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Original Article

Assessment of Children's Health and Indoor Air Contaminants of Day Care Centre in Industrial Area

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Abstract

Background: Carbon dioxide (CO_2) is one of the most commonly used indicators of indoor air quality (IAQ) in industrial area. The higher concentration level of CO_2 and particulate matter (PM_{10}) in day care centre could affect children's health. The objective of this study was to assess children's health symptom, and measure the CO_2 and PM_{10} concentration level as IAQ parameters in different locations of day care centres near the industrial area at Kuala Lumpur, Selangor and Hulu Langat as urban, suburban and rural areas respectively.

Methods: The data of children's health symptom were collected from the distributed questionnaire.

Results: The day care centres (DCC) in Kuala Lumpur has the highest number of children's illness frequency of more than four times annually (11%), followed by the highest number of children who experienced asthma (5.3%), wheezing (3.3%) and coughing (10%). The results of data collection of day care centres in Kuala Lumpur, Selangor and Hulu Langat ranged between 629-830 ppm, 587-823 ppm and 600-830 ppm for CO_2 level, and 60.80-78.60 μg/m^3, 56.90-80.50 μg/m^3 and 59.90-79.10 μg/m^3 for PM_{10} level. The statistical analysis for CO_2 level between areas was significantly different (P<0.05).

Conclusion: Day care centers in Kuala Lumpur have the highest mean rate of CO_2 and PM_{10} as well as frequency of children' illness which could identify traffic congestion and less greenery of a densely populated city.

Keywords: Day care centre (DCC), IAQ, CO_2, PM_{10}, Health symptoms

Introduction

These days, more children are attending day care centres (DCC) in Malaysia. From a young age, they are sent for full time hours to the DCC premises where they would spend most of their time indoors than at any other location whilst their parents are working. Many DCC located in the close proximity of working establishment include offices near the residential area or main roads and factories in industrial areas (IA). While the arrangement seem to satisfy the parents in terms of convenience, the environment surrounding the DCC could be categorized as a high-polluted area, which does not provide sufficient clean fresh air to its neighbouring places (1).

As consequences of their immature immune system, greater food intake and inhaled breath per

unit mass and rapid growth, children are inevitably more vulnerable to compromised IAQ compared to adults. Children who attend the DCC may be more susceptible to infectious diseases than those being cared at home (2-7). Poor IAQ in children's environment is some of the main cause for the development of respiratory symptom and infection problems. Previous researchers have noticed that children attending DCC may be exposed to more pollutants that might increase the risk of allergies and asthma, and younger children specifically are less likely able to understand and describe their symptoms than adults or older children (8, 9). Identification of DCC exposures that affect children's health can have important impact on the prevention of diseases or symptoms in a large number of children (10). Aside from indoor human activities, furnishing and ventilation system, outdoor contaminants from industrial activities, construction sites and traffic combustion could also be major contributors of poor IAQ (11). High CO_2 and PM_{10} concentrations are some of the parameters that serve as an indication of insufficient fresh air, which will further be interpreted as poor IAQ. To rectify the problem, the root of the problem should be discovered and an assessment of IAQ has to be implemented on the DCC premises.

According to the Child Care Act 1993 and Care Centre Regulations 1994 in Malaysia, the average floor space for each child should be at least 3.5 m^2, and the DCC should provide separate room or sick bay for sick children to prevent the spread of viruses and infections. A study has reported thatfor each additional child on every cubic meter in the room, there was an increase in CO_2 level by nearly 70 ppm, while higher level of CO_2 were notably linked with higher number of children present in a particular area with none of the mechanical ventilation system (12).

The objective of this study was to assess the health symptom and illness frequency of the children attending DCC near IA at different places of urban, suburban and rural areas, which are represented enough by DCC in Kuala Lumpur (KL), Selangor (SL) and Hulu Langat (HL) respectively. Astudy conducted in Korea DCC has revealed that CO_2 level in the urban area DCC exceeded 1000ppm, whereas the CO_2 level in rural DCC was still below 1000ppm. The highest PM_{10} concentrations were also detected in urban DCC (6).

Materials and Methods

Recruitment of DCC

From approximately 37 DCC that are located with distant proximity of 1.5 km from the industrial area in KL, SL and HL as part of Klang Valley, Malaysia, 15 DCC were selected in this field measurement. Previously, 22 DCC near IA were approached to contribute in this research based on the similarity of building characteristics, age of children (2-6 years old) and location. However, some difficulties were encountered on that subject due unavailability of valid phone number or address, and with some of the DCC authorities who did not want to be involved in this research. Therefore, only 15 DCC were included in this research.

Questionnaire

Based on pilot studies, which were carried out in 30 DCC, self-administered questionnaires, which contained questions on socio-economic background and health status of the child were distributed, and interviews were conducted to the DCC community specifically to the parents of children and other DCC occupants such as the teachers and caretakers. The questionnaire was filled in and returned before proceeding to the data collection.

Indoor Air Quality Measurement

The data collection commenced on July 2010 and was completed on March 2011. The physical properties of the premises such as temperature, relative humidity and air velocity were measured during the data sampling. The CO_2 and PM_{10}were also recorded and applied as indicators for IAQ. IAQ meter model TSI 8762 was employed to measure the temperature relative humidity and air velocity while DustTrak model TSI 8520 was utilized throughout the data collection. The equipment was placed out of children's reach, at breathing height (0.5-0.7 m) and away from the win-

dows, doors and bookshelves. The measurements were performed during the DCC operating hours from Monday to Friday (8.00 am-5.00 pm) when the daily activities mostly occurred to get the optimal and relevant data on IAQ parameters. One week data sampling was generated on each DCC premise until all data from 15 DCC were subsequently recorded.

Statistical Analysis

The collected data was analysed using the statistical package SPSS version 20. Single classification analysis of variance (ANOVA) was performed after the normality and homogeneity of variance of data had been confirmed. The statistical result of $P<0.05$ represents statistically significant data.

Results

From the questionnaire forms, the answers from the parents as well the respondents were grouped into several categories based on the location of DCC, children's illness and symptoms of sickness. Table 1 shows summary of the result from the questionnaire, which consists of children's age, gender, race, socio-economic status, health and welfare, type of dwelling, and environmental tobacco smoke (ETS) exposure in their homes. Most of the respondents were Malays (46%) with child between 2-6 years of age who lived in single story houses. Most parents who participated in the questionnaire had mostly female children (56%) with an average total household monthly income of $1000 (RM1200). Fifty-five percent of the children had more than two siblings and 63% had maintained their weight and healthy growth since staying a full day in DCC. Thirty-nine percent of the children were with history of hospital admittance, mostly due to dengue, high fever and diarrhoea. Only 29% were exposed to environmental tobacco smoke (ETS) at home. Table 2 reveals the annual occurrence of children's illness in DCC near industrial area. The number of children with their symptoms of sickness in each DCC location is laid out in Table 3. While the information was accurately compiled, bias information could be resulted from parents' answers. From 300 questionnaires that have been analysed using the cross tabulation table to produce data comparison of each area of DCC near IA, it was reported that 42 children (14%) was never sick with the break-out of 2.7% in KL, 7.3% in SL and 4% in HL. Ninety-one children have experienced sickness for once a year with the break-out of 10% in KL, 8.3% in SL and 12% in HL.

Table 1: Personal and home characteristic of the children

Characteristics		n	%
Mean age	2-6 years		
Gender	Male	132	44
	Female	168	56
Race	Malay	138	46
	Chinese	78	26
	Indian	45	15
	Others	39	13
Type of housing	Single house	207	69
	Public residential apartments	63	21
	Private residential apartments	30	10
Socio-economic status	Total monthly income <2K	30	10
	Total monthly income 2>3K	81	27
	Total monthly income 3>5K	102	34
	Total monthly income >5K	87	29
Have more than 2 siblings		165	55
Maintain weight and healthy growth		189	63
Hospital admittance		117	39
ETS (cigarette) exposure at home		87	29

N = 300

A total of 36 children which could be divided into children from KL, SL and HL, have experienced sickness twice a year.

Forty-seven children in KL, SL and HL experienced sickness three times a year. Eighty-four children of DCC near IA, which divided into 11% in KL, 8.3% in SL and 8.7% in HL experienced sickness four times and above annually. The result reported that most parents have claimed that their children experienced illness only once every year. Based on an interview with notable paediatrician and researcher, it is considered serious when children experience sickness for four times and above annually. Children of DCC near IA in KL had the highest percentage of illness of 4 times and above in a year compared to children in SL and HL areas. The highest percentage of children's illness symptoms were coughing and runny nose, followed by asthma, fever, wheezing, tummy ache and sore eye. Most of asthma and wheezing symptoms were reported in KL area, whereas for the reported case of coughing and runny nose symptoms for children, DCC in KL and SL had the same percentage. Children in HL DCC had the highest rate of sore eye and tummy ache, whereas the children in DCC in SL had the highest percentage of fever.

Table 2: Table of frequency of children's illness in DCC near IA per annum

Number of Sickness		DCC KL (n=100)	DCC SL (n=100)	DCC HL (n=100)	Total (n=300)	χ^2	*P*
None	Number	8	22	12	42	4.45	.108
	Number of sickness (n= %)	19	52.4	28.6	100		
	Sickness in DCC (n= %)	8	22	12	14		
	% of total (N=300)	2.7	7.3	4	14		
1 time	Number	30	25	36	91		
	Number of sickness (n= %)	33	27.5	39.6	100		
	Sickness in DCC (n= %)	30	25	36	30.3		
	% of total (N=300)	10	8.3	12	30.3		
2 times	Number	12	13	11	36		
	Number of sickness (n= %)	33.3	36.1	30.6	100		
	Sickness in DCC (n= %)	12	13	11	12		
	% of total (N=300)	4	4.3	3.7	12		
3 times	Number	17	15	15	47		
	Number of sickness (n= %)	36.2	31.9	31.9	100		
	Sickness in DCC (n= %)	17	15	15	15.7		
	% of total (N=300)	5.7	5	5	15.7		
≥4 times	Number	33	25	26	84		
	Number of sickness (n= %)	39.3	29.8	31	100		
	Sickness in DCC (%)	33	25	26	28		
	% of total (N=300)	11	8.3	8.7	28		

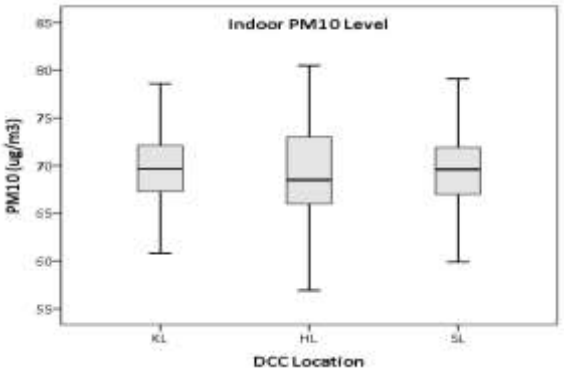

Fig 1: Indoor PM_{10} level between DCC areas

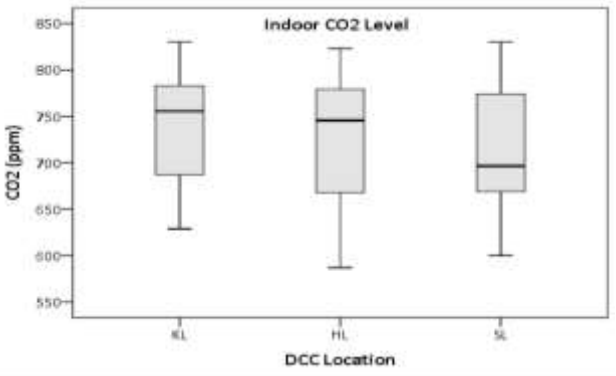

Fig. 2: Indoor CO_2 level between DCC areas

Table 3: Data of children's illness based on the symptom in each DCC location near IA

Symptom of sickness		DCC			χ^2	*P-value*
		KL (n=100)	SL (n=100)	HL (n=100)		
Asthma	Number	16	7	12	3.901	.142
	% within Symptom	45.7	20	34.3		
	% within DCC	16	7	12		
	% of total (N=300)	5.3	2.3	4.0		
Wheezing	Number	10	8	9		
	% within Symptom	37.0	29.7	33.3		
	% within DCC	10.0	8.0	9.0		
	% of total (N=300)	3.3	2.7	3.0		
Fever	Number	10	13	10		
	% within Symptom	30.3	39.4	30.3		
	% within DCC	10	13	10		
	% of total (N=300)	3.3	4.3	3.3		
Coughing	Number	30	30	29		
	% within Symptom	33.7	33.7	32.6		
	% within DCC	30	30	29		
	% of total (N=300)	10	10	9.7		
Runny nose	Number	28	28	23		
	% within Symptom	35.4	35.4	29.2		
	% within DCC	28	28	23		
	% of total (N=300)	9.3	9.3	7.7		
Sore eye	Number	3	5	5		
	% within Symptom	23	38.5	38.5		
	% within DCC	3	5	5		
	% of total (N=300)	1	1.7	1.7		
Tummy ache	Number	3	9	12		
	% within Symptom	12.5	37.5	50		
	% within DCC	3	9	12		
	% of total (N=300)	1.0	3	4		

Discussion

Particulate Matter (PM10) and Carbon dioxide (CO2)

The reading of temperature, relative humidity and air velocity in all DCC were on the average of 23-33°C, 47-76% and 0.08-0.19 m/s respectively. The recommended threshold level for respirable particulates (for particulate ≤ 10μm) in the Malaysian Code of Practice is 150 μg/m^3, whereas the recommendation value for CO_2 exposure should not exceed 1000 ppm for 8 hours period (13). In Table 4, the indoor PM_{10} levels of DCC in KL, HL and SL is reported while the PM_{10} value was analysed with One-way ANOVA. The result shows that the difference is not significant (*P>0.05*).The mean concentration of PM_{10} was the highest for DCC in KL, which was 69.893 μg/m^3. The result was similar with the previous study, which also compared PM10 levels between two DCC in highly polluted and low pollution areas (1). This concentration did not exceed the local guideline of 150 μg/m^3.

Result for CO_2concentration in DCC is presented in Table 5. It displays the CO_2 data run by ANOVA, which shows a significantly different result (*P<0.05)*.The mean concentration of CO_2 was the highest for DCC in KL, which was 739.22 ppm. This concentration did not exceed the local guideline of 1000 ppm. The mean result of CO_2 level in this study (726.7 ppm) was higher than the mean result of 123 DCC studies in Singapore with the obtained result of 514 ppm (14). Figure 1 and Figure 2 show the graph of the indoor PM_{10} and CO_2 values in three different DCC locations of Kuala Lumpur, Hulu Langat and Selangor areas.

Table 4: Description of indoor PM_{10} average in each DCC area using ANOVA

CO_2	N	Minimum	Maximum	Mean	Std. Deviation	*P-value*
KL	50	60.8	78.6	69.893	3.627	0.267
HL	50	56.9	80.5	69.169	4.838	
SL	50	59.9	79.1	69.297	3.769	
Total	150	56.9	80.5	69.453	4.117	

*Significant at *P<0.05*

Table 5: Description of indoor CO_2 average in each DCC area using ANOVA

CO_2	N	Minimum	Maximum	Mean	Std. Deviation	*P-value*
KL	50	629	830	739.22	54.589	0.003
HL	50	587	823	724.767	64.376	
SL	50	600	830	715.987	60.286	
Total	150	587	830	726.658	60.516	

*Significant at *P<0.05*

The areas where the DCC are located and the structure of the buildings are important factors in determining the IAQ. Traffic is one of the most important sources of indoor and outdoor air pollution, which affects the local air quality at schools (15). Being located in the close proximity to IA, the IAQ of DCC in this research was influenced by its surrounding environment overwhelmed by exhaust release from plantation disposal, vehicles and industrial activities. The PM_{10} level can vary due to the floor level and the closing of the windows. Since PM_{10} usually suspends above the breathing zone level, good ventilation is needed to decrease the concentration of PM_{10} indoors. The

indoor levels of CO_2 in DCC premises depend on the outdoors and the density of occupants indoors.

KL has less greenery with heavy traffic flow, which is far heavier than HL and SL areas. The city also has a congested and dense ambience. The result was indicated by higherPM_{10} and CO_2 levels in DCC in KL, which were significantly higher than the other two locations. Besides that, human activity inside the room could also be responsible in raising the indoor CO_2 levels. The results from this study were in line with the reported study in Singapore (14).

The value of IAQ parameters served as an evidence of correlation between high IAQ contaminant levels and prevalence of illness on children. The IAQ parameters discussed in this research could be used to specify whether the ventilation in DCC is appropriate for the occupants. Although the CO_2 and the PM_{10} concentrations were still below the recommended threshold level, DCC in KL which had the highest level of both CO_2 and PM_{10} also had the highest percentage of coughing and wheezing symptoms, asthma prevalence, as well as the highest percentage of children's illness of about more than four times annually. Therefore, it is a concern that continuous exposure to these pollutants may pose a risk to the health of the children whose body system is still developing.

Conclusion

Based on the assessment, all participating DCC, which was also contributing factors on the health effects on children have, fulfilled the requirement in the guidelines of the Child Care Act 1993 and Care Centre Regulations 1994. There was no assurance of adequately good IAQ and proper ventilation in the DCC premises with CO_2 level below 1000 ppm since the result shows that with the range of 629-830 ppm for CO_2 concentration, there were still reported illnesses, which are more than four times annually. Future research in this area could be directed towards investigating IAQ condition in DCC under different climate and condition such as haze.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

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