\mu g/m^3$ (Jinsart *et al.*, 2002). Previous studies have shown that PM_{10} and O_3 play a very important role in the increasing prevalence of asthma (Goren *et* al., 1999; and Koren, 1995). In this study, the concentration of PM_{10} and O_3 in Bangkok was statistically significantly lower than Ayutthaya. The prevalence of bronchial asthma in Ayutthaya was higher than Bangkok. Thus, PM_{10} and O_3 might be a factor affecting the prevalence of bronchial asthma in schoolchildren.

The percentage of the willingness to participate in this study was high and the children included in the analyses should be reasonably representative of all children of a similar age in Bangkok. This study was in the beginning stage of health effect study in Bangkok children. Since, the cross-sectional study was applied, the causal association may not be determined. However, from the results, this study could suggest that living in highly polluted areas in Bangkok will lead to the chronic effects on respiratory systems in addition to the acute health effects as reported by previous study (Ostro *et al*., 1999).