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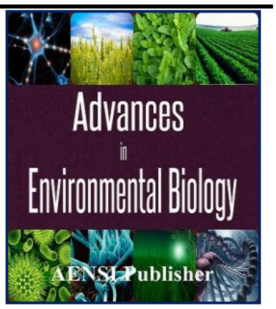

Indoor Air Quality and Its Association with Respiratory Health among Malay Preschool Children in Shah Alam and Hulu Langat, Selangor

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ABSTRACT

Background: Indoor pollution sources are the primary cause of indoor air quality problems that will cause adverse health effects to the children. **Objective:** To determine the exposure of IAQ and its association towards respiratory health among preschool children in industrial and non- industrial area. **Methods**: A cross-sectional comparative study was carried out among Malay preschool children in Shah Alam and Hulu Langat, Selangor. A total of 50 preschool children aged 5- 6 years old from preschools located in Shah Alam (exposed group) and Hulu Langat (comparative group) were selected. A set of questionnaire was used to obtain the background information, exposure history and respiratory symptoms.MM-SPOO4 Tabletop Portable Spirometer were used to conduct a lung function test among the children. IAQ parameters obtained includes indoor concentration of particulate matter (PM), Volatile Organic Compounds (VOCs), carbon monoxide (CO), carbon dioxide (CO2), temperature, air velocity (AV) and relative humidity. **Results:** There was a significance difference between IAQ in exposed and comparative preschools for all parameters measured ($p< 0.005$). There were also significant associations between PM10 with cough, phlegm and chest tightness (PR=5.25, 95% CI= 1.12-24.6), (PR=2.63, 95% CI= 1.09-6.31) and (PR=1.63, 95% CI= 1.40-1.91). Results also show significant associations between PM10 and VOCs with FEV% (PR=5.55, 95% CI= 2.189-14.07), (PR=6.15, 95% CI= 2.565-14.73). **Conclusion:** The finding showed that exposures to poor IAQ might increase the risk of getting lung function abnormality and respiratory illness among study respondent.

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INTRODUCTION

Indoor air quality (IAQ) is a term referring to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. Reasons for this include the amount of time people spend indoors, the wide and varied range of indoor emission sources and the increased concentration of some pollutants indoor compared with outdoors [8]. Decarro *et al.* [6] previously stated that a good indoor air is very important because we spend much of our time in a building, about 80-95% of our life.

The World Health Organization (WHO) has assessed the contribution of a range of risk factors to the burden of disease and revealed indoor air pollution as the 8th most important risk factor and is responsible for 2.7% of the global burden of disease [22]. Rafia *et al.* [17] stated that the total number of acute respiratory infection cases increased from about 6000 cases to more than 30, 000 during the same period in Malaysia. It is now known that indoor air pollution likely has equal or even greater impact on children's health when compared to that of outdoor pollutants. This occurs because time spent indoor is usually higher than time spent outdoor; also, there is a great variety of indoor sources, that include outdoor and specific indoor sources associated with formaldehyde and volatile organic compounds (VOCs) emissions, leading frequently to higher concentration than outdoor [20].

There are many parameters or determinant which we can use to determine the level of indoor air quality. The most common of measurement are indoor air velocity, relative humidity and also temperature. Meanwhile, in more advanced studies, the presence of indoor air pollutants such as particulate matter, volatile organic compounds (VOCs), mold or fungi, bacterial contaminants and also formaldehyde are taking into consideration

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of measurement indoor air quality. The indoor environment in any building is a result of the interaction between the site, climate, building system (original design and later modifications in the structure and mechanical systems), construction techniques, contamination sources (building materials and furnishings, moisture, processes and activities within the building, and outdoor sources), and building occupants. Outdoor sources of pollutants for example are house location near industrial areas and highways, and construction activities [8].

The objective of this study is to assess the IAQ and their associations with respiratory health among preschool children as the children are highly vulnerable to air pollution effects for a variety of reasons, being considered a risk group (Sousa et al., 2012). The lung is not well formed at birth, and development of full functionality does not occur until approximately 6 years of age. During early childhood, the bronchial tree is still developing. This results in greater permeability of the epithelial layer in young children. Children also have a larger lung surface area per kilogram of body weight than adults and, under normal breathing, breathe 50% more air per kilogram of body weight than adult (Schwartz, 2004).

MATERIALS AND METHODS

A. Study design and Study location:

The cross sectional comparative type of study was carried out among male and female Malay preschool children who attended preschool in Shah Alam area that served as an industrial area while the population for comparative group was selected among male and female children who attended preschool in Hulu Langat area that served as non- industrial area.

B. Study sample:

A total of 100 preschool children aged 5 - 6 year old were selected from six preschools located in Shah Alam and Hulu Langat, Selangor. Exposed populations were selected among Malay boys and girls who attended preschool in Shah Alam area, while the population for comparative group was selected among Malay boys and girls who attended preschool in Hulu Langat area. Random sampling method was used to select the respondents with several inclusive criteria; only preschool children ranging from 5 to 6 years old, healthy, Malays, and free from any respiratory illness were selected. The name list of children was obtained from the teachers.

C. Instruments and procedures:

The questionnaire used was adapted from The American Thoracic Society, 'Questionnaire ATS-DLD-C WHO' for children. The questionnaire was pre-tested for pre-school children and the total respondents for the pre-test were 10% of the sample size. Indoor air quality assessments were conducted in each preschool using several indoor air monitoring instruments. The monitoring phase included air sampling for at least a 4 hour period during preschool normal activities. The indoor air quality monitoring instruments used in this study includes TSI 8520 DustTrak Airborne Particle Monitor for PM10, PbbRAE Portable VOC Monitor (pbbRAE 3000) for VOCs, Q-TrakPlus Model 8554 Monitor for CO2, CO, Relative humidity and Temperature, and TSI Velocicalc Plus Model 8386 for air velocity. Instruments for PM10 and VOCs were placed at a height of about 0.6-1.5 meters above the floor, approximately at the breathing zone level of the children. The selected place was not closer than 1 meter to a wall, a door or an active heating system. Whenever possible, all the instruments were placed at the back of the classroom to avoid disruption of sound from instruments during learning session and to avoid attraction from children. Meanwhile, the measurements of CO2, CO, temperature, relative humidity and air velocity were taken periodically and spread throughout many areas in the building to be sure that they were distributed evenly. MM-SP004 Tabletop Portable Spirometer was used to conduct a lung function test among the study respondents. In this study, evaluation of lung function test was performed by comparing the obtained value with normal values (standard value). The predicted value was calculated based on the study by Azizi et al. [4]. Meanwhile, the evaluation of lung function was done based on American Thoracic Society [1]

D. Data analysis:

Statistical analysis was carried out using SPSS version 20.0. To study the association and differences between indoor air pollutant concentrations and the respiratory health of children, T-test, Mann-Whitney U test, and Chi square test were used. Multiple regressions test was performed to determine the main variables that influence the respiratory health of the children.

3. Results:

A. Distribution of Respondent's Outdoor Residential Background between Study Groups:

According to the results obtained, the majority of respondents in the exposed group live within the industrial area while only 13 out of 50 respondents live outside the industrial area. Whereas, for the comparative group 5 out of 50 respondents live outside the non- industrial area. The Chi-square test shows a significant difference between the two study groups ($\chi2$ = 42.04, p = 0.001). Majority of the children from the exposed group (46%) resided more than 500 and 1000 meters from the main road whereas majority of the children from the comparative group (98%) resided more than 1000 meters from the main road. The Chi-square test shows a significance difference between the two study groups ($\chi2$ = 33.56, p= 0.001).The comparison between the distances of respondent's house from factory between the exposed and comparative groups shows a significance difference ($\chi2$ = 18.06, p= 0.001). Most of the children in the exposed groups (54%) resided more than 500 meters from the factory whereas most of the children in comparative group (90%) resided more than 1000 meters from the factory.

Table 1: Distribution of Respondent's Outdoor Residential Background between Study Groups Variables

Variables	Exposed group (n=50) Number (%)	Comparative group (n=50) Number (%)	χ^2	P
Housing Area				
Industrial	37(74)	5(10)	42.04	0.001*
Non- industrial	13(26)	45(90)		
Distance from main road				
<100 meters	2(4)	0(0)	33.56	0.001*
>100- 500 meters	2(4)	0(0)		
>500 meters	23(46)	0(0)		
>1000 meters	23(46)			
Distance from factory				
<100 meters	5(10)	0(0)	18.06	0.001*
>100- 500 meters	5(10)	0(0)		
>500 meters	27(54)	5(10)		
>1000 meters	13(26)	45(90)		

N=100
*Significant at p

B. Comparisons of Indoor Air Quality between Study Areas:

The results obtained show that the data for particulate matter were normally distributed, and non-parametric test (Mann- Whitney U Test) was conducted in order to compare indoor air pollutant concentrations between study areas. Indoor Air Quality (IAQ) parameters measured in the exposed group classroom and comparative group classroom for this study, which includes PM10, VOCs, CO_2, CO,

Temperature (°C), Relative humidity (%) and Air velocity (m/s). Table 2 shows that the mean of indoor PM10, VOCs, CO_2, CO, Temperature (°C), Relative humidity (%) and Air velocity (m/s) in the exposed area was higher (325.6 ± 4.3), (0.11± 0.001), (860.6 ± 14.3), (2.42 ±0.03), (29.3± 0.06), (67.3± 0.5), (50.2± 0.3) compared to the comparative group (123.7 ± 3.9), (0.07± 0.002), (501.0 ± 10.4), (1.21 ±0.05), (29.0± 0.03), (70.6± 0.72), (0.29± 0.007). Mann-Whitney U Test found a significant difference between the levels of indoor PM10, VOCs, CO_2, CO, Temperature (°C), Relative humidity (%) and Air velocity (m/s) in both study areas (Z= -8.861, p<0.001), (Z= -8.915, p<0.001), (Z= -8.845, p<0.001), (Z= -8.905, p<0.001), (Z= -4.040, p<0.001), (Z= -4.231, p<0.001), and (Z= -8.884, p<0.001).

Table 2: Comparison of Indoor Air Quality between Study Areas

Variables	Exposed group (n=50) Median (IQR)	Comparative group (n=50)	Z	P value
PM10(µg/m3)	352 (60)	110 (40.3)	-8.861	0.001*
VOCs (ppm)	0.12 (0.02)	0.07 (0.02)	-8.915	0.001*
CO2 (ppm)	949 (201)	475 (120)	-8.845	0.001*
CO (ppm)	2.6 (0.4)	1.2 (0.3)	-8.905	0.001*
Temperature (0C)	29.7 (0.9)	28.8 (0.5)	-4.040	0.001*
Rh (%)	70.4 (7.0)	75.4 (10)	-4.231	0.001*
Air velocity (m/s)	52 (4.0)	0.27 (0.08)	-8.884	0.001*

C. Comparison of lung function:

The mean for FVC (Liter) were 0.55 ± 0.38 and 0.73 ± 0.01 for the exposed and comparative children respectively. Whereas for FEV1 (Liter), the mean for the exposed and comparative children were 0.52 ± 0.03 and 0.69 ± 0.01. The mean for FVC% were 0.57 ± 0.24 and 0.73 ± 0.19 for the exposed and comparative children respectively. Meanwhile the mean of FEV1% obtained were 0.64± 0.37 for the exposed children and 0.73 ± 0.18 for comparative children. As for FEV1/FVC%, the mean for exposed children were 101.27 ± 5.43 and 4102.52± 5.83 for comparative children. Mann-Whitney U Test was performed to compare the values of the FVC (Liter), FEV1 (Liter), FVC%, FEV1%, FEV1/FVC% values among exposed and comparative children. The test reveals that FVC (Liter), FEV1 (Liter), FVC%, were significantly lower among the exposed group compared to the comparative group (Z = - 4.561, p< 0.001), (Z = 5.502, p<0.001) and (Z = -4.852, p<0.001).The prevalence of lung function abnormalities among the exposed and comparative children whereby the values of FVC%, FEV1%, and FEV1/ FVC were assessed in both study groups. As for FVC% for children in the exposed group, the majority of them 31 (62%) is having an abnormal lung function, whereas 19 (38%) of them are having normal lung functions. Differ with comparative groups, majority of children having normal lung function 31(62%) compared to abnormal one 19 (38%). 38 (76%) out of 50 children from the exposed group are having an abnormal lung function while 12 (24%) of them were normal for FEV1%. As for comparative groups, 17 (34%) of children are having an abnormal lung function while 33 (66%) of them are having normal lung function for FE1%. Results also show lung function abnormalities among children for FEV1/FVC%. For the exposed group, only 1 (2%) child is having abnormal lung functions for FEV1/FVC% while the rest 49 (98%) were normal. Whereas for the comparative children, all children were normal (100%) for FEV1/FVC%. The lung function status among children was evaluated based on FVC (Liter), FEV1 (Liter), FVC%, FEV1%, FEV1/FVC% parameters.

Table 3: Comparison of Lung Functions among Preschool Children

Variables	Exposed group (n=50) Mean (S.D)	Comparative group (n=50) Median (IQR)	Z/t value	P value
FVC (Liter) a	0.55± 0.38	0.73±0.01	-4.561a	0.001*
FEV1 (Liter) a	0.52±0.03	0.69±0.01	5.502b	0.001*
FVC % a	0.57±0.24	0.73±0.19	-4.852a	0.001*
FEV1% a	0.64±0.37	0.73±0.18	-1.789a	0.074
FEV1/FVC% a	101.27±5.43	102.52±5.83	-0.627a	0.530

Table 4: Lung Function Abnormalities among Children

Lung Function			Exposed (n=50)		Comparative (n=50)	
	Abnormal (%)	Normal (%)	Abnormal (%)	Normal (%)	χ2	P value
FVC% a	31 (62)	19 (38)	19 (38)	31 (62)	5.76	0.016*
FEV1% a	38 (76)	12 (24)	17 (34)	33 (66)	17.8	0.001*
FEV1/ FVC% a	1 (2)	49 (98)	0 (0)	50 (100)	1.01	0.315

D. Prevalence of respiratory symptoms:

Most of the children who reportedly have cough was from the exposed group with 12(24.0%) as compared to comparative group with 4 (8.0%), which were 3 times more likely to get cough. Result from Chi- square test reveals that the prevalence of respiratory symptoms was significantly higher among the exposed group for cough (PR=3.63, 95% CI=1.08-12.2). Other symptoms such as chest tightness were also reported by parents whereby 1(2%) child from the exposed group and 0 (0%) children for comparative group reported chest tightness symptoms, which were 2 times more likely to get chest tightness. Result from Chi-Square test reveals that the prevalence of respiratory symptoms was significantly higher among the exposed children for chest tightness (PR=2. 02, 95% CI=1.66-2.50). Phlegm was another symptom that commonly occurred among children attending preschool in the exposed group with 24 children (48.0%) and the children in the comparative group with 21 children (42.0%). Result from Chi-Square test reveals that the prevalence of respiratory symptoms was not significantly different among the exposed children for phlegm (PR=1.28, 95% CI=0.58-2.8).Wheezing was another symptom that did not commonly occur among children attending preschool in the exposed group with 2 children (4.0%) and the children in the comparative group with 1 child (2.0%). Results from Chi-Square test reveal that the prevalence of respiratory symptoms was not significant different among exposed children for wheezing (PR=0.49, 95% CI=0.04- 5.58).

Table 5: Prevalence of Respiratory Symptoms among the exposed and Comparative Preschool Children

Variables	Exposed group (n=50)	Comparative group (n=50)	χ^2	p value	PR	95%CI
	Total (%)					
Cough						
Yes	12(24)	4(8)	4.76	0.30	3.63	1.08-12.2
No	38 (76)	46 (92)				
Phlegm						
Yes	24 (48)	21 (42)	0.36	0.50	1.28	0.58-2.8
No	26 (52) 29 (58)					
Wheezing						
Yes	2 (4)	1(2)	0.34	0.56	0.49	0.04- 5.58
No	48 (96) 49 (98)					
Chest tightness						
Yes	1 (2)	0 (0)				
No	49 (98)	50 (100)	1.01	0.32	2.02	1.66- 2.50

E. The association of exposure between indoor air pollutants and lung function (FVC %) and (FEV1%) among preschool children in the exposed and comparative group:

The associations between indoor air pollutants and lung function (FVC %) among the exposed and comparative groups were shown in Table 6. The indoor air pollutant concentrations were categorized based on standard value. Value that was higher than standard was categorized as high while the value that was lower than standard was categorized as low. Results show there were significant association between VOCs with the abnormality of FVC% among study respondents (p=0.016, PR=2.262, 95% CI= 1.187-5.970). The children who exposed to high indoor concentration of VOCs were 2 times more likely to get the abnormality of FVC%. Results also showed that the risk was increased in lung function reduction but not statistically significant for the indoor concentration of PM10.

The associations between indoor air pollutants and lung function (FEV1%) among the exposed and comparative groups were shown in Table 7. The indoor air pollutant concentrations were categorized based on standard value. Value that was higher than standard was categorized as high while the value that was lower than standard was categorized as low. Results show there were significant association between PM10 and VOCs with the abnormality of FEV1%among study respondents (p=0.001, PR=5.550, 95% CI= 2.189-14.07) and (p=0.001, PR=6.147, 95% CI= 2.565-14.73). The children who exposed to high indoor concentration of PM10 was 2 times more likely to get the abnormality of FEV1% while the children who exposed with high indoor concentration of VOCs was 6 times more likely to get the abnormality of FEV1%.

Table 6: The association of exposure between indoor air pollutants and lung function (FVC %) among preschool children in the exposed and comparative group

Variables	Lung Function		χ^2	p value	PR	5% CI
	Abnormal	Normal				
PM_{10}						
High						
(> 150 µg/m^3)	33(66)	29(58)	0.679	0.410	1.406	0.625- 3.163
Low						
(< 150 µg/m^3)	17(34)	21(42)				
VOCs						
High						
(>0.01 ppm)	31(62)	19(38)				
High			5.76	0.016*	2.262	1.187-5.970
(<0.01 ppm)						

Table 7: The association of exposure between indoor air and lung function (FEV1%) among preschool children in the exposed and comparative group

Variables	Lung Function		χ^2	p value	PR	95% CI
	Abnormal	Normal				
PM_{10}						
High						
(> 150 µg/m^3)	37(74)	20(40)	14.20	0.001*	5.550	2.189-14.07
Low						
(< 150 µg/m^3)	13(26)	30(60)				
VOCs						
High						
(>0.01 ppm)	3 33(66)	12(24)				
High			17.82	0.001*	6.147	2.565-14.73
(<0.01 ppm)	17(34)	38(76)				

F. The association of exposure between indoor air pollutants with respiratory symptoms among preschool children in the exposed and comparative group:

The associations between the prevalence of indoor air pollutants in preschools with respiratory symptoms among study respondents were shown in Table 8 and Table 9. The associations between indoor PM10, VOCs, CO2 and CO inside different classrooms in preschools with the prevalence of respiratory symptoms were established using the standard and median value. Indoor PM10 concentration in preschools was categorized into high value, which is above, or more than (>) 150 µg/m3 and low value which is less than (<) 150 µg/m3. Median value was also used to categorize indoor VOCs, CO2 and CO concentration inside the classroom. The median value for indoor VOCs concentration was categorized into high value, which is above, or more than (>) 0.01 ppm and low value which is less than (<) 0.01 ppm. High and low values for both indoor CO2 and CO concentrations were also categorized using median values. Values that were same or above (>) 671.5 ppm were categorized as high indoor CO2 level while values lower than (<) 671.5 ppm were categorized as low indoor CO2 level. Similarly, values that were same or above (>) 1.85 ppm were categorized as high indoor CO level while values lower than (<) 1.85 were categorized as low indoor CO level.

Table 8: Results from statistical analysis show significant associations between PM10 with cough, phlegm and chest tightness. (PR=5.25, 95% CI= 1.12-24.6), (PR=2.63, 95% CI= 1.09- 6.31) and (PR=1.63, 95% CI= 1.40-1.91). The children who exposed with high indoor concentration of PM10 was 5 times more likely to get coughs, 2 times more likely to get phlegm and 1 times more likely to get chest tightness. Table 9: Results from

statistical analysis show significant associations between VOCs, CO2 and CO with coughing and chest tightness. (PR=3.63, 95% CI= 1.08-12.2) and (PR=2.02, 95% CI= 1.66-2.50). The children who are exposed to high indoor concentration of VOCs, CO2 and CO were 3 times more likely to get cough, 2 times more likely to get chest tightness.

Table 8: The association of exposure between indoor air pollutants, PM10 and respiratory symptoms among preschool children in the exposed and comparative group

Variables	PM10 (high)	PM10 (low)	χ^2	p value	PR	95% CI
	Total (%)					
Cough						
Yes	14(28)	2(4)	5.26	0.02	5.25	1.12- 24.6
No	36 (72)	48 (96)				
Phlegm						
Yes	30(60)	10(20)	4.78	0.03	2.63	1.09- 6.31
No	20(40)	40(80)				
Wheezing						
Yes	2 (4)	1(2)	1.08	0.30	0.30	0.03- 3.37
No	48 (96)	49 (98)				
Chest tightness						
Yes	2(4)	0				
No	49 (96)	50 (100)	1.25	0.26	1.63	1.40-1.91

Table 9: The association of exposure between indoor air pollutants, VOCs and respiratory symptoms among preschool children in the exposed and comparative group

Variables	VOCs CO_2 CO (high)	VOCs CO_2 CO (high)	χ2	p value	PR	95% CI
	Total (%)					
Cough						
Yes	12(24)	4(8)	4.76	0.03*	3.63	1.08-12.2
No	38 (76)	46 (92)				
Phlegm						
Yes	24 (48)	16 (32)	2.67	0.10	1.96	0.87-4.42
No	26 (52)	34 (68)				
Wheezing						
Yes	2 (4)	1 (2)	0.34	0.56	0.49	0.04- 5.58
No	48 (96)	49 (98)				
Chest tightness						
Yes	1 (2)	0 (0)	1.01	0.32	2.02	1.66- 2.50
No	49 (98)	50 (100)				

G. Factor Influenced the Abnormality of Lung Function (FEV %) among study Respondents after Controlling All the Confounders:

Logistic regression was carried out in order to determine the factors that influenced lung function (FEV %) among study respondents after controlling all the confounders such as distance from road, distance from the factory, income, father's education level, mother's education level, indoor smoking, usage of repellents and usage of carpets. Table 10 shows the factors influenced the abnormality of lung functions among study respondents after controlling all the confounders. The result shows that there was significant regression between the distances from the factory with the abnormality of FEV1% among study respondents (p=0.032, PR=2.564, 95% CI=1.087-6.051.

Table 10: Factor Influenced the Abnormality of Lung Function (FEV %) among study Respondents after Controlling All the Confounder

Independent Variables	B	S.E.	p-value	PR	95% CI
Constant	-1.581		3.833	0.680	
PM10	-0.037	0.015	0.013	0.963	0.935- 0.992
VOCs	-75.800	68.303	0.267	0.001	0.001- 1.715
CO2	0.010	0.012	0.392	1.010	0.987-1.034
CO	3.840	2.081	0.065	46.48	0.787-2744
Distance from road	-0.057	0.420	0.892	0.944	0.414- 2.153
Distance from factory	0.942	0.438	0.032	2.564	1.087-6.051
Income	1.087	0.662	0.075	2.579	0.809-10.85
Father's education level	-1.542	0.947	0.103	0.214	0.033-1.369
Mother's education level	0.881	0.613	0.151	2.414	0.726-8.027

Indoor smoking	0.948	0.533	0.075	2.579	0.908-7.327
Usage of repellents	1.465	0.925	0.113	4.328	0.707- 2.780
Usage of carpet	-0.216	1.241	.862	.806	0.071- 9.167

N=100
95% CI= 95% Confidence Interval
B= Regression Coefficient
S.E= Standard Error
* Significant at $p<0.05$

Discussions:

A. Comparison of Indoor Air Quality between Study Areas:

A total of 100 Malay preschool children aged between 5 and 6 years old were studied to determine the relationship between indoor air pollutant concentrations and respiratory health. It was carried out at 6 different preschools, 2 preschools from Shah Alam (studied) and 4 preschools from Hulu Langat (comparative) were selected. Respondents were categorized into two sample units, studied and comparative groups. The results from this study indicate that indoor air pollutants may affect respiratory health. Indoor Air Quality (IAQ) parameters measured in 6 different schools in this study includes PM10, VOCs, CO2, CO, Temperature (°C), Relative humidity (%) and Air velocity (m/s). This can be seen with the high concentration indoors pollutant such the mean of indoor PM10, VOCs, CO2, CO, Temperature (°C), Relative humidity (%) and Air velocity (m/s) in the exposed area was higher (325.6 ± 4.3), (0.11± 0.001), (860.6 ± 14.3), (2.42 ±0.03), (29.3± 0.06), (67.3± 0.5), (50.2± 0.3) compared to the comparative group (123.7 ± 3.9), (0.07± 0.002), (501.0 ± 10.4), (1.21 ±0.05), (29.0± 0.03), (70.6± 0.72), (0.29± 0.007).

Statistical analysis indicated that there was a significant difference in the concentration levels of PM10 between studied and comparative areas, suggested that the preschool locations might contribute to the concentration of the particulates. The location of preschools that situated in the industrial area as well as outdoor and indoor combustion activities being the major contributor to the high level of PM10 in studied area. Factories were the major contributors to particulate urban air pollution, emitting fine primary particles. Outdoor sources of particulate matters such as generation of dust from paved or unpaved roads might also contribute to the high level of particulate matters indoor. Differ from preschools in comparative area, both preschools in studied area were located near too busy roads. Thus, heavy traffic

and vehicle fossil fuel combustion might contribute to high levels of particulate matters in studied areas. According to Noor Hisyam et al. [13], Preschool children living near an industrial area are highly exposed to indoor air pollutants as compared to those in the sub-urban area.

Previous study by Tezara et al. [21] also found that the concentration of indoor PM10 in day care centers was almost similar to the mean concentration of indoor PM10 in areas near the main road and industrial area (69.8 µg/m3 and 68.8µg/m3, respectively) and slightly lower in day care centers in residential area. The study also revealed that the reasons for the indoor PM10 concentration to be higher might be due to building age, floor type, shelf area, dust from fans and presence of curtain in the daycare center. The findings from this study might be related to the findings of that previous study as most of the preschools involved were present with all the factors mentioned by Tezara et al. [21]. A recent study by Gauderman et al. [9] also 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. The comparison between the distances of the respondent's house from factory between the exposed and comparative groups shows a significance difference ($\chi 2$ = 18.06, p= 0.001). Most of the children in the exposed groups (54%) resided more than 500 meters from the factory whereas most of the children in comparative group (90%) resided more than 1000 meters from the factory.

VOCs concentration levels were slightly higher in comparative area compared to the studied area due to the presence of VOCs-emitting material inside preschools buildings. Both of preschools in comparative area used woods for the school's furniture, including children's desks and chairs. Most of them were made of pressed woods, where these pressed wood products sometimes contain urea-formaldehyde, which may release gas formaldehyde over a substantial period of time. According to EPA [8], the rate at which products like pressed wood release formaldehyde can change. Formaldehyde emissions will generally decrease as products age. When the products are new, high indoor temperatures or humidity can cause increased release of formaldehyde from these products. High levels of CO2 can result inadequate ventilation systems, inadequate air exchanges from the opening and closing of windows and doors, and overcrowded classrooms. Occupied and air- conditioned rooms measured higher levels of CO2 than rooms cooled with ceiling fans. CO2 measurements have become a commonly used as a screening test of indoor air quality because levels can be used to evaluate the amount of ventilation and general comfort. At high levels, the carbon dioxide itself can cause headache, dizziness, nausea, and other symptoms [11].

A higher concentration of CO was majorly contributed by mobile vehicles, as well as the close proximity of the preschool itself with the busy roads, especially during peak hours. Therefore, the children might be exposed to the traffic air pollutants that went inside their classroom. This usually occurred in the morning, when the school buses and parents congested the preschool areas.

Other than that, in order to feel comfortable, The Department of Occupational Safety and Health (2010) stated that the indoor temperature should be in between 23-26 degree Celsius (°C). Too little humidity in a space may create static build up and people will sense that their skin feels dry, whereas too much humidity will cause skin to feel sticky. According to American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) [2], standard 55, indoor humidity levels should be monitored between 30-65% for optimum comfort level. The acceptable range of air movement was between 0.15 to 0.50 m/s. Inadequate ventilation, high temperature and humidity can increase concentrations of some indoor pollutant.

B. Comparison of lung function:

The results reveal that FVC (Liter), FEV1 (Liter), FVC%, were significantly lower among the exposed group compared to the comparative group. Azwani et al. (2014) revealed that the mean for FVC (Liter) was 0.63 ± 0.18 and 0.79 ± 0.21 the exposed and comparative children respectively. Whereas for FEV1 (Liter), the mean for the exposed and comparative children were 0.60 ± 0.17 and 0.76 ± 0.19. The mean for FVC% predicted was 69.93 ± 17.03 and 85.94 ± 19.81 for the exposed and comparative children respectively. Meanwhile the mean of FEV1% predicted obtained was 72.02 ± 18.17 for the exposed children and 88.69 ± 18.16 for comparative children. As for FEV1/FVC% predicted, the mean for the exposed children was 103.12 ± 7.17 and 104.09 ± 7.73 for comparative children. T-test analysis was performed to compare the values of the FVC (Liter), FEV1 (Liter), FVC% predicted and FEV1% predicted among the exposed and comparative children. The test reveals that FVC (Liter), FEV1 (Liter), FVC% predicted and FEV1% predicted values were significantly higher among comparative children compared to the exposed children ($t = -4.160$, $p<0.001$), ($t = -4.484$, $p<0.001$), ($t = -4.811$, $p<0.001$) and ($t=-4.577$, $p<0.001$). Meanwhile, Mann-Whitney U Test was used to compare the values of FEV1/FVC% predicted among the exposed and comparative children where statistical analysis reveals that the values of FEV1/FVC% predicted among the exposed and comparative children was not significantly different. Meanwhile, the median for FEV1/FVC% predicted was 103.69 ± 05.67 and 105.62 ± 6.81 for both the exposed and comparative groups. Overall, the prevalence of lung function was lower among the exposed children compared to the comparative children. The lung function status among children was evaluated based on FVC (Liter), FEV1 (Liter), FVC%, FEV1%, FEV1/FVC% parameters. Based on a study by Azizi and Henry (1994), both FVC% and FEV1 % were obtained from the predicted equation for the normal value of lung function parameters among children in Malaysia.

C. Prevalence of respiratory symptoms:

Most of the children who reportedly have cough, chest tightness and phlegm were from the exposed group. According to Chua et al. [5], there were strong associations were reported between risk factors (particulate matter, volatile organic compounds, indoor mold and microorganisms, indoor concentration of carbon dioxide and carbon monoxide) and respiratory effects among school children. Study by Ayuni [3] revealed that reported respiratory health symptoms were significantly higher among the exposed children, which were 5 times more likely to get cough (PR = 5.09, 95% CI = 2.23-11.65), and 9 times more likely to get phlegm (PR = 9.66, 95% CI = 2.10-44.46), chest tightness (PR = 9.08, 95% CI =1.09-75.0) and wheezing (PR = 9.07, 95% CI =1.89-25.2) compared to comparative group. Other than that, study by Aida et al (2014) stated that, the self-reported numbers of respiratory symptoms (cough, phlegm, and chest tightness) were higher among urban area children compared to rural area children. Only wheezing was reported to be higher among rural area children compared to urban area children. Even though the data collected were only based on questionnaire feedbacks without further carrying out clinical test, parents and teachers were given instructions on how to complete the questionnaire before filling them in. Statistical analysis results show that urban area children experience more respiratory symptoms compared to rural area children. Living near road traffic and construction areas might be related to an increase in prevalence of adverse respiratory health problems. Several local studies carried out in Klang Valley have found that most of the children (5-12years old) living in urban areas also show higher prevalence of chronic cough, phlegm and chest tightness as compared with rural area [15]. This might be due to high exposure to gaseous and particles emissions from vehicles and constructions area near their preschool. Besides attending preschools, most of the children stayed in residential areas near the preschools and there are possibilities of increasing their exposure. However, there were lesser traffic and construction areas in rural regions as the greenery is still maintained.

D. Association between indoor air pollutants and lung function among study respondents:

Results showed there were significant associations between PM10 and VOCs with the abnormality of FEV1% among study respondents. Poor indoor air quality can be particularly harmful to children and interfere with the growth of their lung function as they spend much of their time indoors [10]. According to EPA [8] those exposed to levels of total suspended particulate matter exceeding 1000 μm/m3 would run the risk of respiratory diseases. Particle effects on the respiratory system depend on its chemical content. The chemical compositions of particles are different and it depends on the source where it is produced. Therefore, the PM10 is a health related issues that should be considered accordingly. Particulate matters will not only settled deeper into the lungs, but it contains a quantity of organic materials is large and will cause significant long-term effects. Similarly, a greater exposure to PM2.5 and PM10 are associated with higher expression of IL-6 level suggesting that the concentration of indoor particulate in urban density area significantly influence the health of children [12].

E. Association between indoor air pollutants and respiratory symptoms among study respondents:

Results from statistical analysis show significant associations between PM10 with cough, phlegm and chest tightness. Other than that, the results from statistical analysis also showed significant associations between VOCs, CO2 and CO with coughing and chest tightness. The children who are exposed to high indoor concentration of VOCs, CO2 and CO were 3 times more likely to get cough, 2 times more likely to get chest tightness. Study by Ayuni [3] revealed that reported respiratory health symptoms were significantly higher among the exposed children, which were 5 times more likely to get cough (PR = 5.09, 95% CI = 2.23-11.65), and 9 times more likely to get phlegm (PR = 9.66, 95% CI = 2.10-44.46), chest tightness (PR = 9.08, 95% CI =1.09-75.0) and wheezing (PR = 9.07, 95% CI =1.89-25.2) compared to comparative group. Pierse et al. reported a higher prevalence of cough without cold in a cohort of 4400 preschool children with increased exposure to locally generated particulate matters pollution mainly from the road. Overall, the prevalence of respiratory symptoms was higher among the exposed children with significance associations found between cough and chest tightness among the exposed and comparative group in this study. The study by Azwani et al. (2014) revealed that the associations between indoor PM10, VOCs, CO2, and CO inside different classrooms in preschools with the prevalence of respiratory symptoms were established using the median value. Indoor VOCs concentration was categorized into high ($\geq$0.103 ppm) and low ($<$0.103 ppm) values. From the results obtained, there were no significant associations found between phlegm and chest tightness with indoor VOCs concentrations. However, there were significant association found between cough and wheezing with indoor VOCs concentration (PR=3.62, 95% CI=1.29-8.25), and (PR=0.23, 95% CI=0.09-0.61). As for the association between indoor air pollutant concentrations inside classrooms with respiratory symptoms among children, significant association was found between PM10, VOCs, and CO with respiratory symptoms, but not for CO2.

F. Factor Influenced the Abnormality of Lung Function among Study Respondents after Controlling All the Confounders:

The result showed that there was a significant regression between the distances from the factory with the abnormality of FEV1% among study respondents. Study by Ritchie et al. [18] 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.

Conclusion:

In summary, this study indicated that the exposure to indoor air pollutants might increase the risk of getting respiratory symptoms among primary school children living near industry area. Besides that, children living near to industrial area might have a reduction of lung function impairment due to exposure of PM10 and VOCs. This study suggests that knowledge should be given to the public, preschool managements and parents, specifically about the risk of getting respiratory problems due to poor indoor air quality. Further studies are needed to confirm the observed association between indoor air pollutant concentrations and respiratory health among preschool children in the industrial area and non- industrial area.

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