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Hospital Soundscape: Acoustics Evaluation in the Intensive Care Unit of a National Hospital in Central Jakarta, Indonesia

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ABSTRACT

An intensive care unit requires a noise-free environment to accommodate the need of high precision for the workers in order to increase the work efficiency. In contrary, there are only few researches which focus on the long term impact of noisy wards to the workers. According to soundscape study, not all the sources of sound can be nullified because some sources are considered as important. This study assesses the acoustic condition of an intensive care unit in a national hospital located in Central Jakarta, Indonesia, from both objective and subjective aspects via measuring the noise levels and the nurses' questionnaires. Result shows that the acoustic condition of the intensive care unit mentioned above does not perform well, as the noise levels exceed the maximum limit suggested by World Health Organization and Ministry of Health of Indonesia, not to mention that the acoustic condition is marked as bad based on the opinion of the nurses. The improvements that can be applied to significantly lower the noise levels in the intensive care unit include installation of absorber and diffusor panels at the ward's ceiling, replacement of ceiling and wall materials, relocation of the nurse station, and rearrangement of patients with ventilators.

Keywords: Soundscape, Hospital, Intensive Care Unit

1. INTRODUCTION

Hospital as a health support medium for patient recovery needs to fulfill a conducive environment condition such as noise-less room. Noise in hospital gives a meaningful impact to both medical attendant and patient. About 91% of medical attendant in a private hospital in Sweden stated that noise gives negative impact to their daily work environment, and most if the medical attendants (96%) stated noise in Intensive Care Unit will develop a potential disturbance to the patient psychology and physiology which could affect to the health condition and recovery rate. [1]

Noise in hospital caused by many factor. Based on research for acoustical condition conducted in various hospital in Canada, England, United States of America, Sweden, Turkey, and Jordan, 6 of 11 research conclude that the main factor that caused noise in Intensive Care Units is speech between medical attendant and patient, also between medical attendant themselves. [2]

Past research in hospital acoustic mostly focused in reduction of sound pressure level. High sound

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pressure level usually correlated with uncomfortable environment, and low sound pressure level usually correlated with conducive environment. This method might be useful in some cases but reducing sound pressure level might interfere with important sounds such as ventilator alarm and other medical equipment. In 1960, R. M. Schaffer introduce soundscape, a concept of a comprehensive sound mapping of an area and finds relation and correlation between sounds, humans, and environment. [3] Since hospital requires an all-inclusive of sound identification and its interactions with patient and medical attendance, soundscape method was used in this study.

2. METHODS

The method used for analyzing the room acoustics condition in the intensive care unit was the soundscape method through objective evaluation of sound pressure level measurement and subjective evaluation from the medical attendants' perspective. The result of both objective and subjective evaluation could be used to determine the important and disturbing noise in the intensive care unit. Therefore, further solution to increase the room acoustic performance of the intensive care unit could be developed.

2.1 Objective Evaluation

The objective evaluation was conducted to obtain the value of sound pressure level and records of overall room acoustics condition within the frequency range of 20 Hz to 20000 Hz through sample data taken in 1 x 24 hours. This information could be calculated further to retrieve the value of L_{eq}, L_{10}, L_{50}, and L_{90} of the room acoustics condition.

The acoustics measurement and recording was done according to ISO 3382-3:2012 standard with several adjustments due to the actual condition of the intensive care unit. [4] The ISO 3382-3:2012 was chosen to meet the function of the intensive care unit as a workplace for the medical attendants. The adjustments were added to minimize the potential disturbances to the patients caused by the measurement by choosing the measurement points that caused less impact to the patients but still represented the actual condition of the room acoustics, shown in Figure 1 with the X marks describing patients' positions.

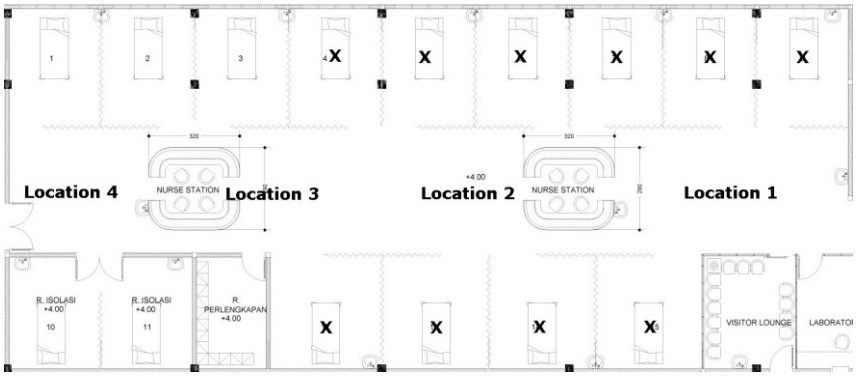

Figure 1 – Measurement Positions in the Intensive Care Unit

The acoustics measurement and recording was conducted in three minutes on every hour in 1 x 24 hours, within the same duration needed by the respondents to fill the subjective questionnaire. [5] The information of noise sources during the acoustics measurement and recording was also taken for further identification of the noise sources during analyzing the data.

2.2 Subjective Evaluation

The subjective evaluation was conducted to perceive the medical attendants' perception on the acoustics condition of the intensive care unit. The respondents of the subjective evaluation through questionnaire were 27 medical attendants with 9 respondents from the morning shift, 7 respondents from the noon shift, and 11 respondents from the night shift. The respondents were asked to fill the questionnaire about their views on the acoustics condition of the intensive care unit.

3. RESULTS

3.1 Objective Evaluation Results

Based on measurement which conducted on location 1, location 2, location 3, and location 4 as shown in Figure 1, sound pressure level and sound recording data were obtained. Gathered data then processed to obtain acoustic objective parameter such as L_{eq}, L_{10}, L_{50}, and L_{90} in every hour for 24 hours. Figure 2 shows gathered data in 24 hours. Event log was also used during the measurement to help and support sound source identification process which could affect the changes in objective acoustic parameters.

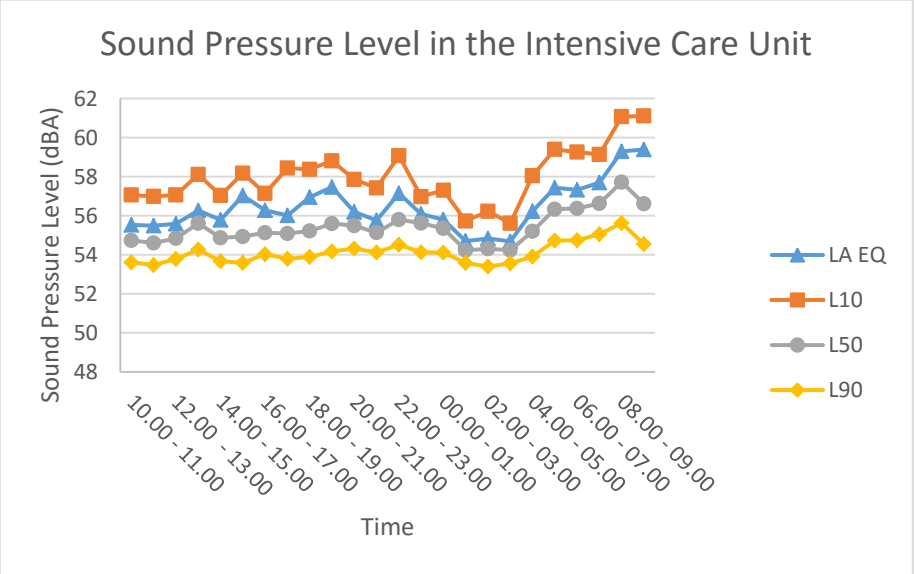

Figure 2 – Sound Pressure Level in the Intensive Care Unit

After completely identify all the sound source that happen during the measurement based on event log and sound recordings, sound sources which gave significant impact to the measurement of sound pressure level and sound recording could be determine. Figure 3 below shows the sound sources which gave significant impact to the measurement.

Figure 3 – Identified Noise Sources Appear During Measurement

From Figure 2, we could see there are a small difference between L_{10} and L_{90} value at 01.00 – 02.00 WIB, 02.00 – 03.00 WIB, and 03.00 – 04.00 WIB. Meanwhile at 05.00 – 06.00 WIB, 08.00 – 09.00 WIB, and 09.00 – 10.00 WIB there are a big difference between L_{10} and L_{90} value. Differences between could indicate appearance of incidental noise during the measurement. Additionally, by correlating Figure 2 and Figure 3, we can conclude that small difference between L_{10} and L_{90} value exist due to little events occurred in the ICU and big difference between L_{10} and L_{90} value exist due to lot of activity in the ICU.

3.2 Subjective Evaluation Results

Questionnaire was filled by 27 ICU medical attendants' respondent with various age and gender. Respondents has been working in the ICU ranging from 2 months to 33 years with the median is 9.3 years and standard deviation about 8.0 years. Statements below are translated from Indonesian to convey the general intention for judging the acoustical performance of the intensive care unit. Figure 4 below shows noticeable sounds heard in the ICU.

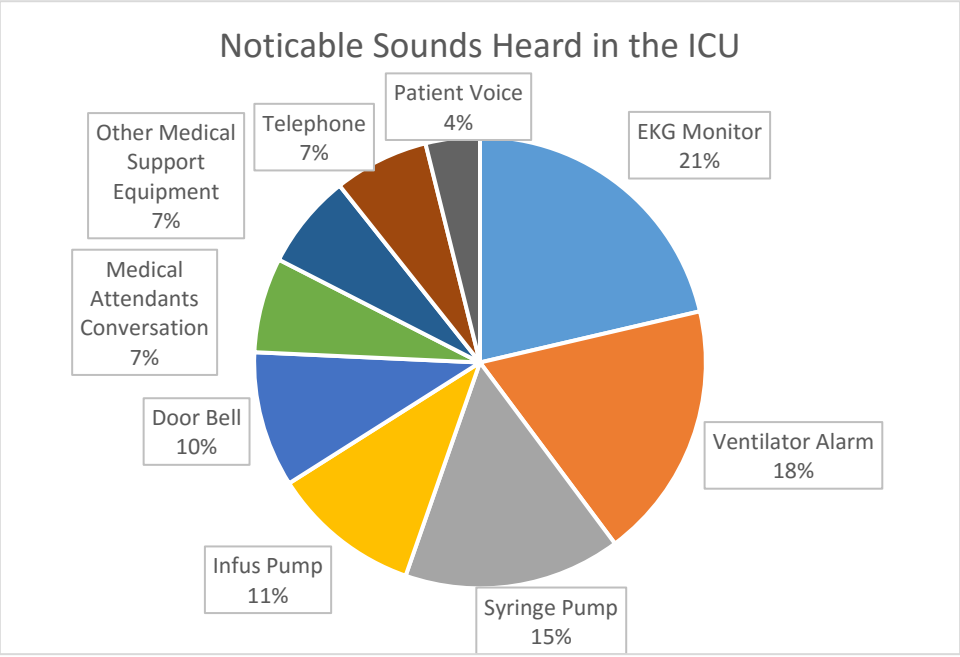

Figure 4 – Noticeable Sounds Heard in the ICU

In the Figure 4, other medical support equipment consists of trolley, containers, and racks. Sound of EKG Monitor is considered as the most heard sound in the ICU. This fact is supported by the objective measurement that stated that EKG monitor beeps periodically. Since there were 10 patients during the measurement was conducted, and every patient had personal EKG Monitor with different alarm settings, the sound of EKG Monitor heard throughout the entire measurement.

Next, ventilator alarm is the second most noticeable sound heard in the ICU. Although ventilator alarm beeps periodically, ventilator alarm beeps less frequently than EKG Monitor. Then there was Syringe pump and Infusion pump which beeps as frequent as EKG Monitor but generate less sound pressure level than EKG monitor so it was only audible in quiet room condition. Also incidental sounds such as door bell, conversation between medical attendants, and telephone recognized by respondents as noticeable sounds.

After listing all the noticeable sounds heard in the room, respondent determine important sound and annoying sound heard in the room as shown in the Figure 5 and Figure 6 below.

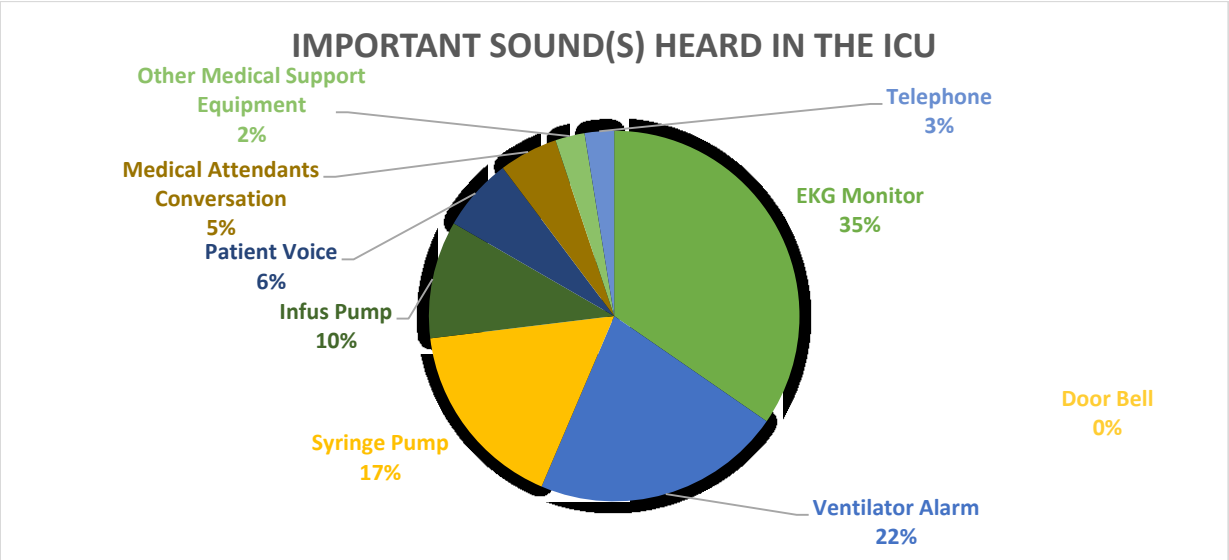

Figure 5 – Important Sounds Heard in the ICU

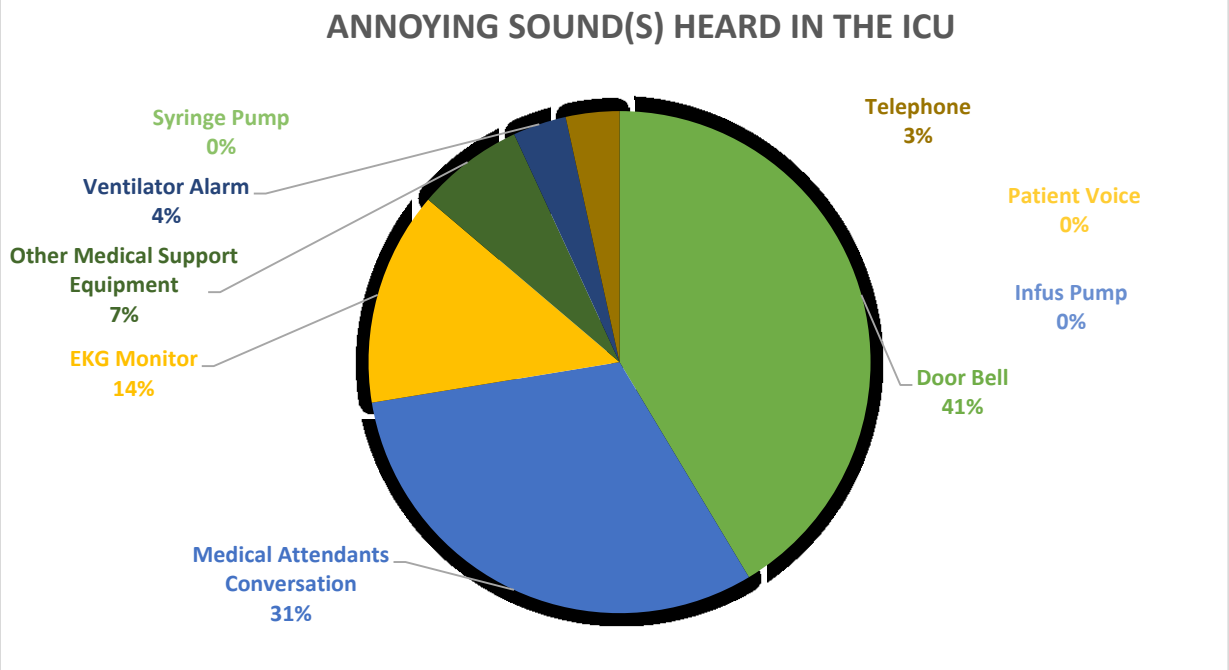

Figure 6 – Annoying Sounds Heard in the ICU

Based on Figure 5, three most important sound heard by respondent were EKG monitor, ventilator alarm, and syringe pump. Sounds that were generated by these equipment are crucial to monitor each patient condition. Based on Figure 6, three most annoying sound heard by respondent were doorbell, medical attendants' conversation, and EKG monitor. Referring to Figure 2 above, door bell and medical attendants' conversation considered as an incidental noise with a high pressure sound level, meanwhile EKG monitor beeping continuously with different period which could create uncomfortable environment to respondent.

Respondent also assessed the acoustic performance of the ICU. Generally, respondent stated that the acoustic condition of the ICU room is fairly satisfying. Respondent perceptions were influenced and affected by work length and also the ability to adapt to the sounds in the ICU. Median of respondent work length is 9.3 years so there was a chance that most of the respondent has already adapt to the ICU environment. This factor caused the respondent accepted acoustic performance in ICU which exceeded the standards designated by World Health Organization and Health Ministry of the Republic of Indonesia with the maximum equivalent sound pressure level of 35.0 dBA [6] and 45.0 dBA [7] respectively.

3.3 The Correlation between Objective and Subjective Evaluation Results

Based on the objective and subjective evaluation results, it was concluded that the main noise sources were doorbell on the frequency of 5 kHz to 7 kHz, the conversation between doctors and health attendants on the frequency of 250 Hz to 2 kHz, and the EKG monitor on the frequency of 250 Hz to 2 kHz. According to the function of the intensive care unit, the noise sources that could affect the privacy and acoustics comfort needed in the intensive care unit were the conversation between doctors and health attendants that contained confidential information of patients' medical record and all of the EKG monitor that beeped in different periods. These two sources acted as the main focus to be treated to improve the acoustics condition of the intensive care unit. The improvements that can be applied to significantly lower the noise levels in the intensive care unit include installation of absorber and diffuser panels at the ward's ceiling, replacement of ceiling and wall materials, relocation of the nurse station, and rearrangement of patients with ventilators.

4. CONCLUSION

The equivalent sound pressure level of the intensive care unit of a national hospital in Central Jakarta exceeded the maximum value suggested by the World Health Organization and the Health Ministry of the Republic of Indonesia with the range of 54.7 dBA to 59.4 dBA. Out of 27 respondents taken from the health attendants working on the intensive care unit, 20 respondents agreed that the acoustics condition of the room was still below their expected comfort level. The main noise sources were the door bell, the conversation between doctors and health attendants, and the sound of the EKG monitor. According to the function of the intensive care unit, the noise sources that could affect the privacy and acoustics comfort needed in the intensive care unit were the conversation between doctors and health attendants and the sound of the EKG monitor. These two sources could be treated by installing acoustics absorber and diffuser, replacing room materials, relocating the nurse station, and rearranging the patients' position.

ACKNOWLEDGEMENTS

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