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GEOGRAPHY | RESEARCH ARTICLE

Relationship between indoor environmental quality and sick building syndrome: a case study of selected student's hostels in Southwestern Nigeria

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ABSTRACT: An improved indoor environmental quality (IEQ) is a major determinant of human comfort in an occupied space. The current cross-sectional study investigates the link between indoor environmental quality (IEQ) and sick building syndrome symptoms (SBS) emergence with a case study of selected students' hostels in a Nigerian private university. A quantitative research design method was adopted where 376 (n = 376) copies of the questionnaire were purposely administered to the student's occupants. A mini environmental quality meter was also objectively used to measure the indoor air temperature, relative humidity, air velocity, and lighting levels in the selected hostel rooms in February and March 2019. The data obtained were subjected to descriptive and analysis of variance (ANOVA) inferential statistics using the Statistical Package for Social

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PUBLIC INTEREST STATEMENT

Hostels are essential facilities provided on a university campus to serve the student's housing needs. A high level of indoor environmental quantity (IEQ) is required in hostels in achieving student's well-being and academic performance. IEQ defined the acceptable air temperature, relative humidity, air velocity, acoustic, lighting, and indoor air quality in a building. Issues related to poor IEQ are linked to the emergence of sick building syndrome (SBS). Generally, SBS is used to describe situations in which building occupants experience serious health and comfort challenges related to the time spent in a building but with no specific illness or cause to be identified. This issue calls for investigating the relationship between selected IEQ components and the emergence of SBS among students' occupants in private university hostels in Southwestern Nigeria. The study's findings brought potential implications for developing healthy university hostel policies.

Sciences (SPSS) 25.0 version. The research findings revealed that students show SBS symptoms like tiredness, sensitivity to odor, sneezing, and blocked nose during their hostels' occupancy. Meanwhile, the objective measurement results showed an average indoor temperature of 29.93 °C, 31.64 °C, and 30.71 °C. Simultaneously, average relative humidity values of 79.00%, 72.06%, and 81.01% were obtained in the monitored rooms for the morning, afternoon, and evening. The ANOVA result established a positive relationship between poor IEQ condition and the SBS symptoms of odor, stuffy nose, and nausea. Therefore, it is recommended that the hostel facilities' SBS be mitigated through acceptable IEQ parameters of air temperature and relative humidity, increasing students' wellbeing, academic performance, and reputation.

Subjects: Environmental Studies; Environment & Health; Environmental Change & Pollution

KEYWORDS: Indoor environmental quality; Sick building syndrome; Hostel; Thermal comfort; Academic performance

1. Introduction

A growing body of knowledge recognizes the need for satisfactory indoor environmental quality (IEQ) in the built environment. According to Zuhaib et al. (2018) and Tang et al. (2020), acceptable IEQ is a vital factor in achieving a productive and healthy building environment, reduces sick building syndrome (SBS), and minimizes short-term absence. The authors viewed IEQ as an acceptable level of thermal, visual, and acoustic comfort in addition to indoor air quality (IAQ). Building and health sciences/epidemiological studies have related poor indoor environments to the emergence of SBS in homes and office buildings across the globe (Suzuki et al., 2021). For instance, recent studies revealed that a low ventilation rate was responsible for the higher elevated concentration of formaldehyde and volatile organic compounds in Chinese homes (Sun et al., 2019) and economic losses in commercial buildings in the UK and US (Mujan et al., 2019). In the same vein, earlier studies of Gupta et al. (2007) and Wong et al. (2009) found indoor air contaminants as significant contributors to SBS symptoms in occupied spaces. Therefore, providing a conducive indoor environment could be a promising means of preventing occupants from exposure to preventable illnesses like SBS.

SBS symptoms are vital discoveries of the 1970s in the indoor environment (Fu et al., 2021a), with considerable literature growing around the theme (Vance & Weissfeld, 2007). It is recognized as a group of health issues attributed to indoor chemical and biological pollution, including uncomfortable temperature and humidity or other personal factors while in a building (Fu et al., 2021b; Takigawa et al., 2009). Nonspecific subjective symptoms are defined in three key groups, including mucosal symptoms (eye irritation, nose catarrh, and obstruction, dry and sore throat), general symptoms (headache, fatigue, nausea, dizziness, flu-like symptoms, and inability to concentration), and dermal symptoms (itching and rash in the skin, face, hands or scalp). Although, similar terms as building-related illness (BRI) and sick house syndrome (SHS) describe the same symptoms in other regions. Crook and Burton (2010) opine that SBS is UK/Europe terminology, BRI is used in the US, while Japan adopted SHS terminology. The authors posit that the common thing about these terms is the cessation of the symptoms when out of the building and generally reported in office buildings with extensions in schools, hospitals, and homes. Invariably, the health challenges due to the SBS symptoms in the indoor environment may raise serious concern for university students residing in the hall of residence, otherwise known as a hostel.

The university's hall of residence is one of the most important facilities provided on any conventional university campus to serve students' housing needs (Valiyappurakkal, 2021). The hostel facilities accommodate students who would daily spend an average of 8–12 hours within the facility outside other learning facilities (Busch-Geertsema & Sahlin, 2007). It is a communal facility and shared space with limited access that helps build students' intellectual capacity

(Busch-Geertsema & Sahlin, 2007). A hostel facility that is well designed, constructed, and maintained provides students with a quality and productive indoor environment that would sustain them, attract better-qualified students' enrolment into the university and achieve the institutional goals (Najib et al., 2012; Valiyappurakkal, 2021). Consequently, addressing the students' knowledge and exposure to unfavorable indoor physical environmental factors associated with SBS symptoms due to the facility's time is significant for their wellbeing, future design and construction, and policy formulation.

The poor indoor environment is a significant problem in the built environment and the leading cause of SBS symptoms (Wong et al., 2008). Indeed, poor IEQ and attendant SBS symptoms could concern hostels where students from various backgrounds and sensitivity to IEQ are accommodated. Najib and Tabassi (2015) linked students' academic performance and social adjustment to hostel facilities' quality service performance. Hostels are known for high occupancy rates, affecting occupants' health, comfort, and performance conditions. These issues may be unpalatable, disruptive, driver of loss of academic work time and low performance, absenteeism, and even litigation between students and management. For instance, Mujan et al. (2019) and Tang et al. (2020) in their studies reported that lack of adequate fresh air in the UK and US commercial buildings occasioned reduced productivity in workers, and illness amounts to an estimated monetary loss of 15 billion pounds and 38 billion dollars. The researchers also relate poor students' cognitive abilities to the bad indoor environment of hostel facilities.

In recent years, investigators have examined IEQ factors' effect on human health, comfort and job productivity in educational buildings, offices, and homes. Toward this course, Amin et al. (2015) evaluated thermal conditions and SBS symptoms in three air-conditioned engineering education laboratories in a Malaysian university. Building-related factors, objective measurement of mean radiant temperature, relative humidity, air temperature, and questionnaires were used to capture the specific building data and respondent's perceptions. Results showed that all the student respondents experienced SBS symptoms of dry skin, runny nose, dry eyes, blocked/stuffy nose, tiredness, and flu-like symptoms with unacceptable thermal conditions present in the laboratory. A similar study by Wang et al. (2015) utilized a questionnaire instrument in a two-year longitudinal study to gather information on IAQ perception and onsite measured IAQ parameters in selected Sweden's elementary schools. Reduced ventilation rate and illumination were reported to have a direct effect on SBS symptoms on the pupils.

Lim et al. (2015) investigated the relationship between SBS symptoms, selected personal factors, office characteristics, and indoor office pollutions among university office workers in Malaysia. The health information of the subjects was collected via a self-administered questionnaire. Office settled dust and mite were collected through a vacuum and analyzed for chemical toxins. Office indoor temperature, relative humidity, carbon monoxide, and carbon dioxide were measured using a direct-reading instrument. The study showed that the combined house dust mite and high nitric oxide pollutions were the risk factors for SBS symptoms. Lu et al. (2016) also examined the association between outdoor air pollution, metrological parameters, indoor exposures, building characteristics, and SBS symptoms in Chinese homes. Standard questionnaires and field measurements were used in collecting data among selected adult respondents and indoor pollution factors within the three months. Their findings concluded that indoor air pollution such as mold/dampness and poor ventilation contributed to SBS symptoms in homes.

A study by Kishi et al. (2018) measured the indoor air and dust pollutants in 128 homes in Japan in establishing the relationship between SHS and poor air quality among children and adults. The building characteristics were first examined, followed by administering a questionnaire to respondents where their demographic, lifestyle and house features were captured. Findings indicated that children have a higher prevalence of any SBS symptoms than adults in the studied homes. Also, Sun et al. (2019) studied the association between IAQ and SBS in Chinese homes, where a background study of the building characteristics was initially performed. Environmental quality of air temperature, relative humidity, carbon dioxide, ventilation rate, volatile organic compounds (VOCs), particulate matters, and ozone was physically measured. A questionnaire was supplemented in gathering occupant's perceptions of SBS symptoms and odor. Logistic regression model results revealed a low ventilation rate and higher concentrations of formaldehyde and VOCs responsible for an increased SBS prevalence.

Studies targeted at thermal environmental conditions of only hostel facilities have been documented in recent times. Dhaka et al. (2013) probed conventional hostel buildings' existing thermal environmental state and its influence on students' perception in India's composite climate during the summer period. Field study results found indoor air velocity of 0.41 m/s and relative humidity of 36% as acceptable indoor physical quantities. Six major users' expectation and satisfaction performance criteria of visual comfort, thermal comfort, aural comfort, fire safety, hygiene, and information technology in hostel facilities in Hong Kong were identified and analyzed by Lai (2013) through gap theory and indicative post-occupancy evaluation method. Visual comfort was found to be the most satisfying criterion by the users. Shan et al. (2018) investigated the impact of IEQ parameters of the thermal condition and air quality in tutorial rooms in Singapore on students' wellbeing and performance through a life cycle costing tool. Their findings brought to the relevance of incorporating student wellbeing and performance in educational building design, construction, and operations leading to the system's total net benefits.

Similarly, a more recent study by Kumar et al. (2019) investigated the thermal environmental setup of multi-storey naturally ventilated hostel buildings in Jalandhar, India, with the views of acquiring acceptable indoor thermal conditions and adaptation behavior of student's occupants. The study found that switching on ceiling fans followed by opening external doors and windows was the primary adaptative criterion to restore comfort for occupants. Akanmu et al. (2021) determined the major labels of ideal IEQ (acoustic, visual and thermal) conditions of selected academic libraries in three universities in Minna, Nigeria, through objective measurement. Their findings showed that the investigated facilities' IEQ components values were above the established standards threshold. Yang and Mak (2020) proposed fuzzy comprehensive evaluation methods for assessing IEQ components' impact in Hong Kong university classrooms. Their findings revealed the thermal condition component of IEQ as the most important factor of the indoor environment.

A recent study by Tang et al. (2020) conducted an IEQ investigation of public buildings in China, including university classrooms, through survey and field measurement approaches. The study showed that the combined effects of the thermal, acoustic, visual, and IAQ components of IEQ influence a building's sustainable performance. Sadick et al. (2020) subjectively assessed the IEQ satisfaction factors' variants, job satisfaction, and self-reported productivity among faculties and staff office users in a Ghanian university. The authors' findings suggested that IEQ satisfaction factors are more inclined to professionals than academics.

In Nigeria, past studies on the indoor environment and its relationship with SBS symptoms were focused on commercial buildings (Okolie & Adedeji, 2013; Olajoke et al., 2014), public buildings (Nduka et al., 2018a, 2018b) and domestic homes (Eghosa Noel & Babajide, 2015; Ekhaese & Omonhinmin, 2014). A study by Morakinyo et al. (2016) determined the effect of vegetations on the indoor and outdoor thermal comfort conditions of two similar urban buildings in Akure, Nigeria. The study underscores the need for greening as a means of improving thermal comfort in Nigerian cities. In addition, Adaji et al. (2019) used thermal comfort survey and air temperature measurement techniques in arriving at the dissatisfied thermal environment in low-income to middle-income residential buildings in Abuja, Nigeria.

While substantial research has been carried out on this subject in offices, domestic homes, and schools' buildings in many regions, to the authors' knowledge, very little is known about this theme in hostel buildings, especially in Nigeria's tropical climate zone. Consequently, this present study will bridge this gap in the literature by investigating the link between selected IEQ factors and the prevalence of SBS symptoms among students residing in university hostels in Southwestern Nigeria.

2. Methods and materials

2.1. Study design and questionnaire

A cross-sectional design study was conducted at the undergraduate hostel facilities of a privately owned university, located within the geographical latitudes 6°41′8.16” N to 6°41′24.77” N latitudes 3°11′15.01” E to 3°11′34.23” E, between February and March 2019. A cross-sectional study establishes a relationship between variables of interest as they exist in a definite population at a single point or over a short period. The study period is designated dry season in Nigeria, with a mean maximum temperature ranging from 30.3 °C to 41.4 °C, and rains ranged from 0.5 mm to about 74.4 mm in 1– 2 rain days in the country's southern region (Nigerian Metrological Agency, NIMET, 2019). The hostels were inspected, and details on building construction, materials, lighting, and type of ventilation system were noted. The authors also investigated any signs of building dampness, such as damp spots, water leakage, or indoor mould growth in the hostels. The occupation of hostel facilities is usually in line with the university's academic calendar of two semesters in one session.

Each semester lasts for an average of 16 weeks, with at least four weeks of holidays separating the semesters. Since educational activities started in early August 2018, the students had been 6–7 months in the hostels. Students were mostly Nigerian natives from various geo-political zones of Nigeria. A questionnaire was administered on the indoor environment of the hotels and likely SBS symptoms. The objectives of the study were explained to them to get a full corporation. Seven undergraduate hostels out of 10 (Oyedepo et al., 2015) were purposively selected, given the entire room spaces' complete occupation. 376 out of 6178 occupants' population of the hostels (Worgwu, 2019) were chosen as a sample size using Yaro Yamane's sampling formula. The formula is as stated below:

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

Where; n = samples size, N = population of the study and margin of error, e = ± 5% precision. Therefore,

n = ?

N = 6178

$$n = \frac{6178}{1+6178(0.05)^2} = 375.68376\text{subjects.}$$

A questionnaire based on “questions for SBS studies” by Raw (1996), as reported by Shan et al. (2018), was adapted, and 54 questionnaires were self-administered to respondents in each hostel where IEQ parameters were monitored. The content of the questionnaire was explained to respondents to arrive at high valid responses and reduce errors. Section A of the questionnaire centred on gender, maximum and minimum stay in hostels in terms of hours and months. Symptoms experienced during the last three months form section B of the questionnaire. The symptoms are as follows: watery eyes, runny nose, sneezing, coughing, tiredness, dizziness, the sensation of difficulty in breathing, sensitivity to odors, blocked or stuffy nose, dry throat, pain in/poor concentration, dryness, and irritation of the skin, tightness of the chest and nausea. For each symptom, any of the responses were possible: very often, often, undecided, rarely, and never. The respondents were further asked if the symptoms disappeared after leaving the facility with purported responses like no, undecided, and yes. If respondents reported any SBS symptoms related to an indoor hostel environment, they were designated positive for SBS symptoms. Those who complained at least one confirmed sign were categorized as experiencing SBS. In section C, the questionnaire included queries about the perception of the IEQ. The questions are too much air movement, too little air movement, temperature too hot, temperature too cold, the air too humid (presence of excess moisture in the air), the air too dry, lighting too dim, lighting too bright, presence of visible water damage on the walls and unpleasant odor. For each factor, respondents were required to indicate their responses on four Likert scales: strongly disagree, disagree, not sure, agree, and strongly agree.

2.2. Field measurements and data analysis

Fieldwork was conducted involving the measurements of IEQ parameters of indoor air temperature (°C), relative humidity (%), air velocity (m/s), and illumination level (lux). The main instrument was a 150 g hand-held mini environmental quality meter readable with dual display LED screen features and powered with 9 V dry battery. The measuring device is embedded with a thermometer, hygrometer, anemometer, and light meter. The measurement for each parameter in selected rooms was taken three times for 10 mins for the morning (6:00–10:00 am), afternoon (12:00–3:00 pm), and evening (6:00–10:00 pm) each day for an average of six times in two months. The measurements were taken with the instrument being held at an approximate height of 1.1 m from the floor level in line with the American Society of Heating, Refrigerating and Air-Conditioning Engineers, ASHRAE-55 (2017) & BS EN ISO 7730 (2005) recommendations. Each room's air velocity rate was measured while turning the ceiling fan to the maximum and the windows open. The window blinds were left open for the illumination level, and the artificial lightings turned off while measurements were taken during the daytime. For the evening lighting levels, artificial lightings were turned on while the window blinds were shut.

IBM SPSS 25.0 was used in performing the statistical analysis of the acquired data. The questions' statistical reliability was initially tested using Cronbach's alpha coefficient test to examine the listed SBS symptoms and IEQ questions' general consistency. Descriptive statistics of tables, frequency, mean, standard deviation, and percentages were used to describe the data. In contrast, the inferential statistics of ANOVA were adopted to analyze the relationships between indoor physical quantities and SBS symptoms in the hostels. Using P-values < 0.05, statistical significance was established.

3. Results

3.1. Descriptive statistics of the respondents

The reliability of the questions within the questionnaire was tested using Cronbach's alpha coefficient test. In line with the reliability statistics, the Cronbach's alpha of these questions (24 items) was 0.827, indicating that the questions excelled the reliability test. 359 students of 376 (95%) from seven hostel facilities participated in the questionnaire survey. Table 1 shows the description of respondents and their period of occupancy. A higher number of female students of 53.2%, against 46.8% of male students, participated in the study. Between 4–6 months, the occupancy period had the highest occupancy rate of 50.1%, followed by a 7– 9 months occupancy period of 26.2%. Higher percentages of 35.9% and 27.6% indicate that they spent between 11–13 hours and 7– 9 hours respectively in their rooms each day. Results also show that 87.5% of students voted 6 pm—6 am as the time mostly spent in their rooms.

3.2. Buildings characteristics

The characteristics of the buildings were investigated. The hostel facilities are majorly naturally ventilated four-story concrete frame structures aged 17 years. The external and internal walls are enclosed and partitioned with sandcrete blocks and finished with plasters. Long span aluminum roofing sheets serve as the roof coverings. The room dimensions varied from 3.74 m × 5.62 m to 4 m × 6 m. Two opposing windows measuring 1.20 m × 1.20 m and 1.20 m × 1.80 m assembled with two to three sliding single tinted glass and aluminum frames were installed in all hostels. One

Table 1. Description of respondents and the period of occupancy

	Frequency (n)	Percentage (%)
Gender		
Male	168	46.8%
Female	191	53.2%
Total	359	100.0%
Period of Occupancy		
0–3 months	74	20.6%
4–6 months	180	50.1%
7–9 months	94	26.2%
above 10 months	11	3.1%
Total	359	100.0%
Time usually spent in rooms		
0–3 hrs.	4	1.1%
4–6 hrs.	68	18.9%
7–9 hrs.	99	27.6%
11–13 hrs.	129	35.9%
Above 14 hrs.	59	16.4%
Total	359	100.0%
Time of the day mostly spent in hostel rooms		
6am-10am	7	1.9%
10am-2pm	6	1.7%
2pm-6pm	32	8.9%
6pm-10pm	85	23.7%
10pm-6am	229	63.8%
Total	359	100.0%

metal door of size 0.9 m × 2.10 m is fixed and familiar to all rooms. Ceramic tiles and emulsion paint are the finishing given to the floors and walls, respectively. Each room accommodated a maximum of four students and was equipped with one ceiling fan and four fluorescent lamps fitted in two luminaires.

3.3. Respondents perception of SBS symptoms in and out of the hostel facilities

Table 2 demonstrates the SBS symptoms experienced by the respondents in the hostel facilities. Descriptive analysis was conducted to investigate SBS symptoms. Results show that tiredness received the highest mean score (3.63), followed by sensitivity to odor (3.43), sneezing (3.01), blocked or stuffy nose (2.85), and difficulty in/poor concentration (2.81) in all the hostel facilities surveyed. Perceptibly, the lowest mean score ranges from 2.11–2.57 for water eyes, tightness of the chest, the sensation of difficulty in breathing, nausea, and dry throat in all surveyed hostels.

Figure 1 shows that 45% of the respondents believed that the SBS symptoms did not disappear after exiting the hostels. On the other hand, 40% reported that the surveyed signs left upon exiting the building, while 15% were undecided on the symptoms. Thus, it can be said that the symptoms experienced by the students cannot be linked to the indoor environment of the hostels alone, while the poor IEQ of the rooms cannot be ruled out.

Table 2. Prevalence of SBS symptoms among students in the studied hostels (n = 359)

Symptoms	N	Mean	Std. Deviation	Ranking
Tiredness	359	3.63	1.35	1st
Sensitivity to odor	359	3.43	1.31	2nd
Sneezing	359	3.01	1.31	3rd
Blocked or stuffy nose	359	2.85	1.35	4th
Difficulty in/ poor concentration	359	2.81	1.32	5th
Dizziness	359	2.72	1.39	6th
Coughing	359	2.71	1.22	7th
Runny nose	359	2.64	1.33	8th
Dryness and irritation of the skin	359	2.58	1.45	9th
Dry throat	359	2.57	1.23	10th
Nausea	359	2.36	1.37	11th
A sensation of difficulty in breathing	359	2.19	1.23	12th
The tightness of the chest	359	2.12	1.30	13th
Water eyes	359	2.11	1.34	14th

3.4. Perceived indoor environmental qualities factors conditions

Table 3 presents the indoor environmental factors' perceived conditions that may drive SBS symptoms in the hostels' rooms. Results indicate that too hot temperature with a mean of 4.15 ranked first, followed by unpleasant odor with a mean of 4.13, presence of visible water damage on walls with a mean of 3.96, too little air movement with a mean of 3.91and too humid air had a mean of 3.50. Noticeably, the lowest-ranked are lighting too dim with a mean of 3.24, the air too dry with a mean of 2.63, lighting too bright had a mean of 2.47, too much air movement had a mean of 2.16, and temperature too cold ranked the least 2.15.

3.5. Relationship between sick building syndrome symptoms and the physical environmental

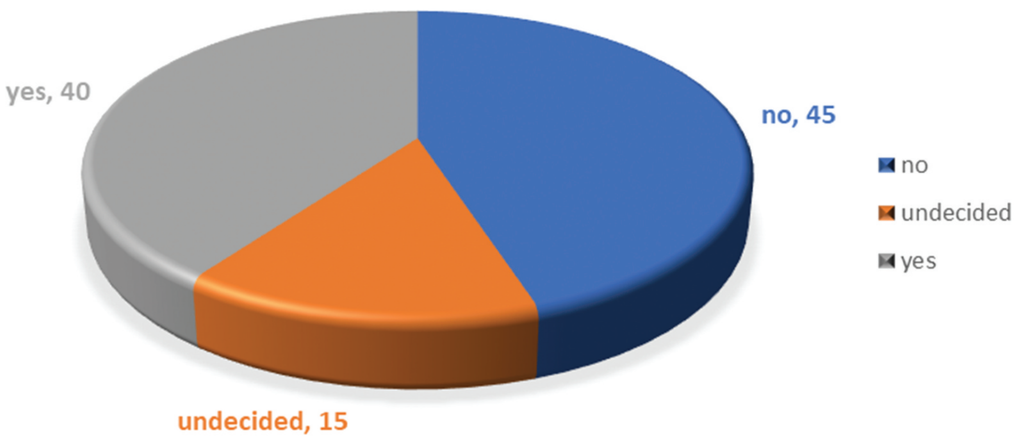
The relationship between SBS symptoms and the physical environmental conditions surveyed in the halls was postulated in null and alternate hypotheses stated below:

H_{01}: There is no possible relationship between SBS symptoms and the physical environmental factors surveyed in halls of residents and

H_1: There is a possible relationship between SBS symptoms and the physical environmental factors surveyed in halls of residents.

In testing these hypotheses, the relationship was measured using ANOVA. The dependent variables were SBS symptoms, and the independent variable was IEQ factors experienced by the respondents. Table 4 shows the ANOVA of the symptoms of SBS concerning IEQ factors. Using the decision rule, if the p-value is less than 0.05, the null hypothesis is rejected, and the alternate hypothesis is accepted and vice versa. Therefore, from Table 4, the SBSs with p-values less than

Figure 1. The disappearance of SBS symptoms on exiting the building.



Perception of IEQ	N	Mean	Std. Deviation	Ranking
Temperature too hot	359	4.15	1.11	1st
Unpleasant odour	359	4.13	1.21	2nd
Presence of visible water damage on the walls	359	3.96	1.30	3rd
Too little air movement	359	3.91	1.17	4th
Air too humid (presence of excess moisture in the hall)	359	3.50	1.20	5th
Lighting too dim	359	3.24	1.30	6th
Air too dry	359	2.63	1.31	7th
Lighting too bright	359	2.47	1.16	8th
Too much air movement	359	2.16	1.24	9th
Temperature too cold	359	2.15	1.15	10th

Table 3. Mean, standard deviation and ranking of perceived IEQ in hostels

0.05 are sensitive to odor, blocked or stuffy nose, and nausea. These SBSs were considered to be the most prevalent in the halls of residence of studied facilities. Hence, there is a relationship between sensitivity to odor, blocked or stuffy nose and nausea symptoms of SBS, and indoor environmental, physical factors.

3.6. IEQ evaluations in hostels

The measured IEQ are indoor air temperature (°C), relative humidity (%), air velocity (m/s), and illumination level (lux). The indoor air temperature limits in the studied hostels represented as H1—H7 are presented in Figures 2–6. As shown in Table 2, the indoor air temperature readings from the morning, noontime, and evening and across the floors varied slightly. The average indoor air temperature of 29.93 °C, 31.64 °C, and 30.71 °C was recorded across the floors in the morning, noon, and evening. Similarly, an increment of 7.36% and 2.54% was observed in the noon and cogent • social sciences

Table 4. ANOVA Relationship between Sick Building Syndrome and Covenant University Halls of Residence

Sick Building Syndrome	df	Mean Square	F	Sig.
Water eyes	6	2.686	1.510	.174
	352	1.778		
	358			
Runny nose	6	1.772	1.010	.419
	352	1.755		
	358			
Sneezing	6	3.300	1.965	.070
	352	1.679		
	358			
Coughing	6	.234	.156	.988
	352	1.501		
	358			
Tiredness	6	1.077	.590	.739
	352	1.827		
	358			
Dizziness	6	1.754	.908	.489
	352	1.933		
	358			
The sensation of difficulty in breathing	6	.296	.173	.984
	352	1.710		
	358			
Sensitivity to odor	6	3.577	2.140	.048
	352	1.671		
	358			
Blocked or stuffy nose	6	6.137	3.497	.002
	352	1.755		
	358			
Dry throat	6	.549	.333	.919
	352	1.650		
	358			
Difficulty in/ poor concentration	6	1.884	1.093	.366
	352	1.723		
	358			
Dryness and irritation of the skin	6	1.795	.858	.526
	352	2.092		
	358			
Tightness of the chest	6	2.268	1.344	.237
	352	1.688		
	358			

(Continued)

Sick Building Syndrome	df	Mean Square	F	Sig.
Nausea	6	5.464	3.007	.007
	352	1.817		
	358			

Figure 2. Objective assessment of indoor air temperature (°C) in hostels.

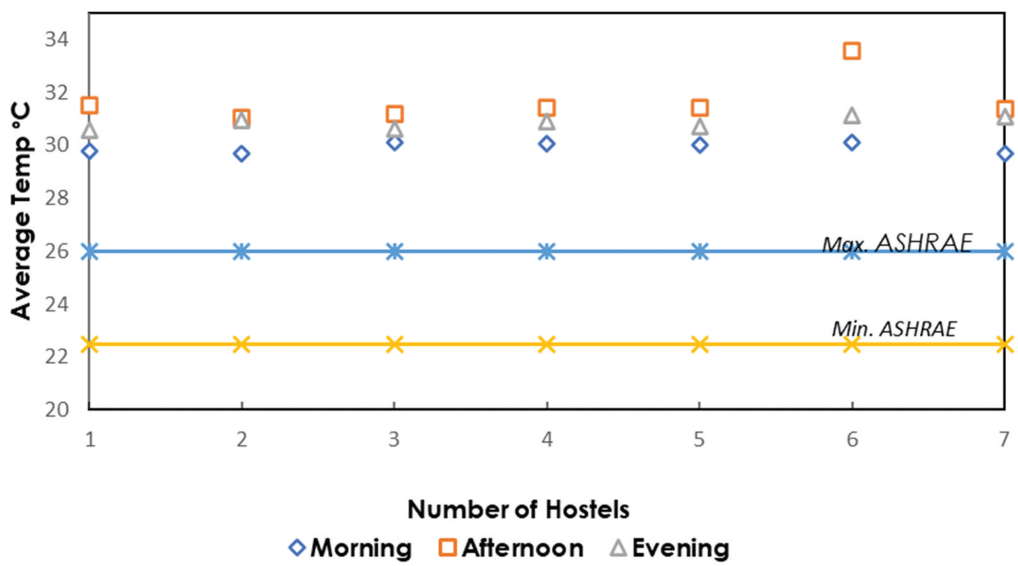


Figure 3. Objective assessment of indoor relative humidity (%) in hostels.

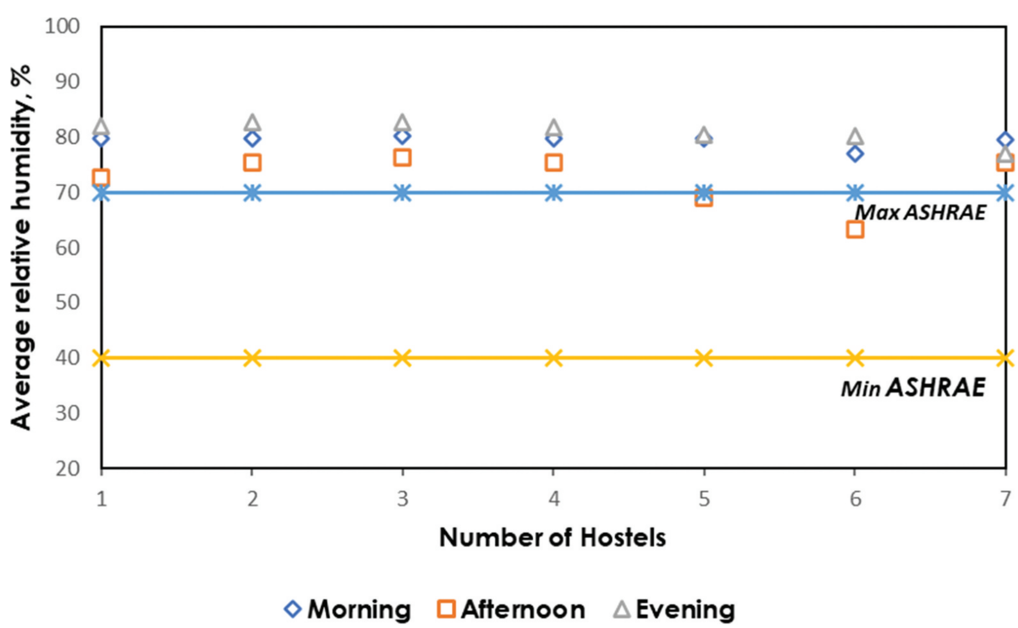


Figure 4. Objective assessment of indoor air velocity (m/s) in hostels.

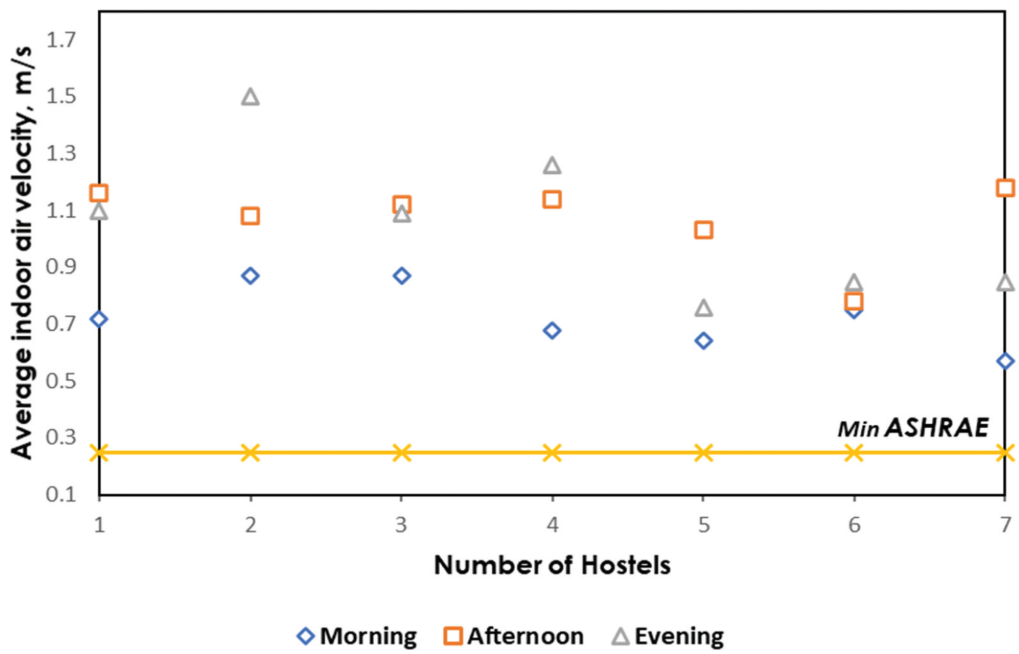
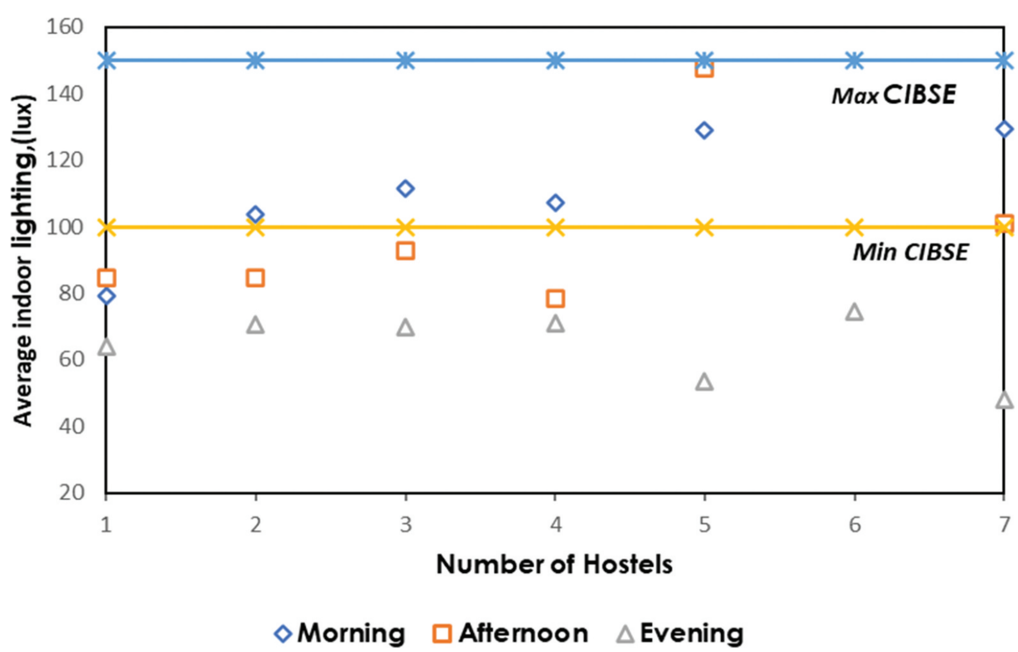


Figure 5. Objective assessment of indoor lighting (Lux) levels in hostels.



evening compared to morning readings. The increased indoor temperatures may be linked to higher sun intensities in Nigeria's tropical climates as the day progresses.

The indoor relative humidity (RH) results in the hostels are as shown in Figure 3. The hygrometer embedded in the mini environmental meter recorded the RH in the investigated rooms. The results revealed the minimum and maximum values of indoor RH in each room. The RH was least in the noontime followed by morning and highest in the evening. An average of 79.00%, 72.56%, and 81.01% RHs was recorded in the morning, noon, and evening across the floors. There is a noticeable decrease of 9.07% RH in the noontime than the morning RH value and 10.45% in the evening compared with the noontime RH value.

The limits of indoor air velocities of the occupied hostels were objectively monitored at various times when operating ceiling fans, which is presented in Figure 4. As shown in Figure 4, the average air velocity in the afternoon (1.07 m/s) was highest, followed by evening (1.06 m/s) and lowest in the morning period (0.72 m/s) across floors of the buildings investigated.

Lighting, be it daylight, or artificial is essential for use in any residential building, and its quality unarguably brings comfort and productivity. The analysis presented in Figure 5 reveals the indoor lighting levels objectively monitored in two months in hostel facilities. The lighting levels varied across rooms and periods of the day. An average value of 107.95 lux, 177.45 lux, and 64.43 lux was obtained for the morning, afternoon, and evening readings.

4. Discussion

The occupancy of the respondents in hostels indicates that a full academic session in a typical Nigerian university runs for a maximum of nine calendar months. Students' occupancy time in hostels is expected to be associated with their health and intellectual capacity development. As with the case of other hostels in other regions, the study revealed that students spent half of their day in the hostels, especially in the night till early morning, to start their daily academic work. This result confirms the assertion of Busch-Geertsema and Sahlin (2007) on an average ten hours daily occupation of hostel facilities by higher education institutions (HEIs) students. The results are also consistent with students' typical living conditions in hostels, as Kumar et al. (2019) pointed out. The analysis showed that tiredness, sensitivity to odor, and sneezing were the student's most popular perceived SBS symptoms experienced in the hostel facilities. Thus, it can be inferred that these symptoms cannot be related to only one IEQ factor. The SBS symptoms may have emerged from the dust, mold, chemicals, air quality, and chemicals exposed to occupants from other campus learning facilities. Also, individual factors like age, gender, and current health conditions that are not considered here are likely contributors to SBS symptoms. However, existing studies have pointed out that poor indoor temperature, relative humidity, air velocity, and lighting instigate SBS symptoms (Sarkhosh et al., 2021).

The study found that hot indoor temperature, unpleasant odor, and dampness on walls were the three most perceived poor IEQ parameters in the studied hostel facilities that may propel SBS. The undesirable conditions may be because the rooms were only equipped with a ceiling fan. Also, the study period is the designated dry season in Nigeria, with a mean maximum temperature ranging from 30.3 °C to 41.4 °C. The results suggest that indoor air temperature needs to be improved while the study facilities' undesirable odor and moisture presence on walls should be controlled. The results are following the submission of Kumar et al. (2019), who revealed that the thermal condition component of IEQ is the most important factor of the indoor environment. Prevalence of SBS symptoms and IEQ components perceptions are the vital factors in determining the student's wellbeing and intellectual capacity development in HEIs hostel facilities. The ANOVA result stipulates that the model is significant from 0.05, as revealed by the significant values. There is a suggestion that at least one P-values is not equal to zero, signifying that the model had a strong clarifying capacity. The P-values obtained showed that the chosen model has a good fit for the data. Except for sensitivity to odor, blocked or stuffy nose, and nausea, all the dependent variables had expected values. It is on this premise that the study fails to reject the hypothesis. Hence, there is a relationship between sensitivity to odor, blocked or stuffy nose and nausea symptoms of SBS, and indoor environmental, physical factors. Therefore, the study infers that the objectionable IEQ parameters in hostels will trigger the emergence of SBS symptoms of odor, stuffy nose and nausea in the studied hostels.

The measured indoor air temperature was above the acceptable limit for the thermal environment for human occupancy set by ASHRAE (2017) and the World Health Organization (WHO (1990). ASHRAE (2017) & WHO (1990) set the minimum and maximum indoor air temperature at 22.50–26.00 °C and 24–28 °C, respectively. These findings show the need for an adequate mechanical ventilation system in all the rooms, especially during the studied months (February and March), and confirm "temperature too hot" as perceived by the respondents. Wargocki et al. (2000) found that at 30 °C, there is usually a 10% decrease in task execution at the workplace, while room temperature of 21°C tends to improve workers' wellbeing and efficiency. Moreover, Maula et al. (2016) pointed out that high temperature facilitates a bad mood, motivation, and concentration problems. Therefore, the recorded higher indoor temperature could be suitable for the emergence of SBS symptoms in the hostels. Similarly, all the measured internal RH were above the acceptable limit for an indoor thermal environment for human occupancy set by ASHRAE (2017) and BS EN ISO 7730 (2005). ASHRAE (2017) & BS EN ISO 7730 (2005) set the minimum and maximum indoor RH at 40–70% and 40–60%, respectively. It is reported that RH above 60% is considered a hot and sticky condition (Sun et al., 2013). Moreover, moistness introduction can cause muscle issues, blacking out, heatstroke, and even intensifying fundamental ailments, such as lung or coronary illness (Maula et al., 2016). Thus, the unaccepted higher RH in the investigated space is a pointer to water leakages and poorly ventilated rooms.

Comparing the values of air velocities with relevant standards, the measured air velocities in the studied rooms met the minimum 0.25 m/s requirements of ASHRAE 55 (2017) & WHO (1990) for thermal comfort when operating ceiling fans. The results showed the relevance of ceiling fan operation in rooms for the tropical climatic condition of Nigeria. Edward and Fountain (1993) discovered that air velocity of up to 1.2 m/s imposed by a ceiling fan's inclusive turbulent flow at an air temperature of 31°C is conducive for indoor comfort. Therefore, it is inferred in this study that the induced turbulent flow of the ceiling fan serves as an advantageous means of support in the room space. Chartered Institution of Building Services Engineers, CIBSE (2013) states the limits for indoor hostels lighting for rooms and reading desk at 100 lux and 150 lux, respectively. Based on this recommendation, the investigated rooms met the illumination level criteria except for study desk areas that require 150 lux for optimum visual performance. This non-compliance may cause difficulty in concentration, tiredness, and watery eyes, inconsistent with the previous study by Jafari et al. (2015) that found poor lighting in rooms to be one of the leading causes of SBS symptoms.

5. Conclusion and recommendations

This cross-sectional study investigated the relationship between the indoor air temperature, relative humidity, air velocity, and lighting levels components of IEQ and SBS prevalence in the student's halls of residence of a private university in Nigeria. Using structured questionnaires and field measurement, the study inferred, among other things, that SBS symptoms were experienced in the hostels but cannot be linked to poor IEQ. The objective measurement results showed indoor temperature and relative humidity in the monitored rooms was inconsistent with ASHRAE 55 (2017) and WHO (1990) relevant standards for human occupancy's thermal environment. The average air velocity measured in the rooms while operating ceiling fans were within ASHRAE 55 (2017) minimum requirements for thermal comfort. An average lighting level value met Chartered Institution of Building Services Engineers, CIBSE (2013) limits for hostels' indoor lighting while the reading desk area was compromised. A longitudinal study on the link between IEQ and SBS on hostel buildings in Nigeria and a comparative study between private and public university hostels in Nigeria on IEQ and SBS prevalence are recommended for further studies. Therefore, this study's findings have potential practical implications for developing healthy university hostel policies for Nigerian students' wellbeing and academic performance.

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