Indoor Particulate Matter 2.5 ($PM_{2.5}$) and Lung Function among Children Living Near Busy Road in Cheras, Kuala Lumpur

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ABSTRACT: A huge amount of cars in the city, mostly heavy traffic jam during rush hours may cause air pollution. Epidemiological studies have provided evidence that exposure to $PM_{2.5}$ decreases the lung function among children living near busy road. The aim of this study was to determine the exposure of indoor $PM_{2.5}$ and lung function among children living near busy road, and comparative group of children living near less busy road in Cheras, Kuala Lumpur. Purposive sampling method was used where the samples selected were those who fulfilled the inclusive criteria for each location studied. Personal and socio-demography background, and other related information were adopted from standardized and structured questionnaire of American Thoracic Society. Air sampling pumps based on gravimetric principle were used to measure indoor $PM_{2.5}$in the respondents' house. Lung function was measured using Chest Graph Spirometry. There was a significant difference of indoor $PM_{2.5}$, lung function abnormality and respiratory symptoms between exposed and comparative group with the value of (t=-2.496, p=0.014); (χ^2=17.926, p=0.000) and (χ^2=7.259, p=0.007) for predicted FEV% and FVC%; and (p=0.000) respectively; however overall lung function status was weakly associated with indoor $PM_{2.5}$.Children living near busy road have significantly higher indoor $PM_{2.5}$concentration than less busy road which makes them at higher risk of respiratory illnesses. However, the specific airborne toxicants that facilitate and promote respiratory effects are still not clearly known. Since population characteristics are specific, the results of this study cannot be generalized.

Keywords: Children, lung function, $PM_{2.5}$, respiratory symptoms

Introduction

Particulate Matter (PM) can be divided into different size fractions, PM_{10} (PM ≤/10 mm), $PM_{2.5}$ (PM ≤/2.5 mm) and $PM_{0.1}$ (PM ≤/0.1 mm), based on the aerodynamic diameter (50% cut off) of the particles, and measured as mass (WHO, 2005). Major sources of $PM_{2.5}$ include power plants, oil refinery and metal processing facilities, tailpipe and brake emissions from mobile sources, residential fuel combustion, and wildfires (Simkhovich, 2008).

The capacity of particulate matter to produce adverse health effects in humans depends on its deposition in the respiratory tract. Particle size, shape, and density affect deposition rates. The most important characteristics influencing the deposition of particles in the respiratory system were size and aerodynamic properties. Particles with aerodynamic diameter smaller than 2.5µm ($PM_{2.5}$), called fine particles, correspond to the respirable particle fraction capable of penetrating the alveolar region of the lung. Inhaled particles come in contact with surface of the respiratory system. These particles passed the proximal airway (throat and larynx) of the respiratory tract, and deposited in the tracheobronchial conductive airway of the lungs (bronchial and bronchiolar airway) or in the gas exchange region (respiratory bronchioles, alveolar ducts, and alveoli of the lung parenchyma (WHO, 2005).

Study done by Pope *et al* (2002) also provided strong evidence that long-term exposure to fine particulate air pollution common to many metropolitan areas was an important risk factor for cardiopulmonary mortality. In addition, elevated fine particulate air pollution exposures were associated with significant increases in lung cancer mortality. Although potential effects of other unaccounted factors cannot be excluded with certainty, the associations between fine particulate air pollution and lung cancer mortality, as well as cardiopulmonary mortality, are observed even after controlling for cigarettes smoking, BMI, diet, occupational exposure, other individual risk factors, and after controlling for regional and other spatial differences.

Children were at greater risk from exposure to air pollution, including fine particles, than adults because their bodies were still growing, they took in a greater volume of air per pound of body weight than adults do, and they spent more time doing physical activities outdoors. A more recent study emphasized the importance of proximity to freeways as another factor affecting lung function in children. In this study, children living in southern California (mean age = 10 years) living 500 yards from freeways had substantial deficits in lung function growth compared to children living at least 1500 meters from a freeway (Gauderman, 2007).

A child's exposure to $PM_{2.5}$occurs in a variety of outdoor settings, and in some instances, outdoor PM can move indoors through windows, open doors, and other openings or through the ventilation system, resulting in higher overall exposures of $PM_{2.5}$ (and other pollutants). Residing close to major streets and highways increases the risk of developing adverse health effects, as does living near other potential sources, especially high-risk sources such as outdoor wood boilers, open burning of yard and household trash, and burning of agricultural and construction wastes (Bruce, 2005).

This study was conducted to determine the indoor $PM_{2.5}$and lung functions among children living near busy road in Cheras, Kuala Lumpur. Based on previous study carried out, it showed that this study was relevant to be executed as it was anticipated to give knowledge to the public and parents specifically about the risk of getting lung abnormalities due to exposure to indoor air pollution from traffic emissions.

Methodology

Study Design

A cross-sectional comparative study design was used in this study where it aimed to measure ambient exposure variables and health effects simultaneously. Therefore, the indoor exposure of the particulate matter ($PM_{2.5}$) and the lung function among children living near busy road and near less busy road were determined by using this study. Two study groups were identified based on their exposure probability to traffic air pollutants ($PM_{2.5}$). Exposed group was those children living near busy road and comparative group was children living near less busy road.

Subject selection

Purposive sampling method was used where the samples selected were those who fulfilled the inclusive criteria for each location in this study. The samples were selected among children aged 7 to 12 from both exposed and comparative groups. The selection of samples were done to prevent any psychosocial confounder where any person older than the age of 12 will have higher chances to involve in social problems such as smoking, illegal race, and so on which will increase their probability to have exposure to $PM_{2.5}$ other than from traffic exhaust. Children had more lung surface area compared to their body weight and therefore inhale more air pound-for-pound than adults (Bruce, 2005). Furthermore, children with existing chronic medical history were excluded to ensure all the respondents were those of healthy person and the current exposure that affected the lung function were not influenced by their medical status. All the respondents were children that lived at the same place since born. This selection being made to remove the possibility of other than $PM_{2.5}$exposure or exposure to $PM_{2.5}$ which was not due to traffic emission affected the respondents. Moreover, only 1 race which was Malay was studied. Race was frequently used by clinicians and biomedical researchers to make inferences about an individual’s ancestry and to predict whether an individual carries specific genetic risk factors that influence health (Barnshad, 2005). This was to homogenize the respondents so that no confounding genetic factor influenced the result validity. Other than that, it was important to exclude any respondent who owns pet as this confounding factor may lead to wrong association of health effect and exposure. Pet possess allergens and technological advances have made it possible to test the hypotheses that environmental allergen exposure was related to sensitization, asthma prevalence and severity, and asthma incidence rates. In addition, asthma prevalence and severity have clear dose-response relationships to allergen exposure (Eggleston, 2009).

Selections of studied places were based on traffic counts and distance to the road where traffic counts were performed on roads where the houses of the respondents were located within 100m. Distances from residences to roads were measured using maps at 1:10 000 or 1:5000 scale. Traffic counts were used to differentiate between busy road and less busy road.

Materials and Data Collection

Questionnaires

Personal and socio-demography background, and other related information were obtained from standardized and structured questionnaire of American Thoracic Society.

Air Monitoring

Prior to execution of air monitoring, all sampling equipments such as assorted flexible rubber tube, pumps, cyclone, cassettes and filter paper were prepared accordingly. Air sampling pumps based on gravimetric principle were used to measure indoor $PM_{2.5}$in the respondents' house. The cyclone attached to the instrument was put at the high of respondent's breathing area while the instrument itself was positioned at the area of common routine activities performed by the children inside the house to measure ambient $PM_{2.5}$ indoor. Prior to monitoring, communication on procedures on the sampler and importance to follow the procedures were given to the respondents to avoid any misused of the instruments. Calibration of each of the personal air sampling pump was done before the monitoring. These exposure monitor and calibration was carried out based on National Institute of Occupational Safety and Health United States (NIOSH US) standard method. The cassettes containing samples collected were sealed with parafilm and transported in zip lock plastic bags. Then they were stored in desiccators for further analysis.

$PM_{2.5}$Concentration Analysis

Analyses on $PM_{2.5}$were done based on NIOSH standard method 1994.

Spirometry/ Lung Function Test

Lung function was measured using Chest Graph Spirometry. Prior to the test, respondents' weight were taken using Tanita digital machine and height without shoes measurements were obtained by SECA body meter. Spirometric measurements include forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), FEV_1/FVC%. All subjects were trained to properly blow 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 analyses. Test acceptability was determined by examining the flow and volume time curve as recommended by ATS. FEV_1 and FVC (greater than) 80% predicted were used as the criteria for normal lung function. The test was carried out based on the American Thoracic Society (ATS) Standardisation of Spirometry where the values were adjusted based on Malaysian children normal value by Azizi (1994).

Data analysis

Univariate analysis was a descriptive analysis where it was conducted to analyze the mean, median, mode and standard deviation value of the data obtained from the study carried out. All the data collected were analyzed using Statistical Package for Social Sciences (SPSS version 15) where this includes the modified questionnaires distributed, air monitoring and spirometric test carried out.

As for the bivariate test, the value of indoor $PM_{2.5}$ of exposures monitoring were analyzed to compute the comparison between exposure near busy road and less busy road by using parametric t-test. Lung function status and lung function symptoms also were compared among children living near busy road and less busy road where parametric t-test and non parametric Mann Whitney U test were used. All the variables in this study were analyzed according to univariate and bivariate analysis.

Results

The study consists of 108 respondents where it was divided into two groups that were 54 respondents for each exposed and comparative group. All the respondents selected fulfilled the inclusive criteria set where all the respondents were Malay male children living near busy road.

Exposure to Indoor $PM_{2.5}$ Sources

Table 1 showed the possible indoor particulate matter 2.5 ($PM_{2.5}$) sources. Several of the sources were usage of mosquito repellant, indoor smoking and cooking activities. The number and percentage of the used of mosquito repellant showed that 39 (72.2%) and 47 (87%) of the exposed and comparative group respondents used the repellant respectively. As for indoor smoking of exposed and comparative group respectively, 46 (85.2%) and 47 (87%) of the respondents' father smoke inside the house whereas none of the mothers were. Moreover, all the respondents' families performed cooking activities at home.

Table 1: Comparison between exposed and comparative group of indoor $PM_{2.5}$ sources

Variables	**Exposed Group (n = 54)**	**Comparative Group (n = 54)**	**χ^2value**	**p value**
	Number (%)	**Number (%)**		
Mosquito Repellant Use				
Yes	39 (72.2)	47 (87)	37.926	0.0001*
No	15 (27.8)	7 (13)		
Indoor Smoking				
Yes (Father)	46 (85.2)	47 (87)	56.333*	0.0001*
No (Father)	8 (14.8)	7 (13)		
Yes (Mother)	0 (0.0)	0 (0.0)	-	
No (Mother)	54 (100)	54 (100)		
Cooking Activity				
Yes	54 (100)	54 (100)	-	
No	0 (0.0)	0 (0.0)		

* Statistically significance at $p < 0.0001$

Table 2 showed in depth information on possible indoor $PM_{2.5}$ information where it will be clarified on the types of mosquito repellant used, types of smoking material and types of cooking style. There were several types of mosquito repellants used by the respondents; mosquito coils, mosquito net, electrical and aerosol spray. Based on these types, respondents' number and percentage of each exposed and comparative group were 15 (38.5%) and 21 (44.7%) for use of mosquito coils; 2 (5.1%) and 5 (10.6%) for use of mosquito net; 7 (17.9%) and 3 (6.4%) for use of electrical mosquito repellant; and 15 (38.5) and 18 (38.3%) for use of aerosol spray respectively.

As for the types of smoking materials, none of the respondents' father smoked cigar and/or pipe. However, 43 (93.5%) and 43 (91.5%) of the exposed and comparative group respondents' father respectively smoked cigarettes. 3 (6.4%) of the comparative group and none of the exposed group respondents' father smoked both the cigarettes and pipes. Furthermore, only 1 (2.1%) of the comparative group and 3 (6.5%) of the exposed group respondents' father smoked both cigarettes and cigar. Referred to **Table 2**, types of cooking style, it showed that 41 (75.9%) and 52 (96.3%) of the exposed and comparative groups used liquid petroleum gas (LPG) respectively. In addition, 2 (3.7%) and none of the exposed and comparative groups use electric/hot plate to cook; whereas, 11 (20.4%) and 2 (3.7%) of the exposed and comparative groups use both LPG and electric/hot plate respectively.

Table 2: Comparison between exposed and comparative group of indoor $PM_{2.5}$ sources

Variables	**Exposed Group (n = 54)**	**Comparative Group (n = 54)**	**χ^2 value**	**p value**
	Number (%)	**Number (%)**		
Types of Mosquito Repellant Used	**(n_{1b} = 39)**	**(n_{1a} = 54)**		
Mosquito Coils	15 (38.5)	21 (44.7)	31.860	0.0001*
Mosquito net	2 (5.1)	5 (10.6)		
Electrical	7 (17.9)	3 (6.4)		
Aerosol Spray	15 (38.5)	18 (38.3)		
Types of Smoking Materials	**(n_{2b} = 46)**	**(n_{2a} = 47)**		
Cigarettes	43 (93.5)	43 (91.5)	146.387	0.0001*
Cigarettes and pipe	0 (0.0)	3 (6.4)		

Cigarettes and cigar	3 (6.5)	1 (2.1)		
Types of Cooking Styles	**(n_{3b} = 54)**	**(n_{3a} = 54)**		
Liquid Petroleum Gas (LPG)	41 (75.9)	52 (96.3)	137.056	0.0001*
Electrical (Hot Plate)	2 (3.7)	0 (0.0)		
LPG and electrical	11 (20.4)	2 (3.7)		

* Statistically significance at $p < 0.0001$

Table 3 showed the frequency of exposure to possible indoor $PM_{2.5}$ sources. For the mosquito repellant used, the indoor $PM_{2.5}$ sources that have been recognize to give significance exposure were by the used of mosquito coils and aerosol spray; therefore, both of these variables were studied deeper. Based on the table, the result of the amount of mosquito coils used weekly for exposed and comparative groups were 7 (46.7%) and 12 (57.1%) for less than 7 times; and 8 (53.3%) and 9 (42.9%) for equals or more than 7 times respectively. As for the amount of aerosol spray used weekly for exposed and comparative groups were 11 (73.3%) and 10 (55.6%) for less than 7 times; and 4 (26.7%) and 8 (44.4%) for equals of more than 7 times respectively. On the other hand, for smoking activity of exposed and comparative groups, the table showed that 34 (73.9%) and 28 (59.6%) for less than 7 times; and 12 (26.1%) and 19 (40.4%) for equals of more than 7 times a day the indoor smoking activity were executed respectively. Moreover, in the table it showed, the amount of cooking activities carried out for exposed and comparative groups were 32 (59.3%) and 44 (81.5%) for less than 2 time; and 22 (40.7%) and 10 (18.5%) for equal or more than 2 times a day respectively.

Table 3: Comparison between exposed and comparative group of indoor $PM_{2.5}$ sources

Variables	**Exposed Group (n = 54)**	**Comparative Group (n = 54)**	**χ^2value**	**p value**
	Number (%)	**Number (%)**		
Amount of Mosquito Repellant Used				
Mosquito Coils/Weekly (No. of mosquito coils used)	**(n_{4b} = 15)**	**(n_{4a} = 21)**		

≥ 7	7 (46.7)	12 (57.1)	0.111	0.739
< 7	8 (53.3)	9 (42.9)		
Aerosol SprayUsed/Weekly (Frequency)	**(n_{5b} = 15)**	**(n_{5a} = 18)**		
≥ 7	11 (73.3)	10 (55.6)	2.455	0.117
< 7	4 (26.7)	8 (44.4)		
Amount of Smoking Activity/Day (No. of cigarettes)	**(n_{6b} = 46)**	**(n_{6a} = 47)**		
≥ 20	34 (73.9)	28 (59.6)	10.333	0.001**
< 20	12 (26.1)	19 (40.4)		
Amount of Cooking Activity/Day (Daily)	**(n_{7b} = 54)**	**(n_{7a} = 54)**		
≥ 2	32 (59.3)	44 (81.5)	17.926	0.0001*
< 2	22 (40.7)	10 (18.5)		

* Statistically significance at $p < 0.0001$

** Statistically significance at $p < 0.05$

The comparison between exposed and comparative group of indoor particulate matter 2.5 ($PM_{2.5}$) sources information were shown in **Table 1, 2** and **3.** The statistical results obtained demonstrated that indoor $PM_{2.5}$ sources that were mosquito repellant used; fathers' indoor smoking; types of mosquito repellant used, smoking materials and cooking styles; and amount of smoking and cooking activity showed significant difference between exposed and comparative group based on Chi Square test carried out. However, as for the amount of mosquito coils and aerosol spray used, the study showed no significant difference between exposed and comparative group with p value of (0.111) and (0.739); and (2.455) and (0.117).

Indoor Particulate Matter 2.5 ($PM_{2.5}$) Concentrations

$PM_{2.5}$ measurements have been conducted throughout all respondents' houses where the measurements were carried out for 24 hours. *Kolmogorov Smirnov* normality test was carried out and the result showed that the $PM_{2.5}$ distribution for exposed and comparative group were normal that was ($p>0.05$) with mean and standard deviation of (13.81 ± 5.004) and (11.37 ± 5.139) respectively.

Table 4 showed the comparison between exposed and comparative group of indoor $PM_{2.5}$ concentration. The statistical results obtained demonstrated that indoor $PM_{2.5}$ concentration showed significance difference between exposed and comparative group with t value and p value of (-2.496) and (0.014).

Table 4: Comparison of exposed and comparative group of indoor $PM_{2.5}$ concentration

Variables	**Exposed Group (n = 54)**		**Comparative Group (n = 54)**		**t value**	**p value**
	Mean ± SD	**Range**	**Mean ± SD**	**Range**		
Indoor $PM_{2.5}$(μg/m^3)	13.81 ± 5.00	2.85 – 25.06	11.37 ± 5.14	2.85 – 21.64	-2.496	0.014*

* Statistically significance at $p < 0.05$

Respondents' Lung Function

Lung function test has been carried out to all respondents' using Chest Graph spirometer. The outcomes of the *Kolmogorov Smirnov* normality test confirmed that all the data analyzed were normally distributed. **Table 5** showed the comparison between exposed and comparative group of respondents' measured FEV_1, FVC and FEV_1/FVC; and predicted FEV_1 %, FVC % and FEV_1/FVC %. The statistical results obtained demonstrated that respondents' measured FEV_1, FVC and FEV_1/FVC ; and predicted FEV_1 % and FVC % showed no significance difference between exposed and comparative group with the t/Z value and p value of (0.137) and (0.892); (0.252) and (0.802); (-1.343) and (0.179); (1.444) and (0.152); and (1.605) and (0.112) respectively. Meanwhile, **Table 5** showed no significance difference of predicted FEV_1/FVC % between exposed and comparative group with the Z value and p value of (-2.517) and (0.012) based on Mann Whitney U test.

Table 5: Comparison between exposed and comparative group of lung function status based on FEV_1 and FVC

Variable	Exposed Group (n = 54)		Comparative Group (n = 54)		t/Z value	p value
	Mean ± SD	**Range**	**Mean ± SD**	**Range**		
Measured FEV_1 (L)	1.51 ± 0.54	0.49 – 2.46	1.52 ± 0.35	0.84 – 2.39	0.137[b]	0.892
Measured FVC(L)	1.52 ± 0.55	0.49 – 2.46	1.54 ± 0.34	0.90 – 2.39	0.252[b]	0.802
Measured FEV_1/ FVC(L)	1.00 ± 0.02	0.93 – 1.00	0.99 ± 0.03	0.85 – 1.00	-1.343[a]	0.179
Predicted FEV_1%	94.80 ± 38.72	26.91 – 170.74	104.86 ± 33.46	51.62 – 207.21	1.444[b]	0.152
Predicted FVC%	87.25 ± 35.72	24.52 – 159.02	97.65 ± 31.49	48.55 – 193.13	1.605[b]	0.112
Predicted FEV_1/ FVC%	1.09 ± 0.02	1.02 – 1.10	1.08 ± 0.04	0.92 – 1.10	-2.517[a]	0.012*

* Statistically significance at $p < 0.05$ [a] Mann Whitney U Test [b] t-Test

All the respondents (children) lung function status has been categorized based on ATS (2005) to verify the abnormality of the lung functions. **Table 6** showed the lung function abnormality prevalence based on predicted FVC %, predicted FEV_1 %, and predicted FEV_1/FVC %. From the table, it showed that 42 (77.8%) of the comparative group 34 (63%) of the exposed group have normal lung function status; whereas 12 (22.2%) of comparative group and 20 (37%) of exposed group have abnormal lung function based on predicted FEV_1% indicator. As for the predicted FVC % indicator, the lung function abnormality prevalence for exposed and comparative group were 30 (55.6%) and 38 (70.4%) respectively normal; and 24 (29.6%) and 16 (44.4%)

respectively abnormal. Table 6 also showed the predicted FEV_1/FVC % indicator, where the lung function abnormality prevalence for exposed and comparative group were all 54 (100%) normal. Moreover, **Table 6** showed the comparison between exposed and comparative group of respondents' abnormality prevalence based on predicted FVC %, predicted FEV_1 %, and predicted FEV_1/FVC %. The statistical results obtained demonstrated that predicted FVC % and FEV_1 % were significantly different between exposed and comparative group with the Chi Square value and p value of (17.926) and (0.000); and (7.259) and (0.007) respectively. In contrast, predicted FEV_1/FVC % was not significantly different between exposed and comparative group with the Chi Square and p value of (37.889) and (1.000).

Table 6: Comparison between exposed and comparative group of lung function abnormality prevalence

Variables	Exposed Group (n = 54)	Comparative Group (n = 54)	χ^2 value	p value
	Number (%)	Number (%)		
Predicted FEV_1 %				
Abnormal	20 (37)	12 (22.2)	17.926	0.000*
Normal	34 (63)	42 (77.8)		
Predicted FVC %				
Abnormal	24 (44.4)	16 (29.6)	7.259	0.007**
Normal	30 (55.6)	38 (70.4)		
Predicted FEV_1/FVC				
Abnormal	0 (0.0)	0 (0.0)	37.889	1.000
Normal	54 (100)	54 (100)		

* Statistically significance at $p < 0.0001$

** Statistically significance at $p < 0.05$

Respondents' respiratory symptoms

Table 7 showed the respondents' respiratory symptoms. Several of the respiratory symptoms studied were chronic cough, congestion and/or phlegm, wheezing and chest illness. The prevalence was obtained from the questionnaire given to the respondents. Referring to the table above, it showed that 17 (31.5%) and 7 (13%) of the exposed and comparative group respectively had chronic cough without colds; whereas, 37 (68.5%) and 47 (87%) did not. Furthermore, as for congestion and/phlegm without colds, the number and percentage of exposed and comparative group having the symptoms were 13 (24.1%) and none; and 41 (75.9%) and 54 (100%) of the respondents did not. Moreover, as for wheezing without colds, the number and percentage of exposed and comparative group having the symptoms were 2 (3.7%) and none; and 52 (96.3%) and 54 (100%) of the respondents did not. Chest illness, on the other hand, states 7 (13%) and 2 (3.7%) of the respondents of exposed and comparative group had the symptoms; while 52 (96.3%) of comparative group and 47 (87%) of exposed group did not.

Table 7: Comparison between exposed and comparative group of respondents' respiratory symptoms

Variables	**Exposed Group (n = 54)**	**Comparative Group (n = 54)**	**χ^2 value**	**p value**
	Number (%)	**Number (%)**		
Chronic Cough Without Colds				
Yes	17 (31.5)	7 (13)	33.333	0.000*
No	37 (68.5)	47 (87)		
Congestion and/or Phlegm Without Colds				
Yes	13 (24.1)	0 (0.0)	62.259	0.000*
No	41 (75.9)	54 (100)		
Wheezing Without Colds				
Yes	2 (3.7)	0 (0.0)	-	-

No	52 (96.3)	54 (100)		
Chest Illness (prevent usual activities)				
Yes	7 (13)	2 (3.7)	75.000	0.000*
No	47 (87)	52 (96.3)		

* Statistically significance at $p < 0.0001$

The comparison between exposed and comparative group of respondents' symptoms were shown in **Table 8**. The statistical results obtained demonstrated that all the respondents' symptoms that were chronic cough without colds, congestion and/or phlegm without colds and chest illness that prevented usual activities show significance difference between exposed and comparative group with the Chi Square value and p value of (33.333) and (0.000); (62.259) and (0.000); and (75.000) and (0.000) respectively.

TABLE 8: Association of Indoor $PM_{2.5}$ Concentration with Predicted FEV_1 %, FVC % and FEV_1/FVC %

Variables	**Exposed Group Indoor $PM_{2.5}$ Concentration (mg/m^3)**		**Comparative Group Indoor $PM_{2.5}$ Concentration (mg/m^3)**	
	r value	**p value**	**r value**	**p value**
Measured FEV_1 (L)[b]	-0.063	0.327	0.157	0.129
Measured FVC(L)[b]	-0.079	0.286	0.085	0.271
Measured FEV_1/FVC(L)[a]	0.131	0.172	0.403	0.001*
Predicted FEV_1%[b]	-0.044	0.376	0.023	0.436
Predicted FVC %[b]	-0.062	0.328	-0.034	0.404
Predicted FEV_1/FVC%[a]	0.308	0.024*	0.461	0.000**

* Statistically significance at $p < 0.05$ ** statistically significance at $p < 0.0001$

[a] Spearman Rho Test [b] Pearson Correlation Test

Discussion

The comparison between exposed and comparative group of indoor $PM_{2.5}$ concentration demonstrated that indoor $PM_{2.5}$ concentration showed significance difference between exposed and comparative group with (t=-2.496, p=0.014). Based on the result obtained, the hypothesis of: 'There were significant differences in indoor $PM_{2.5}$ concentration between residential near busy road than less busy road' was not rejected. Findings by Pope *et al* (2002), study also provides strong evidence that long-term exposure to fine particulate air pollution common to many metropolitan areas was an important risk factor for cardiopulmonary mortality[3].

The comparison was made between exposed and comparative group of respondents' abnormality prevalence based on predicted FVC %, predicted FEV_1 %, and predicted FEV_1/FVC %. The statistical results obtained demonstrated that predicted FVC % and FEV_1 % were significantly different between exposed and comparative group of (χ^2=17.926, p=0.000); and (χ^2=7.259, p=0.007) respectively. In contrast, predicted FEV_1/FVC % was not significantly different between exposed and comparative group. Supported by previous study, it can be concluded that there were significant differences in partial of lung function indicator among children living near busy road than less busy road. Study by Ritchie *et al.*, (2007) showed that residing close to major streets and highways increases the risk of developing adverse health effects, as does living near other potential sources, especially high-risk sources such as outdoor wood boilers, open burning of yard and household trash, and burning of agricultural and construction wastes.

Furthermore, the comparison between exposed and comparative group of respondents' symptoms demonstrated that all the respondents' symptoms that were chronic cough without colds, congestion and/or phlegm without colds and chest illness that prevented usual activities show significance difference between exposed and comparative group of (χ^2=33.333, p=0.000); (χ^2=62.259, p=0.000); and (χ^2=75.000, p=0.000) respectively. Supported study by Enrica*et al.* (2009), where overall traffic density was weakly associated with asthma symptoms but there was a stronger association with cough or phlegm (high traffic density OR = 1.24; 95% CI: 1.04, 1.49). Children living in zones with intense traffic were at higher risk for respiratory effects.

On the other hand, the association of indoor $PM_{2.5}$ concentration with measured FEV_1 and FVC; and predicted FEV_1 % and FVC% of exposed group were statistically not significance. Likewise, comparative group measured FEV_1 and FVC; and predicted FEV_1 % and FVC% were also not significantly correlated with indoor $PM_{2.5}$. In contrast, the association of indoor $PM_{2.5}$ concentration with measured FEV_1/FVC and predicted FEV_1/FVC %. The statistical results obtained demonstrated that the comparative group was statistically significance correlated with indoor $PM_{2.5}$(r=0.403, p=0.001); and (r=0.461, p=0.000); whereas the measured FEV_1/FVC of exposed group was not significantly correlated (r=0.172, p=0.403). As for the association of indoor $PM_{2.5}$ concentration with predicted $FEV_{1/}$FVC %, it showed that the exposed groups were significantly correlated (r=0.461, p=0.024).

The findings were robust where referred to previous study by Michael *et al.* (2008), where the most accurate measurement tool, personal exposure monitoring, was expensive and logistically difficult, and did not easily lend itself to panel studies involving large numbers of subjects, particularly children. The effect of cigarette exposure, both personal and via passive smoking, acts as a confounder for the assessment of health effects of air pollution (Michael, 2008).

Other potential confounders such as mosquito repellant used and cooking activity might also be expected to affect the result. Buffer zone which contains trees and other figure to filter the $PM_{2.5}$ emitted by the traffic to reach the house also play an important part as confounders. Higher number of amount of mosquito coils used weekly and cooking activity carried out daily by the comparative group may be related to the result disparity of the association between $PM_{2.5}$ concentration and lung function status based on measured FEV_1, FVC and FEV_1/FVC; and predicted FEV_1%, FVC% and FEV_1/FVC%.

Conclusion

This study suggested that there were significant differences between exposed and comparative group for the variables indoor $PM_{2.5}$, respiratory symptoms (chronic cough without cold, congestion and/or phlegm without cold, wheezing without cold and chest illness) and indoor $PM_{2.5}$ sources (mosquito coils used, aerosol spray used, smoking activity and cooking activity).

Children living near busy road have significant reduction in lung function as an indicator of exposure to higher indoor $PM_{2.5}$ compared to children living near less busy road. However, the association between both of the groups and the specific airborne toxicants that facilitate and promote respiratory effects are still not clearly known. Since population characteristics are specific, the results of this study cannot be generalized.

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