Lung function impairment and respiratory symptoms in school children expose to petrochemical pollution in Rayong province, Thailand

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Abstract

Background: Previous epidemiologic studies showed statistical associations between levels of air pollution and respiratory disorders of residents in petrochemical complex areas.

Methods: The health effects of PM_{10}, O_3 and VOCs exposure in industrial area in Rayong Province, Thailand were investigated. This study was carried out during February- August 2013 on 806 elementary school children aged 9-12 years. Children's lung functions, FEV1, FVC, and $FEF_{25-75\%}$were examined by Automated Spirometry. American Thoracic Society's Division of Lung Diseases (ATS-DLD-78C) questionnaires were used to collect the non specific respiratory diseases data. The selection of schools and children in this survey was based on the distance from a major industrial source (Map Ta Phut Industrial Estate) with 1 km. (A), 5 km. (B) and 10 km. (C). The prevalence of respiratory symptoms from questionnaires data and lung function impairment among three study sites were compared using the multiple regression analysis.

Results: The prevalence of respiratory symptoms in school children area A were higher than those subjects in area C with OR= 3.41, 95% CI=1.70-6.85, $p < 0.001$. Gender was associated with the prevalence of impaired lung function, whereas other factors were not related. The impaired lung function of female students were higher than male students with OR= 1.94, 95% CI=1.33-2.84, $p < 0.001$. The percentage of impaired lung function of students in A, B and C schools were 22.9%, 15.2% and 18.1% respectively.

Conclusions: The prevalence of respiratory symptoms and impaired lung function were higher among children studying near industrial sites were higher than those in further distance from major sources.

Keywords: air pollution, respiratory, lung function, industrial area

Introduction

Industry related air pollutants have extensively impact to human health, particularly on respiratory system. Previous epidemiological studies found relatively consistent associations between ambient air pollutions and human health (Tamura, 2003, Karita, 2004, Vichit-Vadakan, 2008). The effects on respiratory symptom from traffic air pollutions were reported in Bangkok school children (Langkulsen,2006) and health effects of sulfur dioxide from power plant has also been reported (Aekplakorn, 2003). Domestic exposure to volatile organic compounds (VOCs) at levels below currently accepted recommendations may increase the risk of childhood asthma. (Rumchev, 2002, 2004, Wilson, 2008)

The Map Ta Phut Industrial Estate (MTPIE) was located in Map Ta Phut Municipality, on the eastern seaboard region, Muang District, Rayong Province about 200 kilometers southeast of Bangkok, at location 12° 30' N and 101° 35' E (Figure 1). The MTPIE was established in 1988 as part of Thai government's policy to develop the eastern seaboard industrial area. Currently, The MTPIE serves as a significant manufacturing base for petrochemical, chemical products, iron and metal, as well as refineries.

Map Ta Phut Municipality, total area of 165.575 km^2 was comprised of 38 communities around the Map Ta Phut Industrial Estate and has a registered population of 53,901 (MTP Municipality, 2012). The weather in Map Ta Phut is very similar to other coastal regions in the country. There are basically three seasons: the hot season, the rainy season and the cool or dry season. Average temperatures are 24-37^{o}C. The highest mean level of rainfall is approximately 267 mm per month during September. The relative humidity ranges 60-95 %. The Map Ta Phut area is influenced by the sea wind, which sweeps from the southwest to the northeast with a wind speed below 6 ms^{-1}(Pimpisut, 2005).There were several research reports on pollution monitoring and health effects such as Thepanondh, 2011, Tanyanont,2012, Kongtip, 2013. Those reports were found significant association between air pollution and adverse effect. However, there has been no investigation on health effects to children yet.

The aim of this study was to investigate the respiratory health effect of children exposed to PM_{10} O_3 and VOCs in industrial areas. In general, children seem to be particularly susceptible to the harmful effects of ambient air pollution because their lungs are growing. Lung growth is guided by a complex and precisely timed sequence of chemical messages. Many ambient air pollutants are chemical agents that have the potential toxic and interfering with these signaling pathways (Trasande and Thurston, 2005). Children have less defensive systems against particulate matter and gaseous air pollutants than in adults. They have an insufficient ability to metabolize and detoxify environmental agents and have an airway epithelium that is more permeable to inhaled air pollutants (Schwartz, 2004). In addition, children have a higher level of physical activity than adults hence the intake of air into the lung is much more than in adults per day (Salvi, 2007).

Nevertheless, chronic health effects of air pollution to children remain uncertain, particularly in the industrial areas. The epidemiological cross-sectional research could be one of the tools inthe study of chronic effects of industrial air pollution exposure. In this study, the association between air pollution and respiratory impairments were evaluated using the ATS-DLD-78-C respiratory questionnaires and lung function test among school children in different distance from industrial sites.

Materials and methods

Study site and population

The selection of schools and children in this survey was based on the distance from a major industrial source, Map Ta Phut Industrial Estate, with 1 km. (A), 5 km. (B) and 10 km. (C).Area A involved four surrounding schools situated with 1 km away from the industrial source; area B and C involved two schools situated 5 and 10 km from the industrial source, respectively (Figure 1).The total eight schools were selected from the close location to the air monitoring stations. The air quality data in the different area A, B and C were compared in Table 1-2. The survey was carried out during February-August 2013 on1365 elementary school children aged 9-12 years.

Air quality data

Air quality data from 2008 to 2013 were obtained from Pollution Control Department (PCD), Thailand. Air pollution concentrations were measured following the standard methods, PM_{10} by Beta attenuator air sampling for average 24 hour units µg/m^3, Ozone (O_3) by Ultraviolet Absorption Photometry for average 1 hour unit ppb; and volatile organic compounds (VOCs) by Canister Analysis with US EPA Method TO-15 then followed by the analysis with Gas Chromatography/Mass Spectrometry (GC/MS), for average 24 hour units µg/m^3.

Annual average PM_{10} level at 29T Stations located in area A was 44.32 µg/m^3. There were 31 out of 1,910 observations, representing 1.62% of the total observations, exceeded the standard level. The PM_{10} level at 74T located in area B was 35.45 µg/m^3 and PM_{10}at 30T located in area C was 29.74 µg/m^3. Annual average Ozone level at 29T Stations located in area A was 21.23 ppb. The concentration level at 74T located in area B was 21.5µg/m^3 and at 30T located in area C was 22.43 ppb, Table 1.

The VOCs concentrations in area A were obtained from MC, NF, TK and MT monitoring stations and in area C from NJ monitoring stations, Figure 1. In area A, Vinyl Chloride, 1,3-Butadiene, Dichloromethane, 1,2-Dichloroethane, Benzene and total VOCs were significantly higher than in Area C. Three VOCs in area A, 1,3-butadiene, 1,2-dichloroethane and benzene were higher than the NAAQS as shown in Table 2.

Lung function test

Lung function of 806 students was measured by automated spirometry (CHESTGRAPH HI-101, CHEST, Japan) following the lung function parameters from reference values in Asia population(CHEST M.I., INC). Spirometric measurements include forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC), FEV_1/FVC%,forced expiratory flow between 25 and 75% expired volumes ($FEF_{25\text{-}75\%}$). The spirometers were performed after the regular calibration. Standing height and weight were measured using the standard equipments and procedures. All subjects were trained by technicians for their proper blowing as fast, hard and long as possible, with at least three spirometry tests. The best spirogram with the highest sum of FVC and FEV_1 was chosen for further analysis. Test acceptability was determined by examining the flow and volume time curve as recommended by ATS. The criteria for normal lung function for FEV_1 and FVC was greater than 80% (The Thoracic Society of Thailand,2012).

Respiratory Questionnaires

American Thoracic Society's Division of Lung Diseases (ATS-DLD) -78C questionnaires, Thai version was random distributed to 1365 school children from total 2145 students. The questionnaires were used to collect the non specific respiratory diseases data (Ferris, 1978).The prevalence of chronic respiratory symptoms (non-specific respiratory disease: NSRD and persistent cough and phlegm: PCP) (see Appendix). The questionnaire consists of general information, respiratory symptoms (cough, phlegm, wheeze, chest tightness), and family history. The Ethics Review Committee for Research Involving Human Research Subject, Health Science Group, Chulalongkorn University approved the study. After obtaining the consent from parents or guardians, the details of the study and consent forms were elaborated.

Statistical analysis

A nonparametric method (Mann-Whitney Utest) was used to compare the levels of pollution (VOCs). Differences in the health-related parameters among the areas of A, B and control groups (area C) were compares using Yates' chi-squared test. Logistic regression techniques were used to assess the association between prevalence of respiratory symptoms, lung function and independent variables such as gender, age, residential years, residential areas, home size, family members, parental smoking habits, use of air conditioners and having domestic pets. The odds ratios (ORs) and 95% confidence intervals (CIs) were obtained as the outcome variables and precision weighting was applied to estimate the degree of association in this study. Statistical processing of the data was carried out using Statistical Package for Social Science (SPSS19). Multiple regressions are used to analyze the correlation between variables.

Table 1 24 hour average concentration of PM_{10} and One hour average concentration of O_3, in 2008-2013

Area (PCD station)	PM_{10} ($\mu g/m^3$)				O_3 (ppb)			
	Range	Average	Frequency of exceeding standard	p	Range	Average	Frequency of exceeding standard	p
A (29T)	209-5.0	44.32	31/1,910 (1.62%)	*vs*B ns *vs*C *	150-0	21.23	81/47,085 (0.17%)	*vs*B ns *vs*C ns
B (74T) †	107-11	35.45	0/725 (0%)	*vs*C ns	149-0	21.5	16/16,672 (0.09%)	*vs*C ns
C (30T)	121.3-5.8	29.74	1/1,941 (0.05%)	-	142-0	22.43	74/45,972 (0.16%)	-
Standard **		120				100		

† in year 2012-2013

* $p< 0.05$, ns = not significant by one-way ANOVA comparing mean of 24h average concentration of PM_{10} and O_3

**PCD, 2013

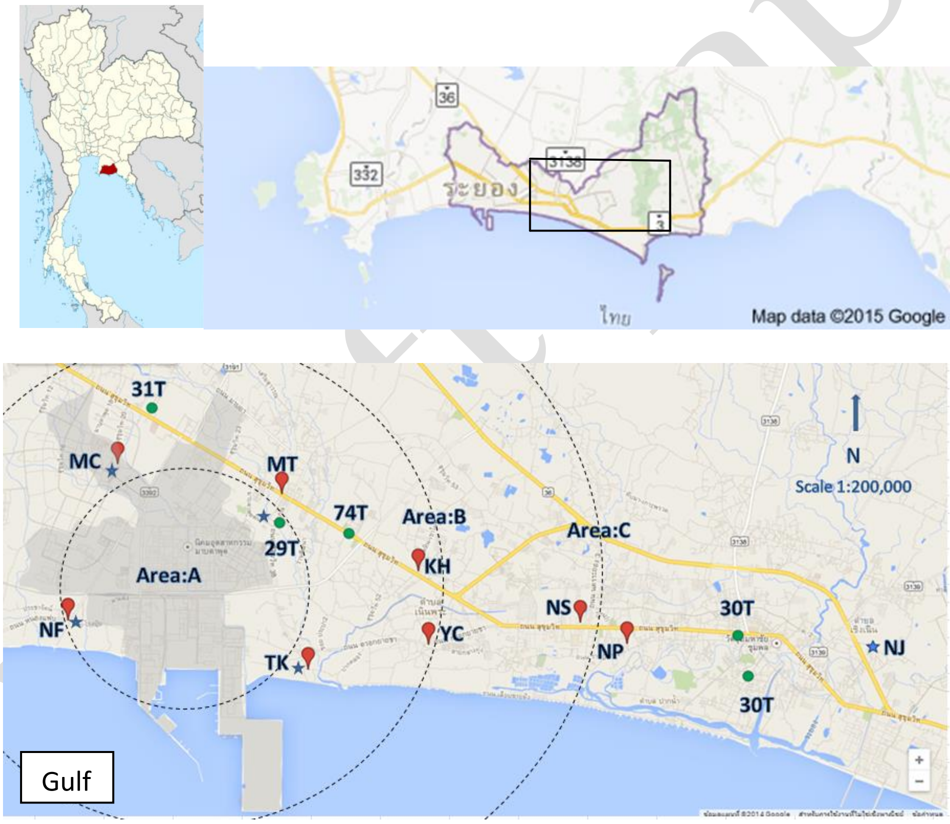

Figure 1: Study location near petrochemical industry.The shaded regions show Map Ta Phut complex.

VOCs monitoring stations PM10 and ozone monitoring stations

Elementary school in each area:

area A (MC = WatMapchalood school, NF= Ban Nongfab school, TK= WatTakurn School, MT= Ban Maptaphut School),

area B(KH= WatKhothinMittraphap school, YC = WatTrokyaycha School) and

area C(NS= WatNongsnom School, NP= WatNuenphraSchool)

Table 2 : AverageVOCs 24 h median concentration, in 2008-2012

Area	Air monitoring station	VOCs (µg/m^3)									
		VinylChloride	1,3Butadiene	Dichloromethane	Chloroform	1,2-Dichloroethane	Benzene	Trichloroethylene	1,2-Dichloropropane	Tetrachloroethylene	Total VOCs
A	MC	0.19*	0.12	0.62*	0.17	0.49*	1.70	0.18	0.10	0.12	3.67*
	NF	0.10*	0.13	0.44	0.24	0.29	2.00	0.18	0.23	0.12	3.71*
	TK	0.18*	0.67*	0.62*	0.12	0.37*	2.85*	0.15	0.09	0.13	5.17*
	MT	0.25*	0.42*	0.70*	0.13	0.63*	2.85*	0.19	0.10	0.13	5.39*
C	NJ	0.04	0.09	0.36	0.11	0.20	1.45	0.16	0.10	0.12	2.61
Annual average standard**		10	0.33	22	0.43	0.4	1.7	23	4	200	

*Significantly higher than control region (areaC) ($p<0.05$), Mann-Whitney U test.
**PCD 2013   Under line = values are exceed the NAAOS

Results

***Lung function test*:**

The 806 subjects, 349 boys and 457 girls were measured lung function, Table 3. Lung function parameters were lower in children living in the industrial region A than in B and C but was not so much significantly different. This may due to small number subjects tested in each area. However, the percentage of impaired lung function in schoolchildren, in A 22.9%, was higher than in the B and C areas15.2% and 18.1% respectively (Table 3).The results of the logistic regression analyses were show in Table6.To evaluate the factors significantly associated with any one of the impaired lung function, independent variables such as gender, age, residential years, home size, family members, parental smoking habits, use of air conditioners, domestic pets and residential area were included in this model. As the results, gender was associated with the prevalence of impaired lung function. The girl significantly increased the prevalence of impaired lung function (OR= 1.94, 95% CI=1.33-2.84).The subjects aged 9 were reported of impaired lung higher than those aged 12(OR= .30, 95% CI=.14-.66). Interestingly, the subjects living in an air conditioner installed house had a reduced risk of impaired lung functions as low as 1.80 times (95%CI=1.14-2.85).

***Respiratory Symptoms*:**

The 806 questionnaires of same subjects as in lung function tests were analyzed and 60% of theses questionnaires were completed by students' mother. Table 4 showed the demographic and risk factor characteristics of these 806 subjects in each study group area A, B and C. All subjects have been livingin the studied sites for at least 1 year and 149 have been in this area more than 10 years (Table 4). The prevalence of respiratory symptoms and impaired lung function of schoolchildren in area A, B and C were shown in Table 5. The respiratory symptoms, chronic bronchitis, bronchial asthma, dyspnea and wheezing, persistent cough, and persistent phlegm were higher in area A than in B and C. The persistent cough and persistent phlegm were significantly higher in children in area A compared with those in area C ($P<0.05$). The results of the logistic regression analyses were show in Table 6,As the results, In children who lived in area A, the prevalence of respiratory symptoms increased significantly compared with those living in the area C (OR= 3.41, 95% CI=1.70-6.85). Gender has slightly increased the significance (OR= 0.46, 95%CI=0.28 -0.75). Other factors such as age, residential years, home size, parental smoking habits, use of air conditioners and domestic pets were not associated.

Table 3 Lung function defect in schoolchildren, Area A, B and C

	Children included in the analysis		
	Area A (n=420)	Area B (n=132)	Area C (n=254)
Lung function*			
FVC(%predicted)	87.9 (10.8)	91.8 (12.8)	90.1 (10.1)
FEV_1 (%predicted)	59.2 (9.4)	60.1 (9.2)	60.7 (9.6)
FEV_1/FVC (%)	103.9 (5.9)	104.9 (6.0)	105.5 (6.0)
FEF_{25-75} (%predicted)	97.8 (22.5)	105.9 (25.1)	105.9 (24.5)
Impaired lung function			
Normal	324	112	208
Impaired lung function, n(%)	96 (22.9%)	20 (15.2%)	46 (18.1%)
Obstruction	0	0	0
Restrictive			
-Mild restrictive	63	12	28
-Moderate restrictive	15	3	5
Mixed obstruction and restrictive	0	0	0
Small airway obstruction or restrictive	18	5	13

*Lung function data are presented as group means (SD)

DISCUSSION

There were total 806 subjects in this study for both questionnaires and lung function analysis. Total school children in 8 selected schools were 2,145 students. Ten percents precision level of sampling size calculated by Yamane, 1973, suggested the minimum number of studied subjects 525.Therefore the number of studied subjects 806 was acceptable. Children living close to the industrial estate area A with high level of PM_{10}andVOCs were found worse respiratory health than those children in the further area B and C. They showed a higher prevalence of persistent cough and phlegm than those living far from the industrial estate. The findings of this study indicate that children living in industrial area could have the impaired lung function and suffer respiratory symptoms. These were conformed to other previous studies in Kulkarni, 2006, Wichman, 2009, Tabaku, 2011 and Pel, 2005. For instance, Kulkarni et al. 2006reported that the small particulate matters entered the lungs and were uptake by macrophages. This demonstrates a direct relationship between the particulate matters density in alveolar macrophages in induced sputum in children and caused lower lung function. In addition, every single increase of 1 μm^2 in macrophage carbon decreases in FVC of 13%, FEV_1 of 17% and FEF_{25-75} of 34.7%, when expressed as a percentage of predicted lung function, were seen.

Table 4: Demographic and risk factor characteristics of children included in the analysis, Map Ta Phut area, 2013 (n=806)

Parameter	Elementary student included in the analysis		
	Area A N=420	Area B N=132	Area C N=254
Mother responder, n(%)	268(63.8)	89(67.4)	150(59.0)
Boys, n(%)	165(39.3)	66(50.0)	118(46.4)
Girls, n(%)	255(60.7)	66(50.0)	136(53.5)
Total born in Rayoung(%)	242(57.6)	67(50.7)	140(55.1)
Mean age ± SD[b](years)	10.96 ±0.9	10.77 ±0.8	10.63 ±0.9
Mean height ± SD[b](cm.)	144.08 ±9.1	140.66 ±8.7	144.05 ±9.9
Mean weight ± SD[b](kg.)	38.67 ±11.3	37.01 ±11.6	39.26 ±12.5
Residential years, n(%)			
0-5	110(26.2)	53(40.2)	103(40.6)
6-10	211(50.2)	63(47.7)	109(42.9)
>10	91(21.7)	16(12.1)	42(16.5)
History of allergic diseases, n(%)			
Dust and Other chemical	96(22.8)	15(11.4)	47(18.5)
Home environmental Exposure			
Home size,room, n(%)			
1	154(36.7)	37(28.0)	61(24.0)
2-5	256(61.0)	91(68.9)	181(71.3)
>5	3(0.7)	1(0.7)	9(3.5)
Family members,n(%)			
1-5	340(81.0)	104(78.8)	198(78.0)
6-10	73(17.4)	22(16.7)	51(20.1)
>10	3(0.7)	1(0.8)	2(0.8)
People sleep with children smoke	89(21.2)	23(17.4)	37(14.6)
Cooking in home			
Gas	347(82.6)	90(68.2)	158(62.2)
Electricity	11(2.6)	5(3.8)	19(7.5)
Coal	13(3.1)	7(5.3)	1(0.4)
Other	48(11.4)	29(22.0)	75(29.5)
Use of air conditioners, n(%)	85(20.2)	26(19.7)	136(53.5)
Domestic pet, n(%)	232(55.2)	73(55.3)	117(46.1)
Parental smoking habits, n(%)	181(43.1)	53(40.2)	96(37.8)
Socioeconomic status			
Father' Education			
No formal education	2(0.5)	2(1.5)	0
Primary school	157(37.4)	45(34.1)	49(19.3)
High School	127(30.2)	39(29.6)	69(27.2)
Bachelor's Degree or higher than	40(9.5)	12(9.1)	75(29.5)
Mother' Education			
No formal education	9(2.1)	5(3.8)	1(0.4)
Primary school	171(40.7)	47(35.6)	60(23.6)
High School	155(36.9)	46(34.9)	90(35.4)
Bachelor's Degree or higher than	26(6.2)	11(8.3)	48(18.9)

Wichman et al. 2009 and Ramchev et al. 2004 suggested that VOCs had directly associated with lung function and respiratory systems among children. In the current study 3 VOCs 1,3-Butadiene, 1,2-Dichloroethane, and Benzene, were exceeded the NAAQS level, Table 2. The highest concentration was detected in north of the MTPIE and the lowest concentration in the west of the MTPIE. This could influence from a part of the sea breeze during the day, the wind blew mostly from the southwest to the northeast. The emissions were carried toward the community to the north of MTPIE, Tanyanont, 2012.High concentrations of benzene and 1,3 butadiene were detected at the monitoring station, close to the factories and the main roads, indicating that both stationary and mobile sources play major roles in contributing such high concentration VOCs. While 1,2dichloroethane was observed merely at the monitored site close to the plastic factory, which used this compound as raw materials in the production process (Thepanondh, 2011).

The high prevalence of impaired lung functions in children in area A Table 3 were in agreement with the previous reports in other industrial sites (Kulkarni et al.,2006 andWichman et al,2009). Gender was associated with the prevalence of impaired lung function. The girls' respiratory health suffered from impaired lung function more than their counterpart1.94 times. The children aged 9 suffered more impaired lung than those aged 12. These may due to the lung physiology development different between age and gender (Hibbert, 1995, Becklake 1999, Uekert 2006). Hence, Langkulsen, 2006 and Wichman, 2009 investigated symptoms and lung function of the children found no different in gender. The current findings also indicate that other contributing factor resulting in impaired lung functions is the course of time spent in the risk area rather than sex difference. Moreover, it is also revealed that availability of home air conditioner is a contributing factor resulting in decreased prevalence of impaired lung function with statistical significance Table 6.

From the questionnaires analysis in Table 5, the prevalence of chronic respiratory symptoms (NSRD and PCD) in area A was higher than in area B and C. The persistent cough and persistent phlegm in area A was higher than in area C ($p<0.05$), which was similar to the findings of Wilson et al, 2008. The areas different in pollutants exposure could also depend on the proportion of time children spending outdoors. If they had spent outdoors in a longer period of time, children could expose higher pollutants. In this study, we assumed that all students in each area spent the same time outdoor activities. However, girls have a higher risk of the respiratory symptoms than boys 0.46 times (95%CI=0.29-0.75). The boys could enjoy outdoor activities rather than indoors, so they could have more pollutants exposure than girls. Our hypothesis is similar to the finding of Ana Claudia Lopes de Moraes ACL et al, 2010, who examined the association between wheezing in children and adolescents and living downwind of dispersion plum of pollutants emitted by petrochemical complex, Brazil. Even with low levels of pollutants, the prevalence of wheezing was higher in male 2.5 times. Interestingly, male preschoolers were the most vulnerable group, probably due to differences in the physiology of the airways (Uekeit, 2006). Liu F et al.2014 examined the association between outdoor and indoor air pollution and respiratory diseases among children aged 6 to 13 years living in a heavy industrial province of China and they found that the prevalent rates of asthma and asthma related symptoms in male were significantly higher than that in female (p<0.05).

Table 5: Number and prevalence (%) of respiratory symptoms and impaired lung function (n=806)

Area[a]	Site	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	
A	MC	35 (33.0%)	2(1.9)	7(6.6)	10(9.4)	9(8.5)	6(5.7)	2(1.9)	24(22.6)
	NF	12 (21.4%)	0	2(3.6)	6(10.7)	2(3.6)	3(5.3)	1(1.8)	10(17.8)
	TK	18 (21.7%)	0	3(3.6)	3(3.6)	0	2(2.4)	0	7(8.4)
	MT	31 (17.7%)	2(1.1)	4(2.3)	5(2.8)	8(4.6)	3(1.7)	1(0.6)	17(9.7)
	total	96 (22.9%)	4(0.9)	16(3.8)	24(5.7)	19(4.5)*	14(3.3)*	4(0.9)	58(13.8)*
B	KH	9 (15.0%)	1(1.7)	2(3.3)	2(3.3)	2(3.3)	1(0.7)	1(1.7)	6(10)
	YC	11 (15.3%)	0	2(2.8)	0	1(1.4)	0	0	3(4.2)
	total	20 (15.2%)	1(0.7)	4(3.0)	2(1.5)	3(2.3)	1(0.7)	1(0.7)	9(6.8)
C	NS	23 (23.7%)	0	1(1.0)	3(3.1)	1(1.0)	0	0	5(5.1)
	NP	23 (14.6%)	0	2(1.3)	4(2.5)	1(0.6)	0	0	7(4.4)
	total	46 (18.1%)	0	3(1.2)	7(2.7)	2(0.8)	0	0	12(4.7)

a: area A= 4 school that located within1 km. from MTPIE ; area B= 2school that located close to5 km. from MTPIE ; area C= 2school that located close to 10 km. from MTPIE.
b: Results from spirometry test; obstructive ventilatory defect(FEV_1< 80% predicted), restrictive ventilatory defect (FVC< 80% predicted), mixed obstruction and restriction(FEV_1 and FVC< 80% predicted), and small airway obstruction or restrictive (MMEF < 65% predicted)
c: Non-specific respiratory disease, results from the ATS-DLD questionnaire
d: Persistent cough and phlegm, results from the ATS-DLD questionnaire
e: Results from the ATS-DLD questionnaire
*ρ<0.05 by chi-squared test compared with area C

According to a demographic data in Table 4, the level of parents' education has a correlation with health and sickness of their children (Van Lenthe et al, 2004). The children in area C has least prevalence of respiratory diseases and the children's parents in area C have a significantly higher level of education compared to parents in area A and B. However, according to investigation of the correlation, the level of parents' education has no correlation with symptoms of respiratory systems of children. Yang et al, 1997, Tanyanont, 2012, found high acute symptoms more significantly than chronic respiratory symptoms in adults living near an industrial estate. This suggests that children have high susceptibility to pollutant, thus expressing chronic symptoms. We found children have increased exposure to substantial air pollutants compared with adults because of higher minute ventilation and a higher level of physical activities. Spending more time outdoors than do adults, children have increased exposures to outdoor air pollution (Tabaku, 2011)

Table 6: Logistic regression analyses for the association between some independent variables, any of the respiratory symptoms and impaired lung function among school children in Map Ta Phut area

Independent variables	Children (n=806)	
	Any of the respiratory symptoms OR (95% CI)^a	Impaired lung function OR (95% CI)^a
Gender *ref: boy	0.46 (.28-.75)*$^{.002}$	1.94 (1.33-2.84)*$^{.001}$
Age *ref: 9 year		
10 year	2.36 (0.52-10.63)	0.55 (0.27-1.11)
11 year	1.99 (0.44-9.03)	0.56 (0.28-1.13)
12 year	1.74 (0.37-8.13)	0.30 (0.14-.66)*$^{.002}$
Use of air *ref: use air	1.00 (0.55-1.81)	1.80 (1.14-2.85)* $^{.012}$
Areas^b *ref: area C		
A	3.41 (1.70-6.85)*$^{.001}$	1.24 (0.80-1.94)
B	1.36 (0.54-3.45)	0.68 (0.37-1.26)

a: OR: odds ratio, CI: confidence interval

b: area A= school that located within1 km. from MTPIE ; area B= school that located close to5 km. from MTPIE ; area C = school that located close to 10 km. from MTPIE

*Significantly higher than control area ($p < .05$)

The means of PM_{10} (44 µg/m^3) in this current study were lower than those of PM_{10} (59 µg/m^3) in the petrochemical polluted area, similar to Map Ta Phut industrial state in 2013(Kongtip, 2013) and PM_{10} (93.6 µg/m^3) in the industrial estates in Taiwan (Yang,1997). When comparing between the air pollutants in the petrochemical polluted area in present study and the traffic polluted area in Bangkok Thailand, the average level of PM_{10} (44 µg/m^3) in the industrial, polluted area in Rayong Province was considerably lower than the average PM_{10}(65µg/m^3) in the traffic-polluted area in Bangkok (Langkulsen, 2006). The prevalence of symptoms of respiratory systems of children in Bangkok and that of the control group accounted for 22% and 6.8%, respectively, while in this study the study group and control group accounted for 14.9% and 5%, respectively. It can be seen that the children living or studying close to the industrial polluted area have high exposure to lower air pollutants than those in the traffic-polluted area, but it is noted that the chemical compositions in the traffic-polluted area may not comparable to the petrochemical polluted area since toxicity of chemicals depends on types and composition of chemical (Kongtip, 2013).

Finally, all of the volunteer schools in this study were under Rayong Primary Education Service and the schoolchildren subjects were confirmed by their teachers that they were not involved with smoking or narcotic drugs. Some important limitations need to be considered. The obtained monitoring data may not be exactly in the source areas either close to school. We can use only the assessable and available data. Some incomplete questionnaires were excluded. Lung Function test is the time consuming process because of the subjects and trainees performance.

CONCLUSIONS

The data from the present study show that living in area MTPIE with higher level of pollutants, both PM_{10} and VOCs is associated with an increased prevalence of chronic bronchitis, bronchial asthma, dyspnea and wheezing, cough, phlegm and lower lung function. The results also suggest that the petrochemical air pollutants are harmful to population in the close proximity of the industrial estate. Eventually, the health risk may lie particularly in children.

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APPENDIX: Definition of respiratory symptoms

Respiratory symptom		Definition
non-specific respiratory disease: NSRD	chronic bronchitis	phlegm production from the chest two times/day for 4 days/week for 3 months/year for at least 3 years
	bronchial asthma	doctor diagnosed asthma and still have asthma
	dyspnea and wheezing	wheezing or whistling in the chest apart from cold on most days or nights
persistent cough and phlegm : PCP	persistent cough	cough apart from cold on most days more than 4 days/week for 3 months/year for at least 1 year
	persistent phlegm	congested in the chest or bring up phlegm, sputum, or mucus apart from cold on most days more than 4 days/week for 3 months/year for at least 1 year

Adapted from ATS-DLD-78-C Questionnaire

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