# SICK BUILDING SYMPTOMS AMONG CHILDREN IN PRIVATE PRE-SCHOOLS IN MALAYSIA: ASSOCIATION OF DIFFERENT VENTILATION STRATEGIES

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**Abstract**

The health issues among pupils in pre-schools becomes the popular obsession since they are more vulnerable and some indoor environmental quality (IEQ) would be the reason affecting them. Indoor Air Quality (IAQ) in buildings is one of the most important factors affecting the physical development of children. The early education is compulsory and escalated numbers of 4-6 years children has boosted the numbers of private preschool in Malaysia. Frequently it is operate in premises that have been fully refurbished, whether in housing schemes, commercial buildings or institutional buildings. This has invited the questions on the building capability to provide a good environment to the children during the learning activities. Poor indoor air has become a wide-spread problem with serious effects on children health and their performance. This research focuses on identifying occupant satisfaction towards IEQ in selected refurbished pre-school or kindergarten buildings. The broad aim of this paper is to determine SBS among pupils in refurbished private pre-schools with different ventilation strategies and it association with indoor air quality (IAQ) performance. A few parameters have invited several health symptoms to the children and it this is importance of taking into consideration to the owner and policymaker before refurbishing any building into pre-school.

**Key words**: indoor environment quality, indoor air quality, sick building symptoms, absenteeism, pre-schools.

## Introduction

Due to the poor IEQ, physical discomfort has been widely reported at schools either as fatigue condition (Tarcan and Varol, 2004; Frontczak and Wargocki, 2010; Issa et al., 2011), or sick building syndrome (Seppanen et al., 1999; Wargocki et al., 2002; Daisey et al., 2003) in the buildings. There is increasing evidence that exposure to physical, chemical and biological indoor pollutants may cause various health problems among preschool children (Jakkola, 2000; Zuraimi, 2008). Pre-school children spend most of their daytime in classroom and inadequate ventilation is often suspected to be an important condition leading to health symptoms.

Previous studies Mendell and Heath (2004), Earthman (2004), Young et al. (2003), Buckley and Scheineder (2004), Rosen and Richardson (1999), document with the impaired health of students and teachers could influence students' performance directly or indirectly through students behavior and outcomes which may affecting attendance too. Poor quality of facilities and building design has been associated with teachers and student achievement. Uline and Moran (2008) have noted a tendency of academics to be unfocused, unless the learning process is taking place in a building with adequate facilities and environment. It comes into consideration to provide the adequate environment to these children. According to Seventh Schedule, UBBL (2009), the occupant in a classroom required at least 2 $m^2$ each, which implies a required 40 $m^2$ to accommodate twenty pupils at a time. It is definitely a challenge to provide an adequate space to the pupils' in refurbished private pre-school as the classrooms previously were functioned as bedrooms and it should utilizing up to 20 children at a time.

Thus, the broad aim of this paper is to determine SBS among pupils in refurbished private pre-schools association with indoor air quality (IAQ) performance. The objectives of this study are accordingly: i) to assess the health symptoms reported among pupils in natural ventilation (NA) and air-condition (AC) classrooms, ii) determine the IAQ level in both ventilation strategies classrooms in refurbished pre-schools iii) to attain the association of IAQ parameters with the pupils' SBS. The outcomes of the study are foreseen as a benchmark of improvement to pupil's healthiness and improvement to the refurbishment of the private preschool in this country.

**Private pre-school at Malaysia**

Malaysia has experienced high economic growth accompanied by rapid awareness of education. Early education becomes the one of the main focus in the Malaysian Educational Development Master Plan 2006-2010, by providing the preschool class in government school (MOE, 2006). In Malaysia's context, coverage of pre-school education has improved dramatically as the government is making pre-school as well as primary school education compulsory (MOE, 2001). Figure 1 explicates the number of private pre-schools registered with the Ministry of Education has boosted by over 200% from 2000 to January 2012 (EPRD, 2012). Definitely, it has encouraged the private sector to establish pre-schools, despite the increase in the number of pre-school classes in public schools (KL City Hall, 2010).

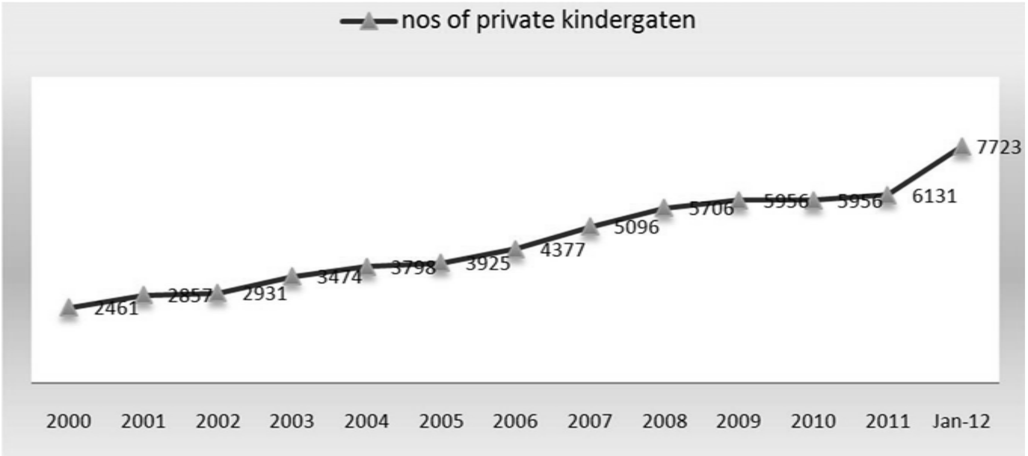


Figure 1: Numbers of private kindergartens in Malaysia, 2000 to January 2012
Source: EPRD (2012)

The escalating numbers of children requiring pre-school education in Malaysia has encouraged the involvement of private initiatives to meet the demand. Thus, the government has encouraged more private pre-school centers to be set up, involving various types of refurbished buildings with various types of property converted into classrooms. Registered private kindergartens frequently operate in premises that have been fully refurbished, either in housing schemes, commercial buildings or institutional buildings. Figure 2 shows the type of premises of private pre-schools in Kuala Lumpur that have been refurbished after previous use (KL City Hall, 2010). The majority are part of housing schemes that have been refurbished as preschools. Figure 3 shows the exemplar of majority private preschool that have been refurbished from the previous housing building.

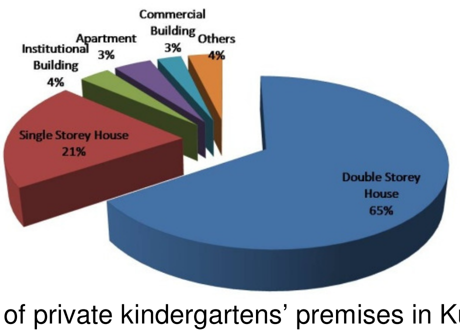


Figure 2: Type of private kindergartens' premises in Kuala Lumpur
Source: KL City Hall (2010)

Figure 3: Double storey link house that has been refurbished as preschool

Often, the preschools' building are accommodate up to 40 pupils at a time, 15-20 pupils per classrooms which were previously bedrooms. Normal practice, three teachers and two teacher's assistants are handling a private preschool. Meaning, five to ten staffs for every refurbished private preschool in Malaysia. The occupants in a classroom require at least $2m^2$ (UBBL, 2009) each, which implies a required $60m^2$ per room. It is important to identify and assess the needs of occupants towards their working and learning environment. This presents a challenge in providing adequate internal environment in congested areas and locations. Figure 4 shows a classroom conditions during learning activity, previously a bedroom converted as classrooms.

Figure 4: Bedrooms has been converted as a classrooms

**SBS at pre-school**

In general, occupants of a building diagnosed with sick building syndrome (SBS) suffer from such symptoms. SBS symptoms include eye, nose, and throat irritation, dryness of mucous membranes and skin, nose bleeds, skin rash, dry or itchy skin, difficulty breathing or chest tightness, mental fatigue, headache, cough, hoarseness, wheezing, nausea, and dizziness (U.S. Department of Labor, 1994). SBS describes an illness with symptoms that occur while in a specific building but subside when away from the building. The symptoms may worsen or only appear in specific zones or rooms. A Swedish study reported the following (Sahlberg et al., 2002):

1) general symptoms were more prevalent at high temperatures,
2) eye symptoms and tiredness were more common at low lighting,
3) headaches were more common for lower levels of daylighting,
4) eye symptoms were related to the total air concentration of bacteria,
5) a relationship between observed building dampness and SBS-symptoms, but only in schools with an air exchange rate below the median value (<1.8 ach)

The sick building syndrome is commonly characterized by a higher prevalence of the same symptoms that are reported in the non-sick building, but in a lower frequency (Bluysen, 2009; Spengler *et.al.*, 2000). It might potentially produce by a single contribution but as well by multiple factor in the same symptoms. Spengler *et.al.* (2001) has also supported the effect of interrelation between different parameters in a building.

The presence of air contaminant has triggers the prevalence of asthma and allergies, especially in children, rose over the past decade (Akinbami, 2006,). After home, school is the most important indoor environment for children. This is especially noteworthy, because individuals with asthma or allergies are potentially more susceptible to indoor air contaminants (Research Triangle Institute, 1995). Children may be more susceptible to indoor air pollution than adults. The U.S. Environmental Protection Agency attributes this to the greater volume of air inhaled by children relative to their body weight, and thus a greater mass of pollutant uptake per body weight (U.S. Environmental Protection Agency 1996). One study positively associates respiratory infections in school children with viable molds in air, viable bacteria, and 3-metylfuran (Norback et al. 2002).The most significant findings related to allergens, asthma, cold/cough, respiratory infections, nasal patency and other SBS symptoms.

The type of ventilation system, recirculation of air and presence of rotary heat exchangers were not demonstrated to be associated with an elevated risk of SBS (Sundell, 1994). Air conditioned rooms have been accounted for to have lower ventilation rates contrasted with those that are regularly ventilated, owing to the fact that no special facility made for ventilation (Suh et al., 1992; Sekhar, 2004). This could decipher to an accumulation of defilement in the latter if the source exists in the room. Unquestionably, Wong and Huang (2004) reported higher convergences of carbon dioxide and human associated bacteria in air conditioned rooms. Furthermore, if not clean regularly, air conditioners can be a wellspring of indoor contamination which can accelerate the gathering of soil in the channels. Spengler et al. (1994) revealed that air conditioning was essentially connected with higher amounts of bronchitis side effects. The association for asthmatic indication seems to approach enormously. In contrast of the research done by Yang et al. (1997), where no companionships of air conditioning use with asthma, wheeze and rhinitis were reported.

Somehow, contaminants are also generating from the different sources from outdoor environment as experienced by another studies Mohd (2011), Mohd Sofian and Ismail (2012). Natural ventilation classrooms rely on the windows and doors openings are susceptible to the outdoors pollutants that ingress the premises. Crowded rooms tend to be overheated, and during this era it was considered that the discomfort in such rooms was due to excessive heat or to elevated concentrations of $CO_2$ (Sundell, 1994).

**Materials and methods**

Monitoring performed in 10 classrooms randomly selected (of the 5 schools) the schools are located in different districts but in 25 km radius with each others. The selections of the schools were based on the similarities of learning and activities systems, foods types serve during recess and school hours. The monitoring of the measurement for relative humidity (RH) monitored by the Gray Wolfsensing Solution IQ604 Indoor Air Quality Probe (Gray Wolf sensing Solution, Shelton, CT, USA). Each monitor was calibrated by the factory once within the calendar year and monthly by the field research team.

Measurement done in three days of each classroom because of the following reason: (1)three as the optimal sample size (verify the mean and the frequency, to identify the valid minimum and maximum results), (2) sampling could be repeated if the instrument fail to measure . It were logging at every 1 minute of measurement. At least 8 hours per day of measurement – (the minimum of exposure to pollutants in determining SBS) (CIBSE Guide A, 2006). Measurements start at 7.30 p.m (at least 30 minutes before the class starts) and end at 4.30 p.m. The monitors placed within a classroom at least 3 feet away from any wall and at least 0.5m from bookshelves and out of the children's reach. The monitors always placed on the same size and model step ladder/tripod to approximate the breathing zone.

The classroom/building walk-through form was used by the research team to inventory the building materials and contents of the classrooms. Data were collected to characterize the materials and condition of the ceiling, floor, interior walls, exterior walls, HVAC equipment, and classroom contents. The buildings have been observed on the location of the building from the main road, surrounding activities, numbers of pupils in a classroom mold, dampness, volume of the classrooms and ventilation systems.

151 parents then asked and to fill up the form about their dwelling's information (the type and condition of the finish materials, room contents, maintenance history, water leaks, pets, renovations, air freshener and candle use, and pesticide use) and pertaining their kids (respondent): on sleep hours, SBS symptoms and numbers of siblings. Meanwhile, the school administration permitted an

access to the attendance records with notice (emergency leave), due to sickness (enclosed with evidence such as notice or medical certificates) and unnoticed leave. Result then to be analyzed using Statistical Package for the Social Sciences package 17.0 (SPSS). Descriptive analysis on indoor RH and Absenteeism, meanwhile correlation on non parametric using Chi-Square test applies to determine any relation of sickness absentees with the dwelling's conditions.

**Building observations**

All the classrooms were operating in double storey terrace house (100m$^2$). Majority of the classrooms was a bedroom. Some of the classrooms attached with washroom. Some classrooms have observed with the absence of mold on wall and the ceiling.

The walkthrough observation of the building (Table 1) has indicated all the buildings have located in urban, residential area and at the roadside. The environment might enclose to the other factors which can contribute to health effects. Anyhow, the distances of the main road to the buildings are varying. 4 of the classrooms are air conditioning and the other 6 classrooms are natural ventilated with ceiling fan and windows open. The whole classrooms were installed with one ceiling fan each.

**Results and discussions**

**a. Identification of SBS in the classroom**

In this section the SBS of the pupil (N=152) has been reported in previously selected ten classrooms. Questionnaires were distributed to parents to fill up. This questionnaire represented the pupils' behavior affected by the classroom's environment. Entire SBS indications of various variables measured to ascertain which factors contributed the most to the symptom. Descriptive analysis was assessed using frequencies with five scales as shown in Table 2 stated number of days annually reported with SBS symptoms. The analysis showed the majority of pupils felt the symptoms of coughing, sore throat and running nose, as these were the common symptoms in this study. The value of these symptoms has a significant association with IAQ.

Table 1: Rating of the symptoms reported annually

| | Percent (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Never** | ***TOTAL UNNOTICEABLE*** | **Sometimes** | **Slightly** | **Regularly** | **Often** | ***TOTAL NOTICEABLE*** |
| Headache | 26.5 | 26.5 | 48.3 | 13.2 | 6.6 | 5.3 | 73.5 |
| Running nose | 6.6 | 6.6 | 31.1 | 33.8 | 9.3 | 8.6 | **82.8** |
| Sore throat | 11.9 | 11.9 | 36.4 | 33.8 | 9.3 | 8.6 | **88.1** |
| Coughing | 7.9 | 7.9 | 38.4 | 33.8 | 11.9 | 7.9 | **92.1** |
| Watery eyes | 44.4 | 44.4 | 31.1 | 15.9 | 4.6 | 4.0 | 55.6 |
| Breathing | 66.2 | 66.2 | 17.2 | 9.9 | 3.3 | 3.3 | 33.8 |
| Wheezing | 68.2 | 68.2 | 15.9 | 8.6 | 3.3 | 4.0 | 31.8 |
| Dizziness | 55.6 | 55.6 | 25.2 | 13.2 | 2.0 | 4.0 | 44.4 |
| Nausea | 64.9 | 64.9 | 24.5 | 5.3 | 0.7 | 4.6 | 35.1 |
| Fatigue | 26.5 | 26.5 | 27.2 | 20.5 | 13.2 | 12.6 | 73.5 |
| Stress | 45.7 | 45.7 | 28.5 | 11.9 | 7.3 | 6.6 | 54.3 |
| Irritation | 70.2 | 70.2 | 18.5 | 5.3 | 1.3 | 4.6 | *29.8* |

Table 3 presents the noticeable percentage of health symptoms for every classroom. When responding about their children, most incidents the parents reported were of dizziness, followed by irritation, watery eyes and nausea. The majority of them were reported to be in natural ventilation classrooms (S7-56A-R1 and KD06-R3). A certain relationship has been described between the eyes and nose that affect each other (Openhaimer, 2010).

Table 2: Noticeable SBS Symptoms in each classroom

| | Room | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Percentage Noticeable SBS Symptom** | **S7-56A-R1[a]** | **S7-43D-R1[b]** | **S7-43D-R2[b]** | **S7-43D-R3[a]** | **SP15-R1[a]** | **SP15-R2[a]** | **SU3-R1[a]** | **PJ-KD6-R1[b]** | **PJ-KD6-R2[b]** | **PJ-KD6-R3[a]** |
| Headache | 7.9 | 13.2 | 0.0 | 7.9 | 13.2 | 7.9 | .0 | 15.8 | 10.5 | 23.7 |
| Running nose | 9.6 | 14.9 | 6.4 | 11.7 | 10.6 | 10.6 | 7.4 | 9.6 | 10.6 | 8.5 |
| Sore throat | 6.4 | 16.7 | 6.4 | 11.5 | 9.0 | 11.5 | 9.0 | 10.3 | 9.0 | 10.3 |
| Coughing | 7.4 | 16.0 | 6.2 | 9.9 | 12.3 | 9.9 | 8.6 | 11.1 | 7.4 | 11.1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Watery eyes | 10.8 | 5.4 | 5.4 | 2.7 | 16.2 | 8.1 | 10.8 | 18.9 | 10.8 | 10.8 |
| Breathing | 16.0 | 12.0 | 4.0 | 8.0 | 8.0 | 12.0 | 0.0 | 16.0 | 8.0 | 16.0 |
| Wheezing | 12.5 | 16.7 | 4.2 | 8.3 | 12.5 | 8.3 | 0.0 | 12.5 | 12.5 | 12.5 |
| Dizziness | 10.3 | 6.9 | 6.9 | 10.3 | 10.3 | 3.4 | 0.0 | 6.9 | 17.2 | 27.6 |
| Nausea | 18.8 | 6.3 | 0.0 | 6.3 | 25.0 | 12.5 | 0.0 | 12.5 | 12.5 | 6.3 |
| Fatigue | 10.0 | 10.0 | 5.7 | 7.1 | 7.1 | 10.0 | 8.6 | 10.0 | 15.7 | 15.7 |
| Stress | 10.3 | 7.7 | 5.1 | 5.1 | 10.3 | 7.7 | 7.7 | 15.4 | 12.8 | 17.9 |
| Irritation | 23.5 | 5.9 | 0.0 | 0.0 | 17.6 | 11.8 | 0.0 | 5.9 | 11.8 | 23.5 |

a: Naturally ventilated classroom b: Air-conditioned classroom

Nevertheless, respiratory problems (running nose, sore throat, coughing, breathing problems and wheezing) were most commonly reported in air-conditioning classrooms with percentage from 14.9% to 18.9%. Air conditioners might be a wellspring of indoor contamination if their cleaning is irregular which can prompt the amassing of dirt in the filters. So, it activates the respiratory indications such as sinusitis, rhinitis, asthma and hypersensitive pneumonitis (Hodgson et al., 2000).
Table 4 shows the sore throat and fatigue were connected with the classroom's ventilation strategies with ($\chi2 = 6.438$, $p < 0.005$), ($\chi2 = 4.985$, $p < 0.005$) and ($\chi2 = 6.438$, $p < 0.005$) respectively. It specifies that natural ventilation classrooms contributed higher applicable health indications to pupil contrasted with AC classrooms owing to the outside contaminants entering the classrooms through the open windows. In contrast, the air-conditioned S7-43D-R1 committed the most astounding number of pupils endured the symptoms.

Table 3: Association of ventilation strategies with SBS symptoms

| **Percentage Noticeable SBS Symptom** | **Classroom Vent AC** | **Na** | ***χ2*** | ***P*** |
|---|---|---|---|---|
| Headache | 37.5% | 625% | 0.019[a] | 0.890 |
| Running nose | 10.0% | 90.0% | 3.654 | 0.056 |
| **Sore throat** | **11.1%** | **88.9%** | **6.438** | **0.011*** |
| **Coughing** | **8.3%** | **91.7%** | **4.985** | **0.026*** |
| Watery eyes | 38.8% | 61.2% | 0.008 | 0.929 |
| Breathing | 36.0% | 64.0% | 0.727 | 0.394 |
| Wheezing | 36.9% | 63.1% | 0.315 | 0.574 |
| Dizziness | 34.5% | 65.5% | 1.535 | 0.215 |
| Nausea | 35.7% | 64.3% | 0.858 | 0.354 |
| **Fatigue** | **25.0%** | **75.0%** | **6.438** | **0.042*** |
| Stress | 41.5% | 58.5% | 1.444 | 0.230 |

*Significant at P<.05

### b) IAQ characteristics at every classroom

The findings of indoors and outdoors IAQ concentrations are summarized in Table 5. For three air condition classrooms (S7-43D-R1, S7-43D-R2 and PJ-KD6-R1), mean indoor temperature were lower than the corresponding outdoor levels. However, the whole classrooms and respective outdoors stated higher value of mean temperature than the recommended range for acceptable indoor air quality of American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE, 2009) at 23.0℃ to 26℃. The I/O for temperature of each classroom stated in small value, range between 0.93-1.11.

Table 4: Indoors and outdoors IAQ concentrations for every classrooms

| | Classroom | Indoor Minimum | Maximum | Mean | S.D | Outdoor Minimum | Maximum | Mean | S.D | I/O |
|---|---|---|---|---|---|---|---|---|---|---|
| Temperature ($^{O}$C) | S7-56A-R1 | 29.70 | 34.90 | 32.31 | 1.49 | 24.10 | 32.70 | 29.12 | 2.89 | 1.11 |
| | S7-43D-R1 | 29.10 | 32.90 | 30.82 | 1.13 | 26.10 | 33.90 | 31.43 | 2.29 | 0.98 |
| | S7-43D-R2 | 27.60 | 31.90 | 29.35 | 1.18 | 26.00 | 34.00 | 31.46 | 2.34 | 0.93 |
| | S7-43D-R3 | 28.00 | 32.60 | 30.57 | 1.34 | 26.60 | 32.80 | 30.51 | 1.55 | 1.00 |
| | SP15-R1 | 27.30 | 33.40 | 30.72 | 1.57 | 20.30 | 33.00 | 29.13 | 3.36 | 1.05 |
| | SP15-R2 | 22.90 | 34.40 | 31.10 | 2.05 | 24.70 | 32.90 | 30.04 | 2.33 | 1.04 |
| | KS-SU3-R1 | 28.10 | 32.20 | 30.26 | 0.92 | 24.90 | 29.90 | 28.14 | 0.99 | 1.08 |
| | PJ-KD6-R1 | 28.20 | 33.20 | 30.52 | 1.50 | 25.90 | 34.70 | 31.42 | 2.25 | 0.97 |
| | PJ-KD6-R2 | 29.20 | 31.80 | 30.51 | 0.78 | 22.30 | 32.30 | 28.09 | 2.97 | 1.09 |
| | PJ-KD6-R3 | 29.40 | 33.90 | 32.03 | 1.32 | 26.60 | 35.20 | 31.52 | 2.02 | 1.02 |
| Humidity (% RH) | S7-56A-R1 | 52.20 | 75.30 | 63.28 | 7.39 | 53.60 | 90.80 | 68.50 | 13.53 | 0.92 |
| | S7-43D-R1 | 53.90 | 78.00 | 62.95 | 5.05 | 53.80 | 85.10 | 63.32 | 9.75 | 0.99 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | S7-43D-R2 | 49.90 | 83.00 | 59.09 | 4.91 | 50.90 | 86.10 | 61.39 | 11.30 | 0.96 |
| | S7-43D-R3 | 60.70 | 83.20 | 70.92 | 7.27 | 57.50 | 84.30 | 66.41 | 6.63 | 1.07 |
| | SP15-R1 | 56.00 | 86.70 | 71.40 | 6.56 | 55.20 | 100.90 | 70.95 | 12.34 | 1.01 |
| | SP15-R2 | 40.60 | 90.90 | 72.12 | 8.39 | 58.50 | 98.00 | 70.79 | 10.27 | 1.02 |
| | KS-SU3-R1 | 68.30 | 88.40 | 77.50 | 5.87 | 71.30 | 93.70 | 79.34 | 4.68 | 0.98 |
| | PJ-KD6-R1 | 50.60 | 78.60 | 58.33 | 5.54 | 45.50 | 87.40 | 58.41 | 10.91 | 1.00 |
| | PJ-KD6-R2 | 35.70 | 65.20 | 57.10 | 6.31 | 56.80 | 103.00 | 75.20 | 13.96 | 0.76 |
| | PJ-KD6-R3 | 50.60 | 80.80 | 63.23 | 9.23 | 43.10 | 88.00 | 58.57 | 11.16 | 1.08 |
| Air velocity ($ms^{-1}$) | S7-56A-R1 | .00 | 0.50 | 0.05 | 0.09 | 0.00 | 2.00 | 0.22 | 0.23 | 0.22 |
| | S7-43D-R1 | .01 | 0.26 | 0.04 | 0.03 | 0.00 | 1.90 | 0.03 | 0.09 | 1.22 |
| | S7-43D-R2 | .01 | 2.04 | 0.05 | 0.09 | 0.00 | 0.28 | 0.03 | 0.05 | 1.54 |
| | S7-43D-R3 | .01 | 1.68 | 0.06 | 0.11 | 0.00 | 0.25 | 0.03 | 0.04 | 2.15 |
| | SP15-R1 | .00 | 1.97 | 0.23 | 0.22 | 0.00 | 0.48 | 0.01 | 0.03 | 23.37 |
| | SP15-R2 | .00 | 1.97 | 0.23 | 0.22 | 0.00 | 0.48 | 0.01 | 0.03 | 21.79 |
| | KS-SU3-R1 | .01 | 1.58 | 0.02 | 0.09 | 0.00 | 1.07 | 0.12 | 0.16 | 0.20 |
| | PJ-KD6-R1 | .01 | 2.24 | 0.03 | 0.12 | 0.00 | 2.21 | 0.28 | 0.40 | 0.10 |
| | PJ-KD6-R2 | .00 | 3.79 | 0.03 | 0.16 | 0.00 | 3.30 | 0.31 | 0.49 | 0.08 |
| | PJ-KD6-R3 | .00 | 0.02 | 0.00 | 0.00 | 0.00 | 2.89 | 0.28 | 0.41 | 0.00 |
| $CO_2$(ppm) | S7-56A-R1 | 551.70 | 1202.70 | 724.26 | 171.77 | 398.70 | 475.30 | 435.92 | 15.06 | 1.66 |
| | S7-43D-R1 | 521.30 | 2186.00 | 1054.31 | 515.08 | 442.30 | 514.30 | 480.56 | 12.89 | 2.19 |
| | S7-43D-R2 | 526.00 | 4576.70 | 1680.35 | 1184.46 | 445.70 | 523.00 | 488.25 | 13.43 | 3.44 |
| | S7-43D-R3 | 418.00 | 1050.30 | 603.18 | 192.83 | 442.30 | 525.00 | 487.11 | 17.93 | 1.24 |
| | SP15-R1 | 449.00 | 662.00 | 537.04 | 48.91 | 338.30 | 447.00 | 393.62 | 26.82 | 1.36 |
| | SP15-R2 | 337.70 | 1005.50 | 640.70 | 123.99 | 344.30 | 463.00 | 404.43 | 27.32 | 1.58 |
| | KS-SU3-R1 | 158.70 | 1276.70 | 699.13 | 288.09 | 147.00 | 526.50 | 326.13 | 100.03 | 2.14 |
| | PJ-KD6-R1 | 509.00 | 2627.50 | 1294.75 | 550.69 | 228.50 | 482.00 | 438.71 | 19.56 | 2.95 |
| | PJ-KD6-R2 | 478.00 | 2709.00 | 1458.78 | 658.08 | 0.00 | 460.00 | 359.60 | 53.99 | 4.06 |
| | PJ-KD6-R3 | 500.00 | 1793.00 | 766.86 | 281.94 | 407.00 | 516.00 | 455.06 | 19.29 | 1.69 |
| CO(ppm) | S7-56A-R1 | 0.00 | 1.00 | 0.32 | 0.33 | 0.00 | 1.70 | 0.31 | 0.35 | 1.02 |
| | S7-43D-R1 | 0.00 | 1.80 | 0.53 | 0.63 | 0.00 | 4.00 | 0.63 | 0.76 | 0.84 |
| | S7-43D-R2 | 0.00 | 1.40 | 0.60 | 0.46 | 0.00 | 1.80 | 0.43 | 0.54 | 1.39 |
| | S7-43D-R3 | 0.00 | 1.30 | 0.39 | 0.44 | 0.00 | 3.00 | 0.50 | 0.62 | 0.78 |
| | SP15-R1 | 0.00 | 1.70 | 0.32 | 0.40 | 0.00 | 2.70 | 0.37 | 0.52 | 0.86 |
| | SP15-R2 | 0.00 | 2.40 | 0.56 | 0.52 | 0.00 | 2.30 | 0.45 | 0.50 | 1.23 |
| | KS-SU3-R1 | 0.00 | 1.10 | 0.26 | 0.31 | 0.00 | 1.20 | 0.44 | 0.36 | 0.59 |
| | PJ-KD6-R1 | 0.00 | 2.00 | 0.46 | 0.64 | 0.00 | 3.00 | 0.26 | 0.54 | 1.77 |
| | PJ-KD6-R2 | 0.00 | 2.60 | 0.83 | 0.66 | 0.00 | 2.00 | 0.12 | 0.19 | 6.72 |
| | PJ-KD6-R3 | 0.00 | 1.40 | 0.31 | 0.43 | 0.00 | 2.70 | 0.25 | 0.58 | 1.25 |
| TVOC(ppb) | S7-56A-R1 | 47.70 | 145.70 | 105.15 | 26.05 | 0.00 | 326.30 | 5.45 | 31.55 | 19.31 |
| | S7-43D-R1 | 0.00 | 189.00 | 157.49 | 41.16 | 0.00 | 257.00 | 3.02 | 20.55 | 52.14 |
| | S7-43D-R2 | 0.00 | 202.70 | 149.95 | 49.72 | 0.00 | 344.00 | 6.73 | 35.22 | 22.27 |
| | S7-43D-R3 | 0.00 | 96.30 | 51.61 | 35.17 | 0.00 | 424.70 | 2.59 | 25.84 | 19.90 |
| | SP15-R1 | 0.00 | 63.00 | 23.60 | 24.37 | 0.00 | 30659.70 | 643.64 | 3340.16 | 0.04 |
| | SP15-R2 | 0.00 | 177.00 | 36.82 | 41.85 | 3.30 | 23331.30 | 1056.85 | 4152.64 | 0.03 |
| | KS-SU3-R1 | 0.00 | 52.70 | 18.50 | 18.66 | 0.00 | 5339.50 | 151.82 | 525.74 | 0.12 |
| | PJ-KD6-R1 | 0.00 | 134.50 | 109.28 | 36.33 | 0.00 | 910.50 | 27.26 | 88.64 | 4.01 |
| | PJ-KD6-R2 | 149.00 | 295.00 | 217.13 | 25.77 | 0.00 | 3363.00 | 142.62 | 442.24 | 1.52 |
| | PJ-KD6-R3 | 0.00 | 144.00 | 95.01 | 42.46 | 0.00 | 1005.00 | 30.14 | 98.84 | 3.15 |
| $CH_2O$ (ppm) | S7-56A-R1 | 0.00 | 0.43 | 0.02 | 0.06 | | | | | |
| | S7-43D-R1 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| | S7-43D-R2 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| | S7-43D-R3 | 0.00 | 0.28 | 0.01 | 0.03 | | | | | |
| | SP15-R1 | 0.00 | 0.24 | 0.02 | 0.04 | | | | | |
| | SP15-R2 | 0.00 | 0.28 | 0.01 | 0.03 | | | | | |
| | KS-SU3-R1 | 0.02 | 0.24 | 0.03 | 0.08 | | | | | |
| | PJ-KD6-R1 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| | PJ-KD6-R2 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| | PJ-KD6-R3 | 0.00 | 0.00 | 0.00 | 0.00 | | | | | |
| $PM_{10}$ (µg/m3) | S7-56A-R1 | 100.00 | 566.00 | 316.24 | 141.21 | | | | | |
| | S7-43D-R1 | 30.00 | 123.00 | 41.00 | 23.38 | | | | | |
| | S7-43D-R2 | 31.00 | 144.00 | 69.59 | 21.70 | | | | | |
| | S7-43D-R3 | 62.00 | 273.00 | 158.57 | 67.69 | | | | | |
| | SP15-R1 | 100.00 | 566.00 | 316.24 | 141.21 | | | | | |
| | SP15-R2 | 65.00 | 370.00 | 208.06 | 66.63 | | | | | |
| | KS-SU3-R1 | 115.00 | 556.00 | 342.82 | 123.45 | | | | | |
| | PJ-KD6-R1 | 36.00 | 135.00 | 73.48 | 18.23 | | | | | |
| | PJ-KD6-R2 | 17.00 | 163.00 | 42.64 | 28.17 | | | | | |
| | PJ-KD6-R3 | 95.00 | 909.00 | 174.25 | 73.47 | | | | | |

Generally, relative humidity in four natural ventilation classrooms (S7-43D-R3, SP15-R1, SP15-R2 and KS-SU3-R1) exceeded the ASHRAE (2009) recommendation limit at 30%-65%. The I/O relative humidity of each classroom have shown in small ranging, except the air-condition classroom PJ-KD6-R2 at 0.76 with the lowest ratio indoor-outdoor, suggesting that the mechanical air-conditioner have controlled the indoor environment**.**

Indoor $CO_2$ concentrations have been referred to as an indicator of indoor air quality. The distribution of $CO_2$ is log-normal. The concentrations of both points (indoor and outdoor) are fluctuated and resulted insignificant to others. Meaning, the outdoor carbon dioxide concentration do not influent the indoor concentration. The mean values of outdoor carbon dioxide range between 326.13 ppm to 488.25 ppm. But, the indoor carbon oxide concentration reveals differently. Ventilation strategies and occupant density have given a significant effect to the level of $CO_2$. The air-conditioned S7-43D-R2 classroom with density of 22 pupils stated the highest mean value of $CO_2$ at 1680 ppm, followed by PJ-KD6-R2 air-conditioned classroom with 20 pupils' density at 1295 ppm, $CO_2$ mean value concentration 1293ppm for PJ-KD6-R1 (pupils density: 19 people) and air-conditioned classroom S7-43D-R1( with 19 pupils density) at 1054 ppm of $CO_2$ mean value. These 4 air-conditioned classrooms have exceeded 1000 ppm as stipulated standard limit in The Malaysian Code of Practice (DOSH, 2005) and ASHRAE Standards (ASHRAE, 2009). Meanwhile, the natural ventilation classrooms (S7-56A-R1, S7-43D-R3, SP15-R1, SP-15-R2, PJ-SU3-R1) seem to have a good indoor air quality, where the indoor $CO_2$ mean value concentrations were below the DOSH, 2005 and ASHRAE 62.1-2009 limit. Although, S7-56A-R1, S7-43D-R1, PJ-KD6-R1 and PJ-KD6-R3 has the similar numbers of pupil density at a time but the mean values of $CO_2$ were vary with different ventilation strategies.

Indoor concentration for $PM_{10}$ was stipulated the maximum allowable concentration in inhabitant area standard is 0.15 mg/m$^3$ (DOSH, 2005). The range of mean concentrations was between 41.0 to 342.82 µg/m$^3$. The mean values of particulate 10 µm for six natural ventilation classrooms (S7-56A-R1, S7-43D-R3, SP15-R1, SP15-R2, KS-SU3-R1 and PJ-KD6-R3) were beyond the Malaysian Code of Practice (DOSH, 2005). However, The air-conditioned classrooms have maintained the $PM_{10}$ level to be below the limit of Malaysia Code of Practice (DOSH,2005). It clearly shows that the outdoors particles have distributed the $PM_{10}$ concentration into the indoor environment.

The mean concentrations of $CH_2O$, CO and TVOC well below the Malaysian Code of Practice (DOSH, 2005) recommended values of 10 ppm for an 8-hour of exposure. The values were ranging between from undetectable to 0.03 ppm, 0.26 ppm to 0.83 ppm and 18.5 to 217.13 ppb respectively. The finding shows a few parameters were beyond the standard limit and suspected as a contribution to the health symptoms among occupants. Relative humidity, temperature, $CO_2$ and respiratory particulate, $PM_{10}$ were found as the inadequate parameters in this study. As mentioned earlier, Malaysia tropics condition might effects the level of temperature and relative humidity. It is impossible to get the adequate level for both environmental parameters.

Running nose, sore throat and coughing were reported higher at both ventilation classrooms. Surprisingly, sore throat, coughing and fatique were significantly perceived in NA classrooms which were recognized with the elevated indoor concentration of $PM_{10}$, temperature and relative humidity. These parameters might as well contribute to the perceived symptoms among pupils in the classrooms (Bluysen, 2009).

## Conclusion

In view of IAQ performance in refurbished private pre-schools it would be understandable to find that overall sources are originated from indoors activities and outdoors materials the from the environmental factors such as urbanization, industrialization, construction activities. The results of the measurement show the differences arise, due to the advantage of the indoor environment. Particularly with the high density of pupils in the classrooms in air condition classrooms has invited the high level and insufficient indoor $CO_2$.This is seen particularly when the high level indoors in the classroom environment contrast strongly with the air outside the pre-school building. The adapted space function which previously is bedrooms is inadequately to provide a good air quality and invited few health symptoms. Meanwhile, the outside particles too have established poor indoor environment through the openings and natural ventilated classrooms found to have high levels of $PM_{10}$. The improper ventilation strategies has encourage some symptoms to children especially to those are really sensitive on the presence of few parameters with the minimum dose.

Yet, the symptoms of health problems may not only begin only when children being at school. The environmental factors such as urbanization, industrialization, air pollution, hygienic conditions, renovation, mould and smoke exposures, building and furnishing materials and diet have been related to increased or decreased risk, and thus prevalence, of allergic diseases and could potentially explain a part of the factor.

This type of study should be extended to the biological contaminants and widely apply to other numerous of refurbished pre-schools in order to be better able sustaining the IAQ management strategies and to apply source apportionment methodologies. The outcomes of the studies are foreseen as a benchmark for future research to improve the pre-schools physicals' environment.

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