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# Subjective Assessment of Occupants' Perception of Indoor Environmental Quality (IEQ) Performance in Hospital Building

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**Abstract.** This study is aim at determining the perceptions of the three occupants' groups in hospital buildings on their assessment of IEQ performance. This study data was collected through the subjective assessment of patients, staff, and visitors using a questionnaire as an instrument in measuring the respondents' perception score on indoor environment variables. The questionnaire administration was carried out in a case study specialist hospital and the data collected was analysed using SPSS Version 22. With a response rate of 90.8%, there was a significant variation in respondents' perception of the four parameters of IEQ, but no statistical variation in their perception of the overall IEQ. There was no statistical difference in the mean score perception of IEQ between patients and visitors, however, a significant difference in mean perception of IEQ occurred between the staff and both patients/visitors. The perception of IEQ in hospital buildings varies across the three occupants' groups in hospital buildings. In order to provide an environment that would be conducive and acceptable to all the occupants in hospital buildings, a level of invariance in their perception must be established.

**Keywords:** Indoor environmental quality, building, perception, occupants, satisfaction.

## 1. Introduction

Sustainable indoor environment in terms of occupants' health, comfort and satisfaction can be achieved where users' perception is a major factor of consideration for the assessment of the building performance. Until recently, the needs to provide health personnel and patients with satisfactory indoor environment have not been given the necessary attention it requires, especially in developing nations. There is therefore a need for all people to have an awareness and knowledge about environmental impact on health and comfort. Achieving an optimal indoor environment for all occupants of healthcare facilities calls for further studies in order to have a better understanding of the indoor environment [1].

The need to provide building occupants with comfortable indoor environment cannot be overemphasized. Smith and Pitt [2] noted that, more attention is been given to green building design in the environmental consideration of the built form, while health and wellbeing of the occupants are given less attention. Standards and guidelines concerning indoor environment are based on individual IEQ parameters [3], while these parameters have been remarkably seen to have combined effects on occupants' satisfaction and efficiency [4].

A study which evaluated the IEQ and its implication on medical activity in an Iranian hospital shows that, either standards are not followed in the design of hospital buildings or the standards do not meet the requirements of the occupants [5]. Therefore, if standards are not meeting the requirements of occupants in hospital buildings, there is a need to redefine their IEQ requirements putting into consideration both the physical environmental attributes and occupants perception of these attributes. Indoor environmental quality as perceived by occupants is often not acceptable, even if standards and guidelines for the different

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parameters are met [6]. Croitoru et al. [5] therefore, suggested that standards with respect to IEQ should be changed and fashioned towards occupant's comfort to enhance their optimal comfort and efficiency. Since standards and guidelines have always been found to be at variance with what the occupants of the building would require. In ascertaining the level of impact of IEQ on comfort and wellbeing, Zagreus, Huizenga, Arens, and Lehrer [7] asserted that, the occupants of a building should be the main source of information.

The subjective assessment of IEQ in buildings is an indication of how the building occupants perceived their indoor environment [8]. Although it's hard to calibrate people, occupants are however the most important instrument for assessing building environment [9]. Different methods and tools for subjective survey of buildings' IEQ have been employed in various studies. These include; the Building Use Studies (BUS) methodology [10], web-based survey with online reporting tool [7], and BASE - Building Assessment Survey and Evaluation [11]. Smith and Pitt [2] also suggested the use of BREEAM as an environmental assessment instrument that may be used to improve buildings quality for the occupants.

Since occupant satisfaction is being moderated by the indoor environmental quality of buildings, an ideal performance indicator would be that which is factored based on occupants perceived satisfaction with the overall quality of the indoor environment. The performance of any building depends on how much quality and comfortable environment it provides for the building occupants. However, the determination of the success of a building in providing a satisfactory comfort for the occupants can be a difficult task [12]. This study therefore seeks to measure the perception of IEQ by the occupants in hospital buildings based on subjective survey assessment.

## 2. Methods

The design of this study involved descriptive survey tool in measuring the perception of the hospital building occupants on the performance of IEQ in a Specialist Hospital. The hospital named 'Plateau Specialist Hospital' is located in Jos, North-Central Nigeria. The study was carried out only in medical and surgical wards of the hospital where the patients are conscious enough to be administered with the questionnaires. The two ward buildings have a total bed space capacity of 64. The same questionnaire design was used in measuring the level of perception of the respondents (patients, staff, and visitors) on the IEQ performance. The 7-points Likert scale was adopted as a means to provide the respondents with broad range of choice on their level of satisfaction or dissatisfaction with the indoor environment variables to be measured. The questionnaire was developed based on the building assessment survey and evaluation (BASE) tool [11]. Only the item aspect relevant to this study was extracted from the BASE questionnaire sample.

The sample size was calculated using an online sample size calculated [13] based on the bed space carrying capacity of the hospital. For the patient sample, a population of 64 gives a sample size of 39 which was rounded to 40 samples. The sample size of 40 each was also used for staff and visitors as part of the study population. The hospital staff are inclusive of both medical and nonmedical personnel while the visitors are the patients' relations. This study was carried out consecutively within a period of three months from April to June, 2014. The same set of questionnaire was administered to the respondents in each of the months in order to ascertain the level of variation that may occur in the occupants' perception of IEQ performance over a period of time. All the data collected for the three months period were organized, coded and analysed using a statistics data editor analysis tool known as "Statistical Package for Social Sciences (IBM SPSS Statistics 22). Descriptive statistics was employed in analysing all the questionnaire items as well as means, and ANOVA inferential statistics

## 3. Results and Discussion

### 3.1. Response Rate

A total of 360 questionnaires; 120 each for patients, staff and visitors were administered within the three months period based on the sampled size. Only a total of 327 questionnaires signifying a response rate of 90.8% were completed and returned. The response rate for both patients and visitors (about 36% each) was more than the response rate of staff (27.2%). The response rate of staff was however due to the tasking nature of their work schedule every day. The response rate for April, May and June is 35.2%, 31.5% and

33.3% respectively of the completed and returned questionnaires. The response rate of patients was 100% for the three (3) months period whereas for the staff, the response rate was 87.5%, 57.5% and 77.5% in April, May and June respectively. The visitors' response rate was 100% both in April and May but however fall to 95% in June.

Table 1: Patients response to study questions

| Item | VD | MD | D | N | S | MS | VS | M | SD |
|---|---|---|---|---|---|---|---|---|---|
| **Thermal Comfort** | | | | | | | | | |
| Satisfaction with Temperature | 3.30 | 12.50 | 23.30 | 5.80 | 37.50 | 13.30 | 4.20 | 4.18 | 1.52 |
| Satisfaction with Air Velocity | 2.50 | 5.80 | 10.00 | 4.20 | 55.80 | 16.70 | 5.00 | 4.75 | 1.30 |
| Satisfaction with Relative Humidity | 2.50 | 12.50 | 16.70 | 9.20 | 36.70 | 18.30 | 4.20 | 4.37 | 1.50 |
| Satisfaction with Thermal Comfort | 4.20 | 3.30 | 25.80 | 8.30 | 44.20 | 5.80 | 8.30 | 4.36 | 1.44 |
| **Acoustic Comfort** | | | | | | | | | |
| Satisfaction with Noise Level | 2.50 | 5.80 | 36.70 | 10.80 | 28.30 | 14.20 | 1.70 | 4.06 | 1.36 |
| Satisfaction with Sound Privacy | 4.20 | 12.50 | 20.80 | 15.00 | 31.70 | 14.20 | 1.70 | 4.07 | 1.46 |
| Satisfaction with Acoustic Comfort | 3.30 | 5.00 | 26.70 | 11.70 | 45.80 | 3.30 | 4.20 | 4.18 | 1.31 |
| **Visual Comfort** | | | | | | | | | |
| Satisfaction with Daylight | 1.70 | 0.00 | 6.70 | 4.20 | 53.30 | 22.50 | 11.70 | 5.22 | 1.11 |
| Satisfaction with Electric Light | 2.50 | 4.20 | 11.70 | 6.70 | 59.20 | 12.50 | 3.30 | 4.67 | 1.21 |
| Satisfaction with Amount of Light | 1.70 | 4.20 | 10.80 | 5.00 | 60.00 | 13.30 | 5.00 | 4.78 | 1.19 |
| Satisfaction with Visual Comfort | 2.50 | 5.80 | 7.50 | 7.50 | 49.20 | 20.80 | 6.70 | 4.84 | 1.33 |
| **Indoor Air Quality** | | | | | | | | | |
| Satisfaction with Air Exchange | 1.70 | 2.50 | 4.20 | 3.30 | 62.50 | 20.80 | 5.00 | 5.05 | 1.05 |
| Satisfaction with Smell/Odour | 6.70 | 15.80 | 39.20 | 9.20 | 21.70 | 5.00 | 2.50 | 3.48 | 1.42 |
| Satisfaction with IAQ | 6.70 | 15.80 | 37.50 | 10.00 | 23.30 | 4.20 | 2.50 | 3.50 | 1.41 |
| **Overall Satisfaction with IEQ** | 4.20 | 4.20 | 21.70 | 25.00 | 25.00 | 14.20 | 5.80 | 4.28 | 1.43 |

**Keys: VD** = very dissatisfied, **MD** = more dissatisfied, **D** = dissatisfied, **N** = neutral, **S** = satisfied, **MS** = more satisfied, **VS** = very satisfied, **M** = mean, **SD** = standard deviation

Table 2: Staff response to study questions

| Item | VD | MD | D | N | S | MS | VS | M | SD |
|---|---|---|---|---|---|---|---|---|---|
| **Thermal Comfort** | | | | | | | | | |
| Satisfaction with Temperature | 2.20 | 9.00 | 18.00 | 46.10 | 18.00 | 5.60 | 1.10 | 3.90 | 1.12 |
| Satisfaction with Air Velocity | 1.10 | 11.20 | 20.20 | 43.80 | 14.60 | 5.60 | 3.40 | 3.90 | 1.20 |
| Satisfaction with Relative Humidity | 3.40 | 12.40 | 18.00 | 43.80 | 11.20 | 7.90 | 3.40 | 3.84 | 1.30 |
| Satisfaction with Thermal Comfort | 3.40 | 5.60 | 28.10 | 34.80 | 22.50 | 3.40 | 2.20 | 3.87 | 1.17 |
| **Acoustic Comfort** | | | | | | | | | |
| Satisfaction with Noise Level | 2.20 | 14.60 | 33.70 | 32.60 | 11.20 | 4.50 | 1.10 | 3.54 | 1.15 |
| Satisfaction with Sound Privacy | 2.20 | 14.60 | 32.60 | 39.30 | 6.70 | 3.40 | 1.10 | 3.48 | 1.08 |
| Satisfaction with Acoustic Comfort | 1.10 | 3.40 | 33.70 | 39.30 | 16.90 | 2.20 | 3.40 | 3.88 | 1.06 |
| **Visual Comfort** | | | | | | | | | |
| Satisfaction with Daylight | 4.50 | 3.40 | 24.70 | 22.50 | 21.30 | 13.50 | 10.10 | 4.34 | 1.54 |
| Satisfaction with Electric Light | 4.50 | 11.20 | 27.00 | 27.00 | 23.60 | 3.40 | 3.40 | 3.78 | 1.33 |
| Satisfaction with Amount of Light | 3.40 | 7.90 | 36.00 | 24.70 | 21.30 | 4.50 | 2.20 | 3.75 | 1.24 |
| Satisfaction with Visual Comfort | 4.50 | 12.40 | 24.70 | 25.80 | 22.50 | 6.70 | 3.40 | 3.83 | 1.39 |
| **Indoor Air Quality** | | | | | | | | | |
| Satisfaction with Air Exchange | 3.40 | 12.40 | 34.80 | 22.50 | 15.70 | 9.00 | 2.20 | 3.71 | 1.34 |
| Satisfaction with Smell/Odour | 11.20 | 11.20 | 36.00 | 27.00 | 11.20 | 2.20 | 1.10 | 3.27 | 1.27 |
| Satisfaction with IAQ | 5.60 | 18.00 | 33.70 | 21.30 | 16.90 | 3.40 | 1.10 | 3.40 | 1.28 |
| **Overall Satisfaction with IEQ** | 7.90 | 5.60 | 37.10 | 30.30 | 6.70 | 7.90 | 4.50 | 3.64 | 1.41 |

**Keys: VD** = very dissatisfied, **MD** = more dissatisfied, **D** = dissatisfied, **N** = neutral, **S** = satisfied, **MS** = more satisfied, **VS** = very satisfied, **M** = mean, **SD** = standard deviation

## 3.2. Patients

The gender distribution of patients was male (42.5%) and female (57.5%). The distribution based on patients age ranged are 10-20 years (4.2%), 21-30 years (42.5%), 31-40 years (30.0%) and over 40 years (23.3%). The descriptive statistics for patient duration of stay in the hospital within a range of period showed that for less than 1 week (51.7%), 1-2 weeks (24.2%), 3-4 weeks (14.1%) and over 4 weeks (10%). Distribution based on hours a patient spent within the hospital ward building revealed that less than 4hours

(0%), 4-8 hours (0%), 9-12 hours (20%) and over 12 hours (80%). The response of patients to the study questions summary are as shown in Table 1.

Table 3: Visitors response to study questions

| Item | VD | MD | D | N | S | MS | VS | M | SD |
|---|---|---|---|---|---|---|---|---|---|
| **Thermal Comfort** | | | | | | | | | |
| Satisfaction with Temperature | 1.70 | 11.90 | 23.70 | 5.90 | 38.10 | 14.40 | 4.20 | 4.27 | 1.47 |
| Satisfaction with Air Velocity | 0.80 | 6.80 | 10.20 | 4.20 | 53.40 | 19.50 | 5.10 | 4.81 | 1.25 |
| Satisfaction with Relative Humidity | 3.40 | 10.20 | 18.60 | 12.70 | 34.70 | 16.90 | 3.40 | 4.30 | 1.47 |
| Satisfaction with Thermal Comfort | 2.50 | 4.20 | 26.30 | 5.10 | 48.30 | 7.60 | 5.90 | 4.39 | 1.36 |
| **Acoustic Comfort** | | | | | | | | | |
| Satisfaction with Noise Level | 3.40 | 4.20 | 31.40 | 17.80 | 25.40 | 16.90 | 0.80 | 4.12 | 1.34 |
| Satisfaction with Sound Privacy | 2.50 | 10.20 | 22.90 | 22.90 | 29.70 | 6.80 | 5.10 | 4.08 | 1.38 |
| Satisfaction with Acoustic Comfort | 2.50 | 4.20 | 22.00 | 16.90 | 45.80 | 5.10 | 3.40 | 4.28 | 1.23 |
| **Visual Comfort** | | | | | | | | | |
| Satisfaction with Daylight | 1.70 | 0.80 | 3.40 | 4.20 | 59.30 | 13.60 | 16.90 | 5.27 | 1.13 |
| Satisfaction with Electric Light | 2.50 | 6.80 | 8.50 | 6.80 | 56.80 | 13.60 | 5.10 | 4.69 | 1.30 |
| Satisfaction with Amount of Light | 1.70 | 5.10 | 5.10 | 7.60 | 54.20 | 19.50 | 6.80 | 4.93 | 1.22 |
| Satisfaction with Visual Comfort | 0.80 | 2.50 | 7.60 | 6.80 | 54.20 | 21.20 | 6.80 | 5.02 | 1.11 |
| **Indoor Air Quality** | | | | | | | | | |
| Satisfaction with Air Exchange | 0.80 | 0.80 | 5.90 | 8.50 | 58.50 | 22.90 | 2.50 | 5.02 | 0.93 |
| Satisfaction with Smell/Odour | 7.60 | 23.70 | 44.90 | 8.50 | 9.30 | 4.20 | 1.70 | 3.08 | 1.29 |
| Satisfaction with IAQ | 7.60 | 22.90 | 44.10 | 11.00 | 10.20 | 2.50 | 1.70 | 3.08 | 1.25 |
| **Overall Satisfaction with IEQ** | 3.40 | 1.70 | 17.80 | 18.60 | 36.40 | 12.70 | 9.30 | 4.58 | 1.39 |

**Keys: VD** = very dissatisfied, **MD** = more dissatisfied, **D** = dissatisfied, **N** = neutral, **S** = satisfied, **MS** = more satisfied, **VS** = very satisfied, **M** = mean, **SD** = standard deviation

## 3.3. Staff

A total of 89 staff responded to the questionnaire administered within the three (3) months period. Their distribution based on gender was; male (38.2%) and female (61.8%), while age distribution was; 10-20 years (1.1%), 21-30 years (56.2%), 31-40 years (15.7%), and over 40 years (27.0%). The distribution of staff based on their years of service showed that, less than 2 years (46.1%), 2-5 years (18%), 6-10 years (5.6%) and over 10 years (30.3%). The distribution with respect to hours spent in the hospital ward is less than 4 hours (0%), 4-8 hours (68.4%), 9-12 hours (20.2%) and over 12 hours (11.3%). Table 2 shows staff response to the study questions.

## 3.4. Visitors

The percentage distribution of visitors about their age was; 10-20 years (4.2%), 21-30 years (28.0%), 31-40 years (33.9%), and over 40 years (33.9%) having a distribution in gender of 22% male and 78% female. The distribution in the amount of time spent in the ward building revealed that less than 4 hours (5.9%), 4-8 hours (16.1%), 9-12 hours (23.7%), and over 12 hours (54.2%).

## 3.5. Analysis of Variations in Occupants' Perception

The test for equality or differences in the perception of the three groups of occupants in the hospital buildings using the Levene's test is shown in Table 5. This test reveals that the variances of the three occupants groups are significantly different ($p<.05$) for overall satisfaction with thermal comfort, acoustic comfort, visual comfort and indoor air quality, whereas, it is not significantly different for overall satisfaction with IEQ ($p>.05$). The variances in the perceptions of the three occupants' groups for the various parameters of IEQ violate the assumption of ANOVA while that for the overall satisfaction with IEQ passed the ANOVA assumption (Field, 2009).

In comparing the perceptions of the different occupants groups, the post hoc tests carried out was based on Games-Howell for the perception in individual IEQ parameters by the groups of occupants since they have different variances while the Tukey was used in comparing differences in the perception in overall satisfaction with IEQ. From the analysis of variances shown in Table 6, there is a significant difference at $p < .05$ in the mean perception of patients, staff and visitors on satisfaction with thermal comfort; $F(2, 324) = 4.67$, $p = .01$, visual comfort; $F(2, 324) = 24.65$, $p = .00$, indoor air quality; $F(2, 324) = 3.31$, $p = .04$, and

overall satisfaction with IEQ; $F(2, 324) = 11.60$, $p = .00$, however, there is slightly no significant difference ($p > .05$) in occupants' perception of acoustic comfort $F(2, 324) = 2.93$, $p = .06$.

A comparison in the perception among the three groups of occupants is as shown in Table 7. The Post-hoc comparison shows that, there is a significant difference in mean scores between the perception of patient ($M = 4.36$, $SD = 1.44$) and staff ($M = 3.87$, $SD = 1.17$, at $p = .02$) on satisfaction with thermal comfort. The mean difference is positive which shows that patients' satisfaction with thermal comfort is higher than that of staff. There is no significant difference between patients' perception of thermal comfort ($M = 4.36$, $SD = 1.44$) and visitors' perception of same thermal comfort ($M = 4.39$, $SD = 1.36$, $p = .98$). Comparing the staff group ($M = 3.87$, $SD = 1.17$) and the visitors group ($M = 4.39$, $SD = 1.36$) reveals a significant difference ($p = .01$) in their perception of thermal comfort which was also higher with the visitors' group.

From Table 7, there is no significant difference ($p = .15$) between patients perception of acoustic comfort ($M = 4.18$, $SD = 1.31$) and staff perception ($M = 3.38$, $SD = 1.06$), and also visitors' perception ($M = 4.28$, $SD = 1.23$) of the same parameter at $p = .83$. However, there is a significant difference ($p = .03$) between the perception of staff ($M = 3.88$, $SD = 1.06$) and visitors ($M = 4.28$, $SD = 1.23$) in their mean satisfaction with acoustic comfort. For satisfaction with visual comfort, there is a significant difference ($p = .00$) in perception of patients ($M = 4.84$, $SD = 1.33$) and staff ($M = 3.83$, $SD = 1.39$), and also a significant difference ($p = .00$) in the perception of staff ($M = 3.83$, $SD = 1.39$) and visitors ($M = 5.02$, $SD = 1.11$), while no significant difference ($p = .51$) exist between the perception of patients ($M = 4.84$, $SD = 1.33$) and visitors ($M = 5.02$, $SD = 1.11$).

There is no significant difference ($p = .87$) in the perception of patients ($M = 3.50$, $SD = 1.41$) and staff ($M = 3.40$, $SD = 1.28$) and also patients ($M = 3.50$, $SD = 1.41$) and visitors ($M = 3.32$, $SD = 1.25$, $p = .16$) on their satisfaction with indoor air quality, while a significant difference ($p = .04$) exist in the perception between patients ($M = 3.50$, $SD = 1.41$) and visitors ($M = 3.32$, $SD = 1.25$). For the overall satisfaction with IEQ in the hospital buildings, there is a significant difference ($p = .00$) between the perception of patients ($M = 4.28$, $SD = 1.43$) and staff ($M = 3.64$, $SD = 1.41$), and also a significant difference ($p = .00$) between perception of staff ($M = 3.64$, $SD = 1.41$) and visitors ($M = 4.58$, $SD = 1.39$). There is no significant difference ($p = .23$) between the perception of patients and visitors in their mean satisfaction with IEQ.

Table 4: Descriptive statistics for one-way ANOVA

| | | N | Mean | Std. Deviation | Std. Error | Min | Max |
|---|---|---|---|---|---|---|---|
| Overall Satisfaction with Thermal Comfort | Patients | 120 | 4.36 | 1.442 | .132 | 1 | 7 |
| | Staff | 89 | 3.87 | 1.170 | .124 | 1 | 7 |
| | Visitors | 118 | 4.39 | 1.359 | .125 | 1 | 7 |
| Overall Satisfaction with Acoustic Comfort | Patients | 120 | 4.18 | 1.309 | .120 | 1 | 7 |
| | Staff | 89 | 3.88 | 1.064 | .113 | 1 | 7 |
| | Visitors | 118 | 4.28 | 1.233 | .113 | 1 | 7 |
| Overall Satisfaction with Visual Comfort | Patients | 120 | 4.84 | 1.328 | .121 | 1 | 7 |
| | Staff | 89 | 3.83 | 1.392 | .148 | 1 | 7 |
| | Visitors | 118 | 5.02 | 1.109 | .102 | 1 | 7 |
| Overall Satisfaction with IAQ | Patients | 120 | 3.50 | 1.414 | .129 | 1 | 7 |
| | Staff | 89 | 3.40 | 1.277 | .135 | 1 | 7 |
| | Visitors | 118 | 3.08 | 1.248 | .115 | 1 | 7 |
| Overall Satisfaction with IEQ | Patients | 120 | 4.28 | 1.427 | .130 | 1 | 7 |
| | Staff | 89 | 3.64 | 1.408 | .149 | 1 | 7 |
| | Visitors | 118 | 4.58 | 1.392 | .128 | 1 | 7 |

Table 5: Homogeneity of variances of the occupants' perception

| | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|
| Overall Satisfaction with Thermal Comfort | 4.66 | 2.00 | 324.00 | 0.01 |
| Overall Satisfaction with Acoustic Comfort | 5.65 | 2.00 | 324.00 | 0.00 |
| Overall Satisfaction with Visual Comfort | 6.19 | 2.00 | 324.00 | 0.00 |
| Overall Satisfaction with IAQ | 4.39 | 2.00 | 324.00 | 0.01 |
| Overall Satisfaction with IEQ | 0.28 | 2.00 | 324.00 | 0.76 |

Table 6: Summary of ANOVA

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Overall Satisfaction with Thermal Comfort | 16.827 | 2 | 8.414 | 4.667 | .010 |
| Overall Satisfaction with Acoustic Comfort | 8.701 | 2 | 4.351 | 2.928 | .055 |
| Overall Satisfaction with Visual Comfort | 79.797 | 2 | 39.898 | 24.650 | .000 |
| Overall Satisfaction with IAQ | 11.533 | 2 | 5.766 | 3.314 | .038 |
| Overall Satisfaction with IEQ | 46.071 | 2 | 23.035 | 11.598 | .000 |

Table 7: Group statistics

Multiple Comparisons

| Dependent Variable | | | Mean Difference | Std. Error | Sig. | 95% Confidence Interval Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|---|
| Satisfaction with Thermal Comfort | Patients | Staff | .493* | .181 | .019 | .07 | .92 |
| | Patients | Visitors | -.031 | .182 | .984 | -.46 | .40 |
| | Staff | Visitors | -.525* | .176 | .009 | -.94 | -.11 |
| Satisfaction with Acoustic Comfort | Patients | Staff | .307 | .164 | .151 | -.08 | .69 |
| | Patients | Visitors | -.096 | .165 | .829 | -.49 | .29 |
| | Staff | Visitors | -.403* | .160 | .033 | -.78 | -.03 |
| Satisfaction with Visual Comfort | Patients | Staff | 1.010* | .191 | .000 | .56 | 1.46 |
| | Patients | Visitors | -.175 | .159 | .512 | -.55 | .20 |
| | Staff | Visitors | -1.185* | .179 | .000 | -1.61 | -.76 |
| Satisfaction with IAQ | Patients | Staff | .096 | .187 | .866 | -.35 | .54 |
| | Patients | Visitors | .424* | .173 | .040 | .02 | .83 |
| | Staff | Visitors | .328 | .178 | .157 | -.09 | .75 |
| Overall Satisfaction with IEQ | Patients | Staff | .643* | .197 | .004 | .18 | 1.11 |
| | Patients | Visitors | -.301 | .183 | .226 | -.73 | .13 |
| | Staff | Visitors | -.944* | .198 | .000 | -1.41 | -.48 |

*. The mean difference is significant at the 0.05 level.

## 3.6. Discussion

The distribution of the demographic data for the patients and staff in this case study hospital cut across the population that is typical in a hospital setting. The gender distribution of the three occupants groups revealed that there are more females than males. Gender has been shown to have influence on occupants' perception of indoor environment variables [14]–[16], with the female gender ascertained to be more sensitive to environmental variables than their male counterparts [17], [18].

Patients and visitors satisfaction with indoor temperature that is higher than the staff might be a result of a response to their short period of stay [16]. The staff are more objective in their perceptions as the hospital is a permanent place of work for them while the patients and visitors are only concern with the recovery from illness [19]. A higher percentage of patients perceived the indoor temperature as satisfactory which is contrary to a study carried out in a Swedish hospital by Skoog *et al*. [16] where a higher percentage perceived the temperature as neutral. The variations in the perception of thermal comfort between the patients/visitors group and the staff group does not necessarily mean that, a different thermal zone be provided each for patients and staff in hospital design as suggested by Khodakarami [20]. However, this variation should be harmonized in order to provide a single thermal environment that will be acceptable to all the three occupants groups in the hospital building, since patients cannot be exclusively be separated from the staff working in the hospital [1].

The hospital staff perceived the noise level as more dissatisfactory as compared with the perception of the patients, which negates the notion that any slight noise increase could be considered as irritable to the patients due to their health conditions. The level of dissatisfaction and satisfaction of the patient with the noise level is almost equal in this study, but satisfaction is higher with the overall acoustic comfort. For visual comfort, the visitors are more satisfied than the patients and staff. The staff would require more lighting level in their task performance especially when trying to trace patients' veins for drips or blood transfusion and also report writing.

There is a greater dissatisfaction with smell/odour by all the three occupants' groups in the hospital buildings, who are also dissatisfied with the overall indoor air quality. However, the high satisfaction recorded for the air exchange as perceived by all the occupants contradicts their dissatisfaction with the air quality, since a building with enough air exchange removes contaminants from within the building thereby providing good air quality [21], [22]. The three occupants groups are dissatisfied with the IAQ in the hospital buildings as compared with the other parameters. There is therefore a need to improve the air quality within the hospital wards in order to prevent the occupants from contracting air contaminated diseases.

Satisfaction with IEQ in hospital buildings could decrease occupants' complaints about health symptoms, and is a sign of better-working environment [17]. On an average, the patients and visitors groups are more satisfied than the staff group with their thermal comfort and acoustic comfort. It is quite ironical to see that the dissatisfaction with noise is higher with the staff than the patients whose health and wellbeing could be greatly influenced by sound. Overall, the staff group in the hospital are more dissatisfied with all the four parameters of IEQ and the overall IEQ performance having a mean rating of less than 3.9. As compared with staff, the patients and visitors are more satisfied with their overall IEQ. The level of this difference in perceived satisfaction is very significant as seen from the analysis of variance. This difference can be explained by the possibility of staff been objective in their assessment of their IEQ as the hospital ward is their permanent place of work. The staff assessment would have also been influenced by their experiences in the hospital ward buildings all through the year. The physiological and psychological mental states of the patients and visitors in the other way round might have contributed to their perception of the environment too.

## 4. Conclusion

The perception of IEQ in the hospital buildings varies across the three occupants' groups in hospital buildings. In order to provide an environment that would be conducive and acceptable to all the occupants in hospital buildings, a level of invariance in their perception must be established. This measured invariance will enable architects and planners to be able to factor their requirements at the design stage in order to provide an environment that promotes healing and work efficiency rather than the one that hinders it. This study have revealed that the indoor air quality (IAQ) of this hospital ward buildings is poor, which is evident in the level of dissatisfaction as expressed by all the three occupants' groups. An improvement to the IAQ especially through proper ventilation that is lacking in the buildings' current states would improve health, wellbeing, and work efficiency of the building's occupants.

The perception of the IEQ in the hospital by the patients and visitors can said to be influenced by their mental and psychosocial state. On the other hand, the hospital staff were more objective in their assessment of the hospital IEQ as their level of dissatisfaction with the IEQ variables can be corroborated by the researchers. A general physical observation of this hospital indoor environment would leave no one in doubt but to suggest for upgrade and more improvement and maintenance. Improving the IEQ will improve the healthcare service delivery, reduce airborne infections and reduce patient's period of stay in the hospital. The outcome of this study would promote the needs to incorporate the environmental requirements of all the occupants groups in hospital building design and maintenance.

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