Assessment of Noise Levels and Their Subjective Annoyance to the Cardiac Patient: A Case Study for an Indian City.

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Abstract - *Assessment of impact of noise on sensitive area especially in hospital environment has become most crucial concern in the recent time. Cardiac patients are one of the most sensitive and worst affected due to noise pollution. A study is therefore conducted on 100 beds cardiac hospital with a focus to assess the noise level in the hospital environment. A 16-hours sound measurement study is done using sound level meter (DAWE Model No. 1421C) to ascertain the noise level. The results indicate that the noise levels exceeded the limit of noise level prescribed by the authority. There is a significant difference ($p < 0.05$) spatially and temporally, in the noise exposure levels at various locations within the hospital premises.*

Key Words: Noise Pollution, Cardiac Hospital, Noise Indices, A- weighted level, Environment

1.INTRODUCTION

1.1 Effect of Noise

In the recent time, increasing exposure to noise pollution has become a serious problem for most of the cities. Noise affects the human health unfavorably both physically and psychologically (Serkan et al. 2008). Hospitals are the most sensitive to the exposure to noise pollution. Noise environment not only affects the patient's health but also to the staff working in noisy situation. Staff finds it harder to concentrate on their job, leading to them being more fatigue, decreased performance and increased chances of error (Tsion et al.1998). Previous investigators studying the effects of the noise on health and healing have registered high noise levels in hospitals, showing that the problem is more serious in intensive care units, both at night and during the day (Tsion et al.1998; Hilton 1985; Neriman et al 2008). The epidemic of noise in hospitals, which is one of the biggest complaints of patients and staff, is something that can no longer be ignored. Cardiac patients being the one who are adversely affected by noise during their hospital stay, they suffer from sleep disturbance, restlessness and disorientation. In addition, it also effects to elevated blood pressure, heart rate, and peripheral resistance by the release of hormones such as norepinephrine, epinephrine, and cortisol (Tsion et al.1998). In spite of the effort taken by the hospital and regulatory authority, the noise environment in hospital settings in India is a generally an unnoticed crisis (Mackenzie et al. 2007). Very few studies are reported specially for hospitals in India on assessment of noise levels and its impacts. A serious effort is therefore needed to control the noise within the hospitals and reduce its negative impacts on the patients and staff. Recent efforts are focused towards monitoring and calculating actual noise exposure and level of annoyance to the patients to actually understand the gravity of the problem due to noise in the hospital (Hilton 1985).

1.2. Sources of Noise

Noise pollution within hospital facilities are mainly caused due to equipment and machinery used during normal work activities and other human activity. The multiple monitors, beepers, buzzers, paging systems, telephones, carts, wheel chairs & gurneys, hospital beds, pillow speakers and nurses call systems, IV poles that role on tiled floors, doors that close abruptly, and carts that squeak, all contribute to increase the noise in the hospital environment (Tsion et al.1998; Neriman et al 2008). Apart from engineering and architectural design, facilities and equipment and, of course, people are paramount (Hilton 1985).

1.3. Standards and Guidelines

World Health Organization (WHO) recommends noise levels limit of 40 dB (A) during the day and 35 dB (A) at nights in hospital (Tsion et al.1998; Mackenzie et al. 2007). In India, the Noise Pollution (Regulation and Control) Rules, 2000 and Noise Pollution (Regulation and Control) (Amendment) Rules, 2010 have been framed under the ambit of Environment (Protection) Act, 1986. The ambient levels of noise for silence zones such as hospitals is about 50 dB (A) during the day and 40 dB (A) at nights (CPCB 2000).

1.4. Noise Descriptors

Noise is commonly used to describe sounds that are disagreeable or unpleasant produced by acoustic waves of random intensities and frequencies or without musical quality, disrupts performance, or sound that causes subjective annoyance and irritation, and it is an obnoxious stimulus for people (Narendra et al. 2004). Equivalent noise level (L_{Aeq}) is the commonly used index which indicates an equivalent noise would generate the same magnitude or quantum of energy as those of all readings over the given duration, covering all fluctuations. Noise pollution level (L_{NP}) is another index which used for analysis which takes into account the variations in the sound signal and hence it should serve as a better indicator of pollution in the environment for both physical and psychological disturbances of people (Ayer et al. 2003). Following are the expressions used for the analysis in the present study:

$$L_{Aeq} = 10 \log_{10} * [{}^{1}/_{N} \sum_{i=1}^{N} (\text{antilog} ({}^{L_{Ai}}/10)) * n_i] \quad (1)$$

$$L_{NP} = L_{Aeq} + (L_{10} - L_{90}) \quad (2)$$

Where

L_{Ai} is the ith A-weighted sound pressure level reading decibels,

N is the total number of readings,

L_{Aeq} is the A-weighted equivalent sound pressure level,

L_{10} is the noise level exceeded 10% of the time. This represents peak noise level.

L_{50} is the noise level exceeded 50% of the time. This represent noise level is near to the mean level for dense population.

L_{90} is the noise level exceeded 90% of the time. So, this value is often surpassed, being normally considered as the background noise level.

L_{NP} is noise pollution level (Tsion et al.1998 ; Ayer et al. 2003 ; Gulab 2006).

1.5. Study Area

A premier 100 bedded cardiac hospital with all modern facilities in cardiology located at Nagpur, India is selected for the present case study. It has cardiac operation theater that matches world standard of A-bacterial environment with the use of Module Laminar Air Flow System. Cardiac interventional procedures which include Coronary Angiographies, Coronary Angioplasties, Balloon Mitral Valvuloplasties, Pacemaker Implantations, Open and Closed Heart Surgeries are normally performed in this hospital. On an average 9 to 10 nos. of Heart surgeries are performed every day in this hospital and over 90 % of indoor facility of the hospital is normally booked throughout the year. A 14 Bedded ICU and 35 bedded post-operative wards are available in this hospital. The Out Patient Department (OPD) is in the morning hours 9.30 -11.30 hrs and about 80 to 90 OPD patients visit the hospital every day. Equal number of floating population (eg: patient's relatives) visit the hospital in the morning hours (9.30 -11.30 hrs) and in the evening (17:00 to 19:00 hrs).

2. MATERIALS AND METHODS

Four sampling station are selected to study the spatial and temporal effect of noise pollution within hospital campus. The four selected sampling locations are reception cum visitor's block, outpatient department, general ward, and intensive care units. The criteria for selection is exposure characteristics of the study area, physical characteristics of all the sampling locations, which represent global noise environment and population characteristics which gives true representative sampled population of the complete hospital area (Ohrstrom et al. 2006). All measurements are made through precision-grade sound level meter DAWE (Model No. 1421C). The instrument is held comfortably in hand with the microphone pointed at the suspected noise source at a distance not less than 1 m away from any reflecting object. This takes care to minimize all type of error during measurement. The equivalent noise level (L_{Ai}) (A-weighted instantaneous sound pressure level) measurements are recorded at intervals of 30 minutes for a period of 16 hours, at all sampling locations. This procedure is carried out for morning (6:00–11:00 a.m.), afternoon (11:00–4:00 p.m.), evening (4:00–7:00 p.m.), and night (7:00–10:00 p.m.) measurements. Based on these measurements, various community noise assessment quantities like the exceed percentiles L_{10}, L_{50} and L_{90} are computed (Olayinka et al. 2010; Ahmed et al. 2006).

3. RESULTS AND DISCUSSIONS

3.1. Noise Measurement

The variations in Sound Pressure Level (SPL) measured at various sampling stations are shown in Figure 1. The plot reveals that the reception had the highest noise levels, followed by outpatient department, due to the presence of the people in a large quantity. From figure 1 which also represent the large fluctuation in sound pressure level (SPL) in general ward, ranges from 45-85 dB (A) throughout the measurement period. The highest peak of sound pressure level is noted, when the cleaning operation is carried out in the general ward, and also during the meal time. The lowest SPL is observed in the night. The observed value of SPL are ranges from 50- 68 dB (A) within the intensive care unit.

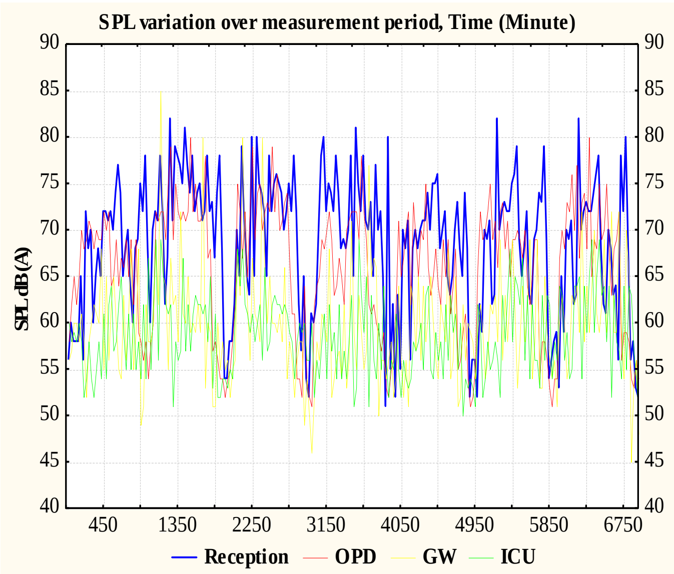

Fig. 1: Plot shows SPL variation over measurement period at various sampling stations of Cardiac Hospital.

To understand the percentage of time the noise level exceeded a particular value, Figure 2 is plotted. It reveals that, the noise level limit of 45 dB (A) is always exceeded over the entire measurement period. On comparing the selected location, it is observed that noise level of 66 to 69 dB (A) remained during most part time of measurement period at reception and OPD, whereas noise level of 58 to 60 dB (A) exceeds 50 % of time of measurement period at general ward & ICU. A noise level of 75 dB (A) exceeded 6.03 % of times during the entire measurement period except at the reception. The maximum recorded at any time is 85 dB (A) at the general ward during the cleaning process.

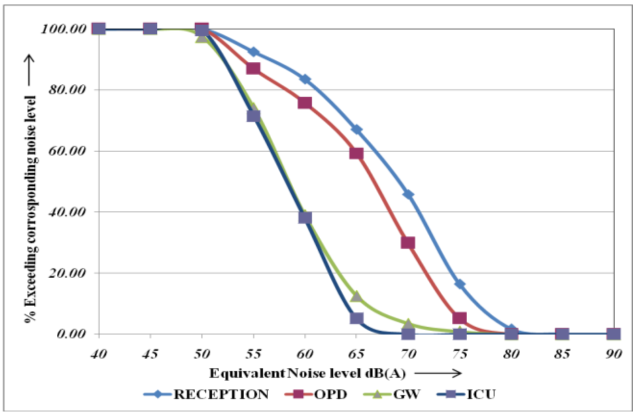

Fig. 2: Plot shows % Exceeding Noise Level over measurement period at various sampling stations of Cardiac Hospital.

Influence of the characteristics of the locations and period of the day on Equivalent Noise Level (L_{Aeq}) and Noise Pollution Level (L_{NP}). There is variation in the noise exposure levels with the period of the day and the nature of the location. Figure 3 & 4 shows variations of equivalent noise levels (L_{Aeq}) and noise pollution level (L_{NP}) with location and period of the day. In general, there is high noise pollution levels (L_{NP}) in the daytime (6:00 am – 4:00 pm) compared with the nighttime (4:00 pm–10:00 pm). Characteristics of location and presence of intrusive noise sources are the major factors found responsible for differences in noise level in the different sampling location surveyed. At reception, outpatient department, general ward, and intensive care unit, both the L_{NP} and L_{Aeq} rises from morning and reach peak values in the afternoon and evening but descend in the night to lower levels. The high noise exposure levels in the morning and evening at these locations can be justified as a result of morning rushing hours of patients, staff, visitors and general public and due to conversation and discussion among the patients, staff and nurses. The noise pollution levels in the evening time (4:00 pm–7:00 pm) at intensive care unit and out patient's department areas are generally low. This is because the majority of the staff nurses are not available at this time.

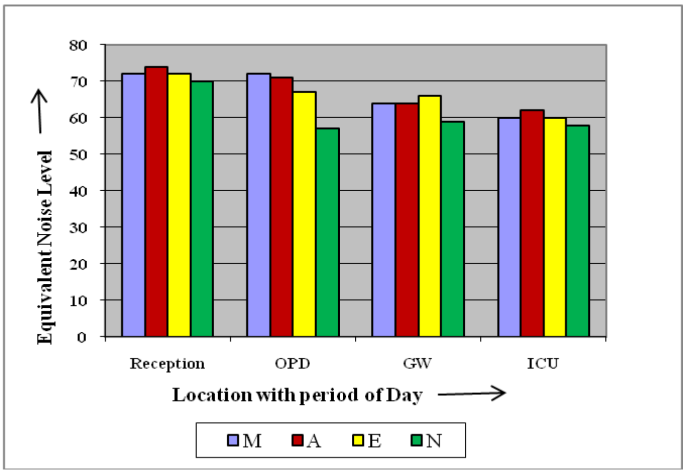

Fig. 3: Variation of the Equivalent Noise Levels (L_{Aeq}) with location and period of the day.

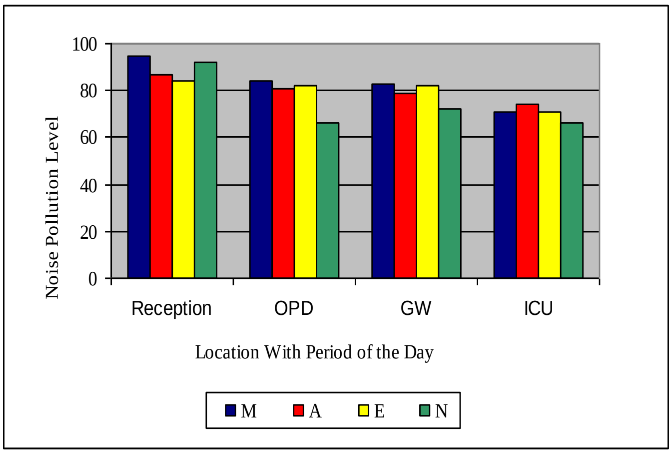

Fig. 4: Variation of the Noise Pollution Levels (L_{NP}) with location and period of the day.

At the time of measurement, the noise equivalent levels is ranges from 53 to 77 dB (A). In the general ward and intensive care unit the L_{Aeq} value observed as 64 dB (A) and 60 dB (A) due to doctor's round and discussion among the patients with their relatives. The highest and lowest noise pollution level (L_{NP}) are observed as 95 dB (A) and 66 dB (A) respectively. The higher noise pollution level (L_{NP}) during the morning period is 95 dB (A) at reception and 84 dB (A) at out patients department is obtained when loud conversation and pulling of chairs is found to be a causative factor at that moment. The higher noise pollution level (L_{NP}) during the morning period of 83 dB (A) and 71 dB (A) is obtained in general ward and intensive care unit respectively, and changing of beds and beeping noise generated by equipment at intensive care unit is found to the source at that moment. Reception and OPD are found to be the noisiest sites with peak noise levels (L_{10}) of 79 dB (A) and 72 dB (A), respectively, compared to the peak noise value GW and ICU of 72 dB (A) and 67 dB (A) respectively. The highest noise level is produced by snoring, crying in pain of surrounding patients in general ward and intensive care unit. But at reception and out patients department, the high noise levels may be a result of the noise produced by various activity carried by patients and their relatives / visitors. The use of electronic appliances such as radio, mobile and printer at the reception and out patients department is become the main causative factor for creating substantial amount of noise level. Noise from nearby surrounding commercial activities and the traffic noise are another sources contributing to the environmental noise. The L_{90} value shows the noise level between 52.75 dB (A) to 53.25 dB (A) occurs due to the normal work activity and normal conversation. This commensurate with the observation made for environmental sound levels with number of specific variables determining the characteristics and sources of noise present at the location (Ahmed et al. 2006; Olayinka et al. 2010).

In order to determine whether the significant difference in noise exposure level at all the sampling locations, surveyed throughout the measurement period (i.e. from morning to night) are significant or not. The data is analyzed through ANOVA for single factor experiment, using F- distribution, is carried out on L_{Aeq} and L_{NP}.

H_0: Difference in noise level exposure is insignificant in the locations surveyed throughout the day.

H_1: Difference in noise level exposure is significant in the locations surveyed throughout the day.

The null hypothesis (H_0) postulated is that the difference in noise level exposure is insignificant. The alternative hypothesis (H_1) is that the difference in noise level exposure is significant there is a variation of noise level exposure. The null hypothesis (H_0) is ascertain the insignificant difference in the noise level exposure in all the sites surveyed throughout the day (from morning to night) its rejection depend on the F value and the critical (tabulated) value $F_{\alpha,q,n-q-1}$ (where α is the confidence level, q is the number of parameter that described the phenomenon in this case q = 3, n is the number of sample size). The hypothesis is rejected if F is greater than $F_{\alpha,q,n-q-1}$, accepted if F is less than $F_{\alpha,q,n-q-1}$ (Ayer et al. 2003). Table 1 and Table 2 are analysis of variance tables for noise pollution levels L_{Aeq} and, L_{NP} respectively. At 90% confidence level, the mean square ratio (MSR) calculated for L_{NP} is 7.60, while the tabulated value is 2.61 (Lipson et al. 1973). Similarly, at the same confidence level, the MSR calculated for L_{Aeq} is 6.90 and the tabulated value remains as 2.61. Since, in the two cases, the calculated MSR is greater than the tabulated value, there is a significant difference ($p < 0.05$) in the noise pollution level (L_{NP}) and equivalent noise level (L_{Aeq}) in the locations surveyed based on the data analyzed at 90% confidence level.

Table 1 Analysis of variance for equivalent noise level (L_{Aeq})

Source of Variation	SS	DF	MS (MS=SS/DF)	MSR ($MSR_c=MS_c/MS_r$)	$MSR_{tabulated}$ ($F_{0.1,3,12}$)
Column	316.50	C – 1 =3	105.50		
Residual	183.50	(N-1) –(C-1) =12	15.29	**6.90**	2.61
Total	500.00	N -1 = 15			

Table 2 Analysis of variance for noise pollution level (L_{NP})

Source of Variation	SS	DF	MS (MS=SS/DF)	MSR ($MSR_c=MS_c/MS_r$)	$MSR_{tabulated}$ ($F_{0.1,3,12}$)
Column	730.69	C – 1 =3	243.56		
Residual	384.75	(N-1) –(C-1) =12	32.06	**7.60**	2.61
Total	1115.44	N -1 = 15			

3. CONCLUSIONS

The present field study in a hospital area shows a significant difference ($p < 0.05$) in the noise exposure levels, spatially and temporally at 90% confidence level. A high noise levels is registered during the afternoon (L_{Aeq} = 67.96 dB) and at morning (L_{Aeq} = 66.79 dB). The noise levels measured during this study indicates that it exceeds recommended levels, during both day and night which are set up by various authorities for hospitals. Keeping in mind the hospitalized patient, the staff of hospital needs to be aware of noise producing activity and adopt remedial measures to reduce them within permissible limit. The staff is needed to be made aware of and sensitive to the issue. Nurses are in key positions where they can identify physical, psychological and social stressors that affect patients during their hospital stay. Staff education, planned nursing activities and proper design of intensive care unit and other units may help combat this overlooked problem.

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