Noise exposure hazard at supporting facilities of Dr. Soetomo General Hospital, Surabaya, Indonesia

D Arifianto1, A Nadiroh1, R D Kartika1 and N Purnami2

1Department of Engineering Physics, Institut Teknologi Sepuluh Nopember, Sukolilo Campus, Surabaya 60111 Indonesia
2Department of Otorhinolaryngology Head and Neck Surgery, Faculty of Medicine, Universitas Airlangga-Dr. Soetomo General Hospital, Surabaya 60231 Indonesia

E-mail: dhany@ep.its.ac.id

Abstract. Noise exposure in a hospital is known to have considerable impact not only to the healthy workers, but affects the ability for speedy recovery to the patients as well. However, recent investigations showed that the noise emission in a hospital tends to increase from year to year, for example John Hopkins Hospital. Dr. Soetomo General Hospital is the largest hospital in eastern part of Indonesia serving 2,500 outpatients and 1,500 inpatients per day as of January 2017, tripled from 2014. This also implies that the activities also increase significantly, from supporting services such as laundry to clinical services. In this paper, we present our recent study on the noise emission focusing on the supporting activities of the hospital such as water pump station, boiler, central kitchen, incinerator and workshop. The aim is to investigate the noise dose exposure to the workers of each supporting facility. We measured the noise emission level of the facility during its respective working hours. The results showed that all the facilities emitted higher level (in decibel) than allowed by the WHO. For the continuous noise, the average noise level for the water pump station was about 89.3 dB(A) and the workers were exposed almost 100 times more than that of the allowed noise exposure daily dose. The crushers at the incinerator facility were the highest of all intermittent noise sources at 98.4 dB(A). Furthermore, the noise level difference between outside and inside the water pump station was only reduced 1 dB, which suggests that either the sound enclosures was no longer effective. To summarize, the overall results showed that either the continuous or intermittent noise source the workers were exposed to high dose of noise daily.

1. Introduction

Generally, the main requirement of a hospital is to be located in a quiet area for an obvious reason which is better rest of the patients for speedy recovery [1]. However, the hospital itself constitutes people, equipments and their activities in the hospital that consequently creates noise in busy health care facilities. For most spaces in hospital, the maximum loudness of sound in the night time should not exceed 40 dB(A) indoors [2]. This was explained from the study by Busch-Vishnia that the night-day noise level in the hospital did not comply with the WHO guidelines, in fact increases from year to year [3]. In previous study, noises in the hospital may affect directly to the patients such as sleep disturbance, annoyance, and communication interference [2], [4].

Most of research work has conducted on areas that are disturb the patient directly such as intensive care units (ICUs), wards including medical and surgical, and emergency unit where patients might stay for treatment and/or recovery [3], [5], [6], [7], [8], [9]. However, it does not mean that research of noise
which conducted outside the area where the patients stay is not important to be explored. Tziaferi et. al. in their published work obtained that noise level was measured high in the boiler room and laundry in the general hospital. This is reinforced by the result of measurement in oncology hospital which shows that the following departments had the highest levels of noise are the boiler unit, ironing room, and sterilization unit located next to the boiler [10]. It is indicate that noise levels in supporting facilities of hospital is necessary to be investigated especially in risk assessment of physical hazards of the workers in those areas.

Dr. Soetomo General Hospital, Surabaya is the largest hospital in eastern part of Indonesia. As one of the central tertiary referral hospitals in Indonesia, Dr. Soetomo General Hospital is an expansive healthcare institution with over 1500 beds and 26 departments [11] which serving 2,500 outpatients and 1,500 inpatients per day as of January 2017. With the large number of patients handled indicates that Dr. Soetomo General Hospital is a hospital with busy activities which means it also affects the rising of activities in supporting facilities of the hospital. The aim of this study is to measure the noise in supporting facilities of Dr. Soetomo General Hospital Surabaya which might to be highest noise source level in this hospital. The noise exposure on the workers of each facility was measured to obtain personal noise dose to assess the noise hazard to the workers.

2. Methods

The noise measurement used the criteria for a recommended standard of OSHA (Occupational Safety and Health Act), standard of the State Minister for The Environment of Republic of Indonesia KEP-48/MENLH/11/1996 for noise threshold level, and standard of the Ministry of Manpower of Republic of Indonesia KEP–51/MEN/I999 for occupational noise threshold level. During the day of the survey, measurement points were determined throughout the supporting facilities, in this study we measured water pump station, boiler, central kitchen, incinerator, and workshop at Dr. Soetomo General Hospital, Surabaya, Indonesia. The measurements were conducted for 2 consecutive days.

![Figure 1. The measurement area.](image-url)
2.1. Noise level measurements

Noise measurements was performed in daytime and nighttime with integrated sound level meter placed on tripod at 1.2 m from the floor. The meter was calibrated on site and capable to measure the value of equivalent continuous sound level ($L_{eq}$) over the whole day, day-night sound level can be calculated. The following settings also recorded 1/3 octave band spectrum to determine source characteristics (frequency dominant).

2.2. Noise dose measurements

The noise dose was calculated to observe the impact of source to the workers in measurement area. Reference and work hour were collected to determine the noise dose according to the Ministry of Manpower of Republic of Indonesia Number: KEP–51/MEN/I999. In addition, personal dosimeters were used to assess personal exposure on some of employees. The daily personal noise exposure levels are defined in terms of the noise dose exposure experienced by a worker during a working day of 8 hours.

3. Results

3.1. Noise levels

3.1.1. Water pump station. Personal noise dose results are shown in Table 1. Five of pumps working simultaneously in this area, with day-night sound level of 89.28 dB(A) for indoor and 88.40 dB(A) for outdoor. All condition, indoor-outdoor sound level was measured 1 meters from source position. The difference level between indoor-outdoor sound level is only 1 dB(A). It means, noise enclosure around station is not effective to reduce noise from water pump station.

3.1.2. Boiler. Personal noise dose results are shown in Table 1. Sound level in this area ranged between 75 – 102 dB(A). Measurement points were taken to the front of boiler room, laundry, and outdoors facing the boiler room and laundry. The boiler room produced the highest noise level of between 91 – 102 dB(A) when the machine was running. It is indicated that boiler is noise source of this area. The measurement was conducted at 1 meters that face the laundry, it is purpose to know sound transmission from boiler into laundry. The result of measurement point near to laundry was much quieter at between 85 – 95 dB(A). The outdoor measurement was also conducted to observe how noise source affecting the environmental area. The meter was positioned at 1.5 meters from the wall facing the boiler room and laundry. The outdoor point measurement that facing the boiler room produced the lowest noise level of between 75 – 87 dB(A) and the other outdoor measurement produced the noise level between 76 – 93 dB(A). From all results of day-night sound level, the difference noise level between boiler room and laundry is 5.53 dB(A). Even though the boiler is noise source in this area, the enclosure of boiler room is good enough to reduce the noise machine that indicated by the difference of day-night sound level between indoor-outdoor is 13.8 dB(A) than the difference in laundry’s point measurement of 6.32 dB(A).

3.1.3. Central kitchen. Personal noise dose results are shown in Table 1. Sound level in this area ranged between 93 – 106 dB(A). Many of the kitchen equipment in this area produced high noise levels, all noise level exceeds 90 dB(A), with $L_{eq}$ of 97.5 dB(A) when nearby stove, 92.2 dB(A) when nearby vegetable washing machine, 100.5 dB(A) when nearby cooker hood 1, and 99.2 dB(A) when nearby cooker hood 2. From the results, we obtain the cooker hood is noise source in this area. Outdoor measurement was not conducted for this area, this is because this area is not the main road and is rarely passed by patients and their families.

3.1.4. Incinerator. Personal noise dose results are shown in Table 1. We measured the sound level for four incinerator and one crusher at position of 2.5 meters from the machines. Sound level in this area ranged between 77.9 – 107.1 dB(A). The main source emanated from working machines in this area,
with noise level \((L_{eq})\) of 97.8 dB(A) for incinerator and noise level \((L_{eq})\) of 98.4 dB(A) for crusher. There is no significant level of noise between two main sources. Due to the incinerator position is far from health care activities, the impact of main sources is only recorded for inside the area.

3.1.5. Workshop. Personal noise dose results are shown in Table 1. There are two main rooms of workshop in the hospital with position adjacent to each other. The first one consists of grinder and compressor with noise level ranged between 73.3 – 102.9 dB(A) and at the other side of the room, the sound source emanated from lathe and grinder, with noise level between 72.2 – 90.4 dB(A) being recorded. We were not measured the outside sound level in this area. The measurement points of grinder and compressor produced noise level \((L_{eq})\) of 93.6 dB(A) and 77.4 dB(A) for lathe and grinder (room 2).

3.2. Noise source characteristics

Even this case in this study is in hospital areas, the environmental noise in supporting facilities in the hospital is due to power of machine. Berglund in Guidelines for Community Noise categorize this noise as an industrial noise. It is describing as noise from fixed installations, such as factories or construction sites, heat pumps and ventilation systems on roofs, typically affect nearby communities [2]. In this study, noise sources were characterized by its frequency content (see Figure 2). This can be assessed by contributions of the frequency components to the total noise. Based on figure 2, the results show that the dominant sound pressure level is in frequency range of 1000 Hz – 8000 Hz except in stove and crusher which in ranged between 250 Hz – 8000 Hz. It means the highest sound level tends to have the dominant frequency in the wider band. The peak of the loudness level with respect to frequency may also suggest that the noise should affect the hearing threshold within 2000 Hz to 4000 Hz [3, 15].

![Figure 2. Octave bands noise level measured in various supporting facilities location.](image-url)
### 3.3. Personal noise dose

Personal noise dose is used to assess the noise exposure which emanated to the workers in this area. Measurement points at each room are adjusted with the position of the operator is located.

#### Table 1. Personal noise dose.

| Area/ Operator/ Machine     | Time Exposure (hrs) | Dose (%) |
|-----------------------------|---------------------|----------|
| **Water Pump Station**      |                     |          |
| Operator A                  | 10                  | 335      |
| Operator B                  | 9                   | 302      |
| **Boiler**                  |                     |          |
| Operator A – Boiler         | 7                   | 1222     |
| Operator B – Laundry        | 5                   | 873      |
| **Central Kitchen**         |                     |          |
| Operator A – Stove          | 7                   | 2235     |
| Operator B – Vegetable washing machine | 7 | 2235     |
| Operator C – Cooker Hood    | 5                   | 1597     |
| **Incinerator**             |                     |          |
| Operator A – Incinerator    | 2                   | 476      |
| Operator B – Crusher        | 2                   | 547      |
| **Workshop**                |                     |          |
| Operator A – Room 1         | 2                   | 181      |
| Operator B – Room 2         | 4                   | 9        |

Based on previous results, noise levels around hospital support facilities shows a high average value that exceeds 85 dB(A). The maximum dose is 85 dBL\(_{eq}\) over 8 hours. It means that the workers were exposed to 88 dB(A) for 4 hours, 91 dB(A) for 2 hours and so on [12]. Table 1 shows the measurement results on the personal noise dose to all workers in supporting facilities at Dr. Soetomo General Hospital, Surabaya. The workers were exposed to noise that far exceeded the recommended exposure limits except the workers in workshop area (room 2). According to OSHA, the noise dose exposed to a worker for eight-hour per one working day should be less than or equal to 50% [13]. According to [12] an intermittent noise may also induce hearing impairment damage if it exceeds the limit time exposure. Therefore, the workers who are exposed to noise levels in excess of the limit time exposure are required to wear ear protection equipment [14].

However, the noise characteristics were different. In term of loudness level, the noise shown in Fig.2 was higher than that of the John Hopkins Hospital [3, 15]. In term of frequency characteristics, the noise was dominantly within 2000 Hz to 4000 Hz region whereas the John Hopkins Hospital showed dominantly in the lower frequency region (below 500 Hz). The hazard of the noise exposure at the Dr. Soetomo General Hospital may have more severe impact on a normal hearing worker.

### 4. Conclusion

Identification of noise hazard in supporting facilities at Dr. Soetomo General Hospital was conducted. Noise levels and personal noise dose are used to assess noise hazard which expose the workers. The results showed that all workers in supporting facilities is indicated to enter in dangerous area due to high noise exposure. The safe area is only in the workshop-room 2 where the lathe and grinder operate. From those results, the use of ear protection equipment shall be applied to reduce the impact of hazards from noise exposure to the workers. Future research investigating physical hazards of workers is important to be conducted and observing the impact of ear protection equipment to compare of those condition.
In addition, the influence of supporting facilities on the ward or building where patients stay is also necessary to observe to know those facilities affects patients comfort in the hospital or not.

5. References

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