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Original Research Article

**Comparative study of noise levels between two architectural designs in Intensive Care Unit****Edwin Pathrose<sup>1\*</sup>, Sanjith Saseedharan<sup>2</sup>, Sunil Poojary<sup>3</sup> and Anant Patil<sup>4</sup>**<sup>1</sup>M.B.B.S. (Smolensk State Medical Academy, Russia), ICU Registrar, S.L. Raheja Hospital (A Fortis Associate), Mumbai, Maharashtra, India<sup>2</sup>M.D. (Anaes), D.A. (Univ), D.A. (C.P.S.), I.D.C.C., F.N.N.C. (Israel), E.D.I.C. (Europe), FIMSA Consultant Critical Care Head-Intensive Care, S.L. Raheja Hospital (A Fortis Associate), Mumbai, Maharashtra, India<sup>3</sup>M.B.B.S. (Volograd State Medical University, Russia), ICU Registrar, S.L. Raheja Hospital (A Fortis Associate), Mumbai, Maharashtra, India<sup>4</sup>C.P.S. Diabetology (S L Raheja Hospital), ICU Registrar, S.L. Raheja Hospital (A Fortis Associate), Mumbai, Maharashtra, India

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Mumbai, Maharashtra, India**\*Article History:****Received:** 10/09/2017**Revised:** 25/09/2017**Accepted:** 26/09/2017**DOI:** <https://doi.org/10.7439/ijbr.v8i10.4384>**Abstract**

In an earlier study done by the first author and team, the average noise levels in a mixed medical-surgical intensive care unit (ICU) ranged from 41dB to 58dB. In this study we attempted to study the impact of partitions between patient beds (effectively single patient cubicles) on the noise levels in the ICU. As per results of our study, introduction of simple, cost effective, non-movable, permanent partitions (not curtains) between patient beds (or presence of cubicles) caused a significant reduction in noise levels. This reduction in noise levels was seen across 24 hours (average noise range from 38 to 52dB).

**Keywords:** Intensive care unit (ICU), noise, partitions, noise reduction strategies.**1. Introduction**

Noise, defined as unwanted or unpleasant sound, has been identified as a health hazard by numerous studies. Its ill effects on the wellbeing and recovery of patients in a hospital environment have been a major concern for medical professionals globally. Generally, noise levels in hospitals overshoot those recommended by World Health Organization's (WHO) guidelines[1] and especially in ICUs where high noise has been suggested to increase the length of stay in an ICU as well as hospital stay of critically ill patients. Our previous study found noise levels to be higher than the recommended values in the ICU of a tertiary care hospital.[2] It also identified the various sources of noise and found that about 60% of these were modifiable. Measures were adopted to reduce noise levels: simple wooden partitions were introduced between the ICU beds to

act as noise containing barriers. Noise levels were monitored after the application of these modifications using methods similar to the previous study. It was observed that partitions were particularly effective in reducing noise levels by acting as barriers and containing noise as well as providing less reflection of sound leading to reduced overall noise.

**2. Materials and methods**

In the previous study, noise levels were noted at 8 different stations during 24 hours in a mixed (medical/surgical) ICU in September 2015 by an investigator using a digital sound meter (Model: SL4010) from Lutron with an accuracy of  $\pm 1.5$ dB (Figure 1). The sound levels were noted down for 5 minutes at the

beginning of every hour at 8 different stations for 10 consecutive days. Stations at which the noise levels were recorded are displayed in Figure 2. Noise recordings were done per minute for 5 minutes and an average of 5 readings was taken. Subsequently, wooden partitions were introduced between the cubicles as illustrated in Figure 3. The same exercise was repeated and readings were noted in September 2016 by the same investigator. Paramedic strength, ventilators, devices likely to produce alarms, and other architecture remained the same. Throughout the study period, patient care remained the same as at the time of the previous study. A graphical representation of the previous study is depicted in Figure 4 while that of the present study is depicted in Figure 5.



Figure 1: Lutron SL 4010 digital sound meter

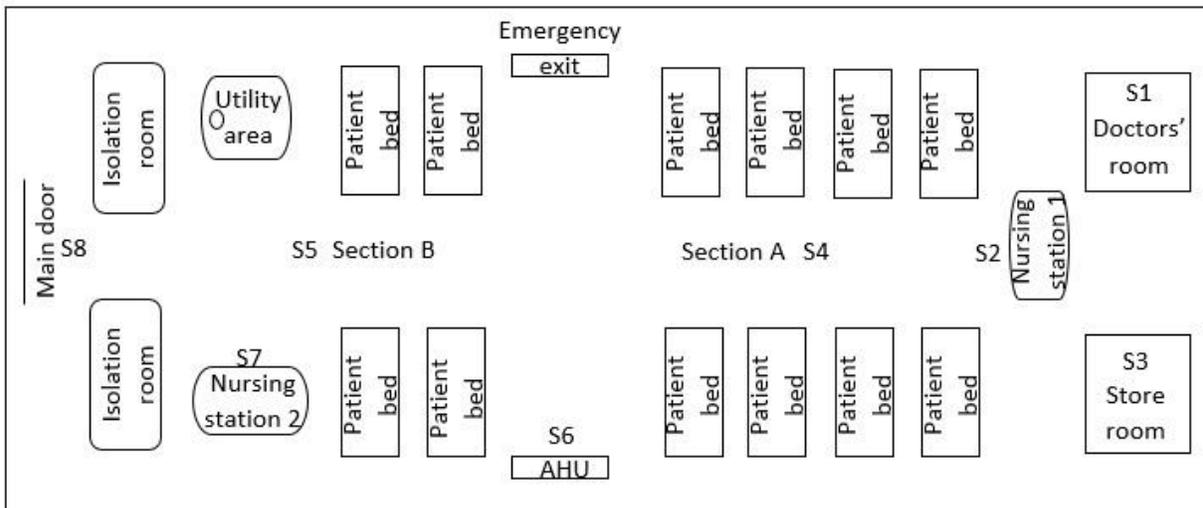


Figure 2: Pre-partition layout of ICU

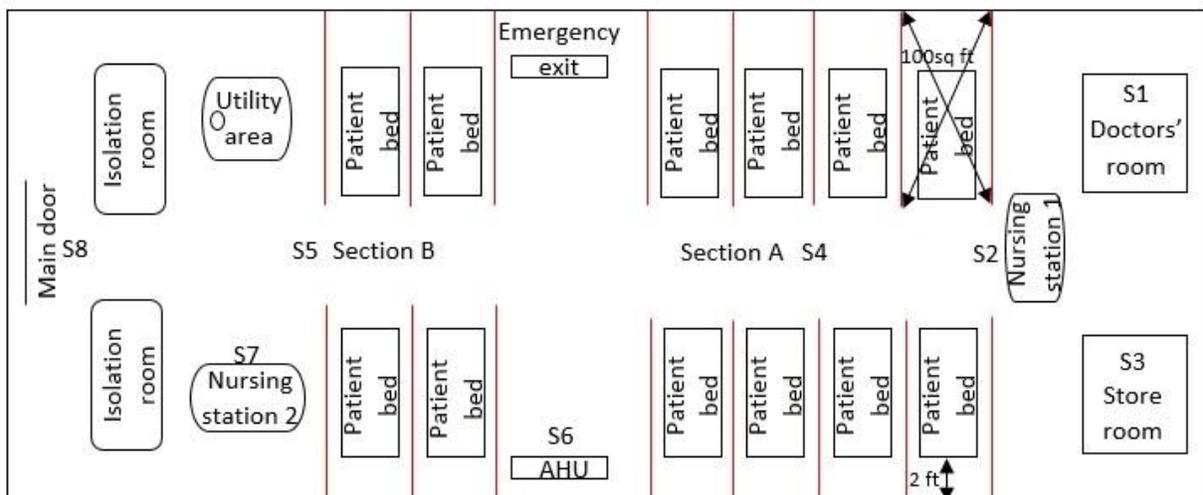


Figure 3: Post-partition layout of ICU

**2.1 Statistical analysis**

The present study was carried out across 8 stations. Each station was monitored at every hour for 24

hours over 8 days. A total of 1536 readings were collected (i.e., 8 stations by 8 days and 24 hours).

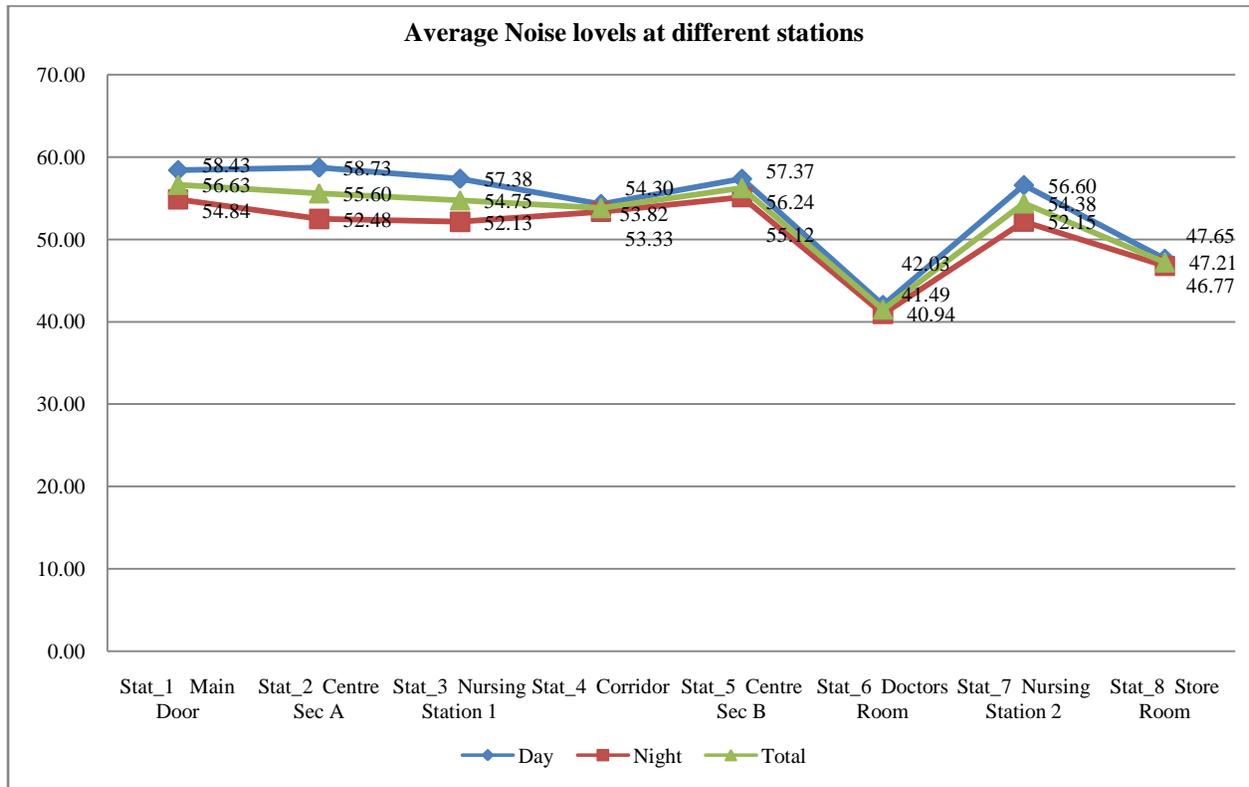


Figure 4: Pre-partition noise levels

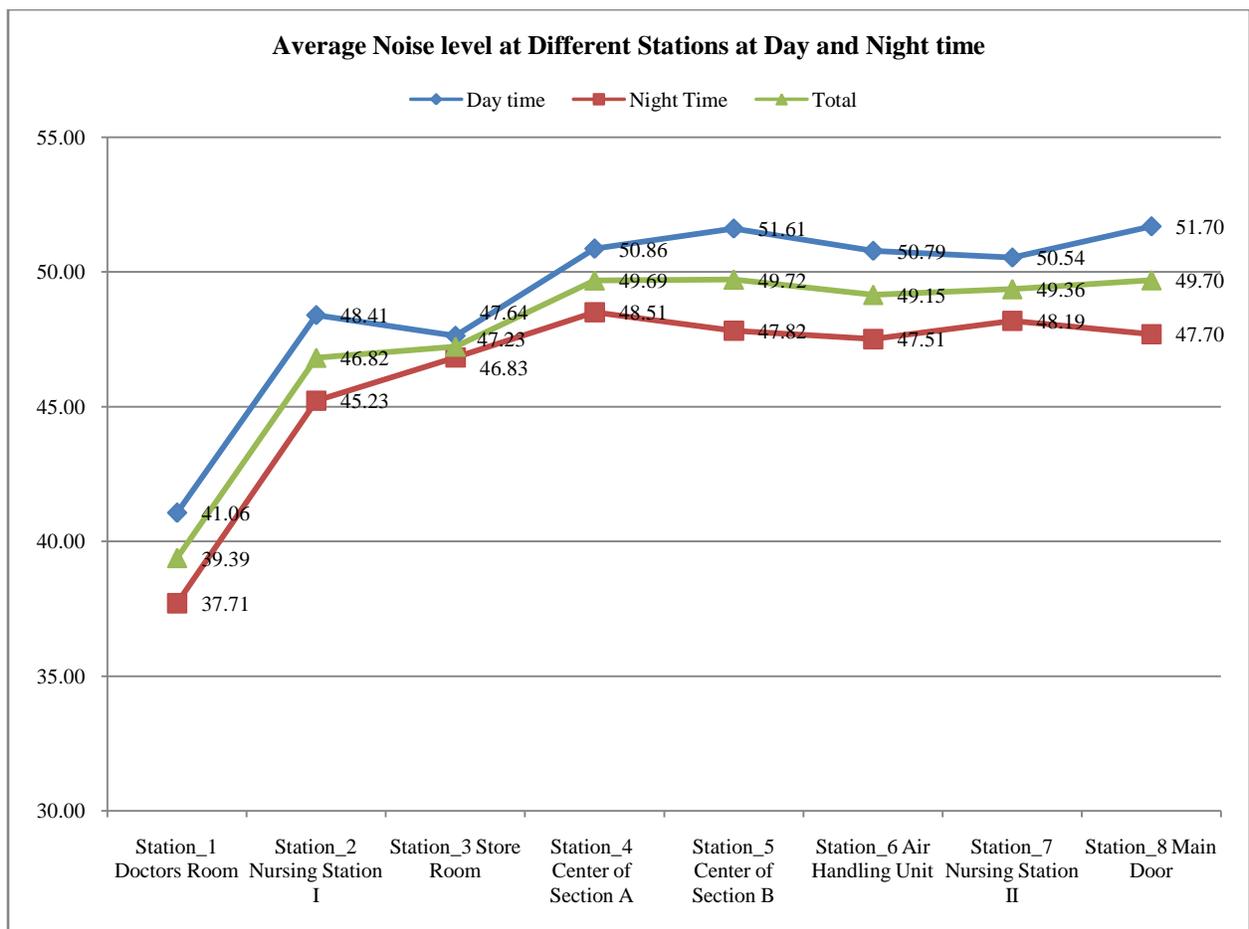


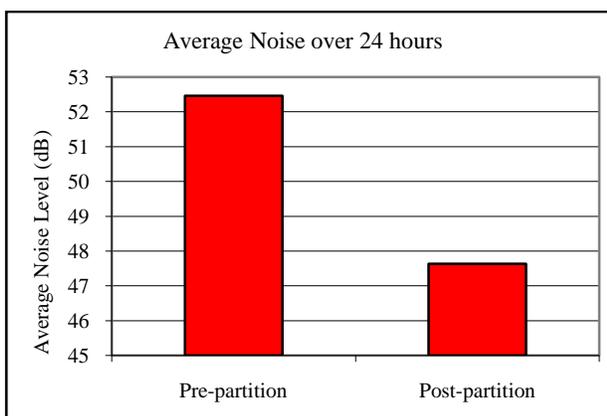
Figure 5: Post-partition noise levels

### 3. Results

On comparing the two studies, it was concluded that the noise levels in the ICU were higher than WHO recommendations in both instances. However, they were found to be significantly lower after the introduction of partitions. The maximum reduction in noise was noticed at sections A and B over 24 hours. Table 1 shows the pre- and post-partition 24-hour noise levels at individual stations. Figure 6 shows the pre- and post-partition (cubicles) difference in noise levels. The results confirm that introduction of partitions between patients can reduce the average noise levels.

**Table 1: Average noise levels**

Stations	Average noise levels (24 hours)	
	Pre-partition	Post-partition
Doctors Room	41.49 dB	39.39 dB
Nursing Station I	54.75 dB	46.82 dB
Centre of Section A	55.6 dB	49.69 dB
Centre of Section B	56.24 dB	49.72 dB
Air Handling Unit	53.82 dB	49.15 dB
Nursing Station II	54.38 dB	49.36 dB
Store Room	47.21 dB	49.70 dB



**Figure 6: Comparison of 24 hours noise levels**

### 4. Discussion

How can we differentiate between sound and noise? From the point of view of physics, they are indistinguishable. The brain classifies any sound as noise once it is received and perceived. As per WHO guidelines, noise inside a hospital environment should not exceed an average of 35 dB and a maximum of 40dB [1]. Similarly, the Environmental Protection Agency (EPA) suggests that average noise levels within a hospital premises should not exceed 45dB [3]. Excessive noise can have detrimental effects on health such as hearing loss, high blood pressure, ischemic heart disease, sleep disturbances, injuries and decreased performance in daily activities [4].

DM Kahn et al[5], in agreement to our initial study[2], state that noise levels in an ICU are exceedingly

high and a majority of the sources are modifiable. One such modifiable risk factor with relation to patient is sleep deprivation leading to delirium [6]. The most common complaint of a critically ill patient is sleep deprivation. An ICU is supposed to and ought to be the quietest section of a hospital primarily because the patients within are not only critically ill but also deal with anxiety. When questioned, 48% of them complained of sleep disorders, the main cause of which was considered to be noise (54%).[7] Freedman et al[8] state that the etiologies for poor sleep quality in an ICU as compared to home are multi-factorial of which the major contributor is noise. They also believe that once the pattern is altered it may take some time to normalize even after the patient is transferred to a general ward. However, Freedman et al[9] and Gabor et al[10] used 24 hour polysomnography and found that alternate factors and not noise alone is responsible for sleep deprivation.

From the healthcare professional's point of view, the modifiable risk factors are noise caused by consultants, ICU registrars, nurses, caregivers, and relatives talking; infusion, ventilator, and monitor alarms; and doctors talking on phone, the same as in our previous study. The main contributors to noise in this study too were caregivers followed by nursing staff. However, the levels were found to be significantly lower than those in the earlier study. This can be attributed to the various noise control programs conducted by the ICU team on the basis of the results obtained in our previous study. The results were exhibited and explained to all the staff members associated with the ICU. This led to awareness among them and all possible attempts were made to reduce the noise levels.

One additional factor considered by the authors was the use of partitions in the ICU as an attempt to curb noise levels. The idea originated from patients' complaints regarding lack of privacy in spite of the presence of curtains, which is the common mode of partition in the majority of ICUs in our country.[11] The guidelines for Indian ICUs state that curtains do help in maintaining privacy to some extent, however, they easily get soiled and get displaced too with the slightest movement of the hospital staff and/or relatives. Suggested alternatives include partitions made of wood, aluminium, or fibre. Also, the guidelines mention that removable ones are preferred compared to fixed ones as the former facilitate increase in floor space as and when required. Hence, on the basis of the above information, our ICU underwent an architectural modification with the addition of fixed wooden partitions. The bed placements were made as per the guidelines for bed designing and spacing. In the authors' opinion, the significant reduction in noise levels after the introduction of partitions could be attributed to:

- a) The partitions themselves acting as barriers and containing noise as well as providing less reflection of sound leading to reduced overall noise.
- b) Eliminating the visual presence of another patient by introduction of partitions itself significantly modified the speaking habit of healthcare workers. Since they cannot see the caregiver in the next cubicle, they tend to refrain from speaking with each other while attending to patients, leading to reduced noise levels.

ICUs of European countries too conducted significant number of studies with their pre-existing architectural designs based on their own guidelines.[12,13] The results of all of those studies resulted in the increased application of architectural modification in ICUs. However, it is not possible everywhere due to cost related issues. This led to practitioners realizing that partition is not the only option among effective noise reduction strategies. Other options include the use of ear plugs/muffs, acoustically absorbent floors and ceilings, sound masking, and alarm algorithms. Several studies were performed using either one or multiple variables in various ICUs across the globe.[14-20] The authors of this study are considering future studies using other strategies to further reduce the noise levels within the workplace in order to facilitate an environment that is more conducive to patient recovery and efficient working practice.

## 5. Conclusion

Majority of Indian (and abroad) ICUs have no partition or just curtains between patients. However, the results of our study clearly indicate the significant reduction of noise levels with the introduction of partitions between patients or having separate cubicles for patients, which seems to be a better option.

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