Malaysian Journal of Medicine and Health Sciences (eISSN 2636-9346)

ORIGINAL ARTICLE

Indoor Air Quality (IAQ) in Preschools and Its Association with Respiratory Inflammation among Pre-schoolers

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ABSTRACT

Introduction: Children spend most of the time indoors and make them easily exposed to indoor air contaminants. Exposure to poor indoor air quality has led to various health problem especially, respiratory-related illness. This study is intended to determine the relationship between indoor air pollutants exposure and the airway inflammation among children aged 5 to 6 years old in selected preschools from mid-2015 until mid-2016. **Methods:** Four hours of indoor air quality assessment had been conducted at six preschools in Puchong district (urban area) and six preschools in Hulu Langat district (suburban area) of Selangor. The respiratory inflammation among 120 healthy preschool children had been assessed using non-invasive biomarker of Fractional Exhale Nitric Oxide (FeNO). Meanwhile, respiratory symptoms and information on possible residential air pollutant exposures were obtained from a standardized questionnaire. **Results:** The indoor air quality measurement demonstrated significant high concentration air pollutants ($PM_{0.1}$, $PM_{2.5}$, PM_{10}, VOCs) at the preschools in the urban as compared to preschools in the suburban area($p < 0.05$). Besides, $PM_{2.5}$ was found to be significantly associated with respiratory inflammation (FeNO value) measured ($p<0.05$). **Conclusion:** The exposure of $PM_{0.1}$, $PM_{2.5}$, and PM_{10} had increased occurrences of respiratory inflammation and respiratory symptoms among susceptible populations like children.

Keywords: Indoor air pollutants, FeNO value, Respiratory symptoms, Preschool, Children

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INTRODUCTION

Children usually spend most of the time in the microenvironment of school and home. There is reliable scientific evidence, on spending time in the indoor environment can increase the risk of various respiratory illnesses from indoor air pollutant exposure, especially among children (1-7). They are compassionate towards air pollutants, as their respiratory system is not fully developed, immature, and have a weak immune system (8-9). Other than that, their breathing zone is lower than adults, so they are more exposed to air pollutants that concentrate at lower levels in the air. Due to these factors, the sensitive group of children has a higher tendency to get respiratory inflammation.

The airway inflammation plays a significant and vital role in the pathophysiology of asthma and can be worsening by the indoor air pollution (10). According to WHO (11), more than 50% of premature deaths among children due to pneumonia and asthma caused by inhalation of particulate matter from the indoor air pollution. In 2010, asthma was among the highest rate of causing death in Malaysia, where it was in ranking 20 out of 50 diseases (12). Therefore, assessing respiratory inflammation is essential for understanding the underlying mechanisms of respiratory disease and its prevention.

Respiratory inflammation is a complex reaction of the immune system to a perceived threat of infectious agents, irritants, and allergens in the respiratory system. Roy et al. suggested that the acute exposure of air pollutions lead to prompt response of airway inflammation and oxidative stress pathway (13). A sensitive non-invasive biomarker such as Fractional Exhale Nitric Oxide (FeNO) was recommended by researchers to quantify pulmonary inflammation and can act as a good predictor of allergic asthma response (14). FeNO conceptually is referring to the concentration level of nitric oxide (NO) which release from the activated epithelial cells of the bronchial wall during inflammation. Previous studies have proved that increased level of FeNO among healthy children in conjunction with the elevated air pollutants concentration, especially particulate matter and volatile organic compound in the microenvironment (1,15, 16).

Besides, a study conducted by Norback et al. depicted an elevated FeNO level among school children and significantly associated with Aspergillus versicolor DNA in classroom dust (2).

This study is intended to determine the relationship of respiratory inflammation (FeNO) with the exposure of ultrafine particles ($PM_{0.1}$), fine particles ($PM_{2.5}$), inhalable coarse particle (PM_{10}) and volatile organic compounds (VOCs) among preschool children in the urban area (Puchong district) and suburban area (Hulu Langat district), Malaysia. As to our knowledge, this is the first study emphasizing the exposure of ultrafine particle in the microenvironment of preschool and association with airway inflammation among the susceptible group of children in Malaysia.

MATERIALS AND METHODS

Study location

This study is a cross-sectional comparative study in early education center or preschools located in Selangor state, Malaysia. Six preschools in Puchong district (urban area) were selected as the study area. Puchong district had experienced rapid urbanization with the expansion of industrial parks, commercial centres, residential area, and has heavy traffic density. Meanwhile, six preschools in Hulu Langat district (suburban area) were selected as the comparative location. This area has insignificant city development and low traffic density.

Study sample

A total of 120 healthy children who met the inclusion criteria (Malay ethnicity, aged 5-6 years old, free from asthma and upper respiratory infection) were randomly selected from the preschools. Questionnaires and consent form were given to the parents or guardians at the early stage of data collection. Permission from them were obtained first to conduct the FeNO assessment.

Questionnaire

A standardized set of questionnaires was distributed to respondents' parents or guardians. It was adopted from the American Thoracic Society, "Questionnaire ATS-DLD-78-C", which covered for respiratory symptoms and residential exposure. Meanwhile, questions on asthma and allergies were adopted from International Study of Asthma and Allergies in childhood (ISAAC) questionnaire [14]. In general, it comprised of 5 main parts includes socio-demographic background, health history, history of exposure, home characteristic (indoor & outdoor), and current respiratory symptoms.

Monitoring in preschools and respondent's home

The measurement of the indoor air pollutants and physical parameter of IAQ (air velocity, temperature, and relative humidity) at six selected preschools were performed for 4 hours during preschool hours (8.00 morning to noon) and 1 hour at respondent's home. The equipment used was TSI P-Trak® Ultrafine Particle Counter (UPC) 8525 for $PM_{0.1}$, TSI Dust-TRAK DRX Aerosol Monitor 8534 for $PM_{2.5}$ and PM_{10}, PbbRAE 3000 for VOCs, TSI Q-Trak 7565 for temperature and relative humidity and TSI's Model 8386 VelociCalc for air velocity. All equipment was calibrated before use and were placed at 1.5 m (within the breathing zone of children) above the floor, avoiding any obstruction.

Fractional exhaled Nitric Oxide (FeNO)

Preschool children were recruited to undergo single-breath FeNO analysis after they had selected by simple random sampling. FeNO was determined by using NIOX MINO Respiratory Inflammation Monitor (Aerocrine) analyzer. Measurement of FeNO by this device was a quantitative, non-invasive, safe, and straightforward method. Before conducting the measurement of FeNO, the respondents were discouraged not to eat, drink, or participate in heavy exercise at least an hour before the measurement. Each respondent used a different NIOX MINO filter for hygiene purpose. The input filter of NIOX MINO is very moist and can prevent virus, microbes, and bacteria from entering the measuring device (17). These steps were conducted with maximum three times only for each respondent, in order to get a reliable and reproducible result. The procedure needs to ensure the children able to keep focus in maintaining the exhalation flow rate and exclusion nasal NO. The measured value of 20 ppb or more was considered elevated values in children (18).

Statistical analysis

The statistical analysis was performed with the aid of software Statistical Package of Social Sciences (SPSS) version 22. Descriptive analyses were computed for socio-demographic distribution of respondents. Normality test was performed to evaluate data distribution. It depicted a not normal distribution data; thus non-parametric testing was applied in this study. Mann-Whitney-U test was applied to determine the median difference between the studied and comparative group. Chi-square test and Spearman Rho's Test were to determine the relationship between indoor air pollutant concentrations and the respiratory health of children. The Multiple Logistic Regression test was performed to identify the most influential associations of indoor air pollutants with FeNO level. The p-value less than 0.05 indicated a significant difference finding.

RESULTS

Socio-demographic

There were almost equal in the number of total genders of respondents for both studied group and comparative group. The boy's group, however, shows significantly higher in number as compared to the girl's group. 33 (55%) and 34 (57%) were boys, 27 (45%) and 26 (43%) were girls for the studied group and comparative group respectively. Most of the respondents from the studied group were staying less than 500 meters from the main road, which was 38 (63.40%). Meanwhile for the comparative group, 49 (81.70%) of respondents were staying less than 500 meters from the main road. The Chi-square test shows that the distance of the house from the main street of both study groups shows no significant difference. The statistical analysis proved a similar distribution in the group being compared, which can minimize the effect of confounding factor.

Concentration of Indoor Air Pollutants at Preschool and Residential

The results found that the measured environmental data was not normally distributed. Mann-Whitney U test was applied for comparing the indoor air pollutant concentration between the preschools of urban and suburban areas. Table I shows the comparison of IAQ concentration and physical parameter of IAQ at the preschools of urban and suburban areas. The concentration of indoor $PM_{0.1}$, $PM_{2.5}$, PM_{10}, air velocity, and temperature of the urban preschools were higher with median (IQR) concentration; 90.50(36.73) μg/m^3, 83.10(254.0) μg/m^3, 86.23 (299.0) μg/m^3, 0.21(0.16) m/s, and 31.19 (7.14) °C compared to the suburban preschools 30.50(6.00) μg/m^3, 37.90(9.00) μg/m^3, 34.77(45.00) μg/m^3, 0.29(0.08) m/s and 30.64(2.30) °C, respectively. Meanwhile, for VOCs and RH, statistical analysis shows that the median (IQR) concentration for the urban preschools were lower 53.83(2.848) ppb and 74.00(8.24) % compared to the suburban preschools 67.17(19.73) ppb and 74.00(8.24) % respectively. A significant difference was found between the levels of indoor $PM_{0.1}$, $PM_{2.5}$, PM_{10} and RH in both study groups ($z = -9.497$, $p < 0.001$), ($z = -7.139$, $p < 0.001$), ($z = -8.130$, $p < 0.001$), ($z = -2.253$, $p = 0.024$), and ($z = -4.274$, $p < 0.001$). As to support the measured data of indoor air pollutants at the preschools in both locations, the residential indoor air pollutants were also measured. Table II reveals the comparison of IAQ parameters in residential between the two study locations. The median (IQR) concentration of indoor air pollutants $PM_{0.1}$, $PM_{2.5}$, PM_{10}, VOCs, and temperature of studied preschool was higher; 44.66(6.00) μg/m^3, 46.65(127.00) μg/m^3, 46.13(169.00) μg/m^3, and 39.13(1.99) ppm respectively, compared to the comparative group; 19.73(2.00) μg/m^3, 17.81(41.00) μg/m^3, 18.31(106.00) μg/m^3, 25.09(0.10) ppm respectively. A significant difference was found between the levels of indoor $PM_{0.1}$, $PM_{2.5}$, PM_{10}, and VOCs in both study areas ($z = -5.482$, $p < 0.001$), ($z = -6.248$, $p < 0.001$), ($z = -6.028$, $p < 0.001$) and ($z = -3.222$, $p = 0.001$).

Table I: Comparison concentration of Indoor Air Pollutants and physical parameter of IAQ in preschool between studied group and comparative group

Variables	Studied Group (n= 60)	Comparative Group (n= 60)	z-value	p-value
	Median (IQR)			
$PM_{0.1}$ (pt/cc)	90.50 (36.73)	30.5 (6.00)	-9.497	<0.001*
$PM_{2.5}$ (μg/m^3)	83.10 (25.40)	37.90 (91.00)	-7.139	<0.001*
PM_{10} (μg/m^3)	86.23(29.0)	34.77 (45.00)	-8.130	<0.001*
VOCs (ppb)	53.83(2.85)	67.17(19.73)	-2.253	0.024*
Air velocity (m/s)	0.21 (0.16)	0.29(0.08)	-0.527	0.598
Temperature (°C)	31.19 (7.14)	30.64(2.3)	-1.594	0.111
Relative humidity (%)	70.50(4.60)	74.00(8.24)	-4.274	<0001*

N = 120, Mann-Whitney U test, *Significant at p<0.05

Table II: Comparison concentration of Indoor Air Pollutants and physical parameter of IAQ in residential between studied group and comparative group

Variables	Studied Group (n= 32)	Comparative Group (n= 31)	z-value	p-value
	Median (IQR)			
$PM_{0.1}$ (pt/cc)	44.66 (6.00)	19.73(2.00)	-5.482	<0.001**
$PM_{2.5}$ (μg/m^3)	46.65 (127.00)	17.81(41.00)	-6.248	<0.001**
PM_{10} (μg/m^3)	46.13(169.00)	18.31(106.00)	-6.028	<0.001**
VOCs (ppb)	39.13(1.99)	25.09(0.10)	-3.222	0.001*
Air velocity (m/s)	0.21(0.11)	0.29(0.12)	-0.524	0.601
Temperature (°C)	29.42(1.57)	29.87(1.84)	-0.473	0.636
Relative humidity (%)	72.95(15.67)	70.27(9.12)	-1.752	0.080

N = 63, Mann-Whitney U test, *Significant at p<0.05, **Significant at p<0.001

Prevalence of the Respiratory Symptoms

The symptoms that were included in the questionnaire were cough, phlegm, wheezing, sneezing, and chest tightness. Chi-square test was conducted to compare the respiratory symptoms among respondents between the studied group and comparative group. Table III shows the comparison of the respiratory symptoms among respondents. Based on Table III, only wheezing and chest tightness shows significant differences. Wheezing and chest tightness were reported to be higher among

Table III: Comparison of the respiratory symptoms among respondents

Variables	Studied group (n=60)	Comparative group (n=60)	χ^2	PR (95%CI)	p-value
	Number (%)	Number (%)			
[a] Cough					
Yes	2 (3)	4 (7)	-	-	0.679
No	58 (97)	56 (93)			
[a] Phlegm					
Yes	1 (2)	0 (0.00)	-	-	1.000
No	59 (98)	60(100)			
[b] Wheezing					
Yes	14 (23)	5 (8)	5.065	3.348 (1.122-9.994)	0.024*
No	46 (77)	55 (92)			
[b] Sneezing					
Yes	6 (10)	8 (13)	0.323	0.722 (0.234-2.224)	0.570
No	54 (90)	52 (87)			
[b] Chest Tightness					
Yes	16 (27)	5 (8)	7.223	4.093 (1.289-12.059)	0.007*
No	44 (73)	55 (92)			

N= 120, [a] Fisher Exact test for expected value <5, [b] Chi-square, *significant at p<0.05, Significant PR at 95% CI > 1 respondents in the studied group which was 23% and 27% respectively as compared to comparative group which was 8% for both symptoms.

Fractional Exhaled Nitric Oxide (FeNO)

Table IV shows the comparison of FeNO level among respondents between study groups. The normality test was performed at first to test the distribution of the data. The statistical analysis shows that the data was not normally distributed and led to non-parametric testing. The result shows for the median (IQR) reading of FeNO value in the studied group (68.47 ±19.00) was higher than the comparative group, i.e. 52.53 ± 16.00. The statistical data also shows that the concentration level of FeNO among preschool children was significantly different between the two groups of children (z= -2.519, p= 0.012).

Table IV: Comparison of FeNO level among respondents between study groups

Variables	Studied group (n=60)	Comparative group (n=60)	z-value	p-value
	Median±IQR			
FeNO(ppb)	68.47±19	52.53±16	-2.519	0.012

N= 120, Mann-Whitney U test, *Significant at p<0.05

Table V shows the association between air pollutants in preschools and residential with respiratory inflammation among studied respondents. Correlation test of Spearman's Rho was conducted for indoor air pollutant ($PM_{0.1}$, $PM_{2.5}$, PM_{10}, and VOCs) in preschools with respiratory inflammation according to each study group. The result shows that there was a significant association between $PM_{0.1}$, $PM_{2.5}$ and PM_{10} measured in preschools with respiratory inflammation (FeNO value) but exhibited a weak correlation with r-value less than 0.30. It depicted a positive association between indoor air pollutant ($PM_{0.1}$, $PM_{2.5}$, and PM_{10}) at the selected preschools with respiratory inflammation (FeNO value). Similarly, the result shows a significant association between residentials $PM_{2.5}$, and PM_{10} with respiratory inflammation (FeNO value), but relatively a weak correlation with r-value 0.327, and 0.251 respectively.

Determination Type of Pollutants Influenced the Respiratory Inflammation among the Respondents

Table VI shows the cause of the respiratory inflammation among studied respondents after controlling all the confounders such as pets, indoor smoking, mosquito coil, carpet usage and distance residence from the main road. From the statistical analysis result, FeNO value differs 2.224 units for every unit difference in $PM_{2.5}$ with equation [FeNO Value= 0.055 + 2.224 ($PM_{2.5}$)]. $PM_{2.5}$ was found to have the strongest associations with FeNO level with a prevalence ratio of 9.242.

Table V: Association between Indoor Air Pollutants in preschools and residential with respiratory inflammation among studied respondents

Variables	Respiratory Inflammation (FeNO Value) N= 120		Respiratory Inflammation (FeNO Value) N= 63	
Location	Preschools		Residential	
Air pollutants	r-value	r-value	0.139	0.276
$PM_{0.1}$	0.194	0.194	0.327	0.009*
$PM_{2.5}$	0.209	0.209	0.251	0.047*
PM_{10}	0.189	0.189	0.106	0.408
VOCs	0.029	0.029	0.139	0.276

Spearman-rho test, *Significant at p<0.05

Table VI: Factors influenced the respiratory inflammation among the respondents

Variables	B	S.E	p-value	PR (95% CI)
Constant	0.055	1.727	0.975	1.056
$PM_{0.1}$	0.514	0.889	0.563	1.672 (0.293-9.557)
$PM_{2.5}$	2.224	0.874	0.011*	9.242 (1.666-51.264)
PM_{10}	-0.085	0.936	0.928	0.919 (0.147-5.749)
VOCs	-1.275	0.712	0.073	0.279 (0.069-1.128)

N = 120, Multiple Logistic Regression, 95% CI=95% Confident Interval, B = Regression Coefficient, S.E = Standard Error, Nagelkerke R Square = 0.284,
*Significant at p<0.05, Significant OR at 95% CI > 1

DISCUSSION

Indoor Air Quality at Preschool and Residential

The assessment of indoor quality at the microenvironment in the urban preschools portrayed the median concentration of indoor air pollutants were higher than the preschools in the suburban area, especially $PM_{0.1}$, $PM_{2.5}$, and PM_{10}. The proximate distance of preschool from the main road and the presence of indoor air pollutants (i.e., cooking activities) contributed to the higher concentration of indoor air pollutants in the preschools. Besides, the finding of this present study coincided with Choo et al., as the indoor air pollutants concentration at the preschools of urban area were significantly higher as compared to the preschools in the suburban and rural area of Selangor (4). Choo et al. suggested the presence of construction activity and road repairment infiltrated into the indoor environment of preschools in the urban area. The mean $PM_{2.5}$ and PM_{10} concentration recorded in that study were 112.62±32.82 and 121.81±33.45 μg/m^3 respectively, which is much higher than the level measured in this present study (4).

Nur Aida et al. also found that the median concentration $PM_{2.5}$ and PM_{10} at the preschool in the metropolitan area were 63.0 and 68.2 μg/m^3, respectively, which were lower than the level measured in this present study (16). However, the particle concentrations measured in the suburban preschools were lower than the concentration measured in Nur Aida et al, ($PM_{2.5}$ was 55 μg/m^3 and PM_{10}, 62 μg/m^3). The study also revealed that infiltration dust from nearby road traffic and construction site activity were the culprit of high particle concentration in the urban's preschool environment. Meanwhile, the difference of level air pollutant measured in the comparative preschools might be contributed by other factors such as the presence of indoor pollutants and frequency of cleaning activity.

Apart from that, particle accumulated on the bookshelf, furniture, wall decoration, fan and windows are critical indoor air pollutant sources for the preschool environment. This finding is corresponding to study by Choo et al. and Tezara et al. (4,19). Also, the resuspension of particle from preschooler activity and active physical movement also directly contribute to the higher particle in the indoor environment (20). Interestingly, daily cleaning activity performed by the preschool's staff at the early morning and end of preschool session also contributes to suspension of settled mineral dust (3). Besides that, the kitchen staff also required to cook at least twice per day and prepare two healthy meals in the attached kitchen. The kitchens located close to main assembly area, which makes the children directly exposed to cooking smoke during the schooling hour. The duration of cooking activities varies as it depended on the type of meal preparation and generally took less than one hour per meal. The absence of kitchen ventilation systems such as exhaust fan and kitchen hood depicted a poor environmental-friendly design and led to the deterioration of indoor air quality. As eloquently studied by Dobbin et al, kitchen ventilation system capable of minimizing cooking emission by increasing air exchange and eradicating in-situ emission before mixing into surrounding air (21).

The residential indoor air quality assessment only comprised of 32 residences from the studied group and 31 residences from the comparative group. It successfully involved a total of 63 houses as the parent or guardian gave permission and full cooperation to conduct the exposure monitoring at their homes. Safety issue, working parents, and time limitation had restricted involvement greater number of respondents for the home assessment. The Mann-Whitney U analysis disclosed a significant difference between the two groups, with the urban's residential area recording higher level of air pollutants than the homes in suburban areas. Several factors contribute to the high concentration of indoor air pollutants at residential were proximity to main street, indoor smoking and mosquito coil, as indicated in the questionnaire. Liu et al, found that a burning mosquito coil could generates abundant concentration of VOCs, polyaromatic hydrocarbon (PAHs), aldehydes and fine particle which poses acute and chronic health risk (22). Wang et al also, found the particulates and gaseous pollutant emission from the mosquito-repellent incense could exceed the permissible level in World Health Organization (23).

Prevalence of Respiratory Symptoms

The respondents in the urban area were three and four times more likely to get wheezing and chest tightness respectively as compared to those respondents in comparative group. Based on the findings, high exposure towards road traffic and home exposure have contributed to high prevalence of respiratory symptoms of wheezing and chest tightness among preschool children in the study groups. This present study shows a similar result with previous studies by Nur Azwani et al and Choo et al. The respiratory health symptom of cough and wheezing were reported significantly higher among the preschooler in the urban area as compared to a similar group in the suburban area in Selangor (4,24). Meanwhile, wheezing and cough symptoms were reported higher among the children in Klang Valley than the comparative group with significant odd ratio (OR), χ^2 7.48, 95%CI 2.592-21.586 and, χ^2 1.607, 95% CI 1.040-2.482 (6).

Fractional Exhaled Nitric Oxide (FeNO)

The interpretation of FeNO measurement was referring to the recommendation of ATS Guidelines. The low FeNO value, which is less than 20 ppb, indicates less likelihood of having the eosinophilic inflammation. Meanwhile, the FeNO value greater than 35 ppb indicates higher tendency having eosinophilic inflammation and response to corticosteroid treatment. In the current study, the eosinophilic airway inflammation, as indicated by FeNO value was significantly higher among the children living in the urban area than the reference group. The result was due to higher degree of indoor air pollutant exposure experienced by preschool children in the urban area. This finding is consistent with previous studies conducted by Noor Hisyam et al. and Nur Aida et al. They found a significant difference in FeNO concentration among children aged five to six years old in the urban area as compared to similar age group in rural area (15,16). A study by Idavain et al. demonstrated children living within 5 km radius from the oil shale industry and power plant had a higher risk of airway inflammation, FeNO levels (≥30 ppb) (1). The children who exposed to highest level of formaldehyde and non-methane hydrocarbon showed the highest odds ratios (1.22, 95% CI 1.06–1.41) and 1.75 (95% CI 1.75–2.62) higher, respectively.

Furthermore, exposure to indoor PM_{10}, $PM_{2.5}$, and NO_2 were associated with concentration levels of Fractional exhaled Nitric Oxide in both areas (15). Frank et al. and Persinger et al. demonstrated a significant association between $PM_{2.5}$ and NO_2 with respiratory inflammation (25,26). Meanwhile, the prevalence ratio of exposure to $PM_{2.5}$ and VOCs on respiratory inflammation among children in East Cost Malaysia are 1.41 times of occurrence (27).

Multiple logistic regression was applied in identifying the factors that influence the respiratory inflammation among the preschoolers. The statistical analysis was performed after controlling the confounders in this study at both study design and statistical analysis. At the study design, restriction and matching of the two comparison groups were applied according to the inclusion and exclusion criteria. Apart from that, the possible confounders also were controlled in data analysis through stratification analysis and multiple variable regression analysis. The regression analysis depicted the children who exposed to higher $PM_{2.5}$ were over nine times more likely to experience airway inflammation than those who exposed to lower air pollution. Based on the value Nagelkerke R Square, the model of Multiple Logistic Regression was 28%, which indicated that this model can be considered as a weak model. Nonetheless, this finding was parallel to Noor Hisyam et al. whereby the indoor $PM_{2.5}$ was found to have the strongest associations with FeNO level (15).

There were some limitations to this study. It only focuses on the association between variables and cannot identify the cause-effect association due to cross-sectional study design being used. Prolonged environmental sampling is highly desirable and recommended as it can represent the actual exposure. The data collection especially FeNO assessment was interrupted due to fluctuated temperature (> 28.0 Celsius) in the early morning. The NIOX MINO device requires a constant and cold environment to maintain its quality control. Last but not least, all the questions being answered by the selected respondents as a representative to the selected preschool children were considered acceptable, without recall bias. Assumptions have been made for all the answered given by parents were true.

CONCLUSION

As a conclusion, this study demonstrated a significant higher indoor air pollutants concentration at the preschool of the urban area compared to the preschool in suburban area, especially particulate matter. The median concentration for ultrafine particle ($PM_{0.1}$), fine particle ($PM_{2.5}$) and coarse particle (PM_{10}) for the urban preschool were 90.50 pt/cc, 83.10, and 86.23 µg/m^3, respectively. Moreover, the exposure of indoor air pollutants had elevated the risk of airway inflammation occurrences among susceptible populations like children. In addition, indoor $PM_{2.5}$ was found to have the strongest associations with FeNO level.

Nevertheless, several factors cause increased exposure of respondents towards sources of indoor $PM_{2.5}$. Indoor smoking and mosquito coil were contributing to $PM_{2.5}$ exposure in indoor residential. On the other hand, cooking activity was a positive contributor to $PM_{2.5}$ exposure in the preschool environment. For the recommendation, regular cleaning of classrooms and homes should be done by parents and preschool management by using microfiber mops or if possible, use a vacuum with a clean high-efficiency particulate air (HEPA) filter. Moreover, cleaning of fan blades and other furnisher should be done weekly by preschools and home management. Special attention must be given for the preschool's kitchen, especially on mechanical kitchen ventilation, i.e. hood attached to the kitchen cabinet and vent fan in the wall, as it able to solve the air pollutants emission from the cooking activity. In order to reduce the entry of outdoor particles into preschool, the use of microfibers mats and limit shoes only at doorways is advisable. Parents should seek medical help immediately to confirm the presence of respiratory inflammation among children in which they may get asthma illness. Lastly, more studies should be done to evaluate the exposure of indoor air pollutants among children to serve as a primary approach towards avoidance respiratory illness among children.

ACKNOWLEDGEMENTS

The authors would like to acknowledge and extend gratitude to the pre-schooler respondents, their guardians, management of the preschools and staffs of FMHS, UPM for providing supportive valuable information to conduct this study successfully.

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