INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES
www.hrmars.com
ISSN: 2222-6990

Association between Indoor Air Quality Parameters ($PM_{2.5}$, CO_2, and Bioaerosols) in Children Day Care Centres with and without Air Purifier in Bangi.

Siti Syazwani Mohamad Som, Eliani Ezani, Nurshahira Sulaiman

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v10-i15/8238 DOI:10.6007/IJARBSS/v10-i15/8238

Received: *15 September 2020,* ***Revised:*** *18 October 2020,* ***Accepted:*** *16 November 2020*

Published Online: 29 November 2020

In-Text Citation: (Som et al., 2020)

To Cite this Article: Som, S. S. M., Ezani, E., & Sulaiman, N. (2020). Association between Indoor Air Quality Parameters (PM2.5, CO2, and Bioaerosols) in Children Day Care Centres with and without Air Purifier in Bangi. *International Journal of Academic Research in Business and Social Sciences*, *10*(15), 127–141.

Special Issue: Youth and Community Wellbeing: Issues, Challenges and Opportunities for Empowerment V1, 2020, Pg. 127 – 141

http://hrmars.com/index.php/pages/detail/IJARBSS | **JOURNAL HOMEPAGE**

INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES
www.hrmars.com
ISSN: 2222-6990

Association between Indoor Air Quality Parameters ($PM_{2.5}$, CO_2, and Bioaerosols) in Children Day Care Centres with and without Air Purifier in Bangi.

Siti Syazwani Mohamad Som
Institute for Social Science Studies, University Putra Malaysia, 43400, Serdang, Selangor, Malaysia, Department of Environmental and Occupational Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.

Eliani Ezani
Institute for Social Science Studies, University Putra Malaysia, 43400, Serdang, Selangor, Malaysia, Department of Environmental and Occupational Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.
Email: elianiezani@upm.edu.my

Nurshahira Sulaiman
Institute for Social Science Studies, University Putra Malaysia, 43400, Serdang, Selangor, Malaysia, Department of Biomedical Sciences, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.

Abstract
Introduction: The use of air purifiers have been demonstrated to reduce the level of indoor air quality (IAQ) parameters, thus these may give beneficial effects to the human health. Studies on the effectivity of air purifier in the indoor settings are still limited especially in sensitive environmental settings such as daycare centres. **Objective:** This study aims to determine the concentration of IAQ parameters between daycare centres with and without the use of an air purifier. **Methodology:** Purposive sampling was used in selecting the daycare centre with (DC3) and without air purifier (DC1 and DC2) within Bangi areas. The walkthrough inspection was conducted and 5 parameters of IAQ including $PM_{2.5}$, CO_2, bioaerosol (bacterial and fungal), relative humidity and temperature were assessed in this study. A standardized and modified questionnaire adopted from The International Study of Asthma and Allergies in Childhood (ISAAC) was distributed to 46 parents to assess sociodemographic and respiratory symptoms among their children. **Result:** The result showed that there is a significant difference between $PM_{2.5}$, CO_2, bacteria and fungi concentration in studied areas. Daycare centres with air purifiers (DC3) found the lowest concentration of $PM_{2.5}$ (18.2 $\mu g/m^3$) and

bacterial count (148 CFU/m^3) except for fungal counts and CO_2 level. The finding showed that $PM_{2.5}$ in daycare centres without air purifier (DC1) had the highest (39.1µg/m^3). All IAQ parameters not exceed the National Ambient Air Quality (NAAQs) and Department of Occupational, Safety and Health (DOSH) standards. All respiratory symptoms showed no significant difference between daycare with and without air purifier except for asthma symptoms. The higher number of children in the DCs without air purifiers experiences a productive cough and allergic reaction compared to the DC with an air purifier. **Conclusion:** The finding suggests that the daycare centers with air purifiers can improve IAQ and lower the risk of respiratory symptoms among the centre's building occupants.
Keywords: IAQ Parameters, Daycare Centers, Air Purifier, Respiratory Symptom

Introduction

Indoor air quality has become an emerging topic due to increasing concern among major public health and environmentalists due to people spend their time approximately 70-90 % indoors especially children (Khamal et al., 2019). Children are most vulnerable and very sensitive towards air pollutants due to their physiological characteristics, immature development of the immune system, higher breathing rates and breathing zones located closer to the ground levels compared to adults (Litonjua & Gold., 2016; Khamal et al., 2019). Most of parents would preferred to send their children to the daycare institutions as early as one-year-old. This may be due to several reasons such as both parents are working in the daytime and others opted to take earlier learning preparation before going to the primary school. Some of children will spend for at least eight hours per day, five days a week of their time in the daycare centres.

Typically, the mixture of indoor air pollutants including particulate matters, chemical contaminants and microorganisms including bacterial and fungal will give harmful effects to the children. Various of sources and activities will contribute to the increasing levels of air pollutants inside daycare centres such as cooking, cleaning agent, higher occupant density and indoor activities. EPA (2018), reported that the particle size of air pollutants may directly linked with health effects; the smallest of their aerodynamic diameter, the deeper it can get into lungs or bloodstream. With short and long term exposure effect of $PM_{2.5}$, CO_2 and microorganisms could exhibit the irritation of mucous membranes, exacerbation of asthma, coughing, wheezing, chest tightness, negative impact on the performance of children's learning, feel discomfort and increased absenteeism due to the adverse health problems (Mannucci & Franchini, 2017). Therefore, it is imperative to ensure a better and healthier indoor air quality in the daycare centres.

According to USEPA (2018), the air purifier has been demonstrated to effectively reduce the indoor particles (i.e $PM_{2.5}$, PM_{10}) level and allergens, therefore will come out with beneficial effects to human's health. Park et al., (2017) demonstrated on benefits of using air purifiers in reducing indoor $PM_{2.5}$ levels to 43% of reduction during the 12-weeks of installation. Their study also found an improved of individual nasal symptoms scores which include congestion, rhinorrhoea, nasal itching, and sneezing during the use of air purifier. Study on the use of air purifier in the indoor settings are still limited and motivated us to conduct this type of experiment. Our study aims to determine the concentration of indoor air quality (IAQ) parameters and the prevalence of respiratory symptoms among children between daycare centres with and without air purifiers. Data on indoor and outdoor air pollutants of particles (bioaerosols and $PM_{2.5}$) and gases (carbon dioxide, CO_2) were collected at three daycare centres with and without air purifier in Bangi. A set of questionnaire on respiratory health symptoms were distributed to the children who attended the daycare centres and filled in by their parents or guardian.

Methodology

Study Design and Location

This study was a quantitative study with a cross-sectional design. Three daycare centres equipped with (DC3) and without (DC1 and DC2) air purifier were chosen in Bangi areas (Figure 2.1). Bangi is located approximately 25 km south from Kuala Lumpur and regarded as one of densely-populated area within the Greater Kuala Lumpur. With its strategic location between administrative area of Putrajaya, homes to higher learning institution and linked to other industrial areas have made Bangi as a great choice for living. Most of busy working parents living in Bangi opted to send their children to the daycare centres. Due to its location and higher economic activities, Bangi is the ideal location to be selected as our study location. Purposive sampling was used to select the daycare centres equipped with and without air purifier. All selected daycare centres are accommodate children who age between 1-6 years old.

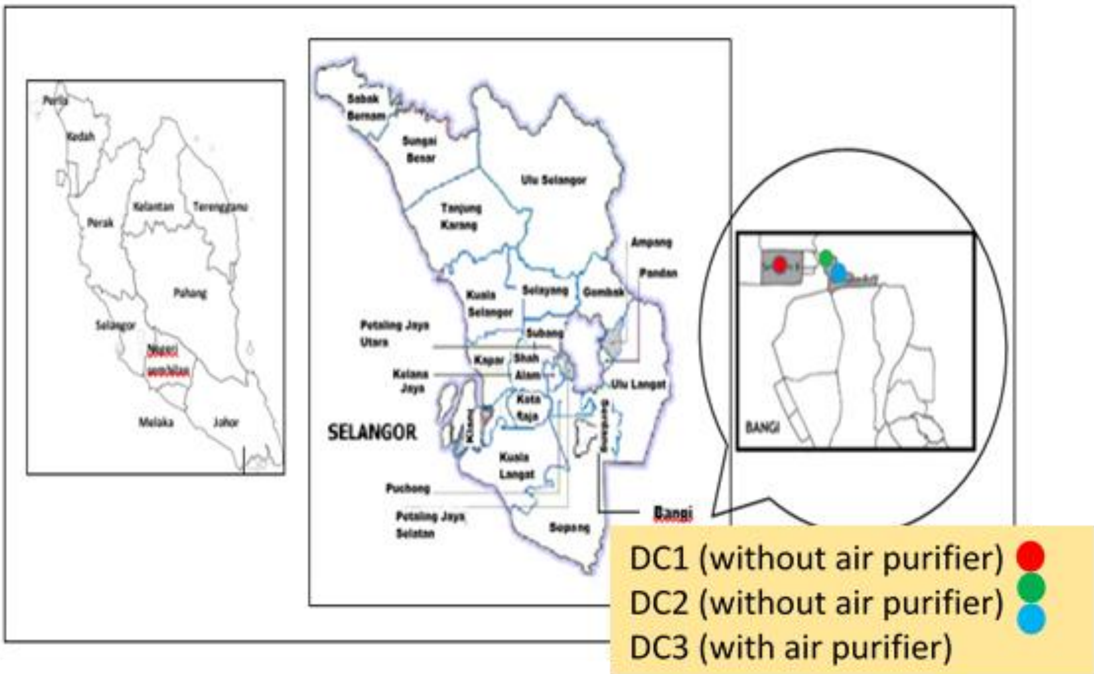


Figure 2.1: Location of the daycare centers in Bangi

Study Sample

The list of daycare centres in Bangi areas was obtained from the Social Welfare Department. The management of DCs was contacted through phone to get approval and being informed about this study. A total of 46 male and female children aged 1-6 years old from 3 selected daycare centres was included to determine the prevalence of respiratory symptoms. Children were selected randomly and all children were from Malay ethnic background. Children in selected daycare centres were choosing after consider several inclusion criteria such as 1-6 years old, attends daycare centres on weekdays only, free from been diagnosed with asthma or COPD and after getting approval to participate from their parents. Air purifiers in selected daycare centres were switched one during the course of sampling observations.

Monitoring of IAQ Parameters

Several air monitoring instruments were used to measure the IAQ parameters from December 2019 to March 2020 in a separated sampling period at three selected daycare centres. Measurement of $PM_{2.5}$, CO_2 and bioaerosol (bacterial and fungal) concentration were taken at 0.8-1.0 meter above the floor which considering breathing zone of children. The measurements were taken 1 meter away from any obstacle such as walls, windows and entrances. The sampling period to collect data was 8 hours which from 9.00 a.m. to 5.00 p.m.

Two sampling point from each daycare centres were identified including indoor and outdoor sampling points. Dusttrak DRX Aerosol Monitor 8534 for $PM_{2.5}$, Q-Trak Indoor Air Quality Monitor 7575 for CO_2, DUO SAS SUPER 360 for bioaerosols and Kestrel Meter 5500 Weather Meter for relative humidity and temperature.

For the bioaerosol parameter, DUO SAS SUPER 360 was used to collect bacterial and fungal samples. The volume air was drawn through the sampler for 1000L and the sampling time was 5 minutes and 30 seconds for each sampling media. Triplicate samples were taken around 9.00 am another two at 11.00 and 3.00 pm. Before sampling, the air sampler was disinfected using isopropyl alcohol swabs and then inserted with an agar plate. Trypticase soy agar (TSA) for bacterial culture and Malt extract agar (MEA) for fungal culture were used in this sampling. After sampling, all samples were sealed and incubated in a laboratory at 37℃ for 24 hours for bacterial culture and for fungal culture at 22℃-25℃ for 2-3 days. For quality control, the field blank was taken for each sample set. The counting counts and calculation for colonies bacterial and fungal were performed and expressed as colony-forming unit per cubic meter (CFU/m^{-3}) respectively after the incubation.

$$\text{CFU/m}^{-3} = \frac{T \times 1000}{t\ (min) \times F\left(\frac{L}{min}\right)}$$

Where *T* is the number of colonies, 1000 is conversion factor of litre to cubic meter, *t* is the duration of sampling and *F* is the pump flow.

Questionnaire

A standardized questionnaire was adopted from The International Study of Asthma and Allergies in Childhood (ISAAC) with some modification and translated into two languages; Malay and English. This set of questionnaires was used to collect data on symptoms of difficulty breathing, asthma, allergies and nasal symptom among the children that attended the daycare centres. The personal information, sociodemographic and home characteristics of respondents were also obtained. The questionnaires were distributed to the parents or guardian with two languages and attached together with a consent letter.

Statistical Analysis

IBM SPSS statistical software version 25 was used to analyse the data. The descriptive statistical analysis was performed to obtain mean, standard deviation minimum and maximum values. Mann Whitney U test and Independent T-test to compare IAQ parameters concentrations between daycare centres with and without air purifiers. Pearson correlation was used to determine the relationship between each of IAQ parameter concentrations with meteorological parameters such as temperature and relative humidity. The association between IAQ parameters with respiratory symptoms of children attending daycare centres were analysed using Chi-square.

Result

Characteristics of Day Care Centres

Three day care centres namely DC1, DC2 (without air purifier) and DC3 (with air purifier) were chosen to conduct this study. All DCs were built more than 5 years old that are using mechanical and natural as their mean of ventilation system. Only one DC (DC3) operated an air purifier during the sampling period. All DCs were cleaned daily by sweeping with a broom and/or wet mopping. A walkthrough inspection was conducted to gather information on the characteristics of the daycare centres (DC1, DC2 and DC3) (Table 3.1).

Table 3.1: Building characteristics in each daycare centers

DC	DC1	DC2	DC3
Building age (yr)	5	5	10
Number of occupants	25	33	26
Type of ventilation system	Mechanical and natural	Mechanical and natural	Mechanical and natural
Presence of air purifier	No	No	Yes
Sign of dampness	N/A	N/A	Have little amounts of moulds on the wall
Doors	4	2	2
Windows	2	3	4
Air conditioners	N/A	N/A	N/A
Singles or double storey	Double	Double	Double
Fans	6	5	5
Presence of trees or shrubs	Yes	No	Yes

Concentration of IAQ parameters in DC with and without air purifier

A total of 72 air samples of agar plates were collected for assessment of bioaerosols (bacterial and fungal counts) in all DCs. In this study, the average of IAQ parameters was measured and compared between daycare centres with and without air purifier. Average $PM_{2.5}$ concentration in DC1 (without air purifier) was higher (39.1µg/m^3) compared to DC 3 (with air purifier). DC 3 showed the lowest average concentration of $PM_{2.5}$ (18.2 µg/m^3). While for CO_2 and fungal concentration in DC3 was slightly higher than DC1, thus showed a significant difference between these two DCs. DC1 that has no air purifier has found to have higher bacterial concentrations compared to DC3 that equipped with air purifier (Table 3.2.1). DC 2 (without air purifier) generated higher levels of $PM_{2.5}$, CO_2, bacterial and fungal concentration compared to DC 3 (with air purifier). It showed a significant decrease (p-value < 0.05) except for fungal concentration between use with or without air purifier (Table 3.2.2). All IAQ parameters were compared with National Ambient Air Quality Guideline and Indoor Air Quality Guideline. All IAQ parameters in selected DCs does not exceed the standard except for $PM_{2.5}$ in DC1 which found exceeding the NAAQ standard (35 µg/m3).

Table 3.2.1: Concentration of IAQ parameters in daycare centers; DC1 and DC3

IAQ parameters	DC1 (without air purifier)	DC3 (with air purifier)	p value
$PM_{2.5}$ (µg/m^3)	39.1 ± 25.9	18.2 ±17.7	0.003*
CO_2 (ppm)	138.9 ± 39.3	175.1 ± 31.6	0.000*
Bacterial (CFU/m^3)	192 ± 67	148 ± 46	0.596
Fungal (CFU/m^3)	50 ± 46	78 ± 18	0.020*

Values present as mean ±standard deviation

Table 3.2.2: Concentration of IAQ parameters in daycare centers; DC2 and DC3

IAQ parameters	DC2 (without air purifier)	DC3 (with air purifier)	p value
$PM_{2.5}$ (µg/m^3)	24.4 ±18.3	18.2 ±17.7	0.049*
CO_2 (ppm)	211.3 ± 24.1	175.1 ± 31.6	0.000*
Bacterial (CFU/m^3)	238 ±94	148 ± 46	0.029*
Fungal (CFU/m^3)	89 ±50	78 ± 18	0.889

Values present as mean ±standard deviation

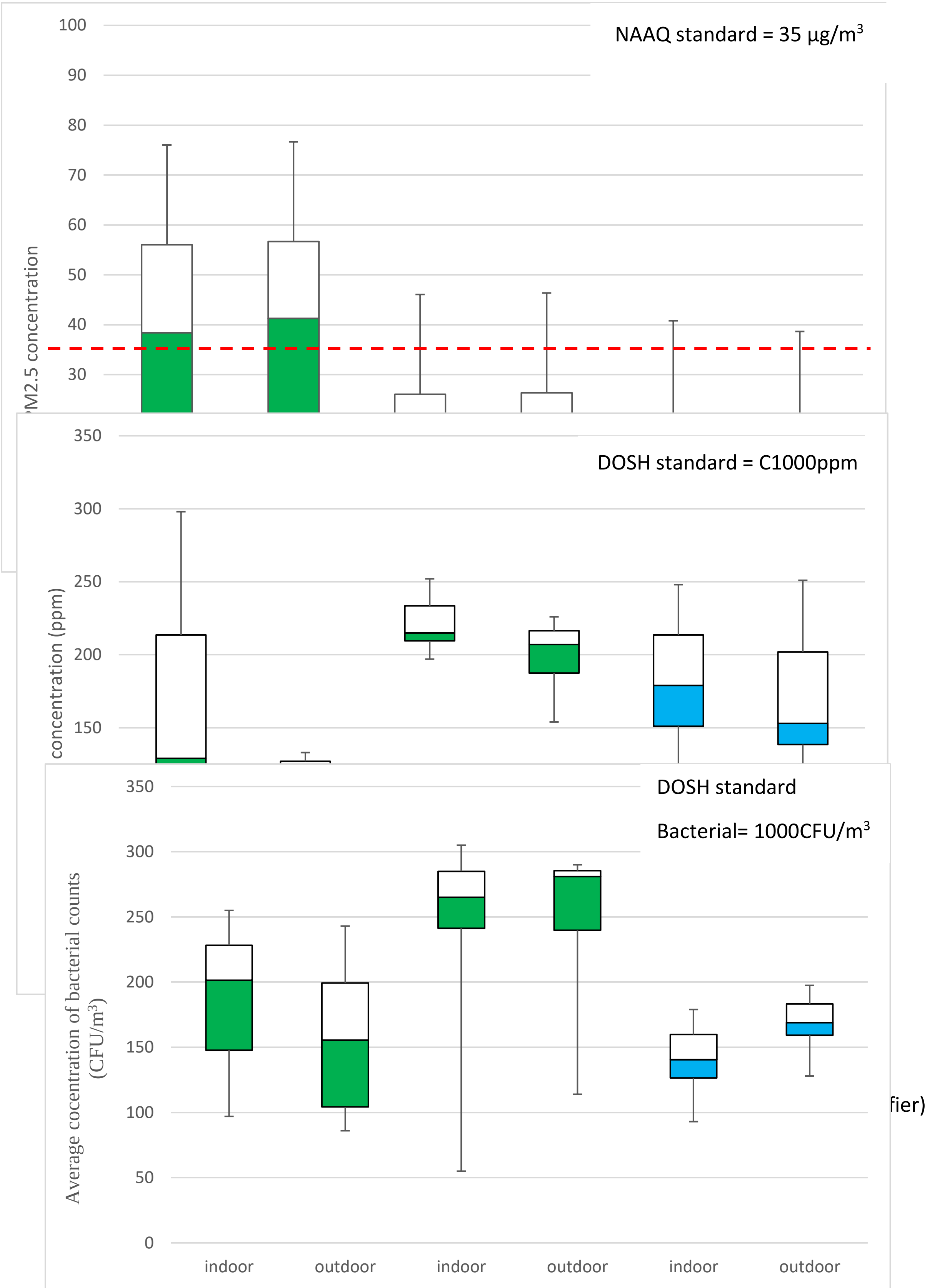
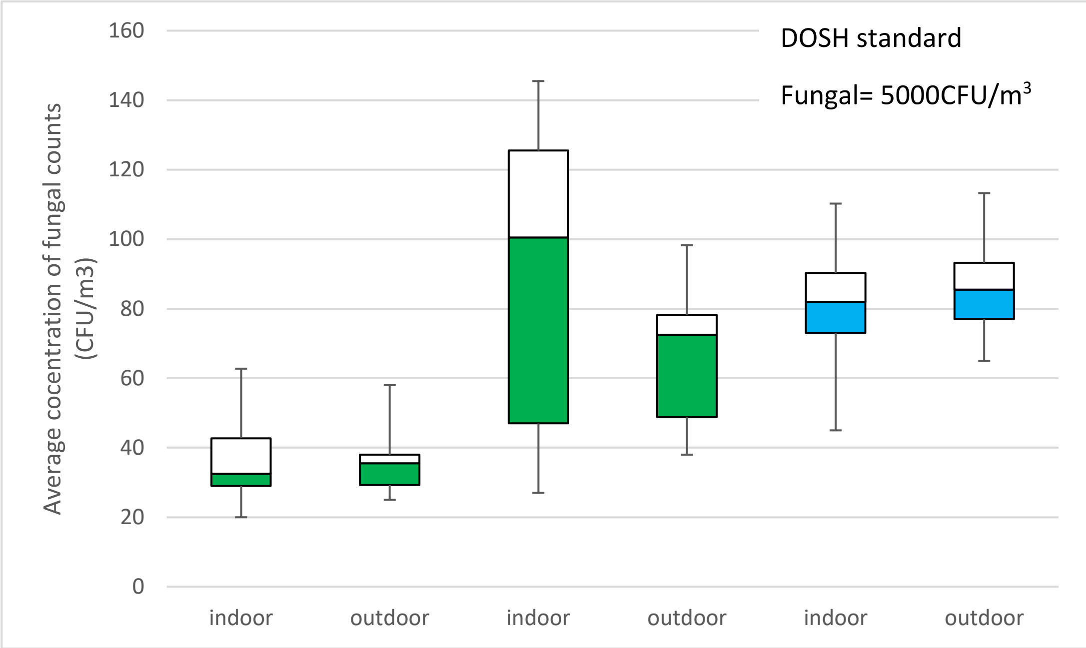

NAAQ standard = 35 µg/m3
PM2.5 concentration
100
90
80
70
60
50
40
30
DOSH standard = C1000ppm
concentration (ppm)
350
300
250
200
150
DOSH standard
Bacterial= 1000CFU/m3
Average cocentration of bacterial counts (CFU/m3)
350
300
250
200
150
100
50
0
indoor
outdoor
indoor
outdoor
indoor
outdoor
fier)

Table 3.3.1:



er)

Summary on aveFigure 3.4: Comparison of bioaerosol

IAQ Parameters with Meteorological Parameters

Table 3.3.1 shows a summary of the average concentration of IAQ and meteorological parameters for three daycare centres. The patterns of temperature and relative humidity were observed at a different location. Values for indoor temperature ranged from 33.1◦C – 34.0◦C and relative humidity from 58.8% - 66.3% in all DCs. Similar values were found in three selected DCs. The average values for temperature in all DCs were exceeding DOSH standard (23-26◦C) whereas relative humidity was within recommended values. Besides, there was a significant correlation between temperature and bacteria concentration in DC1 and DC2, however, there was no significant correlation for all IAQ parameters in DC3 (Table 3.3.2)

Table 3.3.1: Summary average of concentration of IAQ and meteorological parameters for three daycare centers.

Air Pollutant and Meterology		Daycare center 1 (without air purifier)	Daycare center 2 (without air purifier)	Daycare center 3 (with air purifier)
		Mean ± standard deviation		
PM2.5 (µg/m^3)	Indoor	39.1 ± 25.9	24.4 ± 18.3	18.2 ±17.7
	Outdoor	42.8 ± 37.5	22.5 ± 15.5	16.0 ± 14.0
Carbon dioxide (CO_2)	Indoor	138.9 ± 39.3	211.3 ± 24.1	175.1 ± 31.6
Bacteria (CFU/m^{-3})	Indoor	192 ± 69	238 ± 94	148 ±46
	Outdoor	162 ± 73	249 ± 72	166 ±22
Fungi (CFU/m^{-3})	Indoor	50 ± 46	89 ± 50	78 ± 18.0
	Outdoor	38 ± 14	75 ± 39	84 ± 12.0
Temperature (◦C)	Indoor	33.6 ± 1.2	33.1 ± 1.3	34.0 ± 1.5
	Outdoor	34.1 ± 0.7	31.5 ± 2.3	33.8 ± 1.8
Relative humidity (%)	Indoor	60.7 ± 6.0	66.3 ± 7.3	58.8 ± 4.2
	Outdoor	66.8 ± 4.9	67.1 ± 6.6	57.6 ± 4.9

Table 3.3.2: Correlation coefficients between IAQ parameters and meteorological parameters in DC3.

		$PM_{2.5}$		Bacteria		Fungi		CO_2	
		r^2	p	r^2	p	r^2	p	r^2	p
DC1	Temperature	0.293	0.164	-0.678	0.015*	0.264	0.407	-0.345	0.099
	RH	0.328	0.117	0.254	0.425	-0.253	0.427	-0.209	0.328
DC2	Temperature	0.030	0.888	0.671	0.017*	0.464	0.129	-0.495	0.051
	RH	0.129	0.549	-0.382	0.221	-0.285	0.369	0.359	0.085
DC3	Temperature	-0.044	0.840	0.144	0.655	-0.296	0.350	0.041	0.848
	RH	0.387	0.062	-0.124	0.701	0.198	0.536	-0.311	0.139

**showed significant result*

Dose Rate Analysis

The inhalation dose rates for 1-6 years old children in selected DCs. DC2 (without air purifier) showed the highest inhalation dose rate for bacteria and fungi at 2.94×10^{4} and 1.10×10^{4} respectively, DC3 (with air purifier) found the lowest levels only for bacteria dose rate which was 5.66×10^{4}\

Table 3.4: Inhalation dose rate of bacteria and fungi for children in daycare centers.

Daycare centers	Dose rate (CFU/kg^{-1}/day)	
	Bacteria	Fungi
DC1 (without air purifier)	2.38×10^{4}	6.19×10^{3}
DC2 (without air purifier)	2.94×10^{4}	1.10×10^{4}
DC3 (with air purifier)	1.83×10^{4}	5.66×10^{3}

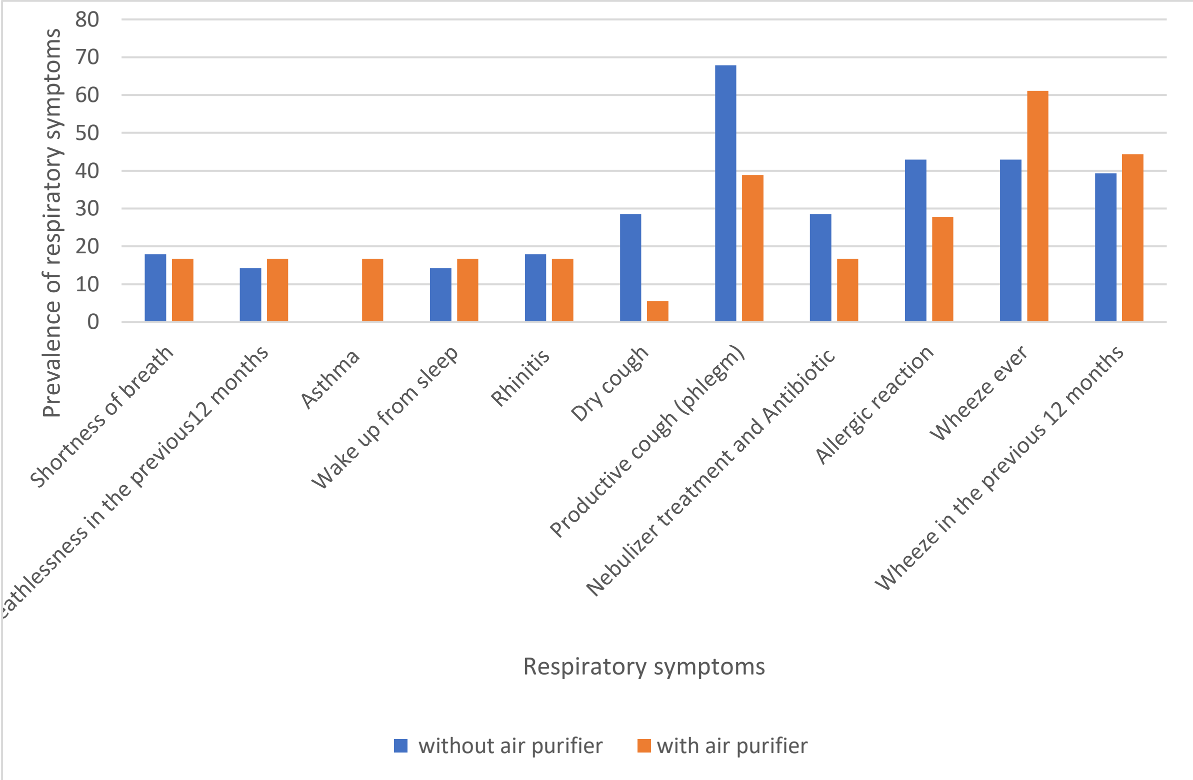
Sociodemographic of Respondents

Total of 46 respondents participated in this study with 28 respondents from DC without use air purifier and another 18 respondents from daycare with use an air purifier. Majority respondents who age 5-6 years old and 1-2 years old respectively. The respondents that use carpets in their home (92.3%), house proximity to main roads (46.2 %) and had a history of family allergy (84.6%) was higher in DC2 (without air purifier) compared to respondents in DC3 (with use air purifier).

Prevalence of Respiratory and Allergy Symptoms among Children in DCs

Table 3.6.1 shows the prevalence of respiratory and allergy symptoms between DCs with and without use air purifier. The symptoms were identified from The International Study of Asthma and Allergies in Childhood (ISAAC). The questionnaires were discussed regarding wheezing, asthma, nasal symptoms, cough, wakeup of the child due to symptoms, diagnosis by physicians and received medicine or nebulizer treatment. Table 3.6.1 presents most of the children who reported for productive cough in DC without air purifier which was 19 of them (67.9%) as compared to DC with air purifier 7 (38.9%). Allergic reaction and wheeze ever were another symptoms found among children in DC without air purifier was 12 (42.9%), while for DC with air purifier were 5 of them (27.8%) had an allergic reaction and 11 of them (61.1%) had wheeze ever. Other symptoms found not commonly occur such as asthma, reported only 3 (16.7%) from DC with an air purifier and no children reported in DCs without air purifier.

Figure 3.6.1: Prevalence of respiratory symptoms between DCs with and without use air purifier.



Discussion

IAQ parameters were collected and measured from 3 different daycare centres in this study. Statistical analysis showed that there was a significant difference for indoor $PM_{2.5}$, CO_2, bacterial and fungal count between daycare centres (p-value <0.001). The highest average indoor concentration of $PM_{2.5}$ (39.1 µg/m^3) was found in DC 1 (without air purifier). The highest concentration of CO_2, bacterial and fungal counts were observed in DC2 (without air purifier). DC3 (with air purifier) showed lowest indoor concentrations for $PM_{2.5}$ (18.2 µg/m^3) and bacterial concentration (148 CFU/m^3) of IAQ parameters except for fungal counts and CO_2. Temperature and relative humidity were recorded approximately the same values in three daycare centres. Department of Occupational Safety and Health (DOSH) reported that indoor temperature in the building should between ranged in 23 to 26 degrees Celsius (◦C) while relative humidity in ranged 40% to 70% to achieve optimum comfort level. The acceptable limits for $PM_{2.5}$ were 35 µg/m^3 according to National Ambient Air Quality Standards (NAAQs) of USEPA. In this study, only $PM_{2.5}$ in DC1 found exceeds the NAAQ standard and temperature values in all DCs were exceeding the DOSH standard. The higher concentration of indoor $PM_{2.5}$ in DC 1 due to indoor and outdoor activities. It was the major contributor to elevate the concentration of $PM_{2.5}$ such as cooking activities and DC located near to main roads and shops which contributes to a higher number of vehicle pass through in front of the daycare. DC also had a kitchen which the distance of indoor playroom to the kitchen was important to determine the exposure towards those air pollutants, thus will lead increase the concentration of $PM_{2.5}$. A study from Kalpana et al., (2004) measures the concentration of respirable particulate at the living area with a different type of kitchen. The concentration of particulate in the separate enclosed kitchen outside the house (280 µg/m ^{3}) was lower compared to the indoor kitchen with (357 µg/m ^{3}) or without partitions (559 µg/m ^{3}) inside the house. DC1 was located near to main roads and shops which contribute to a higher number of vehicles passing in front of the daycare centre. Outdoor sources such as the emission from vehicle exhaust and road traffic nearby were the main sources of $PM_{2.5}$ (Chua et al., 2015). The concentration of particulate matter in preschools of studied areas was higher compared to preschool in comparative areas. This study found preschool in studied areas was located proximity to the busy roads which could be one of the major contributors to a high concentration of $PM_{2.5}$ especially motor vehicles which emits a higher level of fine particles (Rawi et al., 2014). Cooking activities inside the building could generate 30% of the particle's volume and particles less than 0.1 diameters (Kamens et al., 1991; Khamal et al., 2019).

In this study, all daycare centres were using open ventilation system that enhances outdoor air pollutants easily enter into DCs however DC3 consists of air purifier that might filter out some air pollutants from outdoor sources. The CO_2 level, bacterial and fungal counts in DC2 was the highest concentration due to a higher number of occupants, physical activities and poor ventilation. Every additional child in every cubic meter of a room will increase the CO_2 level by almost 70 ppm. It suggested that average floor space should more than 3.5 meters for each child. (Cionita et al., 2014). CO_2 level was increased and reached the value of 4500 ppm during children stay in the classroom while during at night, the values were recorded between 452 ppm to 539 pm (Swiercz & Telejko, 2019). The occupants inside the building with variety of physical activity in small spaces could be another possible reason of pollutants elevation. Findings by Prussin et al., (2016) suggested that human occupancy also the major factors to determine the structure of microbial airborne bacteria and Nazri et al., (2017) states that it can cause contagious due to the transmission of bioaerosol contaminant. Besides, physical activities from teachers and children respiratory fluids may emit via coughing, talking and sneezing which may contribute to a high level of airborne microbes in daycare centres (Nazri et al., 2017). The rate of air exchange become important roles in determining increasing or decreasing indoor fungi concentration (Zuraimi et al., 2008). These findings were supported by An et al., (2006) where high bacterial concentration had associated with a high number of occupancy and inadequate ventilation. The inadequate ventilation might avoid the air pollutants to dilute which generated by occupant's activities (Khamal et al., 2019). Oh et al., (2014) suggests by opening windows and using air purifiers could help in reducing indoor air pollutants.

DC3 with air purifier had the lowest readings except for CO_2 and fungal concentration compared to other DCs. According to Hwang et al., (2017), the use of air purifier and increase number of windows might give positive effect to reduce the concentration of pollutants. It showed that DC use HVAC systems with filter had a lower level of PM and airborne bacteria compared to those only use window ventilation. Besides, air purifier showed effectively removed 86% for $PM_{2.5}$, 62% of airborne bacteria and 55% of fungi within 3 weeks where the concentration was decreased from 39.9µg/m^3 to 5.6µg/m^3 of $PM_{2.5}$, 794.1 CFU/m^3 to 304.4 CFU/m^3 of bacteria and 94.4 CFU/m^3 to 42.5 CFU/m^3 of fungi (Oh et al., 2014). However, this study figures out that indoor CO_2 level and fungal concentration in DC3 with air purifier was slightly higher due to higher number of the occupant in small spaces and found little amounts of moulds on the wall. The concentration of air pollutants might depend on some factors such as relative humidity, ventilation, temperature, air movements and occupant density. Nazri et al., (2017) stated the higher number of occupants with more than 25 people in closed windows and inadequate ventilation may induce a higher risk of infectious transmission in indoor spaces. Previous study reveals that children with a higher occupancy in daycare centres and had closed contact with another child were found more susceptible to cold infections. This is because, viruses from respiratory infection was transmitted through airborne particles (Hou et al., 2020). Other study shows that the workers in sharing offices significantly increased to develop a common cold compared to the worker in single rooms (Louthiala et al., 1995). The study found CO_2 level have an association with an increase of occupant densities in one of the child care centres in Singapore ($p<0.001$) (Zuraimi et al., 2008) where Ferreira and Cardoso (2014) reveals that CO_2 concentration as high to 1942 ppm had associated with respiratory symptoms such as wheezing, rhinitis, asthma, cough, sneezing and headache. Whereas indoor fungi concentration found higher when there is the presence of mould that easily grow on surfaces during the tropical season due to presence of dampness (IOM, 2004) and it peaked in April where there was high temperature and no rainfall, however during the monsoon period in July to October was found a minimum concentration of fungi concentration. The correlation of fungal concentration with temperature was found seven times higher in samples (non- rainy) compared to other samples (Kumar and Attri 2016).

Therefore, other studies reveal that air purifier could reduce 40.9% CO_2 level compared to only using the air conditioner which was 15.2% (Hashim et al., 2019). Japanese study reveals that six houses contained a higher concentration of fungal that exceed their standard which is Architectural Institute of Japan, however, after the installation of air purifier, the fungal concentration was dropped from 53 000 CFU/m^3 to 620 CFU/m^3 in 45 minutes of operation the air purifier (Hashimoto & Kawakami 2018). The inhalation dose rate in DC2 (without air purifier) showed the highest inhalation dose rate for bacteria and fungi at $2.94 \times 10^{\wedge 4}$ and $1.10 \times 10^{\wedge 4}$ respectively, DC3 (with air purifier) found the lowest levels only for bacteria dose rate which was $5.66 \times 10^{\wedge 3}$. Inhalation rates of children differed from adults due to size, behaviour, physical activity and physiology. Metabolic rates and consumption rate of oxygen were higher in children and infants compared to adults. This is because children need for their rapid growth and they have a larger lung surface area (USEPA, 2012). Thus, due to the high susceptibility of children toward airborne exposure in their early life, it might cause severe allergic reaction and asthma.

Our results reveal that the prevalence of respiratory and allergy symptoms for productive cough was the highest number of children in daycare centres without the use of air purifier. Rawi et al., (2015) reported that the prevalence of respiratory symptoms was higher in preschool children at Bangi areas which experienced cough, phlegm, wheezing and chest tightness compared to preschool children in Balakong areas whereas it was showed that PM can influence the severity of wheezing and cough. Khamal et al., (2019) reported the prevalence of wheezing symptoms among toddler in a daycare centre in Seremban areas was 18.9% which revealed that had an association between wheezing symptoms and indoor $PM_{2.5}$ and bacterial count. Lee et al., (2020) study on the effect of indoor air purifier on children with asthma. It showed that the use of air purifier can decrease the concentration of $PM_{2.5}$ and be able to reduce the number of asthma symptoms scores after on-air purifier.

Conclusion

It was indicated that daycare centres using air purifier was the lowest concentration of indoor air pollutants except for CO_2 and fungal concentration. ($PM_{2.5}$; 18.2 µg/m^3) and (Bacterial concentration; 148 CFU/m $^{-3}$). Most prevalence of respiratory and allergy symptoms among children in DC with air purifier had low cases compared to symptoms experienced by children in DCs without use air purifier. Our study suggests that the concentrations of IAQ pollutants in the daycare centres can be lowered with the use of with air purifier however the maintenance of HEPA filter and the air purifier itself deserved a further investigation. The prevalence of productive cough and allergic reaction that experienced by children in daycare centres without use air purifier were found higher compared to children living in daycare centres with an air purifier. Our study have few limitations such as unable to evaluate the efficiency, performance of air purifier and types of filters that have been used in daycare centres which respect to filter pollutants. Besides, the short duration for sampling might cause poor consistency to compare the valuable data between those daycare centres. A limited number of respondents that attending daycare centres and had some non-responsive respondents, missing data and errors also affect the information on the prevalence of respiratory symptoms. Our research provided baseline data on indoor air quality and the application of use clean air technology) in the sensitive community environments and can be expanded in for future intervention studies. It also important to the daycare provider management to take an initiative to consider the use of air purifier at their premise to ensure clean and healthy indoor settings.

References

Azwani, N., Nor, M., Jalaludin, J., & Chua, P. C. (2015). Indoor Air Quality and Respiratory Health among Malay Preschool Children in Selangor.

An H., R., Mainelis, G., & White, L. (2006). Development and Calibration of Real-Time PCR for Quantification of Airborne Microorganisms in Air Samples; Atmospheric Environment. 40 (40): 7924-7939

Environmental Protection Agency, Particulate Matter (PM) Pollution. (2018), https://www.epa.gov /pm-pollution/particulate-matter-pm-basics.

Cionita, T. (2014). Assessment of Children's Health and Indoor Air Contaminants of Day Care Centre in Industrial Area, *43*(3), 81–88.

Hashimoto, K., & Kawakami, Y. (2018). Effectiveness of airborne fungi removal by using a HEPA air purifier fan in houses. Biocontrol Science, 23(4), 215–221.

Hashim, N. H., Teh, E. J., & Rosli, M. A. (2019). A dynamic botanical air purifier (DBAP) with activated carbon root-bed for reducing indoor carbon dioxide levels. IOP Conference Series: Earth and Environmental Science, 373(1).

Hou, J., Lv, D., Sun, Y., Wang, P., Zhang, Q., & Sundell, J. (2020). Children's respiratory infections in Tianjin area, China: Associations with home environments and lifestyles. International Journal of Environmental Research and Public Health, 17(11)

Hwang, S. H., Kim, I. S., & Park, W. M. (2017). Concentrations of PM10 and airborne bacteria in daycare centers in Seoul relative to indoor environmental factors and daycare center characteristics. Air Quality, Atmosphere and Health, 10(2), 139–145.

Kamens, R., Lee, C., T., Wiener, R., & Leith, D. (1991). A study to characterize indoor particles in three non-smoking homes. Atmospheric Environment A: General Topics, vol. 25, no. 5-6, pp 939– 948.

Khamal, R., Isa, Z., Sutan, R., Mohd, N., & Noraini, R. (2019). Indoor Particulate Matters,Microbial Count Assessments,and Wheezing Symptoms among Toddlers in Urban Day Care Centers in the District of Seremban,Malaysia,*85*(1),1–12.

Kumar, A., & Attri, A. K. (2016). Characterization of fungal spores in ambient particulate matter: A study from the Himalayan region. *Atmospheric Environment*, *142*, 182–193.

Martins, A. J., Martins, P. Viegas, J., Aelenei, D., Cano, M., Teixeira, J. P., Paixao, P., Papoila, A. L., Leiria, P., Paula, Pedro, C., Rosado, P., J., Neuparth, N. (2014). Environment and Health in Children Day Care Centres, (ENVIRH) - Study rationale and protocol. Revista Portugese de pneumologia. DOI: 10.1016/j.rppneu.2014.02.006.

Nazri, N. S., Aris, M. S., & Din, S. A. (2017). Indoor air quality assessments in selected child care institutions (nurseries & kindergarten) at Kuantan, Pahang: The implication of occupancy on IAQ. Journal of Built Environment,Technology and Engineering,2,175–181.

Litonjua, A. A., & Gold, D. R. (2016). Early-life exposures and later lung function. Add pollutants to the mix. American Journal of Respiratory and Critical Care Medicine. Volume 193, 2, 110 – 111.

Louhiala, P. J., Jaakkola, N., Ruotsalainen, R., & Jaakkola, J. J. (1995). Form of day care and respiratory infections among Finnish children. Am. J. Public Health, 85 Pt 1, 1109–1112.

Oh, H. J., Nam, I. S., Yun, H., Kim, J., Yang, J., & Sohn, J. R. (2014). Characterization of indoor air quality and efficiency of air purifier in childcare centers, Korea. Building and Environment, 82, 203 – 214.

Park, H., Cheng, K., Tetteh, A. O., Lynn, M., & Nadeau, K. C. (2016). Effectiveness of Air Purifier on Health Outcomes and Indoor Particles in Homes of Children with Allergic Diseases in Fresno: A Pilot Study, Journal of Asthma 54(4), 1–24. DOI: 10.1080/02770903.2016.1218011

Prussin, A. J., Vikram, A., Bibby, K. J., & Marr, L. C. (2016). Seasonal dynamics of the airborne bacterial community and selected viruses in a children's daycare center. PLoS ONE, 11(3), 1–15.

Zender, S. E., & Telejko, M. (2019). Indoor Air Quality in Kindergartens in Poland. *IOP Conference Series: Materials Science and Engineering*, *471*(9).

Zuraimi, M. S., & Tham, K. W. (2008). Indoor air quality and its determinants in tropical child care centers. *Atmospheric Environment*, *42*(9), 2225–2239.