Open Journal of Nursing, 2020, 10, 184-193
https://www.scirp.org/journal/ojn
ISSN Online: 2162-5344
ISSN Print: 2162-5336

# Examining Modifications of the Noise Generated by Nurses' Footsteps and the Use of Pass-By Objects: A Pilot Study

**Tomoko Shimoda[1], Rei Nishijima[2], Sadako Yoshimura[1]**

[1]Faculty of Health Sciences, Hokkaido University, Sapporo, Japan
[2]Department of Health Sciences, School of Medicine, Hokkaido University, Sapporo, Japan
Email: tshimoda@hs.hokudai.ac.jp

**How to cite this paper:** Shimoda, T., Nishijima, R. and Yoshimura, S. (2020) Examining Modifications of the Noise Generated by Nurses' Footsteps and the Use of Pass-By Objects: A Pilot Study. *Open Journal of Nursing*, **10**, 184-193.
https://doi.org/10.4236/ojn.2020.102012

**Received:** January 16, 2020
**Accepted:** February 25, 2020
**Published:** February 28, 2020



## Abstract

A lot of sound can be heard in a hospital. The Ministry of Environment recommends that noise be kept below 50 dBA during the day and below 40 dBA at night to maintain a calm environment inside a medical facility. However, the noise in general wards typically exceeds these standards; therefore, it is necessary to adjust these sounds to foster patients' recuperation. We examined whether the noise generated by nurses in a simulated ward changes with walking speed and the presence or absence of luggage. Sounds generated by nurses include footsteps and pass-by sound from objects (e.g., wagon, stretchers, wheelchairs, bedside tables, overhead tables, beds, IV poles.). Walking speed was classified into three types: slow (0.5 m/s), normal (1 m/s), and fast (2 m/s). Sound (dBA) was measured by measuring the pass-by sound generated when moving in a straight distance (four meters) in the corridor of a simulated ward. Objects were also compared for their pass-by sound generated with and without a load. Results revealed that normal and fast walking speeds generated louder sounds than did the slow speed (the volume of slow, normal, and fast speeds were 37.0 dBA, 39.3 dBA, and 38.7 dBA, respectively). The pass-by sound of objects increased in volume in proportion to nurses' walking speed. The pass-by sound of wagons and stretchers was significantly lower when they had (vs. did not have) a load; however, the reverse was true for wheelchairs carrying patient dummies. The sound of footsteps did not change per walking speed. Decreasing walking speed may thus lead to noise modification. Nurses' awareness of adjusting their walking speed per object use may prevent noise pollution. This study was conducted to obtain basic data regarding the wards' sound environment. Future studies should consider the occurrence of the sound in clinical settings.

**Keywords**

Hospital Environment, Noise, Nursing, Volume, Walking Speed

## 1. Introduction

Hospitals are noisy places. A review of the literature from 1950 to 2005 by Busch-Vishniac *et al.* [1] reported that there was a clear trend of increasing noise levels in hospitals since 1960. The average noise level during the day was 0.38 dBA per year, while the average noise level at night was 0.42 dBA per year. The average noise during the day has increased by 42 dBA from 57 dBA in 1960 to 72 dBA in 2005. According to the World Health Organization (WHO), the noise level at a hospital should be less than 35 dBA during the day and less than 30 dBA at night [2]. However, there are reports stating that the sound in hospitals has exceeded these standard values [3] [4], which contributes to prolonged hospital stay [3] and increased stress on hospital staff [4]. Therefore, we believe that regulating the sound in hospitals is necessary for the sake of patients and hospital staff.

Studies involving noise regulation in hospitals have resulted in minimized staff conversations in intensive care units (ICUs) [5], decreasing the volume of alarms in surgical intensive care settings [6], and modified noise by closing doors inside nursing homes [7]. These reports indicated that there are various sources of noise, including medical equipment, medical personnel, patients, visitors, and so on. Among these sources, sounds from medical equipment often include warning sounds, such as nurse call sounds and alarm sounds. The noise level of alarm sounds has already been examined in the ICU, among other places [5]. Further, as alarm sounds are necessary for patient treatment, there may be instances where its volume cannot be adjusted. On the other hand, sound from conversations, footsteps, and moving objects, which are generated by medical staff in general wards, can be modified; however, only a handful of studies have reported specific measures to achieve this adjustment. Within this context, we examined the reduction of noise level, focusing on the noise generated by nurses in general wards.

The Ministry of Environment recommends that noise in the hospital should be kept below 50 dBA during the day and below 40 dBA at night [8]. According to studies involving sound, opening and closing a door generates 83.7 dBA, the pass-by sound of a wagon is 81.5 dBA, and the pass-by sound of a bathing stretcher is 73.0 dBA [9]. In studies and surveys involving the sound above the standard values set forth by the Ministry of Environment, staff members' conversations and footsteps and the pass-by sound of wagons were reported as noise [10]. According to Yoneyama *et al.* [11], nurses' footsteps (when wearing sneakers) generate an average of 46.0 dBA (range = 42.3 - 49.3 dBA), while sandals generate an average of 48.1 dBA (range = 43.5 - 54.0 dBA). These footstep sounds were generated at a walking speed of 1 m/sec. Yoneyama *et al.* [11] noted the necessity to further examine sound differences per nurses' walking speed, which may have widespread clinical implications. Further, there are almost no reports regarding the pass-by sound of objects such as wagons and noise regulation within hospitals. Consequently, to verify how to modify the sound generated by nurses' footsteps and use of pass-by objects, we examined changes in the noise generated by nurses per different walking speeds and using objects with or without a load.

## 2. Materials and Methods

### 2.1. Design

We employed a quasi-experimental study design in February 2019.

### 2.2. Setting

As shown in **Figure 1**, the study environment was a space inside a room that was assumed to be a corridor in a simulated ward. The room temperature was set at 18˚C to 22˚C, and humidity was set at 40% to 60%.

### 2.3. Types of Measured Sound

Footsteps (nurse shoes) and the following pass-by sound of objects were measured:

1) Wagon (660 × 420 × 860 mm and foldable; Navis (As One), Tokyo, Japan).

2) Stretcher (aluminum high-rise, KK-715; Paramount Bed, Tokyo, Japan).

3) Wheelchair (steel, high-rise bed-type, and self-propelled; KR801N, 42-cm sitting width; Kawamura Cycle, Kobe, Japan).

4) Bedside table (KF-6000 series; Paramount Bed, Tokyo, Japan).

5) Overhead table (KF-832LA; Paramount Bed, Tokyo, Japan).

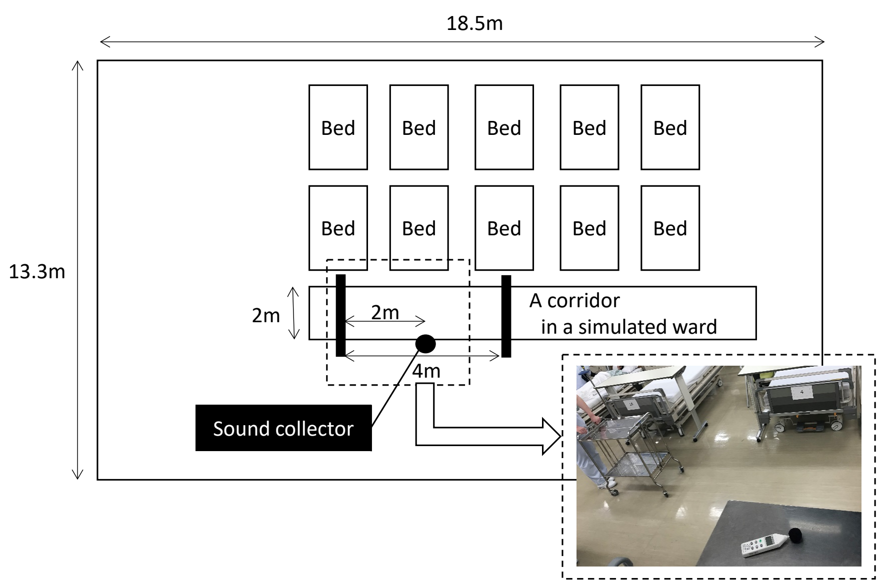


**Figure 1.** Experimental environment.

6) Bed (KA-5000 series bed, KA-5000 series all model; Paramount Bed, Tokyo, Japan).

7) IV pole (Paramount Bed IV stand, KC-508A; Paramount Bed, Tokyo, Japan).

### 2.4. Procedure

The sound generated when moving (passing by) in a straight distance of four meters in the corridor of a simulated ward was measured. A sound collector was installed at a distance of 0.5 m from the center of the corridor (**Figure 1**). Based on an earlier study [12], walking speed was classified into three types: slow (0.5 m/s), normal (1 m/s), and fast (2 m/s). Measurements were taken five times for each type. The person who generated the footstep sounds and moved the objects was healthy and had undergone training to prevent any discrepancies. Further, two researchers checked the walking speed during measurements. The wagon, stretcher, and wheelchair were each measured five times with and without the presence of a load. A towel blanket (155 cm × 200 cm; Japan Towel Inspection Foundation, Imabari, Japan) weighing 4 kg was placed on the wagon. A dummy (all-purpose adult training model; SAKURA, Tokyo Kagaku, Tokyo, Japan) weighing 17 kg was placed on the stretcher and wheelchair.

### 2.5. Statistical Analyses

The sound data measured using the sound collector SL-1370 (measurement range 30 - 130 dB, measurement accuracy (AS ONE Co., JAPAN) were analyzed and sound volume (dBA) data were collected every 0.2 seconds using TEST LINE SE-322 (custom, Japan). Multiple comparisons using Tukey's method were performed by classifying data into three groups per walking speed: slow (0.5 m/s), normal (1 m/s), and fast (2 m/s). A Mann-Whitney U test was performed to compare the two groups with and without a load. Statistical processing was performed using SAS software (JMP 12.2.0), and significance was set at $p < 0.05$.

## 3. Results

### 3.1. Footsteps

The sound volume of the footsteps ranged from 35.8 - 40.6 dBA at slow walking speed, 37.6 - 44.7 dBA at normal walking speed, and 36.3 - 40.9 dBA at fast walking speed (**Figure 2**). The median footstep sound differed between slow (36.8 dBA) and normal (38.7 dBA) walking speeds ($p < 0.05$) and between slow (36.8 dBA) and fast (38.9 dBA) walking speeds ($p < 0.05$).

### 3.2. Pass-By Sound of Objects

As shown in **Table 1**, the maximum value of the pass-by sound of objects exceeded the standard value of 50 dBA for the wagon, stretcher, bedside table, overhead table, bed, and IV pole. The results of the comparisons of the pass-by sound of each object and nurses' walking speed are shown in **Table 1**. As shown

**Table 1.** Pass-by sounds of objects.

| Object | Walking speed | n | Mean (dBA) | Minimum (dBA) | Maximum (dBA) | p |
|---|---|---|---|---|---|---|
| Wagon | Slow | 155 | 43.5 | 28.3 | 58.2 | Slow < Normal*, Normal < Fast*, |
| | Normal | 114 | 44.6 | 37.2 | 51.8 | Slow < Fast* |
| | Fast | 65 | 50.0 | 38.2 | 66.9 | |
| Stretcher | Slow | 142 | 43.8 | 36.4 | 58.0 | Slow < Normal*, Normal < Fast*, |
| | Normal | 85 | 52.4 | 38.0 | 72.0 | Slow < Fast* |
| | Fast | 69 | 57.5 | 40.3 | 78.4 | |
| Wheelchair | Slow | 147 | 37.4 | 35.9 | 39.7 | Slow < Normal*, Normal < Fast*, |
| | Normal | 102 | 39.0 | 36.0 | 43.5 | Slow < Fast* |
| | Fast | 67 | 41.9 | 37.5 | 48.1 | |
| Bedside table | Slow | 154 | 52.4 | 37.9 | 63.5 | Slow < Normal*, Normal < Fast*, |
| | Normal | 98 | 57.8 | 40.7 | 68.6 | Slow < Fast* |
| | Fast | 45 | 68.5 | 40.3 | 79.8 | |
| Overhead table | Slow | 122 | 53.7 | 40.5 | 63.4 | Slow < Normal*, Normal < Fast*, |
| | Normal | 86 | 58.9 | 42.1 | 67.4 | Slow < Fast* |
| | Fast | 56 | 64.1 | 42.5 | 74.3 | |
| Bed | Slow | 86 | 43.0 | 41.1 | 44.5 | Slow < Normal*, Normal < Fast*, |
| | Normal | 48 | 48.7 | 42.7 | 51.6 | Slow < Fast* |
| | Fast | 39 | 53.7 | 46.5 | 63.5 | |
| IV pole | Slow | 123 | 46.4 | 37.0 | 54.6 | Slow < Normal*, |
| | Normal | 74 | 47.5 | 38.1 | 57.5 | Slow < Fast* |
| | Fast | 49 | 51.3 | 36.2 | 64.5 | |

The walking speed was classified into slow (0.5 m/s), normal (1 m/s), and fast (2 m/s). Multiple comparison by Tukey's method, *p < 0.05.

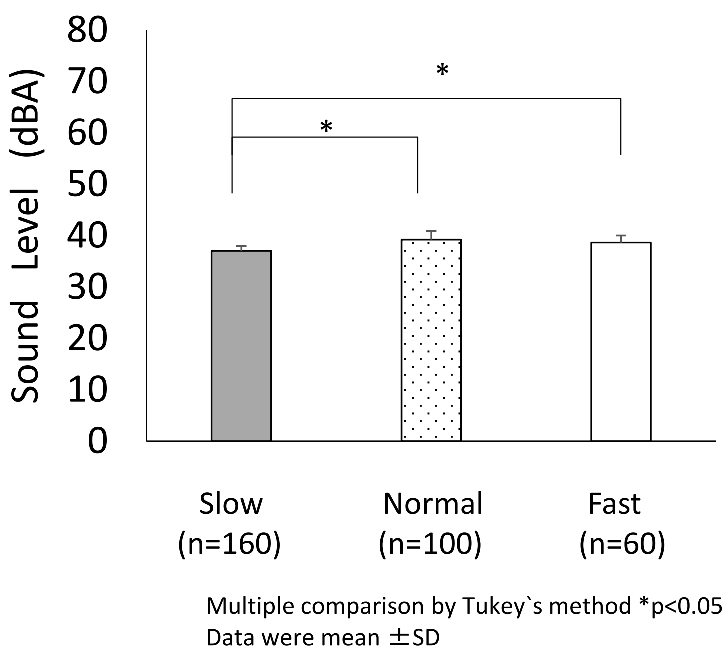


**Figure 2.** The sound volume of the footsteps.

in **Figure 3**, the pass-by sound of objects increased in volume in proportion to nurses' walking speed. There was a significant difference in the noise generated by moving the IV pole between slow and fast walking speeds and be-tween normal and fast walking speeds (Slow 46.4 dBA vs. Nomal 47.5 dBA; $p < 0.05$, Slow 46.4 dBA vs. Fast 51.3 dBA; $p < 0.05$).

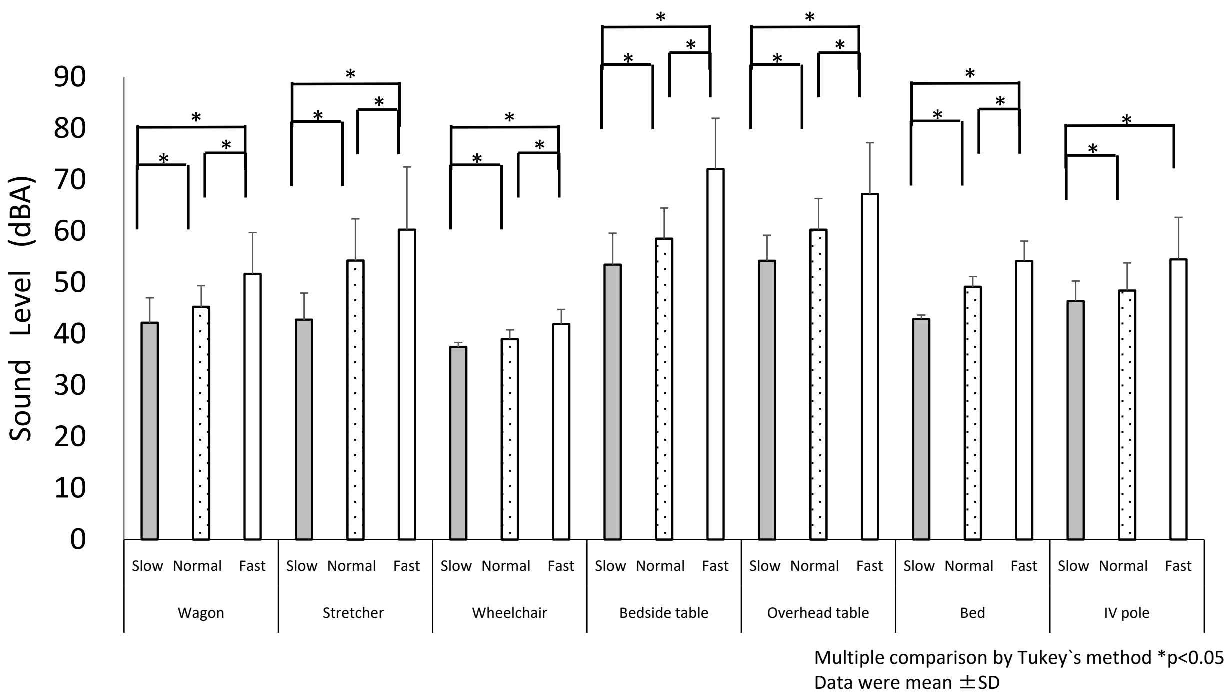


**Figure 3.** The changes in the pass-by sound of objects without the presence of a load.

### 3.3. Comparison of Pass-By Sound of Objects with or without a Load

The changes in the pass-by sound of the wagon, stretcher, and wheelchair with or without the presence of a load are shown in **Figure 4**. The average pass-by sound of the wagon at slow walking speed was 41.6 dBA with a load and 43.1 dBA without a load ($p < 0.05$, **Figure 4(A)**). At fast walking speed, the average pass-by sound was 45.1 dBA with a load and 50.0 dBA without a load ($p < 0.05$). The average pass-by sound of the stretcher at slow walking speed was 40.1 dBA with a load and 43.8 dBA without a load ($p < 0.05$, **Figure 4(B)**). At normal walking speed, the average pass-by sound was 47.6 dBA with a load and 52.4 dBA without a load ($p < 0.05$). The average pass-by sound of the wheelchair at fast walking speed was 44.4 dBA with a load and 41.9 dBA without a load ($p < 0.05$, **Figure 4(C)**).

## 4. Discussion

At all walking speeds, footstep sound was below the noise standard value of 50 dBA. Yoneyama *et al.* [11] reported similar findings that coincide with our current results. Additionally, we believe that wearing specific shoes is one way to maintain a quiet environment in the ward. The results revealed that footstep sounds were lower when walking speed was slow (vs. normal or fast). However, in clinical settings, it is sometimes difficult to walk slowly during emergencies. Our results revealed that there was no difference in the sound generated by normal and fast walking speeds; therefore, walking faster than the normal walking speed (1 m/s) may have a negligible effect on noise pollution inside hospitals.

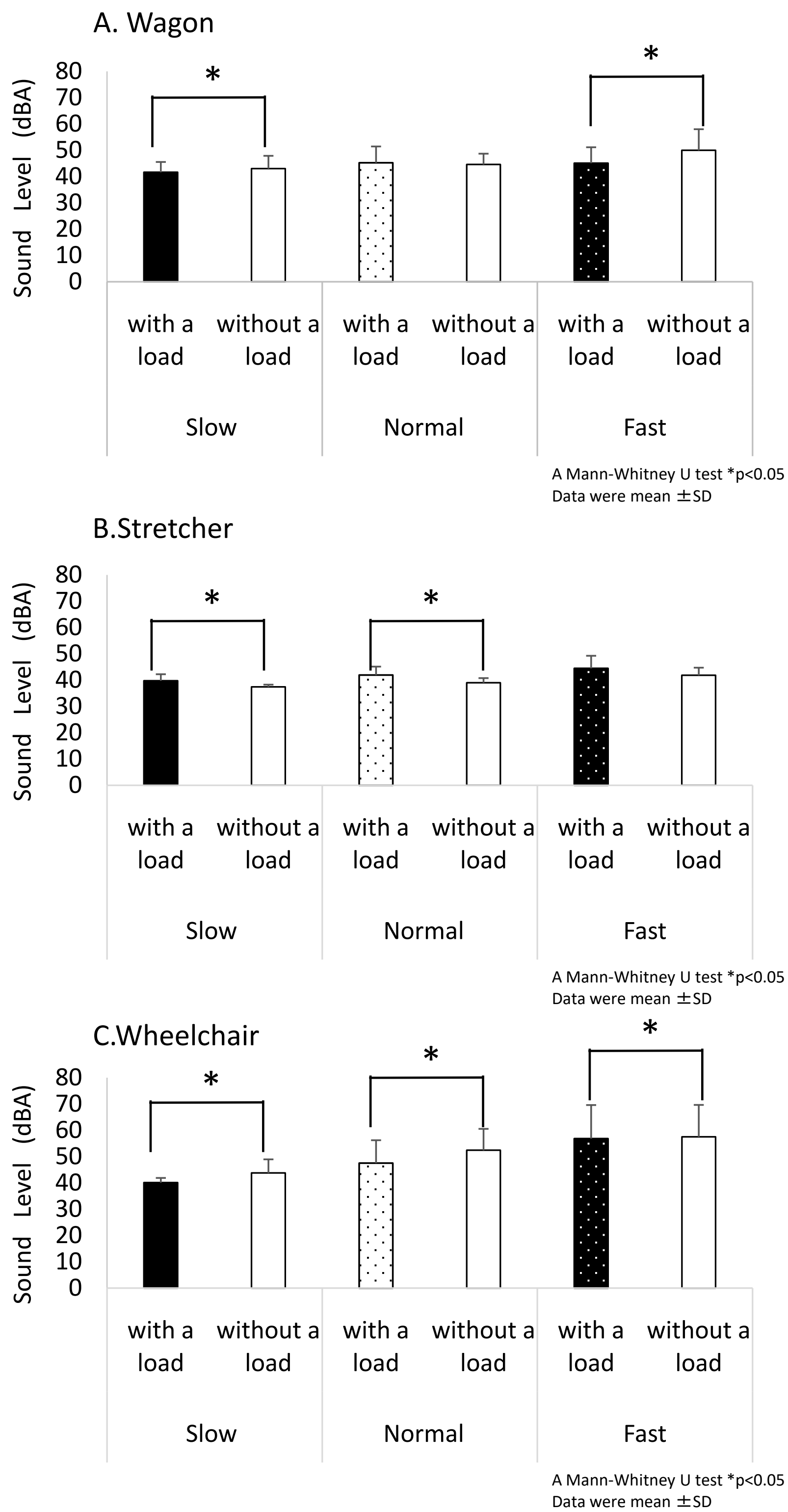


**Figure 4.** The changes in the pass-by sound of the wagon, stretcher, and wheelchair with or without the presence of a load.

Concerning the pass-by sound of objects, the maximum pass-by sounds of the wagon and stretcher were 66.9 and 78.4 dBA, respectively. Previous studies involving the measurement of sound in general wards reported that wagons and stretchers had a maximum pass-by sound of 70 to 80 dBA [9] and showed that their noise generation (20 to 40 dBA) is higher than the WHO's standards [1]. Most of the maximum pass-by sound measured in this study exceeded the allowable noise level of 50 dB; therefore, we could perform the measurement in our simulated ward, which resembled a general ward. To examine whether the pass-by sound of the object could be adjusted through nurses' actions, we examined the generation of sound at three different walking speeds. As a result, the pass-by sound of objects often increased in proportion to the walking speed differences. Taking a wagon as an example, the results showed that the maximum value was about 15 dBA lower for the slow as compared to the fast walking speed. The pass-by sound of the wagon includes multiple sounds, such as the footsteps of the person moving the wagon and the sound of its wheels. In this study, the sound of footsteps alone did not increase in proportion to the walking speed, whereas the sound of the moving wagon increased in volume in proportion to the walking speed. In other words, we believe that the sound from the wheels of the wagon increased in volume in proportion to nurses' walking speed. In clinical practice, it is very likely that loud sounds will be generated when clearing objects with wheels, such as wagons, in a hurry. Owing to this, staff should move objects at slower speeds when possible. One report noted that staff could refrain from using wagons to decrease the noise generated in general wards [10]; however, our results imply that it may be easier to simply adjust one's walking speed when using wagons.

Regarding the presence or absence of load, wagons and stretchers made louder noises when there was no load as compared to when there was a load. Consequently, to reduce the noise caused by the passage of wagons and stretchers in clinical settings, it is necessary to pay more attention to the generation of sound when there is no load after using the object to transport a person or object. On the other hand, the pass-by sound of the wheelchair was louder when there was a load (dummy) as compared to no load; therefore, nurses should aim to push patients in wheelchairs slowly when possible.

### Study Limitations

In this study, we measured the sound generated in a four-meter corridor of a simulated ward by a distinct object. The results may differ depending on the size of the space and the number of objects that were used. This study mainly examined the sounds of nurses' footsteps and use of pass-by objects, we examined changes in the noise generated by nurses. This study was conducted to obtain basic data regarding the sound environment. Future research should consider the occurrence of the sound in area ward environment.

## 5. Conclusions

There are various sources of noise in hospitals such as the sound generated by medical staff, patients, visitors, and medical equipment alarms. However, noises generated by humans are modifiable [13]. Our results showed that the generated sound varied depending on nurses' walking speed, highlighting the impact of human factors. This data informs ways to regulate noise pollution.

The following points were clarified after examining whether the sound generated by the medical staff in a simulated ward can be regulated by the nurses themselves and examining sound generated under different speeds while moving objects with or without a load:

1) The sound of footsteps did not increase in proportion to walking speed. Additionally, since the maximum value of the footstep sounds was below the allowable noise level, wearing specific nursing shoes is one way to maintain a calm environment in clinical settings.

2) The volume of the pass-by sound of objects increased in proportion to the walking speed. Consequently, in clinical settings, reducing walking speed may lead to reduced noise generation.

3) Wheelchairs generated more volume with (vs. without) a load; however, the reverse was true for wagons and stretchers. Nurses should be aware of this and adjust their walking speed accordingly.

## Acknowledgements

We would like to thank Editage (http://www.editage.com) for English language editing.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

[1] Busch-Vishniac, I.J., West, J.E., Barnhill, C., Hunter, T., Orellana, D. and Chivukula, R. (2005) Noise Levels in Johns Hopkins Hospital. *The Journal of the Acoustical Society of America*, **118**, 3629-3645. https://doi.org/10.1121/1.2118327

[2] Berglund, B., Lindvall, T., Schwela, D.H. and World Health Organization (1999) Guidelines for Community Noise.

[3] Fife, D. and Rappaport, E. (1976) Noise and Hospital Stay. *American Journal of Public Health*, **66**, 680-681. https://doi.org/10.2105/AJPH.66.7.680

[4] Morrison, W., Haas, E., Shaffner, D., Garrett, E. and Fackler, J. (2003) Noise Stress and Annoyance in a Pediatric Intensive Care Unit. *Critical Care Medicine*, **31**, 113-119. https://doi.org/10.1097/00003246-200301000-00018

[5] Kahn, D.M., Cook, T.E., Carlisle, C.C., Nelson, D.L., Kramer, N.R. and Millman, R.P. (1998) Identification and Modification of Environmental Noise in an ICU Setting. *Chest*, **114**, 535-540. https://doi.org/10.1378/chest.114.2.535

[6] Walder, B., Francioli, D., Meyer, J.J., Lançon, M. and Romand, J.A. (2000) Effects of Guidelines Implementation in a Surgical Intensive Care Unit to Control Nighttime Light and Noise Levels. *Critical Care Medicine*, **28**, 2242-2247. https://doi.org/10.1097/00003246-200007000-00010

[7] Schnelle, J.F., Alessi, C.A., Al-Samarrai, N.R., Fricker Jr., R.D. and Ouslander, J.G. (1999) The Nursing Home at Night: Effects of an Intervention on Noise, Light, and Sleep. *Journal of the American Geriatrics Society*, **47**, 430-438. https://doi.org/10.1111/j.1532-5415.1999.tb07235.x

[8] The Basic Environment Law, Ministry of the Environment (2012) https://www.env.go.jp/kijun/oto1-1.html

[9] Yamada, T., Komuro, K., Nakayama, S., Kokubo, R. and Sakurai, Y. (2003) Actual Conditions of Noises in Hospitals—On Planning and Conditions of Wards. *Journal of the Institute of Noise Control Engineering of Japan*, **27**, 373-382.

[10] Kawasaki, M., Yamamoto, Y., Iwashina, H., Yoneyama, A., Takano, K., Fukui, S., Iijima, S. and Goto, K. (2009) Noise Level and Night Annoyance in a Neurosurgical and Casualty Ward. *Yamanashi Nursing Journal*, **7**, 5-11.

[11] Yoneyama, A. and Takano, M. (2010) Noise Level and Night Annoyance in a Neurosurgical and Casualty Ward (the 2nd Report). *Yamanashi Nursing Journal*, **8**, 31-37.

[12] Takayanagi, N., Sudo, M., Yamashiro, Y., Niki, Y., Kim, M. and Kim, H. (2015) Relationship between Walking Speed in Daily Living and Walking Parameters in Community-Dwelling Japanese Females. *Japanese Journal of Physiological Anthropology*, **20**, 197-205.

[13] Park, M., Kohlrausch, A., de Bruijn, W., de Jager, P. and Simons, K. (2014) Analysis of the Soundscape in an Intensive Care Unit Based on the Annotation of an Audio Recording. *The Journal of the Acoustical Society of America*, **135**, 1875-1886. https://doi.org/10.1121/1.4868367