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Determination of Ambient Noise Levels in the Medical and Surgical Intensive Care Units and Adult Ward of the Makati Medical Center

ABSTRACT

Objective: To measure the levels of environmental noise in the medical intensive care unit, surgical intensive care unit, and adult ward of the Makati Medical Center for the morning, afternoon, and evening shifts, on weekdays and weekends, and to compare noise levels across shifts, and between weekdays and weekends.

Methods:

Design: Environmental Noise Survey
Setting: Tertiary Private Training Hospital
Participants: None

Results: The overall mean environment noise levels in all the areas surveyed (medical intensive care unit, surgical intensive care unit and adult ward) exceeded World Health Organization recommendations by more than 20 dB across different working shifts on both weekdays and weekends. There was no significant difference in noise levels between weekdays and weekends across shifts in all areas, except for the afternoon shift in the Medical ICU. Using Repeated Measures ANOVA, results showed that there is no sufficient evidence to conclude that at least one shift has significantly different mean noise level in any of the 3 areas (MICU: $F(2)=4.73$, $p\text{-value}=.1124$; SICU: $F(2)=7.91$, $p\text{-value}=.0540$; WARD: $F(2)=2.73$, $p\text{-value}=.1948$)

Conclusion: The overall environmental noise levels in the different areas of MICU, SICU and Adult ward exceeded the WHO recommendation. It is recommended that a change in strategy is needed for prevention of environmental noise, setting guidelines and policies to assure quality health care and noise control. Further investigations to ascertain exact sources may give rise to feasible solutions.

Keywords: noise; decibel; hospital; sound; noise, occupational; occupational exposure/analysis; intensive care unit.

The World Health Organization (WHO) states that “health is not only the absence of disease or infirmity but a state of complete physical, mental and social well-being.”¹ Hospital spaces are built and equipped with staff and medical equipment to diagnose, treat and serve the needs of the sick. The hospital environment should be conducive to quick recovery and wellness. Since the hospital environment is vital to the optimum recovery of patients and efficient health care delivery by providers, the WHO recommends that noise levels in hospital environments be kept within 35 dB during the night and 40 dB during the day.²

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Several studies have shown that most hospital spaces have exceeded the recommendation and several guidelines and steps are needed to assure quality health care.^{2,3-5} In particular, several hospital areas, like the intensive care units, have been associated with greater noise levels than others.² Ironically, it may be argued that patients in such units are in need of more healing than those in other units. Adverse effects of noise pollution include noise-induced hearing impairment, disturbance of rest and sleep, psychophysiological, mental-health, performance effects and interference with speech communication, and the critical effects of noise can cause sleep disturbances, irritation and communication interference.¹

This study aims to measure the levels of environmental noise in the medical intensive care unit, surgical intensive care unit and adult ward of our hospital for the morning, afternoon, and evening shifts, on weekdays and weekends, and compare noise levels across shifts, and between weekdays and weekends.

METHODS

With Institutional Review Board exemption dated March 7, 2019, this environmental noise survey was undertaken at the Makati Medical Center from May 4 to 18, 2019. The areas surveyed were the designated nurses' stations of the Medical Intensive Care Unit (ICU), Surgical ICU and adult ward. In the medical and surgical ICU, the nearest distance from the nurses' station to the enclosed patient's rooms is 5.5 meters and the farthest is 60 meters, while in the adult ward, the nurses' station is separated from the patient area by the nearest distance of 10 meters and farthest distance of 22 meters. These units were chosen because of their proximity, physical layout and patient population.

Environmental noise levels were measured within different shifts (6 am-2 pm, 2 pm-10 pm and 10 pm- 6 am) on weekdays (Monday and Wednesday) and weekends (Friday and Saturday). Sound levels in the designated stations were recorded using a calibrated sound level meter (ISO-TECH SLM-52N, Iso-Tech, Taiwan, China) operated by a certified occupational health and safety officer. Environmental noise levels were measured in decibels (dB) using the sound level meter for durations of 1-minute sampling time per measurement recorded by the certified occupational health and safety officer twice per shift in the 2-week period.

Recorded measurements were averaged and tabulated, and descriptive statistics such as mean and standard deviation were used to summarize the data. A comparison of noise levels on weekdays (Monday and Wednesday) and weekends (Friday and Saturday) was determined using paired t-test for the different shifts. A comparison of noise levels for morning and afternoon, morning and evening, and afternoon and evening shifts was also determined using paired t-test.

Repeated Measures Analysis of Variance (ANOVA) was computed to determine whether any one shift had a significantly different mean noise level in any of the 3 areas. P-values less than .05 were considered significant. All computations were performed using STATA Statistical Software Version 15. (Stata Corp. LLC, College Station, TX, USA).

RESULTS

The overall mean environment noise levels measured in the different areas on weekdays and weekends all exceeded WHO recommendations. The overall ambient noise levels ranged between 60.5 dB to 81.2 dB, at least 20 dB above the WHO recommended thresholds of 35 dB during the night and 40 dB during the day. Average environmental noise levels in the Medical ICU, Surgical ICU and ward during the different shifts are shown in *Tables 1-3*, respectively.

The majority of sounds generally picked by the sound level meter came from the nurse's station. Identifiable contributors to the noise were conversations coming from medical staff, visitors, sounds created by medical machines, ventilation system, computer noise, rattling trolleys, sliding or swinging doors and even phones.

Paired t-tests to compare weekday and weekend noise levels per shift in the Medical ICU revealed no significant differences between weekdays and weekends (79.3 ± 2.7 dB vs. 76.7 ± 4.9 dB; $t(2)=0.6529$ $p=.5809$ and 69.4 ± 0.4 dB vs. 67.2 ± 3.2 dB; $t(2)=1.0160$ $p=.4166$) for the morning and evening shifts, respectively. However, there was a significant difference between weekdays and weekends (79.0 ± 0.5 dB vs. 66.0 ± 3.7 dB; $t(2)=4.8634$ $p=.0398$) for the afternoon shift. For the Surgical ICU, there were no significant differences between weekday and weekend noise levels for the morning (72.9 ± 0.7 dB vs. 71.9 ± 3.8 dB; $t(2)=0.3642$ $p=.7506$), afternoon (70.0 ± 2.0 dB vs. 68.6 ± 1.7 dB; $t(2)=0.7173$ $p=.5477$) and evening (62.4 ± 1.1 dB vs. 64.5 ± 5.7 dB; $t(2)=0.5037$ $p=.6645$) shifts, respectively. The Adult Ward noise levels also showed no significant differences between weekdays and weekends for the morning (69.4 ± 2.6 dB vs. 70.0 ± 1.0 dB; $t(2)=0.2781$ $p=.8071$), afternoon (69.0 ± 1.1 dB vs. 64.0 ± 1.8 dB; $t(2)=3.2982$ $p=.0809$) and evening (66.6 ± 2.5 dB vs. 67.4 dB; $t(2)=0.4444$ $p=.7002$) shifts, respectively.

Overall mean environment noise levels in all three areas ranged between 67.1 ± 2.8 dB to 75.9 ± 5.2 dB, which were all exceeded WHO recommendations by at least 20 dB. There was no significant difference in the overall mean environmental noise levels between weekdays and weekends for all three areas despite the noted difference in the afternoon shift in the Medical ICU as mentioned earlier. (*Table 4*) Repeated Measures ANOVA results showed that there is no sufficient evidence to conclude that at least one shift has significantly different mean noise level in any of the 3 areas (MICU: $F(2)=4.73$, $p\text{-value}=.1124$;

Table 1. Environmental noise levels (dB) in Medical ICU during different shifts and days

MICU Shift	Monday Average Noise Level (dB)	Wednesday Average Noise Level (dB)	Friday Average Noise Level (dB)	Saturday Average Noise Level (dB)
Morning (6AM - 2PM)	81.2	77.4	73.2	80.2
Afternoon (2PM-10PM)	79.4	78.7	68.7	63.4
Evening (10PM-6AM)	69.7	69.2	64.9	69.4

Table 2. Environmental noise levels (dB) in Surgical ICU during different shifts and days

SICU Shift	Monday Average Noise Level (dB)	Wednesday Average Noise Level (dB)	Friday Average Noise Level (dB)	Saturday Average Noise Level (dB)
Morning (6AM-PM)	73.4	72.4	74.6	69.2
Afternoon (2PM-10PM)	68.5	71.4	69.8	67.4
Evening (10PM-6AM)	63.2	61.7	60.5	68.5

Table 3. Environmental noise levels (dB) in Adult Ward during different shifts and days

Adult Ward Shift	Monday Average Noise Level (dB)	Wednesday Average Noise Level (dB)	Friday Average Noise Level (dB)	Saturday Average Noise Level (dB)
Morning (6AM-2PM)	71.3	67.6	69.3	70.7
Afternoon (2PM-10PM)	69.7	68.2	65.3	62.7
Evening (10PM-6AM)	68.4	64.8	67.4	67.4

Table 4. Comparison of overall mean environmental noise levels (dB) between weekdays and weekends in the different designated areas

Location	Weekday Overall Noise Level (dB)	Weekend Overall Noise Level (dB)	p-value
Medical ICU	75.9 ± 5.2	70.0 ± 6.1	.0975
Surgical ICU	68.4 ± 4.9	68.3 ± 4.6	.9717
Adult Ward	68.3 ± 2.2	67.1 ± 2.8	.4315

SICU: F(2)=7.91, p-value=.0540; WARD: F(2)=2.73, p-value=.1948). (Table 5)

DISCUSSION

Our results showed the overall mean of environment noise levels in the different designated areas on weekdays and weekends ranged between 67.1 ± 2.8 dB to 75.9 ± 5.2, exceeding WHO recommendations by more than 20 dB. Although WHO Guidelines for Community Noise state that environmental noise levels vary over time such as different parts of the day or season to season,¹ we found no significant difference in the overall mean environmental noise levels between weekdays and

Table 5. Repeated Measures ANOVA results comparing mean noise levels in the 3 areas

	Morning	Afternoon	Evening	P-value
MICU	78.0 ± 3.6	72.6 ± 7.8	68.3 ± 2.3	.1124
SICU	72.4 ± 2.3	69.3 ± 1.7	63.5 ± 3.5	.0540
WARD	69.7 ± 1.6	66.5 ± 3.1	67.0 ± 1.5	.1948

	Morning	Afternoon	T value	P-value
MICU	78.0 ± 3.6	72.6 ± 7.8	t(6) = 1.2678	.2519
SICU	72.4 ± 2.3	69.3 ± 1.7	t(6) = 2.1656	.0735
WARD	69.7 ± 1.6	66.5 ± 3.1	t(6) = 1.8475	.1142

	Morning	Evening	T value	P-value
MICU	78.0 ± 3.6	68.3 ± 2.3	t(6) = 4.5718	.0038
SICU	72.4 ± 2.3	63.5 ± 3.5	t(6) = 4.2306	.0055
WARD	69.7 ± 1.6	67.0 ± 1.5	t(6) = 2.4175	.0520

	Afternoon	Evening	T value	P-value
MICU	72.6 ± 7.8	68.3 ± 2.3	t(6) = 1.0441	.3367
SICU	69.3 ± 1.7	63.5 ± 3.5	t(6) = 2.9548	.0255
WARD	66.5 ± 3.1	67.0 ± 1.5	t(6) = -0.3026	.7724

weekends for all three areas of the Medical ICU, Surgical ICU, and Ward. The significant difference between weekdays and weekends for the afternoon shift in the Medical ICU may be attributed to more activities done during this shift such as rounds by the medical staff, imaging, and other diagnostic procedures. Specific activities occurring in the afternoon shift should be observed in the Medical ICU to determine the definite reason for the variance.

Although there are external and internal factors that may contribute to the environmental noise in a hospital,⁹ the research only tried to identify internal sources since the external factors, such as construction and automobile noise are not far from the areas being investigated.

The Nurses' Station in each area is where health care providers carry out administrative tasks and clinically associated functions that impact on the delivery of care to patients. Thus, it is not only the registered nurses that go about performing their functions but the physicians, nurse manager, in-patient pharmacist, charge nurse, nursing aides and orderlies that work in the same area who add to the produced noise. It is not only the patients who are affected by the environmental noise causing physical, mental and psychological consequences but healthcare workers as well that may bring poor performance, stress, burnout, fatigue and even work accidents.¹

The Medical Intensive Care Unit (MICU) is a facility that closely monitors, observes and cares for acute or chronically ill patients with potentially severe and physiologically unstable conditions that require sophisticated technical and/or artificial support. Treatment of several



conditions such as problems of the heart, lungs, kidney, blood and digestive system, as well as severe asthma, renal failure, diabetes and sepsis are accommodated in this facility. The presence of essential devices to administer ideal medical management in order to sustain life should account for the noise these machines produce in the areas they occupy. The Surgical Intensive Care Unit (SICU) provides intensive post-surgery care for various major elective and emergency surgical procedures that require close, constant attention by a team of specially trained health professionals. Indications include, but are not limited to, neurologic, cardiac, thoracic, vascular, and trauma caused by natural disasters, accidents such as falls and vehicular collisions. It is unavoidable for the sound of oxygen, suction equipment and respirators to occur in such areas; however, steps should be made to minimize noise exposure.²

The SICU team uses the latest technologies to monitor and guide therapeutic post-surgical management. Identical to the MICU, the SICU is filled with vital medical devices needed by the patient that contribute to the noise picked by the sound level meter. Some of these medical apparatuses are also found in the adult ward that provides care for acute and chronically ill patients with no impending severe critical conditions.

There are several limitations to this study. First, the limited number of ambient noise levels measured per shift, as well as the selection of time sampling points per shift may not reflect the true average noise levels throughout each shift. Moreover, the choice of Mondays and Wednesdays to represent weekdays, and Fridays and Saturdays to represent weekends, may not account for the actual differences between weekdays and weekends. It is usually not feasible to measure noise continuously over a long period of time to completely define the environmental noise exposure; in practice, only a small part of total exposure is actually measured.¹

Second, the locations of ambient noise testing were the nurses' stations in each area, and not the patient's beds. A more appropriate reflection of actual noise exposure endured by patients would be shown by obtaining ambient noise levels from multiple patient locations. This is further reflected in the absence of feedback from the patients in the said areas. Future studies may improve on the process of collection of the ambient noise levels over different patient areas and perhaps utilize a validated questionnaire on noise perception or sleep evaluation of the patients in their areas.

Third, although we generally identified numerous sources of noise that could be modifiable (e.g. discussions among medical staff and guests, sounds created by medical equipment, ventilation system, computer noise, rattling trolleys, sliding or swinging doors and phones), individual noise-emanating or noise-generating sources were not

isolated in this study, which only measured the sum total ambient noise from a particular vantage point (the nurses' station) in each study area (MICU, SICU and adult ward). Future studies can isolate and quantify the noise from separate sources in order to address them.

Proper monitoring, setting of guidelines and strategies are needed to assure quality health care and noise control. There should be further investigation to ascertain the exact source of noise in order for feasible solutions to be proposed. Establishing systems for interpersonal endorsements among staff and educating the public regarding reduction of modifiable noise should be in place.⁶ The use of building sound insulation or using sound absorbent materials can be utilized to develop noise barriers.⁷ Finally, developing noise mapping in order to provide an overall picture of exposure and characteristics of noise environment can help implement and develop noise management plans.¹ Encouraging community involvement in raising awareness on the effects of noise exposure can help decrease the levels of noise in a health care facility.^{6,8}

In conclusion, the overall mean of the environmental noise levels in the specialized areas of the hospital exceeded the WHO recommendations. Necessary steps should be taken to address these concerns in order to promote overall patient healthcare.

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