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Evaluation of Sick Building Syndrome (SBS) Symptoms and Measurement of Indoor Air Quality (IAQ) Parameter in One of Hospital Building in Johor

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ABSTRACT

This study assesses Sick Building Syndrome (SBS) symptoms and Indoor Air Quality (IAQ) parameters among hospital ward staff. Utilizing a thorough methodology, a questionnaire survey and IAQ monitoring were conducted, aligning with Department of Occupational Safety and Health (DOSH) guidelines. IAQ parameters are generally within limits, except for relative humidity which recorded values of 73.09-75.23% for Ward 16 and 62.33-71.13% for Ward 18. Respondents expressed concerns about room conditions, including temperature variations, unpleasant odours, and noise. Fatigue, difficulties concentrating, and various respiratory symptoms were prevalent, suggesting potential health issues linked to indoor pollutants. The findings underscore the urgency of addressing IAQ concerns to improve the well-being of patients and healthcare workers.

1. Introduction

Recently, Malaysia and generally all over the world have been shocked by the issue of COVID – 19 pandemics. Rahardiman *et al.,* [1] found several areas within the hospital during a pandemic, such as the emergency room and treatment rooms, where the concentrations of bacteria and fungi were slightly elevated. The authors suggest that these findings may be due to the increased use of personal protective equipment and cleaning agents during the pandemic, which may have affected the hospital's ventilation system and indoor air quality. Besides, Fonseca *et al.,* [2] reviewed 64 articles published between 2015 and 2020, and they found that indoor air quality (IAQ) in healthcare units is a complex issue that requires a comprehensive approach. The study reveals that the most common indoor air pollutants in healthcare units are biological contaminants, such as bacteria, fungi, and

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viruses, as well as chemical pollutants, such as volatile organic compounds (VOCs) and particulate matter. The sources of these pollutants include patients, medical equipment, cleaning agents, and outdoor air pollution.

Dikmen & Gültekin [3] discussed in their research paper the importance of maintaining good indoor air quality in hospital buildings, and the challenges that hospitals face in achieving sustainable IAQ. There are several sources of indoor air pollution in hospital buildings as described by the author, including biological pollutants such as mould, bacteria, and viruses that can cause respiratory infections and allergic reactions, chemical pollutants such as volatile organic compounds (VOCs) that are released from cleaning agents, disinfectants, and medical equipment, outdoor pollutants such as particulate matter, nitrogen oxides, and sulphur dioxide that can enter the building through ventilation systems or open windows and the occupational pollutants such as latex particles, anaesthetic gases, and drugs that can pose a risk to healthcare workers who are exposed to them on a regular basis. The finding can be supported by reviewing the previous research from [4-7] which discuss detailed reviews of the sources of indoor air pollutants in hospital environments, along with recommendations for monitoring and mitigating their impact on indoor air quality.

The health risks associated with poor indoor air quality in hospital buildings are significant. Patients with weakened immune systems, such as those in intensive care units, are particularly vulnerable to the health effects of poor IAQ. Healthcare workers who are exposed to indoor air pollutants on a regular basis may also be at risk for occupational illnesses. Therefore, it is important to maintain good indoor air quality in hospitals to ensure a safe and healthy environment for everyone. This research addresses a notable gap by specifically concentrating on how building conditions affect indoor air quality and the occurrence of Sick Building Syndrome (SBS) symptoms among hospital staff. Although numerous prior studies have focused on office buildings, there is a clear need to explore the relationship between building conditions, indoor air quality, and SBS symptoms in hospital environment. he significance of this study lies in its potential to enhance our comprehension of the correlation between building conditions, indoor air quality, and SBS symptoms among hospital ward staff in Malaysia. The findings are expected to offer crucial insights for hospital administrators and building managers, aiding in the enhancement of indoor environments in healthcare facilities. The aim of this study is to evaluate SBS symptoms among ward staff and measure the IAQ parameter inside the ward environment.

The International Labour Organization (ILO) defines Sick Building Syndrome (SBS) as occurring when 20% of employees report experiencing symptoms associated with their workplace, especially in connection to air quality [8]. A wide range of nonspecific subjective health symptoms, such as itchy eyes, skin rashes, and symptoms of nasal allergies, are included in SBS. Furthermore, individuals may experience general symptoms such as fatigue, aches and pains, sensitivity to odours, and difficulties in concentration [9]. The impact on health increases with longer and more intense exposure, resulting in a range of symptoms from mild eye irritation, coughing, and wheezing to more serious respiratory problems, reduced heart and lung function, tuberculosis, cardiovascular disorders, and even early death [10-15]. The study by Zainal *et al.,* [16] found that higher levels of VOCs and PM were associated with increased reports of SBS symptoms. The concentration of indoor air pollutants exceeded the recommended levels reported a high prevalence of SBS symptoms, including eye irritation, headaches, and dry or itchy skin [17]. The table discusses the IAQ parameters that were studied, the IAQ problems identified, the sick building syndrome (SBS) symptoms reported, and the methods used to control IAQ levels.

IAQ parameters such as temperature, relative humidity (RH), carbon dioxide (CO_2), volatile organic compounds (VOCs), particulate matter ($PM_{2.5}$ and PM_{10}), total bacterial and fungal count can literally contribute to the SBS symptoms [18-25], effected building occupants by eye irritation, nasal irritation, dryness or irritation of the throat, fatigue, headaches and dizziness. Previous research has provided numerous references discussing the health effects, specifically SBS symptoms, that result from exposure to air pollutants. Some examples of references and respected references are Carbon dioxide (CO_2) [26,27], Carbon monoxide (CO) [28], Nitrogen Dioxide (NO_2) [29], Formaldehyde (HCHO) [30-32], Total Volatile Organic Compound (TVOC) [33], Respirable Particulate ($PM_{2.5}$) [34], Ozone (O3) [35], Total Bacteria count [36,37], Total Fungal Count [38,39]. The primary problem of microbiological contamination arises when the extent of contamination exceeds a particular limit, which is considered ordinary for a specific environment [40]. The mentioned indoor air quality (IAQ) characteristics covered in the research are critical for understanding and improving indoor air quality. Temperature, humidity, carbon dioxide, volatile organic compounds, and particle matter are all significant elements that can affect indoor air quality and occupant health. Monitoring and regulating these characteristics are critical to maintaining a healthy indoor environment. The IAQ issues raised in the research are also noteworthy. Poor ventilation, excessive levels of indoor pollutants, and inadequate air filtering can all contribute to poor indoor air quality and have a negative impact on building occupants' health. By recognizing these issues, researchers can design methods to enhance IAQ. The SBS symptoms reported by inhabitants should also be considered. Poor IAQ can cause a variety of symptoms, including headaches, tiredness, and eye discomfort that can lead to decreased productivity and overall discomfort for building occupants. Finally, the methods used to control IAQ levels are crucial for improving indoor air quality.

2. Methodology

Data collection has been carried out by conducting subjective measurement (ICOP questionnaire) and physical measurements (IAQ monitoring). For the questionnaire survey, the population consisted of all staff ward in WARD 16 and Ward 18 in hospital X and was given a set of structured questionnaires that were adapted from ICOP [41]. These questionnaires included information on the respondents' socio-demographics, health status, and symptoms of SBS, as well as the amount of time they spent in the building each week, their job position, and the quality of the air inside the buildings. To be classified as having SBS, respondents needed to have at least one symptom that occurred at least once a week and have reported experiencing symptoms for at least 3 days per week in the last four weeks [9,45]. Additionally, respondents needed to have reported an improvement in their symptoms when they were away from their place of work. For IAQ monitoring, the selected parameters are temperature, relative humidity, air movement, respirable particulate, TVOC, CO, CO_2, formaldehyde, ozone, total bacteria count, and total fungi count. The sampling method and procedure follows the Industrial Code of Practice (ICOP) developed by the Department of Occupational Safety and Health (DOSH) in 2010 [41].

IAQ parameters should be monitored every eight hours, according to the ICOP unless otherwise specified. In this study, a surrogate measurement approach has been implemented because it is not practicable to undertake continuous 8-hour measures due to preventive interruptions for hospital activities. This involves an intermittent measurement strategy based on the average of half-hour measurements conducted at four specific timeslots. In general, the four timeslots should cover the worst-case scenario, such as peak usage hours, for public venues and be equally distributed among business hours for commercial buildings. If a real-time monitor is being utilized, ensure at least one reading is taken every 5 minutes at each sampling point using a data logging device or appropriately recorded in a field data log sheet. All measurements have been made using calibrated instruments and equipment, and when applicable, the calibration should be carried out in accordance with the manufacturer's instructions. Sampling was performed by using the following equipment as listed;

Portable TSI IAQ meter & Graywolf IAQ meter for temperature, relative humidity, air velocity, carbon monoxide and carbon dioxide and TVOC; Portable environmental sensors formaldehyde meter for formaldehyde; and Respirable particulate for TSI dust-track portable monitor low ozone.

Ethical Issue and Clearance Ethical approval was obtained from the Human Research Ethics Committee of Universiti Tun Hussein Onn Malaysia with code UTHM/RMC/100-9/139 Jld. 3(04) dated 16th August 2023 and from Medical Research & Ethics Committee, National Medical Research Register with code NMRR ID-23-02808-KFP (IIR). The participants completely understand the research's objective, procedure, and outcome. The researchers kept both the individuals' and the company's information private.

3. Result and Discussion

Table 1 presents the data of indoor air quality parameters in Ward 16 and Ward 18, comparing the measured values to the acceptable limits from Industrial Code of Practice (ICOP) set by the Department of Occupational Safety and Health in Malaysia.

Table 1
Comparable of IAQ parameters with ICOP Standard

No.	Parameter	Unit	Acceptable limit (ICOP-IAQ DOSH, 2010)	Measured value of indoor air quality			
				Ward 16		Ward 18	
				Min	Max	Min	Max
1	Temperature	°C	23-26	23.58	24.99	23.11	24.10
2	Air movement	m/s	0.15-0.5	0.113	0.146	0.039	0.087
3	Relative humidity	%	40-70	73.09	75.23	62.33	71.13
4	Carbon dioxide	ppm	C1000	445	533	534	606
5	Respirable particulate	Mg/m3	0.15	0.015	0.038	0.023	0.037
6	Carbon monoxide	ppm	10	2.85	3.45	1.9	2.95
7	TVOC	ppm	3	0.395	1.159	0.106	0.371
8	Ozone	Ppm	0.05	0	0.01	0	0
9	Formaldehyde	Ppm	0.1	0.016	0.051	0.02	0.04
10	Total fungal count	CFU/m3	1000*	151	169	294	353
11	Total bacteria count	CFU/m3	500*	99	156	79	106

When the indoor air quality (IAQ) levels in Wards 16 and 18 are compared to the acceptable limit outlined by the ICOP-IAQ (the Department of Occupational Safety and Health's Indoor Air Quality Guidelines), many notable discoveries emerge. In terms of temperature, carbon dioxide, carbon monoxide, respirable particulate matter, TVOC, formaldehyde, and bacterial/fungal counts, both words frequently maintain acceptable IAQ values, well below the limitations imposed. Ward 18 has no detectable ozone, potentially due to a lack of ozone-emitting sources or inadequate monitoring, but Ward 16 has relative humidity values that surpass the upper threshold. Overall, proactive monitoring and targeted actions in these areas can help to maintain optimal IAQ, improve occupant comfort and well-being while conforming to the ICOP-IAQ standard.

The survey results revealed that a significant proportion of respondents exhibited symptoms compatible with SBS. However, due to limitations in the number of available respondents, the validity of the cross-sectional study might be affected. Moreover, selection bias could have occurred because of unequal respondent rates, which may have affected the prevalence of SBS symptoms. A total of 60 questionnaires were distributed, and the response rate was 95%. All 60 ward staff members, engaged in daily duties within the wards, actively participated in the questionnaire. A careful screening process resulted in the rejection of 5% of the questionnaires, as respondents with existing health conditions were excluded to ensure the validity and reliability of the collected data. Sociodemographic data were obtained from respondents in their respective buildings and are presented in Table 2. The proportion of female respondents was higher than that of males. The age distribution of the respondents was as follows: 52.6% fell within the 40-55, 46.6% were in the age range of 25-39, and the rest is over 55. All respondents spent the same number of hours per week in the buildings, which was 40 hours or 8 hours per day.

Table 2
Characteristics of respondents

Building	Ward 16 & 18
N = 60	
Response rate:	95%
Sex distribution:	
Male	6.3%
Female	94.7%
Age of respondents:	46.6% (25-39)
	52.6% (40-55)
	1.8% (>55)
Working time per week (hours):	All respondents 40h/week @ 8h/day

Based on the responses provided by the respondents, it appears that there are several issues related to the room conditions and indoor air quality in the hospital ward. One of the most reported issues is varying room temperature, with 73.7% of respondents indicating that they have experienced this problem as shown in Figure 1.

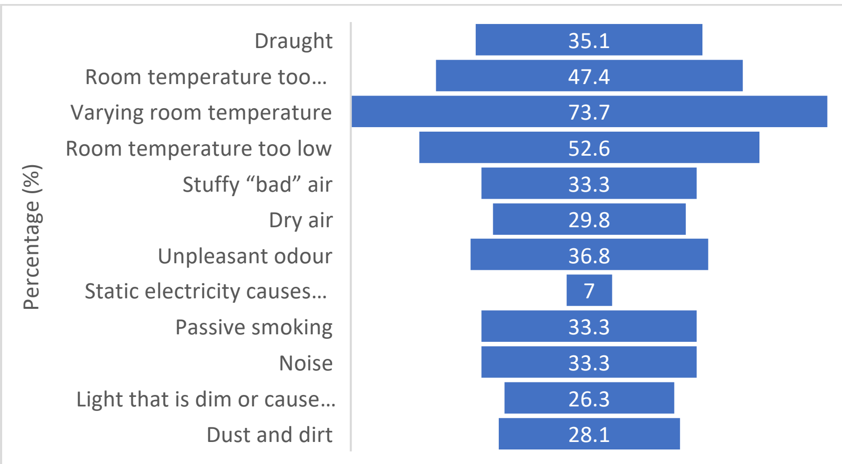

Fig. 1. Respondents feeling in workplace environment

This suggests that there may be an issue with the heating, ventilation, and air conditioning (HVAC) system in the ward that needs to be addressed. Another issue that was reported by a significant number of respondents is room temperature being too low (52.6%) or too high (47.4%). This could have negative impacts on both the patients and the healthcare workers, as excessively warm or cold temperatures can lead to discomfort and potentially even health problems. Additionally, a significant proportion of respondents reported experiencing stuffy or "bad" air (33.3%) and unpleasant odours (36.8%), which could suggest that there are issues with ventilation or cleanliness in the ward. Other reported issues, such as noise (33.3%), dust and dirt (28.1%), and lighting (26.3%), could also have negative impacts on the comfort and well-being of patients and healthcare workers.

Poor indoor air quality can be caused by a variety of factors, such as the presence of indoor pollutants, inadequate ventilation, or high humidity levels, all of which can have contributed to SBS symptoms and negative effects on health and wellbeing. As shown in Figure 2, fatigue was reported by over 80% of individuals in the sample. This high percentage suggests that fatigue may be indicative of an underlying health issue or exposure to a harmful substance or environmental factor in the hospital ward.

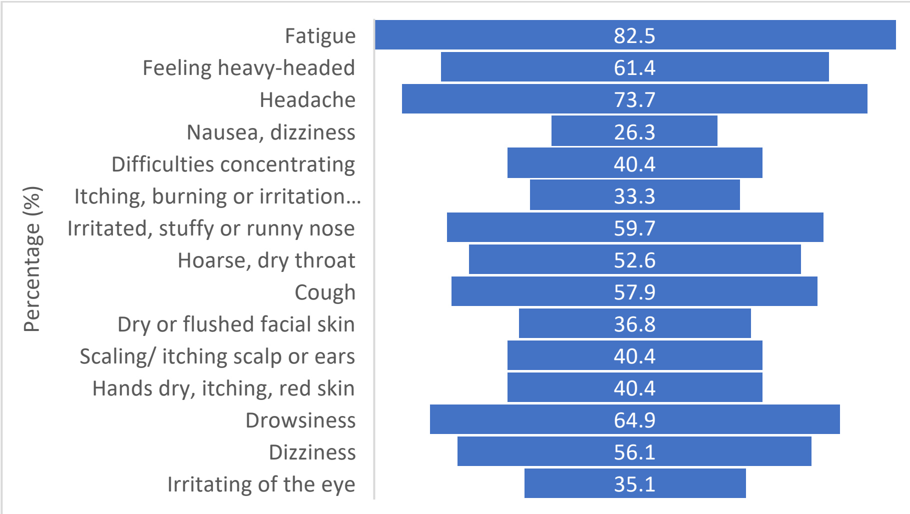

Fig. 2. Present Symptom amongst respondents

Moving on to the symptom with the median reported percentage, difficulties concentrating were reported by 40.4% of individuals in the group. This percentage suggests that difficulties concentrating may be a moderate concern for the group, but not as common as other symptoms such as fatigue or headaches. Looking at the symptom with the lowest reported percentage, the "Others" category was reported by 15.8% of individuals in the group. While it is difficult to determine exactly what symptoms fall under this category, the low percentage suggests that these symptoms are less common than others reported in the data. However, it is important to note that any unusual or concerning symptoms should be reported to a healthcare professional, regardless of how many other individuals in the group may be experiencing them. The other symptom recorded in this survey are feeling heavy-headed at 61.4%, headache (73.7%), nausea (26.3%), itching, burning or irritation of the eyes (33.3%), irritated, stuffy or runny nose (59.7%), hoarse, dry throat (52.6%), cough (57.9%), dry or flushed facial skin (36.8%), scaling/ itching scalp or ears (40.4%), hands dry, itching, red skin (40.4%), drowsiness (64.9%), dizziness (56.1%) and irritating of the eye with (35.1%). Many of the symptoms reported in the data are consistent with respiratory or allergic reactions, such as irritation of the eyes or nose, dizziness, and difficulty breathing. These symptoms may be caused by exposure to pollutants or irritants in the air, such as chemicals or allergens.

4. Conclusions

This study's findings emphasize how critical it is to address the environmental elements influencing indoor air quality (IAQ) in hospital wards as soon as possible. Specific concerns like higher relative humidity and reported symptoms among respondents show possible hazards affecting the well-being of patients and healthcare staff, even while overall IAQ metrics are within acceptable levels. The difficulties that have been found—such as uneven room temperatures, disagreeable smells, and respiratory ailments—highlight the necessity of proactive management in order to guarantee a better indoor environment. It is crucial to address these problems in order to provide a more pleasant and favourable environment for all patients in hospital wards. This may be done primarily through initiatives that focus on temperature regulation, ventilation enhancements, and cleanliness.

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