CHAPTER III

RESEARCH METHODOLOGY

3.1 Study Site and Population

3.1.1 Study Site

Bangkok's climate is classified as tropical savannas. Temperature is warm all year round and very hot in April. Bangkok has three seasons: winter (November- mid February), summer (mid February to mid May) and rainy season (mid May to October). Southwest wind predominates during the rainy season and wind is generally northeast during the winter. During the summer, average temperature is around 30°C and reduces to 25 °C during the winter. Annual rainfall is aproximately 1400 mm and 80-90% of this occurs during the rainy season. The flat plains around Bangkok allow free air movement, so pollutants are generally efficiently dispersed, except when the air is calm.

Bangkok has about 6 million inhabitants with a very high population density, (4,051 inhabitants per km^2). To obtain wide range of air pollution level, different four areas were selected considering the traffic volumes and characteristic zone as well. Based on the level of PM_{10} obtained from the roadside and general ambient PCD monitoring stations, four areas (Highly polluted at roadside area: HR, Highly polluted in general area: HG, Moderately polluted at roadside area: MR and less polluted area as a control: C) with elementary and junior high schools were chosen in Bangkok. Figure 3.1 showed the locations of the studied areas. The annual average of PM_{10} levels in 2004 (PCD, 2005) at Din Daeng Housing Authority Station located in HR was 65 $\mu g/m^3$ also exceeded the standard of 50 $\mu g/m^3$. There were 12 out of 354 observations representing 3.4 percent of the total observations having PM_{10} concentrations exceeding the standard of 120 $\mu g/m^3$. That at Nonsi Withaya School

Station located in HG was 67.5 $\mu g/m^3$. There were 20 out of 354 observations representing 5.7 percent of the total observations having PM_{10} concentrations exceeding the standard. At Thonburi Substation Station located in MR, it was 52.2 $\mu g/m^3$. There were 4 out of 361 observations representing 1.1 percent of the total observations having concentrations exceeding the standard and at Khlong Chan Housing Community Station located in C, it was 47 $\mu g/m^3$. There were 2 out of 366 observations representing 0.6 percent of the total observations having concentrations exceeding the standard (Table 3.1).
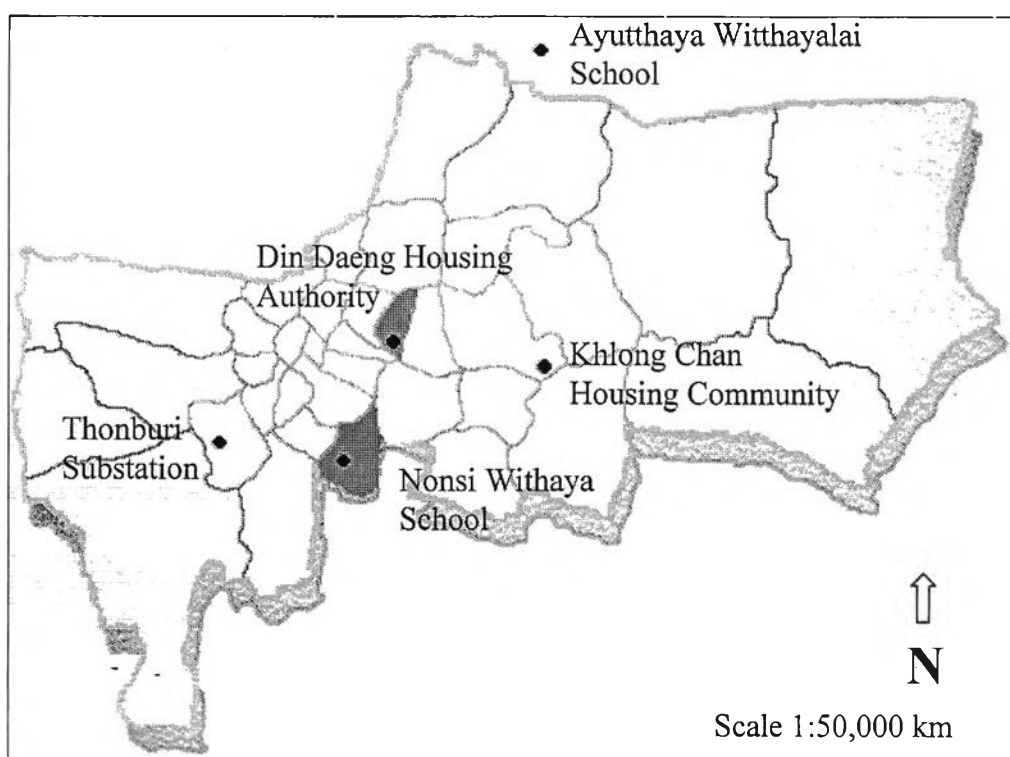

Figure 3.1 Location of air monitoring stations in the study areas. *Dark shading represents high-polluted area* (PCD, 2004)

Ayutthaya as a rural area was selected for compare with Bangkok as an urban area. It located on the flat river plain of the Chao Phraya river valley and central region of Thailand. It was the capital of Thailand and far away from Bangkok 76 km. During the summer, maximum temperature is around 36.8°C and reduces to 21.2°C

during the winter. Annual rainfall is aproximately 880.6 mm. The annual average of PM_{10} levels in 2004 (PCD, 2005) at Ayutthaya Witthayalai School Station as general area located in R, it was 73.7 $\mu g/m^3$. There were 40 out of 340 observations representing 11.8 percent of the total observations having concentrations exceeding the standard.

The comparison of PM_{10} levels (mean) in four areas was shown as table 3.1. One-way ANOVA was used for statistical analysis by comparing all group means of PM_{10}. Multiple comparisons performed by LSD (Fisher's Least-Significant Difference). In HR area, average concentration of PM_{10} was significantly higher when compared to MR and C area ($p<0.001$). In HG area, it was significantly higher when compared to MR and C area ($p<0.001$). In MR area, it was significantly higher when compared to C area ($p<0.005$). There were significant different in PM_{10} concentration (mean) between the different locations (HR vs MR, HR vs C, HG vs MR, HG vs C: $p<0.001$ and MR vs C: $p<0.005$). However, there was no significant difference between HR and HG.

Table 3.1 Traffic volume, zone characteristic, and 24-hour average concentration of PM_{10} in Bangkok, Thailand, 2004

Area[a]	Traffic volume (car/hour)	Characteristic[b]	PM_{10} ($\mu g/m^3$)[c]			
			Range	Average	Frequency of exceeding standard	p
HR	4,973 (Asok Din Daeng Rd.)	Super block zone	29.1-185.1	65.0	12/354 (3.4%)	vs HG[NS] vs MR** vs C**
HG	3,498 (Rama III Express way)	New economic zone	30.0-183.8	67.5	20/354 (5.7%)	vs MR** vs C**
MR	1,364 (Therd Thai Rd.)	Conservative zone	23.6-153.9	52.2	4/361 (1.1%)	vs C*
C	938 (Soi Happy Land)	Residence zone	22.2-130.6	47.0	2/366 (0.6%)	-

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

b: Characteristic zone based on New Urban Cluster 12 zones, BMA.

c: PM_{10} = Particulate matter diameter less than 10 micrometers.

*$p<.005$, **$p<.001$, NS: non significant by one-way ANOVA compared mean of 24-hour average concentration of PM_{10}.

Source: Traffic and Transportation Department and PCD, 2005

3.1.2 Study Population

Schoolchildren aged 10-15 years were recruited for this study. Purposive sampling was used in the selection of one elementary school and one junior high school in each area. Those schools were close to, or within 2 km, of a PCD roadside and general ambient air quality monitoring stations (Table 3.2). Figure 3.2 and 3.3 shows study sites. Total subjects are 1,086 children summed up 10% precision levels of sampling size (Yamane, 1973) of total students in each school (Table 3.3). Subjects aged 10-12 years of fourth to sixth grade elementary students and 13-15 years of junior high school students living in the study areas more than 6 months were sampling systematically from odd ID numbers. Children walk to school in 20 min or

take a trip in 15 min. Each child's exposure level of air pollution was derived from the nearest monitoring stations. They are willing to participate in this study and consent from their parents and school administrator. The overall participation rate was high (82%).

Table 3.2 School and distance from PCD air quality monitoring station

Area[a]	Station	School	Distance[b] (m)	Subject[c]
HR	Din Daeng Housing Authority	Piboon Prachasan	190	n=79: M 39, F 40, 10-12 yr n=73: M 27, F 46, 13-15 yr
HG	Nonsi Withaya School	Pratom Nonsi	670	n=111: M 59, F 52, 10-12 yr
		Nonsi Withaya	-	n=96: M 55, F 41, 13-15 yr
MR	Thonburi Substation	Wat Verurachin	190	n=60: M 27, F 33, 10-12 yr
		Ritthinarongron	280	n=90: M 39, F 51, 13-15 yr
C	Khlong Chan Housing Community	Pratom Banbangkapi	280	n=110: M 57, F 53, 10-12 yr
		Matayom Banbangkapi	280	n=103: M 51, F 52, 13-15 yr
R	Ayutthaya Witthayalai School	Pratoochai	1,650	n=74: M 32, F 42, 10-12 yr
		Ayutthaya Witthayalai	-	n=99: M 73, F 26, 13-15 yr

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

b: Distance from PCD air quality monitoring station to school (meter) by map scale 1:46,000.

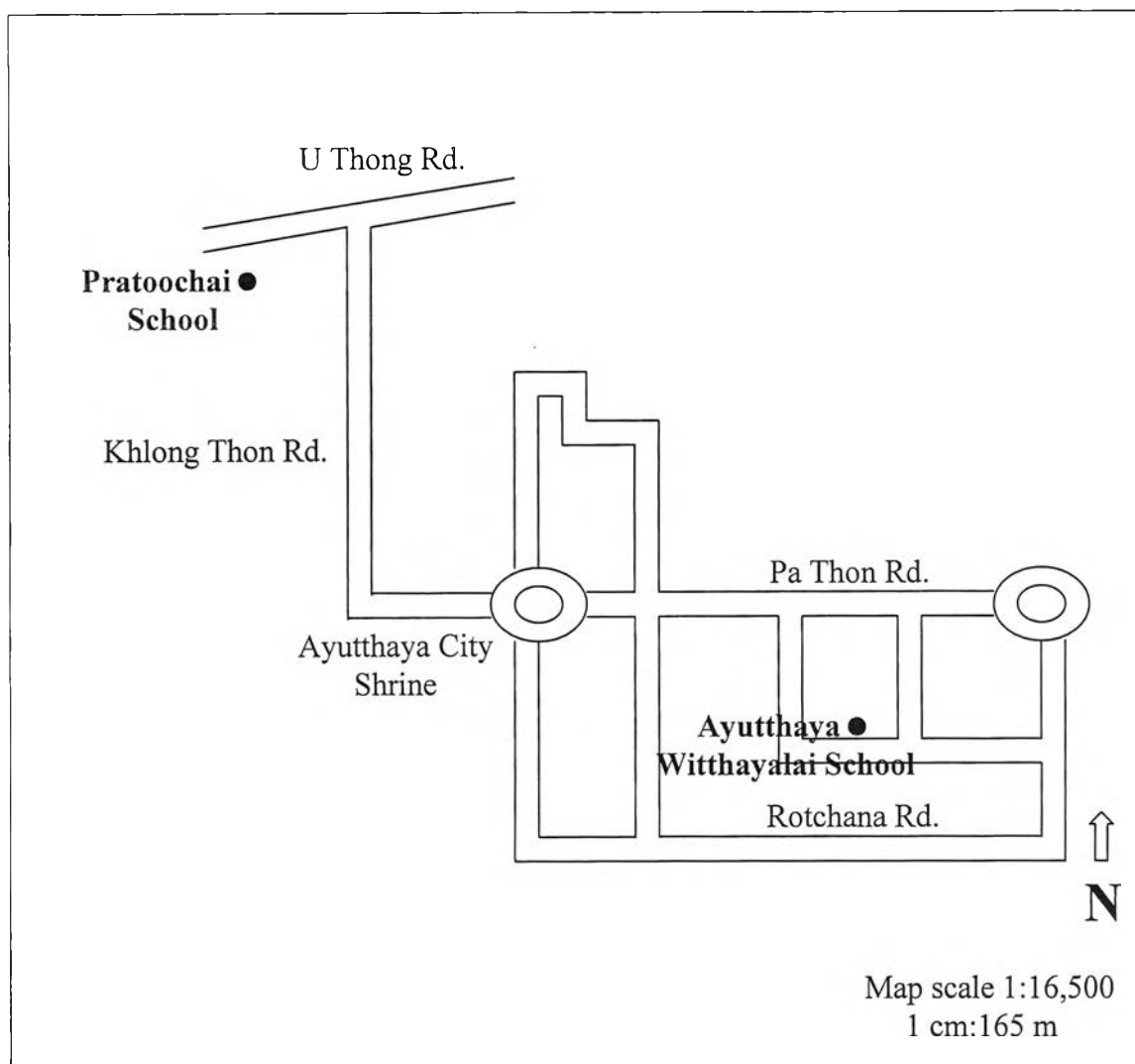c: M = Male; F = Female; n = number; yr = year.

HR

HG

MR

C

Figure 3.2 Map of study sites in Bangkok
Source: Department of City Planning, BMA, 2004

⇧
N
Scale 1:50,000 km

U Thong Rd.

Pratoochai ● School

Khlong Thon Rd.

Pa Thon Rd.

Ayutthaya City Shrine

Ayutthaya ●
Witthayalai School

Rotchana Rd.

N

Map scale 1:16,500
1 cm:165 m

Figure 3.3 Map of study sites in Ayutthaya

Table 3.3 Sample size among study areas

Area[a]	School	Type[b]	Population size	Sample size 10% precision levels[c]
HR	Piboon Prachasan	E	387	79
		J	260	72
HG	Pratom Nonsi	E	390	80
	Nonsi Withaya	J	1,734	95
MR	Wat Verurachin	E	150	60
	Ritthinarongron	J	850	89
C	Pratom Banbangkapi	E	1,603	94
	Matayom Banbangkapi	J	471	83
R	Pratoochai	E	997	91
	Ayutthaya Witthayalai	J	2,078	95

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

b: E = Elementary student; J = Junior high school student.

c: A 95% confidence level and $p = 0.5$ are assumed for equation: $n = N / 1 + N (e)^2$ where n = Sample size, N = Population size, e = Level of precision.

3.2 Materials

3.2.1 Air Pollution Data

This study used the annual average air pollution concentration in each area as an indicator of air pollution and collected air pollution data from January to December 2004 from PCD.

3.2.2 Respiratory Questionnaire

The prevalence of chronic respiratory symptoms (Non-specific respiratory disease: NSRD, and Persistent Cough and Phlegm: PCP) was assessed using Thai version of ATS-DLD-78-C (Ferris, 1978). Criteria of NSRD are (1) Chronic Bronchitis: phlegm production from the chest $\geq$ two times/day for $\geq$ 4 day/week for $\geq$ 3 month/year for at least 3 year; (2) Bronchial Asthma: doctor-diagnosed asthma and still have asthma; (3) Dyspnea and wheezing: wheezing or whistling in the chest apart from colds on most days or nights. Criteria of PCP are (1) Persistent Cough: cough apart from colds on most days more than 4 day/week for 3 month/year at least 1 year; (2) Persistent Phlegm: congested in the chest or bring up phlegm, sputum, or mucus apart from colds on most days more than 4 day/week for 3 month/year at least 1 year. The questionnaire consists of general information, respiratory symptoms (cough, phlegm, wheeze, chest tightness), and family history. Either one of the parents of children completed the respiratory questionnaire after the children were examined for their lung functions (HR=152, HG=207, MR=150, C=213, R=173 cases).

3.2.3 Lung Function Test

Lung function was measured by automated spirometer (Pony Graphic 3.3, Cosmed, Italy) (Figure 3.4) using Spiro Thai 2.0 Program according to predicted lung function parameters from reference values in the Thai population (Dejsomritrutai *et al.*, 2000). Spirometric measurements included forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), $FEV_1/FVC\%$, and forced expiratory flow between 25% and 75% expired volumes ($FEF_{25-75\%}$).

Figure 3.4 Spirometer Pony Graphic 3.3

Figure 3.5 shows steps of spirometry. Three experienced lung function technicians who received certifications from Cardiopulmonary Thailand Association under American Thoracic Society (ATS, 1995) performed the spirometry tests after regular calibration of spirometers. Prepare children through ask about smoking, recent illness, medication use. Testing is completed and reports obtained by enter information: predicted values are calculated using children's gender, age, height, and weight. They were recorded using the standardized equipments and procedures. Spirometry test was start by instructing the children to seal lips around the mouthpiece, take 2-3 normal breaths, inhale completely and fill their lungs, blow out as fast, hard, and long as children can, and keep going until children cannot exhale any more, inhale as fully and with as much force as possible. Each student performs at least 3 spirometry tests in the seated position, without a nose clip. The spirometers display the flow-volume curve in real time and calculate lung function parameters.

The best spirogram with the highest sum of FVC and FEV_1 was chosen for the analysis. Test acceptability was determined by examining the flow and volume time curve as recommended by ATS. All maneuvers complied with the general acceptability criteria of the ATS. Individual flow-volume curves were reviewed for technical acceptability and were considered unacceptable if: (1) the children coughed

or breathed in during the measurement; (2) the curve was flat or rounded without a distinct peak; (3) the top of the curve was to the right or there was more than one distinct peak. Internal printer produces complete, non-fading reports in seconds.
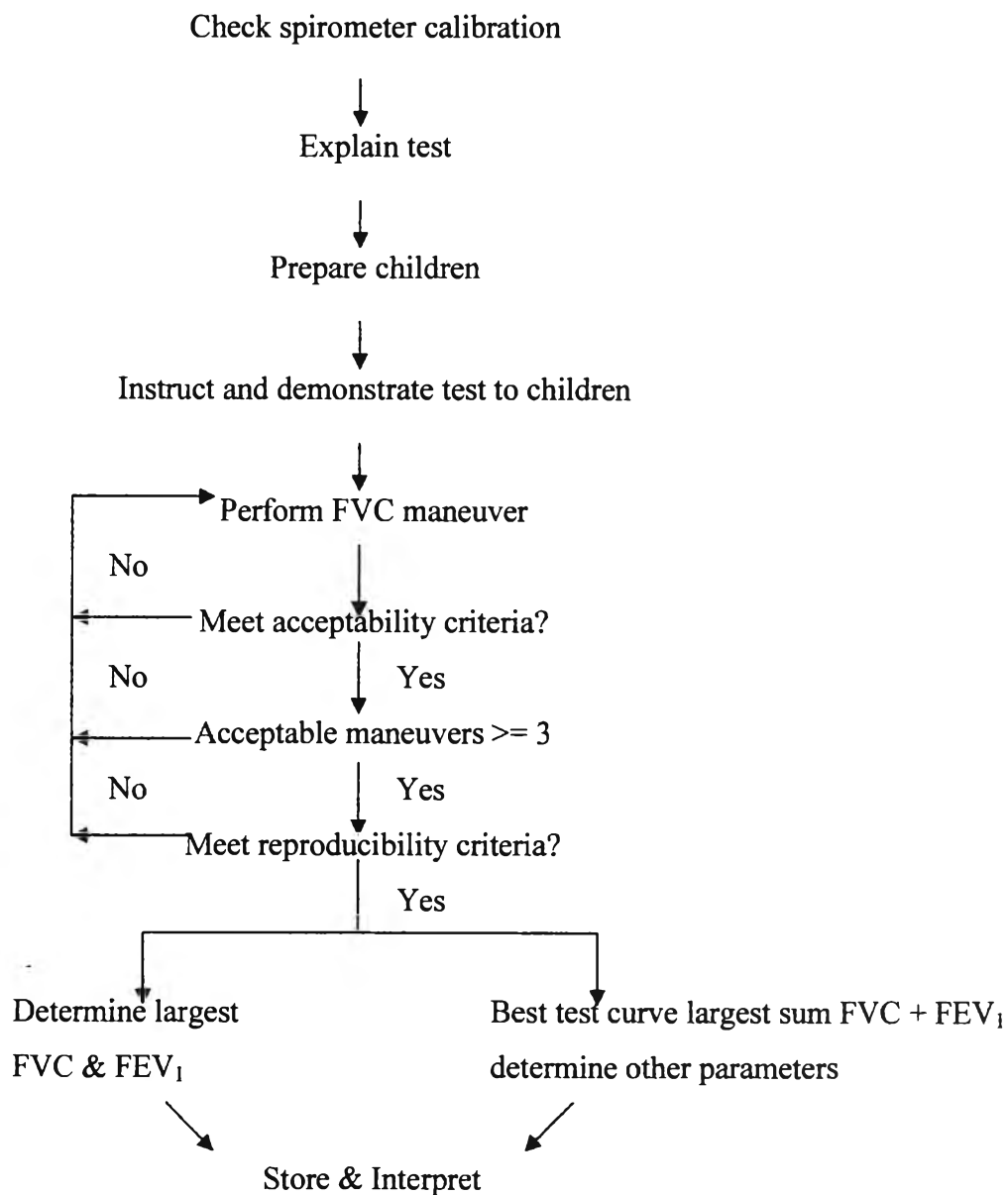
Check spirometer calibration

↓

Explain test

↓

Prepare children

↓

Instruct and demonstrate test to children

↓

Perform FVC maneuver

No

Meet acceptability criteria?

No | Yes

Acceptable maneuvers >= 3

No | Yes

Meet reproducibility criteria?

Yes

Determine largest FVC & FEV₁

Best test curve largest sum FVC + FEV₁ determine other parameters

Store & Interpret

Figure 3.5 Steps of spirometry (ATS, 1995)

Figure 3.6 showed sample of acceptable flow-volume spirogram in schoolchildren. Lung function was measured during May-August 2004 (HR=212, HG=225, MR=226, C=215 cases) (Figure 3.7). FEV_1 and FVC [greater than] 80% predicted were used as criteria of normal lung function. Impaired lung function include (1) obstructive ventilatory defect: FEV_1 less than 80% predicted (mild FEV_1 66-80%, moderate FEV_1 50-65%, severe FEV_1 less than 50%); (2) restrictive ventilatory defect: FVC less than 80% predicted (mild FVC 66-80%, moderate FVC 50-65%, severe FVC less than 50%); (3) mixed obstruction and restrictive: FEV_1 and FVC less than 80% predicted; (4) small airway obstruction or restrictive: no evidence of obstruction or restrictive $FEF_{25-75\%}$ less than 65% predicted (Figure 3.8).
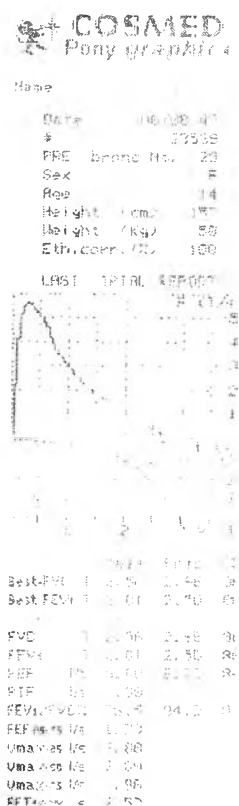

Figure 3.6 Sample acceptable flow-volume spirogram
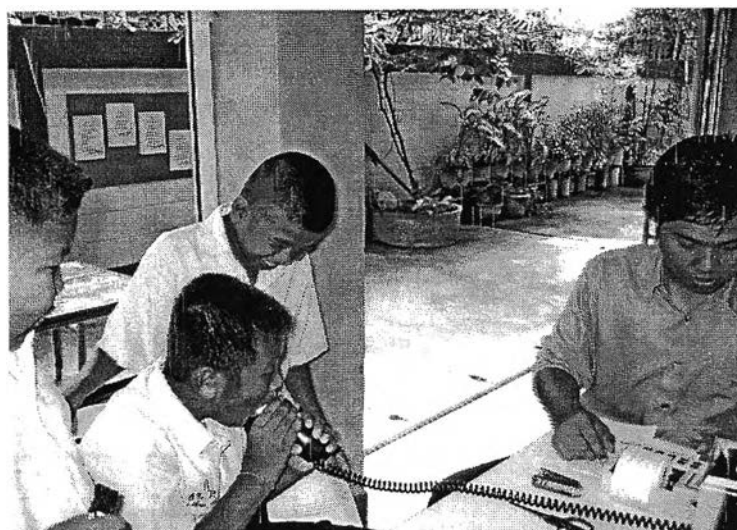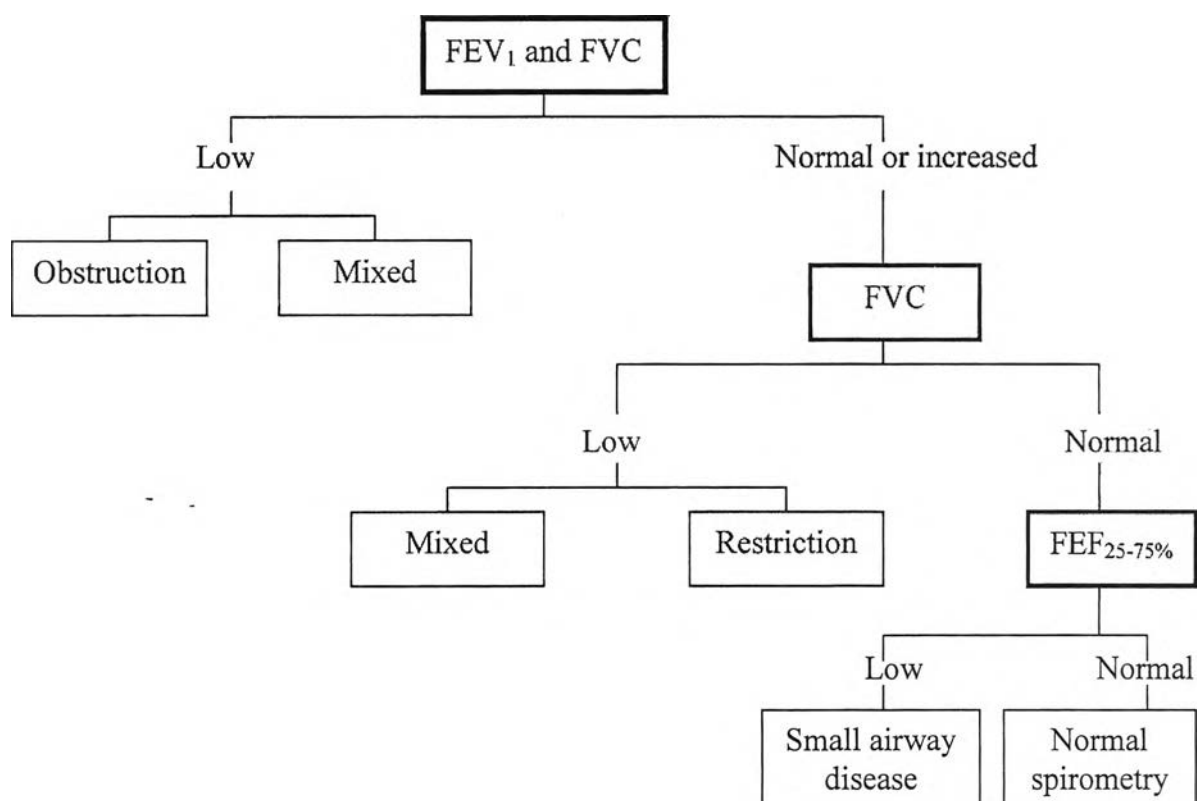
Figure 3.7 Spirometry

Figure 3.8 Guidelines for spirometric interpretation

Source: The Thoracic Society of Thailand, 2002

Generally, spirometry interpretation need for standard reference or predicted values that vary in age, gender, height, and race. Mongoloid people have spirometric

parameters less than Caucasian people. Thus, validity of interpretation should be applied with reference standard from population own country. Reference spirometric values for healthy lifetime nonsmokers, this comes from sampling population in Thailand. Total subjects are 3,954 cases (male 1,655 cases, female 2,299 cases) during 1996 to 1997. The equations for calculate predicted values for Thai population was shown as Table 3.4.

Table 3.4 Spiro Thai 2.0 Program

Parameters	Gender	Equations
FVC (L)	M	$-2.601+0.122A-0.00046A^2+0.00023H^2-0.00061AH$
	F	$-5.914+0.088A-0.0003A^2+0.056H-0.0005AH$
FEV_1 (L)	M	$-7.697+0.123A+0.067H-0.00034A^2-0.0007AH$
	F	$-10.6+0.085A-0.00019A^2+0.12H-0.00022H^2-0.00056AH$
PEFR (L/S)	M	$-16.859+0.037A+0.141H-0.0018A^2-0.001AH$
	F	$-31.355+0.162A-0.00084A^2+0.391H-0.00099H^2-0.00072AH$
FEV1/FVC (%)	M	$19.362+0.49A+0.829H-0.0023H^2-0.0041AH$
	F	$83.126+0.243A+0.002A^2+0.084H-0.0036AH$
$FEF_{25-75\%}$ (L/S)	M	$-19.049+0.201A+0.207H-0.00042A^2-0.00039H^2-0.0012AH$
	F	$-21.528+0.11A-0.00017A^2+0.272H-0.0007H^2-0.00082AH$

M = male; F = female; A = age (years); H = height (cm)

Source: Dejsomritrutai et $al.$, 2000

Although lung function test is a standard method to examine the pulmonary function, but there are some variations in technically and biologically, which may influence the accuracy of pulmonary function tests. Therefore, the quality control is very necessary and important. This study daily calibrated regularly with a 3 liters calibration syringe (Figure 3.9).
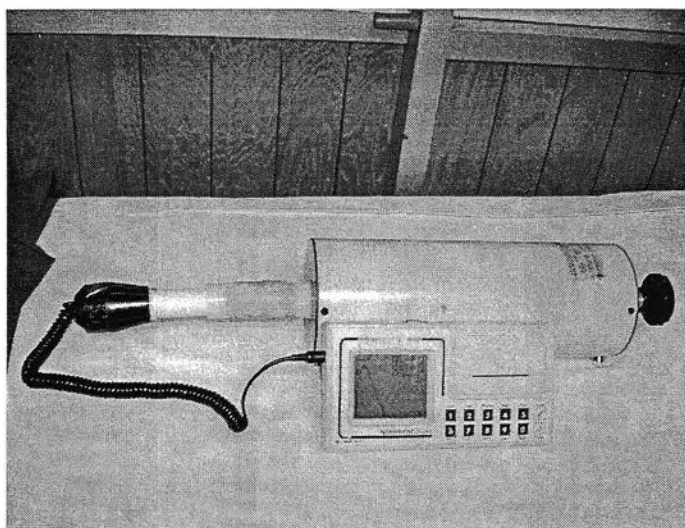
Figure 3.9 Calibration syringe with spirometer

3.2.4 CO breathe test

Measurements obtained from a single expiration. Alveolar CO levels were measured in ppm with color light indicators. Four range of CO level are:

- Level 0 to 6 ppm and green light will indicate a non-smoker.
- Level 7 to 10 ppm and amber light will indicate a light smoker.
- Level 11 to 20 ppm and red light will indicate a smoker.
- Level 20^+ ppm and red flashing light with audible alarm will indicate a heavy smoker.

Figure 3.10 showed CO breathe detector in this study. Ninety-one subjects were examined the CO level in HR, HG, MR and C area.
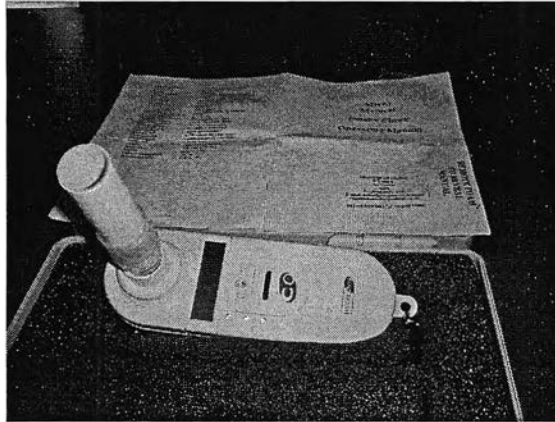
Figure 3.10 CO breathe detector

3.3 Statistical Analysis

This study used SPSS for analysis of the data, which enter the data into the data and variable view. In data view, columns represent variables and rows represent cases or observations. In variable view, each row is a variable and each column is an attribute associated with that variable such as name, type, width, decimals, label, values, missing, columns, align, and measure.

3.3.1 One-way ANOVA

The compare means submenu on the analyze menu provides techniques for displaying descriptive statistics and testing whether differences are significant between two means for both independent and paired samples. One-way ANOVA procedure was used for test whether differences are significant between more than two independent means.

Steps of analysis as follows:

1. Produce 2 columns in SPSS file: column 1 is PM_{10} (daily PM_{10} concentrations in 2004 among four areas that range by date and location

area, respectively) and column 2 is Group (location area: HR=1, HG=2, MR=3, and C=4).

2. Running the analysis; from the menus, choose *Analyze, Compare Means, One-way ANOVA*, respectively. Select PM_{10} in Dependent List, and select *Group* in Factor.

3. Select *LSD* in Post-Hoc multiple comparisons and select *Descriptive* in statistic options.

3.3.2 Yates' Correction Chi-Square Test

Differences of the health related parameters among the areas of HR, HG, MR and control groups were compared using Yates' chi-square test (Wayne, 1978). The health parameters include impaired lung function, NSRD, PCP, and any one of the respiratory symptoms. Forty-eight comparisons were done in four areas both of the elementary and junior high school student.

Steps of analysis as follows:

1. Produce 2-by-2 table as Example:

Elementary student		HG	C	Total
	Yes	9	1	10
Chronic bronchitis	No	102	109	211
	Total	111	110	221

2. Produce 3 columns in SPSS file: column 1 is location, column 2 is disease, and column 3 is cases that weight case.

Location	Disease	Case
1	1	9
1	0	102
2	1	1
2	0	109

3. Running the analysis; from the menus, choose *Analyze, Descriptive statistics, Crosstab,* respectively. Select *Location* as a column variable and *Disease* as the row variable.

4. Select *Exact* in exact tests group, select *Chi-square, Nominal* in statistics group, and select *Counts observed, Percentages row, Residuals adjusted standardized, Noninteger weights round cell counts* in cell display group.

3.3.3 Binary Logistic Regression Technique

Logistic regression techniques were used to assess the dependency between prevalence of respiratory symptoms, lung function and independent variables such as questionnaire responder (mother=1, father or others=0), gender (male=1, female=0), age, residential years, home size, family members, parental smoking habits (mother or father or both smokes=1, neither smokes=0), use of air conditioners (yes=1, no=0), having domestic pets (yes=1, no=0). The factor of residential areas as categorical covariate and the control area were used as a reference category. Three dummy or indicator variables denoting areas were included in this model (HR=1, HG=2, MR=3, C=4). Model I Respiratory symptoms (any of the respiratory symptoms = 1, other = 0) and model II Lung function (impaired lung function = 1, normal = 0) were coded in each model.

To determine whether and to what extent the independent variables are related to the probability of having prevalence of respiratory symptoms and impaired lung function. The regression models were tested with any of respiratory symptoms and impaired lung function as dependent variables, and the residential areas and other risk factors as independent variables listed above. The odds ratios and 95% confidence intervals were treated as the outcome variables and precision weighting applied to estimate the degree of association in this study. The data were analyzed by the Statistical package for social science (SPSS) version 13.0 (SPSS Inc., Chicago, USA, 2001).

Steps of analysis as follows:

1. Select case.

2. Running the analysis; from the menus, choose *Analyze*, *Regression*, *Binary logistic regression analysis*, respectively. Select one dichotomous dependent variable (Model I: Respiratory symptoms, model II: Lung function).

3. Select covariates. To include interaction terms, select ten independent variables (Questionnaire responder, gender, age, residential years, home size, family members, parental smoking habits, use of air conditioners, having domestic pets, and residential areas) involved in the interaction.

4. Select the *Enter* method for enters independent variables into the analysis. The Enter method is a procedure for variable selection in which all variables in a block are entered in a single step. All independent variables selected are added to a single regression model.

5. Select six categorical covariates (except age, residential years, home size, family members as string covariate which is already present in the categorical covariates list) from the covariates list and move them into the categorical covariates list.

6. Select *Probabilities and Predicted group membership* in predicted values group for saves values predicted by the model.

7. Select *Cook's* in influence group for save values from statistics that measure the influence of cases on predicted values

8. Select *Unstandardized and Standardized* in residuals group for save residuals.

9. Specify options group by select *Classification-plots, Hosmer-Lemeshow goodness-of-fit, Casewise listing of residuals, and CI for exp(B)*. Select *At last step* to display statistics group.