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Assessment of Noise Pollution in a Hospital and a Tertiary institution in Taraba State, Nigeria

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Abstract

Noise levels were measured in some chosen locations in a Tertiary institution (TI) and a Public Hospital (PH) in Jalingo. The aim of the study was to compare the measured values so as to make appropriate recommendations. A sound level meter model SL - 4030 was used to measure the noise levels in some selected venues from the chosen institutions for a period of four weeks. The average noise levels in TI varied between 68.2 and 88.4 dBA with the highest value found in the business centre. In PH, the noise level ranged from 76.0 to 88.7dBA, with the highest value obtained in the in-patient ward. Statistical analysis: Least Significant Difference (LSD) shows that the mean difference of the measured noise level was insignificant in PH but significant in TI. These values obtained were higher than the recommended values by the World Health Organization (WHO), United States Environmental Protection Agency (USEPA) and the National Environmental (Noise Standards and control) Regulation (NER). Therefore, effort has to be made to reduce noise pollution in these institutions to enhance a conducive learning and research environment in the case of TI and fast recovery of patients at PH.

1. Introduction

Noise is often comprehended as an undesired or an unwanted sound [1–4]. Research shows that noise pollution is the third most harmful and dangerous type of pollution in large cities after air and water pollution [5]. Our day-to-day activities might mean no harm to the environment but can indirectly pose a lot of hazards to our environments. As such, noise derives its sources from our daily activities such as transportation gadgets, agricultural machineries, defence equipment, public address system, manufacturing industries, generators, communication system etc. [5–7].

Unfortunately, all the sources of noise pollution are of paramount importance to life. However, the effects of noise pollution supersede the perceived importance as it affects health and the quality of life [8–9]. It is no longer news that exposure to noise pollution exceeding 75decibels for more than eight hours daily for a long period of time can result in loss of hearing [6]. Moreover, health centres are sensitive to noise due to the activities they harbour [10]. Noise is an annoyance and even offence to patients in hospitals, it produces physiological or psychological response in individuals and has implications in chronic mental and physical health [11–13]. Higher levels of noise also hinder

organization of the developing brain in premature or pathological new-born [14]. Furthermore, noise has devastating effects on human health such as: difficulty in sleeping, cardiovascular problems hypertension, higher blood pressure, stress related illness, memory loss, severe depression, hearing loss and panic attacks. [3,15,16]. Environmental noise present in hospitals all over the world is a common stressor and is recognized as a serious health hazard and not just as a nuisance [12]. It is unfortunate that most researches that are conducted to assess noise levels in hospitals yields negative results [17].

To address the significance of these health concerns, the United States Environmental Protection Agency (U.S. EPA) devised standard values for hospital noise: 45 dBA during daytime and 35 dBA at night [4,15,18]. The World Health Organization (WHO) also recommends that at night, noise levels around hospital environment should not exceed 35dB and 40dB during the day respectively [19, 20]. Meanwhile, the threshold value of noise recommended by WHO is 30dB in hospitals and libraries [10,21].

Apart from hospitals, there are other places that have little or no tolerance for noise; a perfect example of such a place is a school environment, long term exposure to noise reduces student's motivation to learning at schools [22]. As such, many studies have already addressed the devastating effect of noise pollution. According to the WHO the average daily exposure at school should be 72dB, meanwhile during teaching and learning hours, noise level should not exceed 35dB [11]. The Threshold Limit Value (TLV) of the noise for the school is 55 dBA [22]. The value of TLV of >55 dBA is bad, would be a stressor and will distract students from comprehending their lessons if they are continuously exposed to these frequencies [23]. In summary, table 1. shows noise level assessment from noise quality control.

Despite those hazardous effects, recent research shows that environmental noise increases day by day [10]. However, this study aimed to analyse noise pollution level in a Public Hospital (PH) and a Tertiary institution (TI) in Jalingo. This study is motivated by the daily number of patients and visitors to the chosen PH, being one of the two Tertiary health-care institutions in the State. One has to spend several hours before being attended to because of the high influx of patients to the hospital. We imagined what the situation in the various wards would be in terms of noise pollution. Also, the Tertiary institution has witnessed a geometrical increase in the number of students admitted in an academic session over the past 2 years (2017-2018). The number of yearly students' intake has grown from 3,500 to more than 5,000 students with no commensurate improvement in facilities like lecture halls and hostels. This situation further stimulated this study. The aim is primarily to assess the level of noise pollution in these institutions and make necessary recommendations.

Table 1. The Noise Quality Recommendation During Working Hours

NOISE (dBA)	QUALITY	Noise Recommendation	Quality
0 – 30		Excellent Quality	
31 – 40		Very Good Quality	
41 – 60		Good Quality	
61 – 75		Satisfactory Quality	
76 – 90		Unsatisfactory Quality	
90 – 100		Hazardous Quality	
> 111		Not Allowed	

Source: [24].

2. Methodology

2.1. Study Area

The study area is a public hospital owned by the federal government, and the Taraba State University, Jalingo, which are all located in Jalingo city, the capital of Taraba State, Nigeria. Jalingo is located at latitude 8°89"29' N and longitude 11°37"71' E and at an elevation of 384 meters above sea level. The noise level data was acquired in two different Institutions; Tertiary institution (TI) and a Public Hospital (PH) in Jalingo. Sixteen locations were selected from the two institutions for the study. The measurement's locations were as stated in table 2.

Table 2. Sample Locations with their positions

SAMPLE LOCATION	**SAMPLE POSITIONS**	
Tertiary institution (TI)	**Latitude**	**Longitude**
Hostels		
Male Hostel	N 8^0 55'	E11° 19'
Female Hostel 1	N 8^0 53'	E11° 18'
Female Hostel 2	N $8^0$54'	E11° 17'
Lecture Halls		
TI 18	N 8^0 52'	E11° 16'
TI 19	N 8^0 50'	E11° 19'
TI 24	N 8^0 56'	E11° 15'
TI Business Center	N 8^0 52'	E11° 18'
Admin Block	N 8^0 58'	E11° 15'
Public Hospital (PH)	**Latitude**	**Longitude**
MALE WARD 1	N$8^0$53'	E11° 22
MALE WARD II	N$8^0$53'	E11° 23
FEMALE WARD I	N$8^0$55'	E11° 24
FEMALE WARD II	N$8^0$55'	E11° 21
MATERNITY WARD	N$8^0$52'	E11° 24
PEDIATRICS WARD	N$8^0$56'	E11° 23
IN PATIENTS	N8^0 54'	E11° 20
OUT PATIENTS	N$8^0$50'	E11° 28

The measurement of the sound level was carried out using the sound level meter Model SL-4030 available in the Department of Physics, Taraba state university, Jalingo. The instrument is very suitable for environmental noise level measurement. It has large LCD display and it is easy to read. It's time weighting and frequency weighting meet IEC 61672 type 2. It's A & C weighting networks are in conformity to standards. It also has a time weighting (Fast & Slow) dynamic characteristic mode. The instrument was held at arm levels, 2 to 3 meters away from the perceived noses sources [5]. The data was collected during working hours in the morning hours between 8am and 10am and afternoon between 2pm and 4pm for the period of four weeks (14th October, 2019 – 9th November, 2019). The

measurement was carried out for six days (Mondays, Tuesdays, Wednesdays, Thursdays, Fridays and Saturdays) in each week.

The instrument was set at the 'A' weighting network and the corresponding A-weighted, equivalent continuous sound level in decibels (LAeq), measured over a stated period of time [24] was taken for the various locations. In studies that involve the environment and industries, the A weighted network is often used. The rate of hearing loss tends to follow the "A"– scale that one could tolerate higher levels of low frequency noise for a longer period without hearing impairment [24,25]. From the LAeq, other noise parameters or indices such as the noise percentiles (L_{10}, L_{50} and L_{90}), Noise Climate (NC) and noise pollution level (L_{np}) could be evaluated. They are related accordingly as [25].

$$NC = L_{10} - L_{90} \quad \textbf{Eqn. 1}$$

$$L_{eq} = L_{50} + \frac{NC^2}{60} \quad \textbf{Eqn. 2}$$

$$L_{np} = L_{eq} + NC \quad \textbf{Eqn. 3}$$

Where Noise climate (NC) denotes the range of fluctuation of sound level in an interval of time, L_{10} is the noise level exceeded for 10% of the measurement time, L_{90} is the noise level exceeded for 90% of the measurement time [25].

2.2. Experimental Section

The statistical tool used in this work is the Least Significant Difference (LSD) method. However, to be successful in this method, we have to start with the Analysis of Variance (ANOVA) so as to be sure if there is a significant difference in the mean noise levels measured at different locations before proceeding with the LSD. A JB test on the data shows that it was obtained from a normal population. Below is the corresponding hypothesis.

(a). H0: The mean noise levels in the selected sample locations in the TI are the same ($\mu_1 = \mu_2 = \cdots \mu_n$)

H1: Not all the mean are the same ($\mu_1 \neq \mu_2 \neq \cdots \mu_n$).

(b). H0: The mean noise levels in the selected sample locations in the PH are the same ($\mu_1 = \mu_2 = \cdots \mu_n$)

H1: Not all the mean are the same ($\mu_1 \neq \mu_2 \neq \cdots \mu_n$).

At the significant level of $\alpha = 0.05$ and the corresponding degrees of freedom ($df_1 = k - 1, df_2 = n - k$), the critical value: $F_{(\alpha=0.05),}(df_1 = 7, df_2 = 376) = 2.0339$. It implies that our result will be significant at $p < 0.05$, $F \geq 2.0339$, then and only then we shall continue with the LSD statistics, afterward, we shall reject or accept the null hypothesis if the mean differences are greater than the LSD and vice versa.

Suppose that SSTr is the sum of squares for treatment, SSE is the sum of squares for errors, MSE is the mean of squares for errors and MSTr is the mean of squares for treatment. According to [26],

$$F = \frac{MSTr}{MSE} \quad \textbf{Eqn. 4}$$

$$LSD = t_{(\alpha)(v)}\sqrt{\frac{2MSE}{n}} \quad \textbf{Eqn. 5}$$

Where n is equal for all sample locations. The data was obtained for 24 days in the morning and in the afternoon, making 48 measurements per location (8 locations in TI and 8 locations in PH).

Therefore, average $n = \frac{n}{k} = \frac{48}{8} = 6$

The criteria used for selecting venues in TI were :

i. Lecture halls with high carrying capacity (500 – 750) of students. (TI 24)
ii. Lecture halls with average carrying capacity (200) of students (TI 18, 19)
iii. Hostels (lecture free zones, with extra-curricular activities)
iv. Crowded student zones outside class rooms (Business centre)
v. Zones with less students (admin block)

3. Results and Discussion

3.1 Results from the Tertiary institution

The noise level in TI ranged from 65.2 to 89.9 dBA (Table 2). These values are higher than the WHO recommended value of 35 dBA for schools [27] and the National Environmental (Noise Standards and Control) Regulation [28] value of 45 dB(A). The highest values were obtained in the TI Business Centre. The value in the business centre ranged from 80.4 to 89.9 dBA with an average value of 86.7 ± 1.427118 dBA for the four weeks considered. The four-weeks average noise level for three lecture halls (TI 18, 19 and 24) studied were 77.6 ± 0.7588, 77.0 ± 0.8180 and 82.1 ± 0.5377 dB(A) respectively as shown in Table 2, figure 1 and figure 4.

Table 2. Summary statistics of the weekly noise level (dBA) in the Tertiary institution

Sampling Location	Statistics	Week 1	Week 2	Week 3	Week 4	Average ± standard deviation
M. Hostel	Min-Max	74.3 – 77.8	74.9 – 77.5	75.7 – 78.4	74.5 – 76.4	76.0±0.695
	Average	76.1	76.0	76.9	75.2	
F. Hostel 1	Min – Max	75.3 – 81.9	78.1 – 85.7	79.3 – 85.9	75.9 – 80.8	80.4±2.831
	Average	78.8	83.0	82.8	77.4	
F. Hostel 2	Min – Max	72.1 – 78.2	75.2 – 79.1	75.5 – 78.5	75.2 – 77.5	76.3±0.311
	Average	76.1	76.3	76.6	76.8	
TI 18	Min – Max	74.3 – 83.8	75.8 – 78.4	76.3 – 80.4	75.6 – 79.2	77.6±0.759
	Average	77.9	77.2	78.8	77.2	
TI 19	Min – Max	75.3 – 77.3	75.8 – 79.7	75.4 – 80.9	75.4 – 81.3	77.0±0.818
	Average	76.1	78.0	77.6	77.2	
TI 24	Min – Max	78.9 – 85.6	79.8 – 84.5	79.8 – 83.5	76.5 – 82.1	82.1±0.537
	Average	82.5	82.0	82.0	81.2	
B. Centre	Min – Max	80.4 – 89.6	85.9 – 89.2	85.7 – 89.9	82.6 – 86.8	86.7±1.427
	Average	86.4	87.2	88.4	85.0	
A. Block	Min – max	65.4 – 70.9	67.6 – 72.3	67.9 – 73.4	65.2 – 69.5	68.9±1.579
	Average	68.2	70.0	70.1	66.8	

These values respectively represent 54.6%, 54.5% and 57.4% increase above the WHO recommended standards. The high noise level values in this location are expected. This is an area where commercial activities take place within the University. Restaurants, eateries, bookshops and

stationeries and other retail outlets located in this area attract large crowds of students and staff members. Also, due to poor electricity supply, power generators are mostly used to operate equipment like computers, photocopiers and printers etc. which also add to the noise level in this vicinity.

Table 3 presents some other important additional noise indices in TI. The variation of those noise parameters as plotted in the figures; 2 and 3 produced a result which is not far from Table 2.0 and the figures; 1 and 4. This implied that the lecture halls investigated are not conducive for teaching and learning. Excessive levels of noise usually affect the outcome of students learning process negatively because it interferes with their rate of understanding and assimilation during lectures.

Table 3. Noise indices in TI

Sampling Location	**L_{10}**(dBA)	L_{50}(dBA)	**L_{90}**(dBA)	**NC**(dBA)	**Leq**(dBA)	**L_{np}**(dBA)
M. Hostel	76.66	76.05	75.44	1.22	76.07481	77.29481
F. Hostel 1	82.94	80.8	77.82	5.12	81.23691	86.35691
F. Hostel 2	76.74	76.45	76.16	0.58	76.45561	77.03561
TI 18	78.53	77.55	77.2	1.33	77.57948	78.90948
TI 19	77.88	77.4	76.43	1.45	77.43504	78.88504
TI 24	82.35	82	81.44	0.91	82.0138	82.9238
B. Centre	88.04	86.8	85.42	2.62	86.91441	89.53441
A. Block	70.07	69.1	67.22	2.85	69.23538	72.08538

Besides its effects on students, teachers are also affected health wise [11, 29, 30]. Higher noise level in these lecture halls is attributed largely to the increase in the number of admitted students due to the introduction of additional Faculties and courses. This leads to congestion in the lecture halls thereby creating increased noise levels during classes. Although, outdoor noise levels (especially from vehicles) were not considered, it might also contribute to the high noise level measured inside the halls.

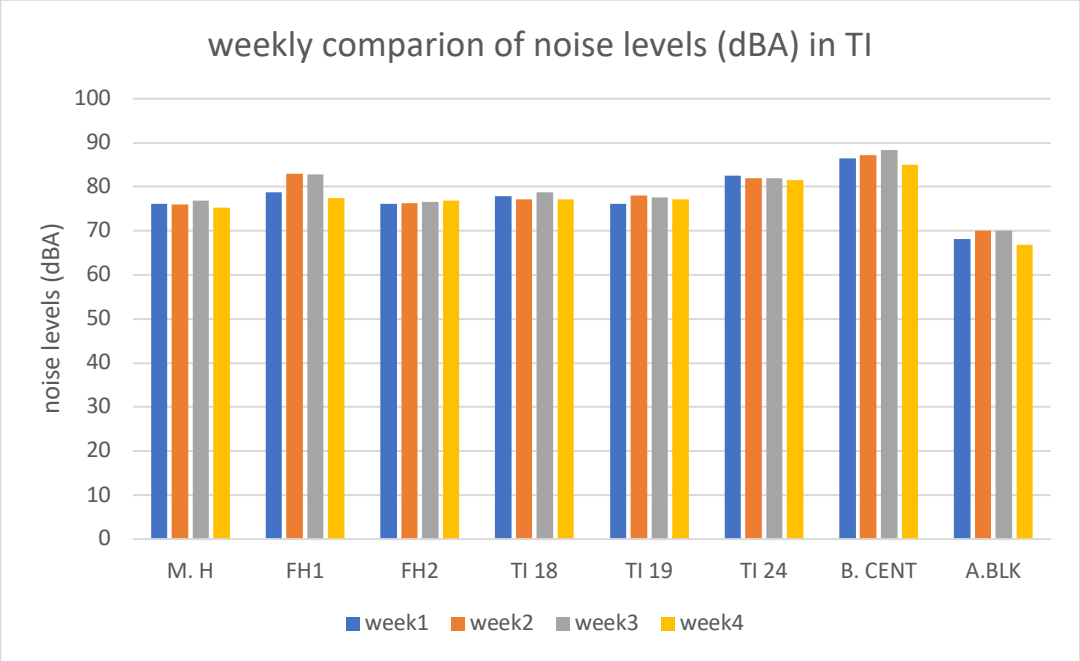

Figure 1. A histogram showing Weekly noise levels (dBA) in TI (plotted from T table 2)

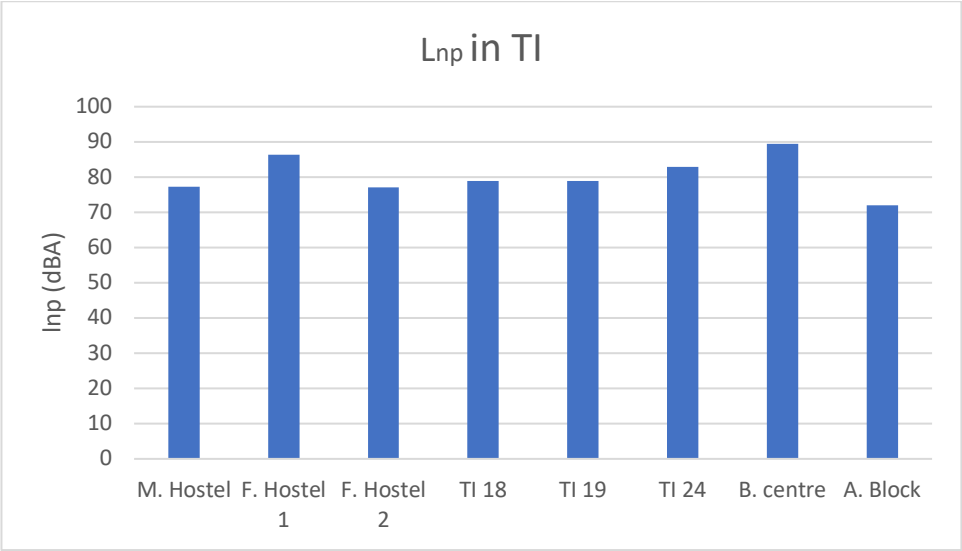

Figure 2. Noise pollution levels (dBA) in TI (plotted from table 3)

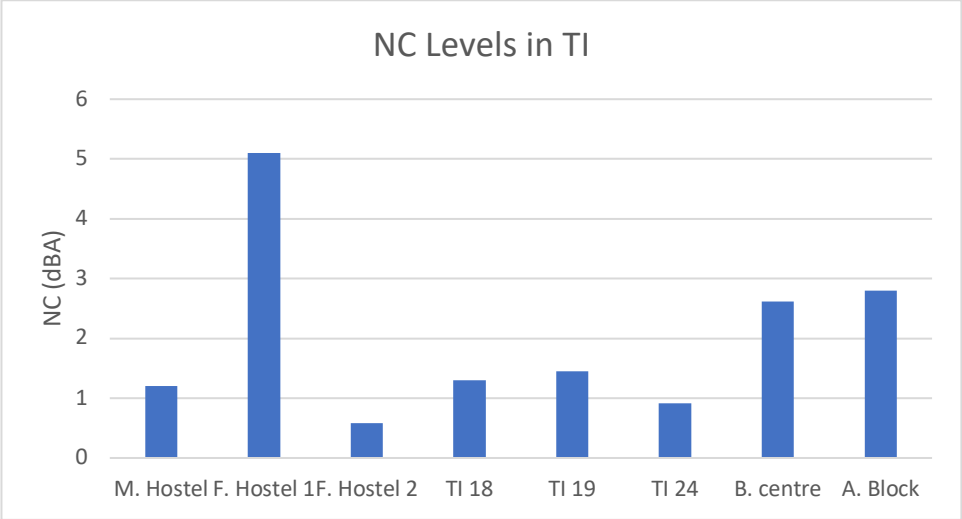

Figure 3. Noise Climate in TI (plotted from table 3)

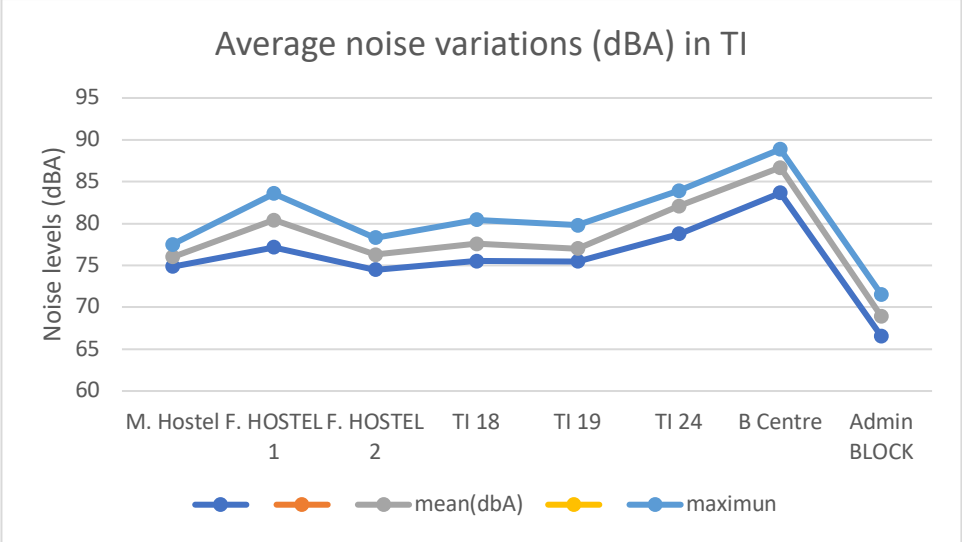

Figure 4. A graph showing the Average noise variations (dBA) in TI (plotted from table 2)

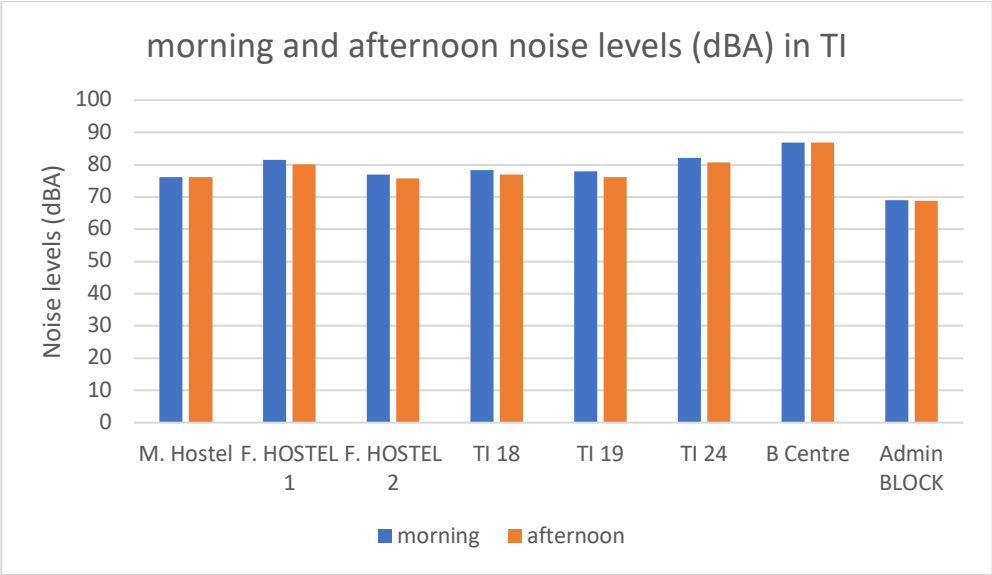

Figure 5. Comparing noise level (dBA) between morning and afternoon in TI (plotted from table 2)

Evaluation of the noise levels in the hostels also indicated increased values above the guidelines from the regulatory bodies. Both male and female hostel had higher values above the permissible levels. The values ranged from 74.3 – 78.4 dB(A), 75.3- 85.9 dB (A) and 72.1 – 79.1 dB(A) respectively for the male hostel and female hostels 1 and 2. The high level of noise in the hostels is least expected, since measurements were carried out between 7:00 am to 4.00 pm when lectures are supposed to be taking place. Although not all students take lectures at the same time, majority of the students should not be in the hostel within this period. Perhaps, the source of noise at this time in the hostels may be linked to the growing number of students, which had caused overcrowding of the limited available hostel accommodation. The high noise level in the TI hostels is detrimental to students.

The least values were recorded in one of the administrative blocks (A. Block, table 2) of the institution with values varying between 65.2 and 70.5 dB(A). Even though the noise level in the Admin block was lower than in other locations in the institution, it is still higher than the allowed values given by the both WHO, USEPA and NER [17, 27,.28]. The admin block was supposed to serve as a control in TI but the influx of students for registration and other administrative purposes has increased the noise levels in the building. To reduce the noise level here, online registration and payment of any form should be adopted by the management of the institution; otherwise, the health of both staff and students exposed to this daily noise dosage will be affected [11, 29].

On comparing the results obtained in this study with similar studies carried out in other Nigerian Universities, the results were not different. Higher noise levels above permissible values have been obtained by Otutu [31] in Delta State University, Abraka, [32] in University of Uyo and [33] in Federal University of Technology, Owerri. Elsewhere in University of Damman, Damman, Saudi Arabia, noise level during study, exams and holidays were found to be 65.5, 63.1 and 55.6 dB respectively [34] which is also in excess of the allowed limit. Students and staff members in this condition are liable to suffer the critical effects of noise pollution given by WHO, such as annoyance, interference, inhibition of information acquisition, difficulty in reading and understanding, information dissemination between teachers and students and between students [35]. Meanwhile the noise levels with their corresponding remarks as stated by the International Standardization Organization [23] is given in the table 4. Accordingly, table 5a and 5b compares the noise levels obtained from the assessed institutions with the recommendations from table 2.

Table 4: The Noise Quality Recommendation During Working Hours

NOISE (dBA)	QUALITY	Noise Recommendation	Quality
0 – 30		Excellent Quality	
31 – 40		Very Good Quality	
41 – 60		Good Quality	
61 – 75		Satisfactory Quality	
76 – 90		Unsatisfactory Quality	
90 – 100		Hazardous Quality	
> 111		Not Allowed	

Source: [23].

Table 5a: The summary result for the month and the Noise Quality Levels in Each Location in TI.

Research Locations	Latitude	Longitude	Average(dBA)	Noise Quality Recommendation
Male Hostel	N 8^0 55’	E11° 19’	76.0±0.695222	Unsatisfactory
Female Hostel 1	N 8^0 53’	E11° 18’	80.4±2.830783	Unsatisfactory
Female Hostel 2	N $8^0$54’	E11° 17’	76.3±0.310913	Unsatisfactory
TI 18	N 8^0 52’	E11° 16’	77.6±0.758837	Unsatisfactory
TI 19	N 8^0 50’	E11° 19’	77.0±0.818026	Unsatisfactory
TI 24	N 8^0 56’	E11° 15’	82.0±0.537742	Unsatisfactory
TI Business Center	N 8^0 52’	E11° 18’	86.7±1.427118	Unsatisfactory
Admin Block	N 8^0 58’	E11° 15’	68.7±1.579821	Unsatisfactory

Table 5b: The summary result for the month and the Noise Quality Levels in Each Location (PH)

Research Locations	Latitude	Longitude	Average for the Month (dBA)	Noise Quality Recommendation
MALE WARD 1	N$8^0$53’	E11° 22	75.3± 0.933	Satisfactory
MALE WARD II	N$8^0$53’	E11° 22	75.6± 1.223	Satisfactory
FEMALE WARD I	N$8^0$55’	E11° 21	76.4±1.437	Unsatisfactory
FEMALE WARD II	N$8^0$55’	E11° 21	75.6±0.687	Satisfactory
MATERNITY WARD	N$8^0$52’	E11° 24	79±2.229	Unsatisfactory
PEDIATRICS WARD	N$8^0$56’	E11° 23	78.7±4.134	Unsatisfactory
INWARD PATIENTS	N8^0 54’	E11° 20	83.1±3.345	Unsatisfactory
OUTWARD PATIENTS	N$8^0$50’	E11° 28	82.9±4.417	Unsatisfactory

3.2 Results from the Public Hospital

The day time noise levels in PH were generally higher than thresholds. They range from 73.6 to 88.7 dBA (Table 6). Table 7 also presents some other additional noise indices which are plotted in fig. 9. Unfortunately, these values (LAeq and N_{pl}) hugely exceed the WHO recommended value of 35 dBA and USEPA and NER [17, 27, 28] value of 45 dBA. Though all the sampled places exceeded the

standards given by regulatory bodies, highest values of LAeq were obtained in the out-patient ward. The values in the out-patient ward ranged from 77.8 to 87.8 dBA with an average value of 82.9± 4.417 dBA for the month.

Table 6: Summary statistics of the weekly noise level (dBA) at Public Hospital, Jalingo

Sampling Location	Statistics	Week 1	Week 2	Week 3	Week 4	Average ± standard deviation
M. ward 1	Min-Max	73.8 – 78.2	74.9 – 77.3	74.7 – 75.9	74.5 – 74.7	75.3± 0.933
	Average	76.0	76.1	74.3	74.6	
M. ward II	Min – Max	76.1 – 78.6	74.5 – 76.1	73.8– 76.5	74.5– 74.6	75.6± 1.223
	Average	77.4	75.3	75.2	74.6	
F. ward I	Min – Max	74.8– 82.2	74.8– 77.4	74.6 – 76.8	75.1– 75.5	76.4±1.437
	Average	78.5	76.1	75.7	75.3	
F. ward II	Min – Max	73.6– 79.5	74.6 – 75.5	74.7– 76.5	74.8 – 75.5	75.6± 0.685
	Average	76.6	75.1	75.6	75.2	
Mat. Ward	Min – Max	80.0 – 82.7	77.4 – 82.7	74.8– 81.7	75.6 – 76.5	79 ± 2.299
	Average	81.4	80.1	78.3	76.1	
Ped. Ward	Min – Max	82.0 – 87.6	75.7 – 79.8	75.2 – 76.3	75.7 – 77.3	78.7± 4.134
	Average	84.8	77.8	75.8	76.5	
In-Patient	Min – Max	87.6 – 87.8	78.8 – 86.0	76.7 – 82.7	81.2 – 83.7	83.1± 3.345
	Average	87.7	82.4	79.7	82.5	
Out-Patient	Min – max	86.8– 88.7	84.0 – 86.4	79.1 – 83.0	76.7 – 78.9	
	Average	87.8	85.2	81.1	77.8	82.9± 4.417

Table 7 Noise indices in PH

Sampling Location	**L_{10}**(dBA)	**L_{50}**(dBA)	**L_{90}**(dBA)	**NC**(dBA)	**Leq**(dBA)	**L_{np}**(dBA)
M. ward 1	76.66	76.05	75.44	1.22	76.07481	77.29481
M. ward II	82.94	80.8	77.82	5.12	81.23691	86.35691
F. ward I	76.74	76.45	76.16	0.58	76.45561	77.03561
F. ward II	78.53	77.55	77.2	1.33	77.57948	78.90948
Mat. Ward	77.88	77.4	76.43	1.45	77.43504	78.88504
Ped. Ward	82.35	82	81.44	0.91	82.0138	82.9238
In-Patient	88.04	86.8	85.42	2.62	86.91441	89.53441
Out-Patient	70.07	69.1	67.22	2.85	69.23538	72.08538

Followed by the in-patients ward whose noise level ranges from 76.7 to 87.8 dBA with an average of 83.1± 3.345 dBA. The notorious rise in noise level above the recommended values is suggested to have emanated from some of the activities within the hospital, such as: staff and patient's communication, cell phones, power engines, vehicular traffic, alarm, discussions from friends, family members and other visitors. As such, patients and even staff are liable to face the outcomes which are generally similar or even same. The paediatric ward has an average noise level of 78.7± 4.134 dBA. This is an unsatisfactory result just like male wards I & II, female wards I &II and the maternity ward which has 75.3± 0.933, 75.6± 1.223, 76.4±1.437, 75.6± 0.685 and 79 ± 2.299 dBA respectively. The high noise level in the maternity has been attributed to constant disturbance from visitors, health workers, and members of family, friends and regular opening and closing of doors [36]. In the United States, it was observed that in 12 hours, about fifty-three interruptions were made by newly delivered mothers [37].

The implication is that breast feeding is disrupted, sleep is hindered and potential endangering of post-natal mental problems [38, 39]. It has been noted that in the hospital, high noise levels inhibit smooth communication between staff resulting in associated reactions of annoyance, irritation and fatigue [40-43]. This increases stress, decreases staff well-being and affects workplace performance. Adequate care and attention to patients is drastically reduced. In patients, high noise levels threaten the fast recovery/healing and rest. Other adverse effects include stimulated sensitivity to pains, hostile behaviour, retarding mental health, tinnitus, high blood pressure etc. [40, 42, 4]. Figures 6, 9 and 10 summarised the results obtained from the PH. In Fig. 7, the average monthly noise level is presented while the weekly variation is shown in Fig. 6. The in-patient and out-patient wards had the highest noise level followed by the maternity and paediatrics.

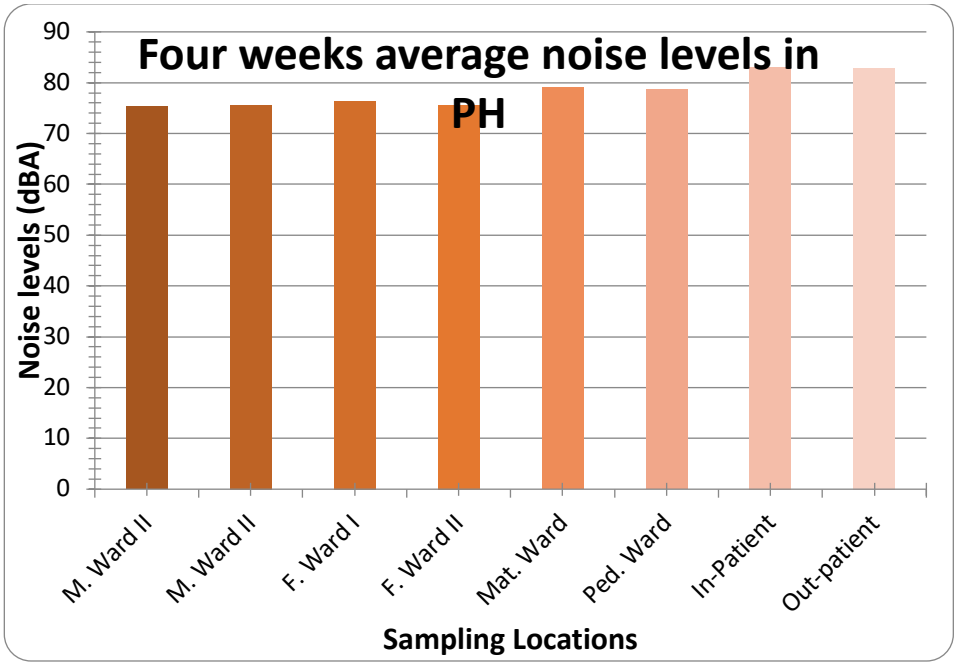

Figure 6. Histogram showing the Four weeks average noise levels in PH (Plotted from table 6)

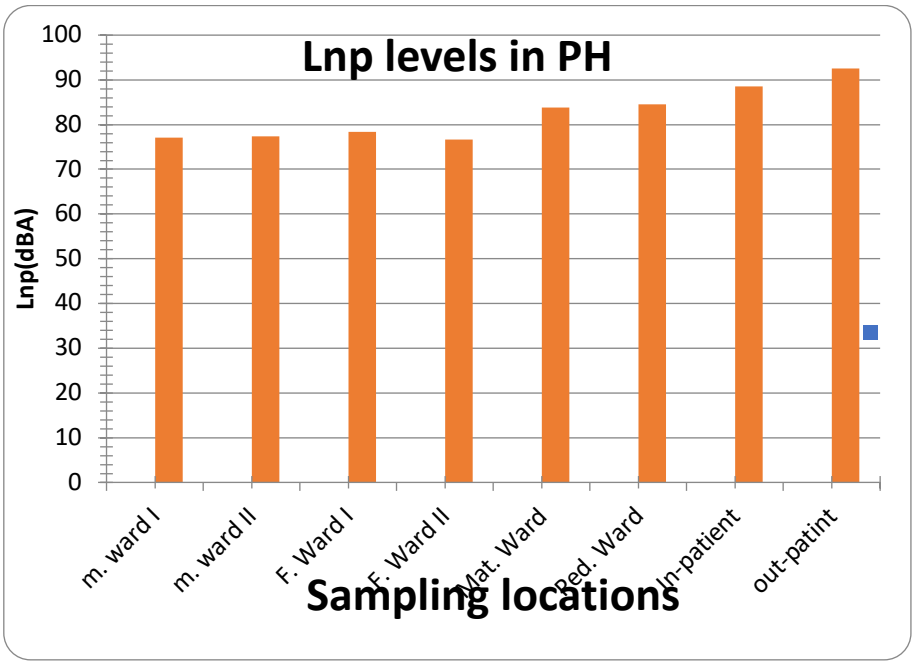

Figure 7. Noise pollution levels in PH. (plotted from table 2)

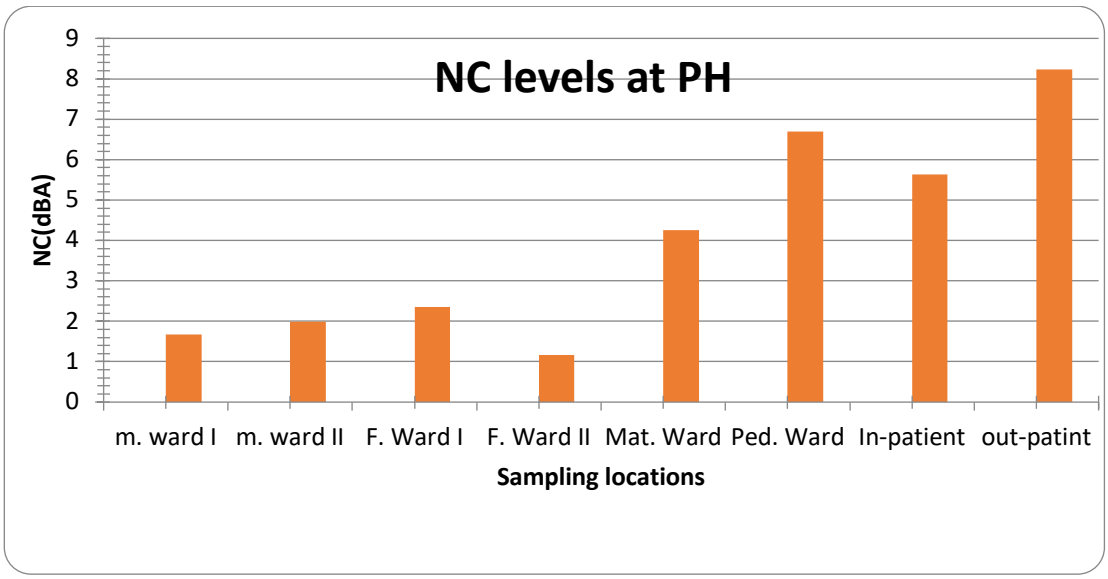

Figure 8. Noise climate in PH (plotted from table 7)

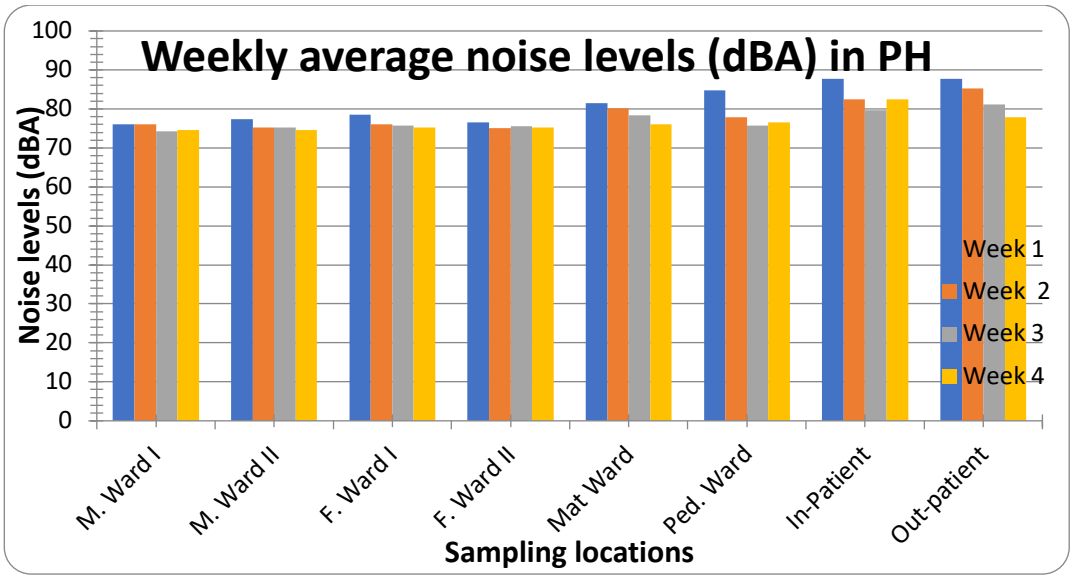

Figure 9. Histogram showing the weekly average noise levels (dBA) in PH (plotted from table 7)

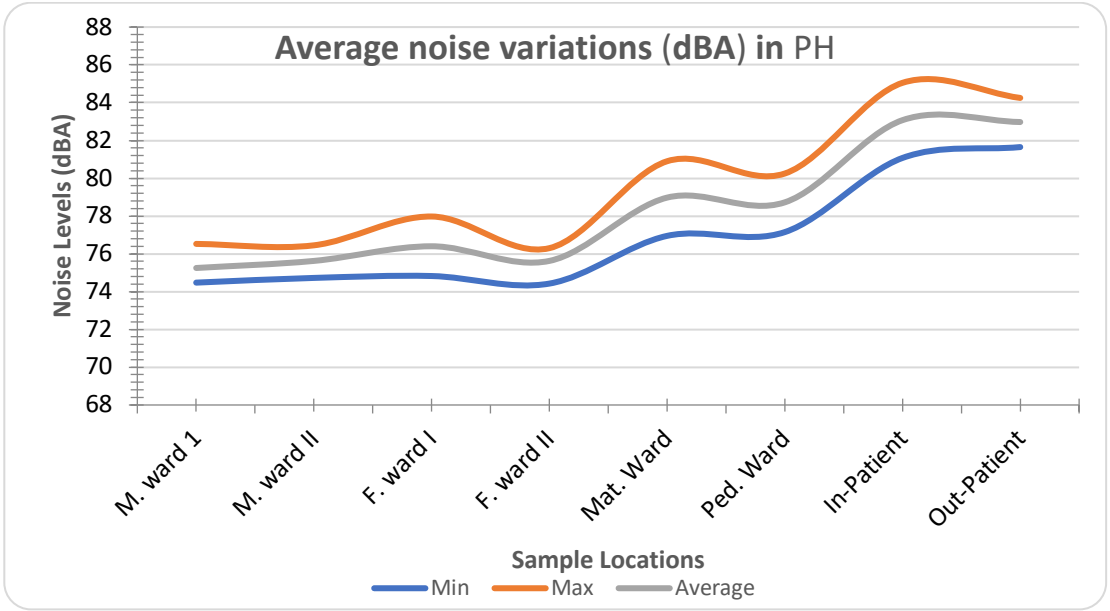

Figure 10. A graph showing the Average noise variations (dBA) in PH (plotted from table 7)

ANOVA RESULT

The tables: 8 and 9 presents the summary of ANOVA for TI and PH respectively.

The ANOVA results shown in tables 8 and 9 both presents the p value (0.00001) less than the significant level (0.05) and the F-statistics has values; 7.298408 and 76.46487 respectively, both greater than the critical value (2.0339). This implies that there is a significant difference in the mean level of noise from one sample location to another. We therefore proceed with the LSD statistics, using administrative block as the control location in TI and Male ward1 as the control location in PH.

Then, from equation (5)

$$LSD(PH) = t_{(\alpha)(v)}\sqrt{\frac{2MSE}{n}}$$

$$t_{0.05(376)} = 1.966$$

$$LSD(PH) = 1.966\sqrt{\frac{2\times 68.12454}{6}} = 9.3686 \qquad \textbf{Eqn. 6}$$

Similarly,

$$LSD(TI) = 1.966\sqrt{\frac{2\times 17.08156}{6}} = 4.6912 \qquad \textbf{Eqn. 7}$$

Table 8: ANOVA for TI

Source	*Df*	*Ss*	*MS = ss/df*	*F*	*P-value*
Treatments	*7*	9142.976	1306.139	76.46487	P < 0.00001
Error	*376*	683.262	17.08156		
Total	383	9826.239			

Table 9: ANOVA for PH

Source	*Df*	*Ss*	*MS = ss/df*	*F*	*P-value*
Treatments	*7*	3480.405	497.2007	7.298408	P < 0.00001
Error	*376*	2724.982	68.12454		
Total	383	6205.387			

Decision from the LSD statistics.

Table 10 and 11 presents the LSD comparison in TI and PH respectively. From equations (6) and (7), the LSD values in TI and PH are 4.6912 and 9.3686 respectively. The comparison in table 10 provides us with strong evidence to reject the null hypothesis (a) above, as majority of the mean differences are higher than their corresponding LSD. This implies that the mean noise levels (dBA) in TI varies significantly in the measured locations.

The table 11 did not avail strong evidence to reject our null hypothesis as all the mean difference are less than their corresponding LSD. The implication is that although the means are not the same (as confirmed from the ANOVA in table 8) but their differences is not significant. Our alternative hypothesis still holds but there is no significant difference among the mean noise levels (dBA) in PH measured in different locations.

Table 10: LSD comparison in TI.

			MEAN DIFFERENCE						
TREATMENT	sample location	mean	Ti-T1	Ti-T2	Ti-T3	Ti-T4	Ti-T5	Ti-T6	Ti-T7
8	B. centre	86.75	17.975*	10.7*	10.3*	9.525*	8.975*	6.25*	4.75*
7	TI 24	82	13.225*	5.95*	5.55*	4.775*	4.225	1.5	
6	F. Hostel 1	80.5	11.725*	4.45	4.05	3.275	2.725		
5	TI18	77.775	9*	1.725	1.325	0.55			
4	TI19	77.225	8.45*	1.175	0.775				
3	f. hostel 2	76.45	7.675*	0.4					
2	Male Hostel	76.05	7.275*						
1	Admin Block	68.775							

Note: * values differ significantly.

Table 11: LSD comparison in PH

TREATMENT NUMBER	SAMPLE LOCATION	MEAN	TI-T1	TI-T2	TI-T3	TI-T4	TI-T5	TI-T6	TI-T7
8	In-patient	83.075	7.825	7.45	7.45	6.675	4.35	4.1	0.1
7	Out-patient	82.975	7.725	7.35	7.35	6.575	4.25	4	
6	Maternity ward	78.975	3.725	3.35	3.35	2.575	0.25		
5	paediatric ward	78.725	3.475	3.1	3.1	2.325			
4	Female ward 1	76.4	1.15	0.775	0.775				
3	Female ward 2	75.625	0.375	0					
2	Male ward2	75.625	0.375						
1	Male ward1	75.25							

Conclusion and Recommendations

This study determined the noise level in a hospital and in a school due to indoor sources. For this purpose, noise levels were measured with the aid of sound level meter. Results obtained indicated that in all sampling sites, the minimum measured values exceeded the recommended levels of 35dBA - 45dBA by regulatory bodies. The result ranged from 73.6 to 88.7 dBA and 65.2 to 89.9 dBA in PH and

TI respectively. Statistical analysis confirmed that the mean values of noise measured at different locations were not the same. In TI, the analysis Showed a significant difference in the mean, and in PH, though the means were not the same but their difference is not significant. Higher noise levels are probably attributed to the activities harboured in those environments such as loud discussions from patients and visitors, vehicular activities, public address system loud speakers, ringing tones from phones and so on. The results of this study clearly indicate undesirable results. Thus, the following recommendations.

Recommendations for the Public Hospital

1. Adequate information should be made available to patients and accompanying family members on likely causes of increased noise levels. This will help them prepare properly ahead.
2. Staff members should be educated to adopt safe practices that will instil a habit of noise reduction for effective health care delivery in the hospitals.
3. There should be a period of visitation where friends and families of patients would be allowed to visit. This ensures that patients have adequate time to rest and workers engage their patients without disruptions.
4.Building and furniture materials used in the hospital should be those recommended from noise control and acoustic designs, so as to enhance noise absorption and to minimize reverberations and echoes from those materials.

Recommendations for the Tertiary Institution

1. Business centres should be distant from lecture halls so as to curtail the detrimental noise effects.
2. More large lecture theatres with carrying capacity of at least 500 students should be built so as to minimize student congestion
3. Building and furniture materials in the schools and should be those recommended from noise control and acoustic designs, so as to enhance noise absorption, optimum reverberations and minimal echoes from those materials

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Conflict of Interest

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

Life Science Reporting

No life science threat was practiced in this research.

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