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DO THE WORKERS OCCUPIED IN THE TRANSPORTATION HUB BUILDING EXPOSED TO INDOOR AIR POLLUTANTS?

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ABSTRACT

Background: Workers who spend most of their working hours being in the building do not realise that indoor air can become a major problem towards their health. Therefore, the objective of this study is to measure the level of indoor air pollutants in the transportation hub building and its relationship with Sick Building Syndrome (SBS) among the respondents.

Materials and Methods: Sample collection and measurement were conducted as guided by the Malaysia standards of Indoor Air Quality. Structured questionnaires were distributed to 77 workers occupied the building. Measurement of indoor air physical parameters was performed according to the method recommended in the Code of Practice.

Result: Results discovered that the prevalence of the respondents having Sick Building Syndrome is 90.1%. All physical parameters measured were within the acceptable limits by the Malaysia standard of Indoor Air Quality, except the temperature at Level 1 and Level 2 of the building. However, the statistical analysis demonstrated that there was no significant association between Sick Building Syndrome with all the IAQ parameters; CO_2 (p=0.233), temperature (p=0.828), relative humidity (p=0.254) and CO (p=0.999).

Conclusion: In conclusion, the indoor air quality of the building is conformed to the permissible limits as stipulated in the Code of Practice, nevertheless, further research to explore other factors of SBS is recommended.

Keywords: Indoor air quality; Sick building syndrome; Transportation hub; Indoor air pollutants.

1.0 Introduction

Health status is one of the major reasons to create a comfortable and better surrounding as the quality of indoor environment may be associated with the health and wellbeing of the occupants in the building (Altomonte, et. al., 2017). If the environment in the building lead to the negative health effects, it could have caused by the design or technical flow of the building system. Building structures are related with the range of health hazard such as those attributable to extreme temperature, indoor air pollution, noise, airborne infectious disease and mold contamination (Silvia et. al., 2017). Many studies had confirmed that long-term and short-term exposure to poor indoor air quality has been associated with the increasing of respiratory and cardiovascular disease. People who lived inside the building for many years are more likely to expose with harmful effect from the bad indoor air quality. People prefer and willing to execute extra efforts to create a better indoor surrounding so that they can feel comfortable and healthy. This will also lift up their mood all day and fulfill the occupant's satisfaction (Frontczak, 2011).

There are many sources of indoor air pollutants such as environmental tobacco smoke emitted due to burning of tobacco product; formaldehyde emitted from furnishings; and volatile organic compounds from the usage of solvents. Some pollutants may particularly affect indoor air quality in office building compared to other, for example, office equipment such as photocopiers and printers. These have been shown to emit respirable particles, ozone and a range of Volatile Organic Compounds (VOCs).

It is generally recognized that most people spend their time of about 70% - 90% indoor either in the office, workplace, school or house. Indoor air toxicants are two to five times and occasionally more than hundred times higher than outdoor air (Jouvan, 2015). For the past few years, the cases of sick building syndrome have increase among workers who has long working hours inside the office or building.

The affected workers will manifest symptoms such as cough, breathing difficulty, runny nose, and fatigue. The symptoms exhibited by the affected workers are best described as sick building syndrome that happened towards workers who spend long time inside the building.

Sick Building Syndrome (SBS) is a condition associated with the feeling of discomfort which include headaches; nausea; dizziness; respiratory irritation and coughing. In addition, it is a situation in which occupants of a building experienced acute health or variety of health symptoms; it is triggered when people spend time in a particular building (Babatsikou, 2011). Previous researchers have discovered that SBS is the result of inadequate ventilation per occupants and the elevated chemical pollutants concentration. The symptoms are often related with time of occupancy and relief often occurred after the occupants leave the affected buildings (Daisey et al., 2000).

SBS has become a common issue in Malaysia in recent years due to the construction of building designated to be energy-efficient with air-conditioning system. However, the poor maintenance and service of Heating, Ventilation and Air-Conditioning (HVAC) system resulted in the increasing levels of indoor air pollutants (Syazwan et al., 2009).

Thus, in Malaysia, the Department of Occupational Safety and Health has introduced the Industry Code of Practice on Indoor Air Quality (ICOP) 2010 (DOSH, 2010). This Code of Practice is presented to make sure the buildings or designated workplaces comply with the minimum standard on selected parameters in a work place. It applies to all enclosed buildings where there are persons working at any domestic buildings. It is designed to avoid negative health effects among occupants of an indoor or enclosed environment or buildings.

Thus, this study is designed to determine the level of IAQ at three different floors in a building, to investigate the occurrences of SBS and to discover the association of the prevalence of SBS with the IAQ physical parameters measured.

2.0 Materials and Methods

2.1 Study design and sampling location

This study is a cross-sectional study which involves gathering of data in a defined time and at short period. This study was conducted at a transportation hub station located at Jalan Reko, Kajang, Selangor, Malaysia (2.9575° N, 101.7914° E). The premise chosen has five floors with the bus hub at the ground level area. There are 112 buses trips per day; departed and arrived from and to various states in Malaysia. The indoor air measurement was conducted in Level 1, 2 and 3 which are located at several government agencies and shop lots.

2.2 Criteria of indoor air measurement and sampling point

The measurement of indoor air was conducted based on the protocol guided by the Industry Code of Practice on Indoor Air Quality (DOSH, 2010). The instrument used was TSI's IAQ-CalcTM Indoor Air Quality Meter 7545. The numbers of sampling points are determined by the estimation of total floor area in the building. The sampling points should be located approximately 1 meter off the edge of the fresh air intake and enclosed in an appropriate shelter to shield from direct sunlight and moisture. Hence, in this research, the number of sampling altogether is 9; with 3 sampling points at each Level 1, Level 2 and Level 3. The reading of IAQ parameter that measures the level of CO2, CO, temperature and humidity were taken for 8 hours and recorded for 30 minutes in each session. The parameter measurement was conducted for consecutively 8 days of working days

2.3 Survey on Sick Building symptoms

A self-administered questionnaire was distributed among 77 respondents (96% response rate) working in the building. The questionnaire consists of socio-demographic, respondents' health status and symptoms of SBS. The respondents will be classified as having SBS if they experience at least one symptom of SBS and the symptoms appeared at least once a week. The respondents also must have reported the occurrence of at least 1 to 3 days per week during the last four weeks and must have reported that the symptoms showed improvement when they were away from the place of work (DOSH, 2010; Norhidayah et al., 2013).

2.4 Statistical analysis

The statistical analysis is using the Statistical Packaging Social-Science (SPSS). Kruskal Wallis test is used to determine the differences of the measured IAQ data with the permissible limits sets by ICOP 2010. Binary logistic regression was used as a further test to find the relationship between the measured IAQ parameters and the SBS symptoms.

3.0 Result

3.1 Comparison of IAQ parameters

Table 1 Comparison of IAQ parameter between three different levels with Standard

Variables	**Acceptable limit ICOP 2010**	**Median (Inter Quartile range)**				
		Floor 1	**Floor 2**	**Floor 3**	**X^2**	**p-value**
Temperature (˚C)	23 - 26	29.1 (28.2-29.6)	26.5 (25.8-26.6)	25.8 (25.7-25.9)	34.91	<0.001**
Relative Humidity (%RH)	40 - 70	63.9 (60.4-70.0)	48.3 (46.9-49.6)	52.8 (51.6-53.5)	38.34	<0.001**
Carbon dioxide (CO_2) (ppm)	C1000	513 (496.3-594.8)	660.5 (644.8-686.0)	659.5 (597.0-716.0)	23.86	<0.001**
Carbon monoxide (CO) (ppm)	10	0 (0.0-0.2)	0 (0-0)	0 (0-0)	8.53	0.014*

Kruskal Wallis Test
*Significance at α<0.05
**<0.001 Highly significant

The finding of IAQ parameter assessment is stated in Table 1. The physical parameters were compared with the acceptable limits by DOSH, Malaysia (DOSH, 2010). All of the parameters met the acceptable limits, except the temperature at Floor 1 and Floor 2 of the building.

3.2 Prevalence of SBS symptoms

Table 2 Percentage prevalence of SBS symptoms

Symptoms	**Floor 1**		**Floor 2**		**Floor 3**	
	N = 15		**N = 27**		**N = 35**	
	n	**%**	**n**	**%**	**n**	**%**
Headache	10	13.0	12	15.6	22	28.6
Feeling heavy-headed	8	10.4	8	10.4	8	10.4
Fatigue/lethargy	5	6.5	13	16.9	12	15.6
Drowsiness	15	19.5	23	29.9	25	32.5
Dizziness	5	6.5	9	11.7	10	13.0
Nausea/vomiting	4	5.2	6	7.8	5	6.5
Cough	7	9.1	8	10.4	8	10.4
Irritated/stuffy nose	5	6.5	8	10.4	9	11.7
Hoarse, dry throat	10	13.0	4	5.2	12	15.6
Skin rash/itchiness	12	15.6	5	6.5	3	3.9
Irritation of the eyes	5	6.5	9	11.7	8	10.4
Scaling/itching scalp or ears	10	13.0	4	5.2	7	9.1

n=77

Table 2 shows the prevalence of Sick Building Syndrome among the respondents in the building. All symptoms were experienced by some of the respondents from each level. The symptoms were found share similarities in each level of the building. As in the table, drowsiness was the most prevalent symptoms in those three levels, which are 19.48% (Level 1), 29.86% (Level 2) and 32.46% (Level 3) among other symptoms.

Table 3 below demonstrates the association between IAQ parameters and SBS symptoms. However, it is indicated that there is no significance association between the IAQ readings and symptoms of SBS.

3.3 Association between IAQ and SBS

Table 3 Association between IAQ parameters and symptoms of SBS

Parameters	B	P-value
Constant	-30.648	0.495
CO_2 (ppm)	0.037	0.233
Temperature (˚C)	-0.217	0.828
Relative humidity (%RH)	0.329	0.254
CO (ppm)	24.924	0.999

Binary logistic regression

$R^2 = 0.133$

4.0 Discussion

As in Table 1, the temperature at Floor 1 and Floor 2 ranges between 28.2 ˚C -29.6 ˚C and 25.8 ˚C -26.6 ˚C. It is due to the design at these floors that adapted open-air environment and located near to the transportation hub at the Ground Level and are occupied with quite a number of individuals. According to Sookchaiya (2008), the number of occupants and type of activities could increase the environment temperature in a building. This could explain the reason why the % RH at Level 1 was the highest as the warm air may hold more moisture than cold air. In theory, it is stated that the amount of water vapour strongly related to the temperature and humidity (Alsmo & Alsmo, 2014).

CO2 concentration in those 3 floors are below the acceptable limit set by DOSH (1000 ppm) suggesting that there was acceptably good distribution of fresh air in those 3 levels and in the building with sufficient ventilation rate. Floor 1 has the most sufficient ventilation rate because it uses open space and natural ventilation. So, the air flow in Floor 1 is better compared to the other two floors. In addition, majority workers especially government workers filled the area and public who needed their services also occupied the area making it more crowded. Therefore, it could be said that the numbers of occupants in any area may have some effect to the level of concentration of CO2 in indoor spaces similarly with the findings stated by Amir Abdullah et al., (2012).

Another IAQ parameter measured was CO. All readings were not exceeding the acceptable limit by the standard. However, a slight reading of CO (0.2 ppm) detected at Level 1 may resulted from cooking activities that use gas stoves as there are several restaurants operated at the level (Ghasemkhani & Naseri, 2008). Also, it is possible that the small concentration of CO is released from motor vehicles as Level 1 is just one floor above the transportation hub.

An individual is declared with SBS when the respondents proclaimed experienced at least a symptom of SBS and the symptom appeared at least once a week (Norhidayah et al., 2013). The score of the SBS was determined based on the positive responses. The mark will be given to the SBS scale if at least one symptom is reported almost every day and if two symptoms reported every day, 2 marks will be given and so on. Thus, the total prevalence of SBS among respondents was 90.1%. Since more than 20% of the respondents experienced SBS, this building shall be categorized as having a sick building syndrome. (Ooi et al., 1998).

Table 3 indicated that there is no significance association between IAQ and symptoms of SBS and this study result was contradicted with a study conducted by Zamani et al. (2013) whom found that there is significant association between prevalence of SBS and CO2 with reading of CO2 more than 672 ppm. Since there is no significant association between them, the prevalence of SBS among respondents in the building may be due to other factors and not due to the indoor environment inside the building.

The reason for SBS symptoms are not clear (Joshi, 2008) but it may due to their own health status which cannot be identified by the questionnaire and need further health screening. Dales et al., (2004) also believed that there is no direct cause has been identified which associate SBS symptoms with an exposure of indoor air pollutants.

A study conducted by Wolkoff (2012) in Malaysia stated that the concentration of CO2 could be one of the risk factors for throat, fatigue and headache symptoms. Nevertheless, this study results showed no association between the IAQ parameters with SBS symptoms and this is supported with a study done by Id et al., (2017) which found out that concentration of CO2 had no association with SBS symptoms. They also stated that various of SBS symptoms are associated with factors such as different personal characteristics, psychosocial and environmental factors.

Since this study shows that there is no association between IAQ and SBS symptoms, the contributor of SBS symptoms among office workers can be from illuminance and noise especially for headache symptoms (Tietjen et al., 2012). The factors of SBS symptoms also could be self- generated. For example, symptoms will develop among workers when they smoke and have high work pressure (Id, et al., 2017). These factors particularly with regard to lower respiratory symptoms such as shortness of breath, coughing and fatigue.

Drowsiness is the highest SBS prevalence among the respondents. This may have happened as they stay for a long time in a room and excessive number of customers especially at the restaurant, seller counter and offices increases the severity of SBS symptoms experienced by the respondents. Most of the workers spend most of their working hours in their offices, hence, they experienced lack of ventilation or air flow inside the rooms that they are in.

Joshi (2008) mentioned that some of the factors that might be responsible for SBS are psychological factors and inappropriate lighting with absence of light, bad acoustics and poor ergonomics. The examples of psychological factors are job dissatisfaction and poor interpersonal skills among workers.

Hence, from the results, most probably the prevalence of SBS symptoms was high among the workers because of other factors since there is no significance association of IAQ parameters and the SBS symptoms.

5.0 Conclusion and recommendation

In conclusion, this study demonstrated that the transportation hub building has good indoor air quality which meets the standards set by DOSH Malaysia. However, there is a high prevalence of SBS among respondents occupied in the building. Meanwhile, there is no significant association between IAQ and SBS symptoms. Thus, this study suggested that advanced research is necessary to include other parameters such as total volatile compounds, total bacteria count and total fungal count. Other than that, multifactorial of SBS such as the environmental conditions such as lighting and noise, ergonomics, and psychosocial climate shall be explored.

Declaration

Author(s) declare that that they have no competing interests with respect to the research, authorship, and /or publication of this article.

Authors contribution

All authors contributed to the preparation of the manuscript, reviewing and approving the final manuscript.

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