forum acusticum 2026
8-12 September · Graz, Austria

TEMPORAL TRENDS IN ACOUSTIC CLIMATE IN HOSPITAL WARDS

Elisa Nannipieri[1], Veronica Amodeo[1], Arianna Astolfi[2], Antonio Baldassarre[3], Lucia Busa[1], Luca Marzi[1], Nicola Mucci[3], Simone Secchi[1]

[1]*Department of Architecture, University of Florence, Italy*
[2]*Department of Energy, Polytechnic of Torino, Italy*
[3]*Department of clinical and experimental medicine, University of Florence, Italy*

This paper is a revised version of the authors' submitted manuscript that was peer-reviewed by at least two anonymous reviewers.

Abstract

In recent years, various studies have been conducted to measure noise levels in hospital settings; in most of these studies, noise levels were found to exceed the limits recommended by the World Health Organization (WHO) [1]. The aim of this work was to determine, through a systematic review of scientific articles, typical noise levels in different types of hospital environments and to identify the noisiest wards. This work is part of the research activities of the INAIL BRIC Project 2024 (ID07), which aims to investigate the possible extrasensory effects of noise on healthcare staff.

Keywords: *Noise, Hospital environment, Systematic review, Public health.*

1. Introduction

Noise inside hospitals can have a negative impact on patients' recovery, on visitors' well-being, and, particularly, on the performance and health of hospital staff [2, 3]. Several studies show that the limit levels set by the World Health Organization (WHO)—35 dB(A) L_{eq} during the day and 30 dB(A) L_{eq} at night [1]—are easily exceeded in hospital settings. Furthermore, noise levels have increased over the years due to the progressive automation of the hospital environment, with the widespread use of audible alarm signals associated with medical devices and call systems [4, 5]. The aim of this systematic review was to survey research conducted between the years 2000 and 2025 pertaining noise measurement in hospitals around the world by examining scientific and academic journals [4 – 30].

2. Research metodology

The literature review was conducted by consulting three databases: ScienceDirect, Scopus, and Web of Science. Initially, the keywords "Noise" and "Hospital" were entered; subsequently, the word "Hospital" was replaced with the names of the wards under investigation. The search covered a time period of approximately 25 years (2000–early 2026). The selected articles reported data on sound pressure level measurements recorded inside hospital environments.

3. Database

Using the criteria outlined in the research methodology, more than 55 scientific articles were analyzed. In the database there are noise levels measured in 305 different hospital wards. Most of the studies have been published in medical journals [6 – 20]. These are followed by engineering and acoustics journals [4, 5, 21 -31]. The authors are specializing in medicine, engineering, or architecture.
Most of the articles consulted were published in the last 10 years [5, 12 – 20, 24 – 31].
The selected articles come from various parts of the world (see Figure 1): European Union (13 studies), United States (10), China (6), Turkey (5), Brazil (4), United Kingdom (4), Australia (2), Canada (2), India (2), Bangladesh (1), Colombia (1), South Korea (1), Iran (1), Nigeria (1), Singapore (1), Switzerland (1). Most of the measures were carried out in university hospitals (109 cases), followed by general public hospitals (75 cases) and military or private hospitals (10 cases). The remaining cases do not specify the type of hospital or its name, making it impossible to determine the hospital type. Two cases concerned a healthcare facility where traditional Chinese medicine is practiced [20].

***Corresponding author**: first.author@email.ad.*

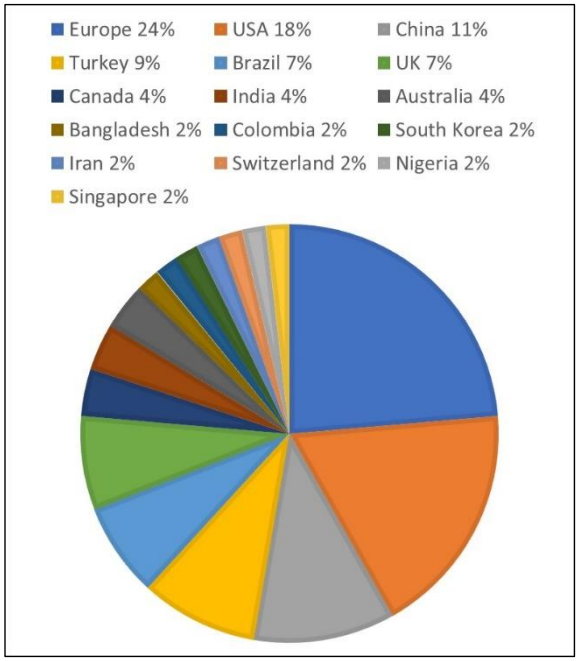


Figure 1. Countries where studies were performed.

3.1 Measurement methods and parameters used

The selected articles report L_{Aeq} (dBA) as the measured parameter. In 158 measurement environments, L_{Aeq} was averaged over a period of at least 24 hours; in 8 environments, L_{Aeq} was averaged over a period of at least 14 hours; in 54 environments, L_{Aeq} was averaged over a period of 8 hours; the remaining data refer to measurements of shorter duration or unspecified duration.

In 42% of the analyzed environments, L_{Amin} was measured in addition to L_{Aeq}; while in 44%, L_{Amax} was measured. Only in 18% of the analyzed environments was at least one L_{An} statistical parameter recorded.

In 31% of cases, a questionnaire was given to medical staff or patients; whereas in only 6% of cases (all studies conducted in intensive care units), other environmental parameters (temperature, lighting, air quality) were recorded in addition to noise.

The analysis also included data, referring to the same environment, with a range of variation, by calculating the logarithmic mean of the published values.

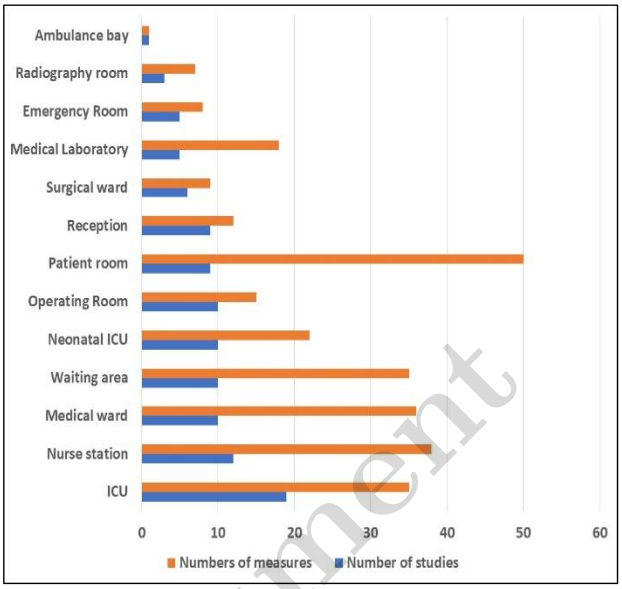
Most studies also specify criteria for microphone position, such as height and distance from reflective surfaces. The instruments were positioned at a height of 0.8 to 1,7 m from the floor and at least 1 m from any reflective surfaces; in 59 wards the microphones were installed on the ceiling or objects in order to protect the equipment and not disturb the hospital routine. In 23 wards, the microphones were positionated near the head of the patient or near the head of the bed.

In 52% of cases, the measurements were taken using a Class 1 sound level meter.

3.2 Comparison of the measured levels

In the selected studies, the "intensive care unit" was the most frequently studied setting, followed by the "nurses' station." Most of the measurements, however, were taken in patient rooms (see figure 2).

Figure 2. Hospital environments and number of studies and measures conducted



Some authors [12] report on the main sources of noise in hospital settings. Among the causes of the highest noise levels are the accidental dropping of objects and the equipment used to remove casts (>90 dBA), followed by equipment used to refrigerate and sterilize medical tools (＞88 dBA). The levels reached by various alarm signals connected to staff monitors are also very high similar to the noise made by people talking and moving around (>70 dBA). These sources have an impact on noise levels in certain wards; some of the noisiest areas are the operating theatre and the surgical ward. Other particularly noisy wards are the emergency room, the laboratory, the waiting rooms, the reception area and the nurses' station (figure 3).

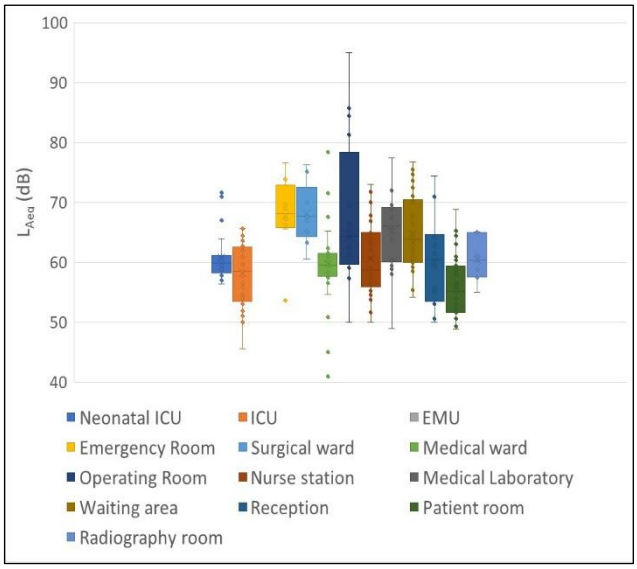


Figure 3. Noise levels derived from the litterature

4. Evolution of noise in hospital wards

The A-weighted equivalent sound level values, measured in various hospital settings, were correlated with the year in which the measurements were taken and, where not specified, with the year of the study's publication.

The results of this comparison show that the noise limits recommended by the WHO are being significantly exceeded; in fact, over the past 25 years, there has been a clear trend of steadily rising noise levels in hospitals, as illustrated by the straight line plotted on the data shown in Figure 4.

The straight line fit to the data show an increase, on average, of 0.28 dB per year.

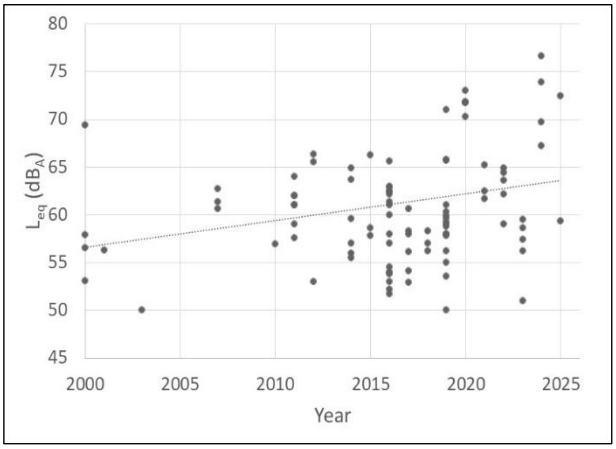


Figure 4. Sound pressure levels by year of measurement or year of study publication.

The increase in noise levels is greater in those wards where the number of medical and electro-medical alarm devices has risen over time. A clear example of this is found in surgical and intensive care wards, as shown in the figures 5 and 6. In both wards, noise levels have increased by approximately 0.31 dB per year.

No significant changes in noise levels were observed in the neonatal intensive care unit in the last 20 years. The 21 cases range from 56 to 61 dB, with a few exceptions.

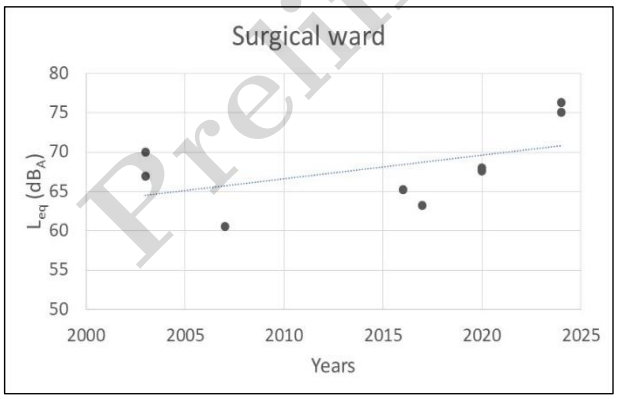


Figure 5. Sound pressure levels by year of measurement measured in surgical wards.

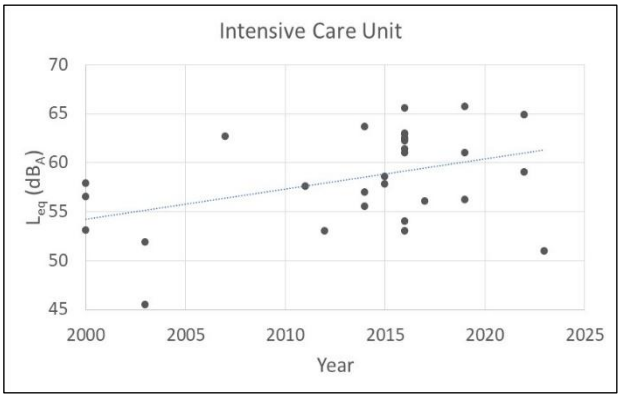


Figure 6. Sound pressure levels by year of measurement measured in ICU wards.

In the nurses' station and the analysis laboratories, too, the increase in electronic equipment has led to a rise in noise levels of around 0.2 dB per year (figure 7 and 8).

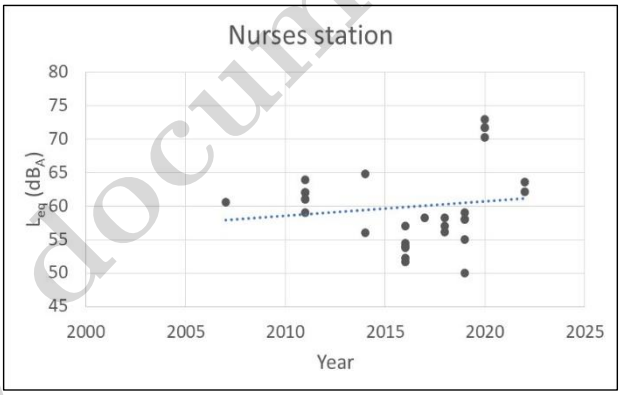


Figure 7. Sound pressure levels by year of measurement measured in nurses station.

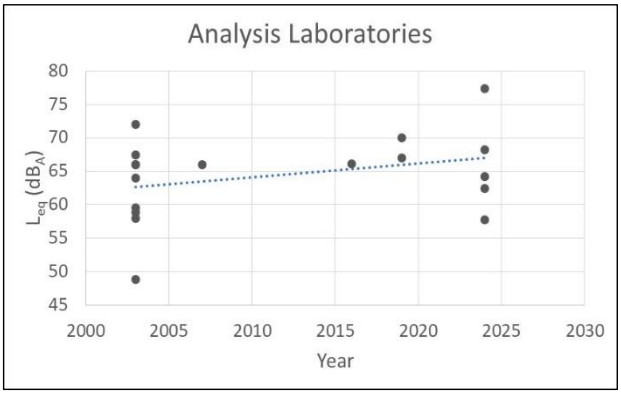


Figure 8. Sound pressure levels by year of measurement measured in analysis laboratories.

In areas such as the waiting room and transit areas, there has been no increase in noise levels over time; however, the differences are mainly due to the size of the space analysed and the number of people present.

5. Conclusion

Over the past 25 years, numerous scientific articles on noise levels in hospital environments have been published in various countries around the world. The most of these articles report noise levels exceeding the limits set by the WHO (World Health Organization).

The L_{eq} levels measured in indoor hospital environments varied from 41,0 (measured in a medical ward) to 96,3 dB (A) (measured in operating room).

Furthermore, a review of the literature has made it possible to identify the most critical situations within a hospital in terms of noise levels. In recent years, the acoustic environment in some hospital wards has deteriorated due to technological advances aimed at improving the precision of procedures, reducing patient recovery times and enhancing safety across the various wards.

References

[1] World Health Organization (WHO), "Environmental noise guidelines for European Region", WHO Regional Office for Europe, 2018.

[2] S. Secchi, N. Setola, L. Marzi, V. Amodeo, "Analysis of the Acoustic Comfort in Hospital: The Case of Maternity Rooms", Buildings, 12(8), 2022.

[3] S. Secchi, V. Amodeo, L. Marzi, R. Panichi, "Analysis of bedroom distribution layouts to improve acoustic comfort in hospital wards", proceeding of 10th Convention of the European Acoustics Association Forum Acusticum, Turin (ITA), Scopus index, 2023.

[4] I. J. Busch-Vishniac, J. E. West, C. Barnhill, T. Hunter, D. Orellana, R. Chivukula, R. Chivukula, "Noise levels in Johns Hopkins Hospital", Journal of Acoustic Society of America, 118(6), 3629–45, 2005.

[5] Bliefnick JM, Ryherd EE, Jackson R. "Evaluating hospital soundscapes to improve patient experience". J Acoust Soc Am. 2019 Feb;145(2):1117.

[6] L. S. Zun, MD, MBA, LaVonne Downey, "The Effect of Noise in the Emergency Department", ACAD EMERG MED, July, Vol. 12, No. 7, 2005.

[7] M. Christensen, "Noise levels in a general intensive care unit: a descriptive study", British Association of Critical Care Nurses, Nursing in Critical Care, Vol 12 No 4, 2007.

[8] M. H. Otenio, E. Cremer, E. M. Turini Claro, "Noise level in a 222 bed hospital in the 18th health region - PR", Rev Bras Otorrinolaringol;73(2), 245-50, 2007.

[9] Chen L, Brueck SE, Niemeier MT. "Evaluation of potential noise exposures in hospital operating rooms". AORN J. 2012 Oct;96(4):412-8.

[10] Johansson L, Bergbom I, Waye KP, Ryherd E, Lindahl B. "The sound environment in an ICU patient room--a content analysis of sound levels and patient experiences". Intensive Crit Care Nurs. 2012.

[11] Konkani A, Oakley B. "Noise in hospital intensive care units--a critical review of a critical topic". J Crit Care. 2012 Oct;27(5):522

[12] Filus W, Lacerda AB, Albizu E. "Ambient Noise in Emergency Rooms and Its Health Hazards". Int Arch Otorhinolaryngol. 2015 Jul;19(3):205-9

[13] Garrido Galindo AP, Camargo Caicedo Y, Vélez-Pereira AM. "Noise level in intensive care units of a public university hospital in Santa Marta (Colombia)". Med Intensiva. 2016 Oct;40(7):403-10.

[14] Hasegawa Y, Ryherd E. "Clustering acoustical measurement data in pediatric hospital units". J Acoust Soc Am. 2020 Jul;148(1):265.

[15] de Lima Andrade E, da Cunha E Silva DC, de Lima EA, de Oliveira RA, Zannin PHT, Martins ACG. "Environmental noise in hospitals: a systematic review". Environ Sci Pollut Res Int. 2021 Apr;28(16):19629-19642.

[16] Adams C, Walsan R, McDonnell R, Schembri A. "As loud as a construction site: Noise levels in the emergency department". Australas Emerg Care. 2024 Mar;27(1):26-29.

[17] Chang C, Huang R, Deng Q, Wu B, Cheng J, Zhang T, Cai J. "Noise characteristics and its influence analysis of the waiting areas in a Chinese children's hospital". Sci Total Environ. 2024 Dec 20;957:177441.

[18] Fusch G, Mohamed S, Bakry A, Li EW, Dutta S, Helou SE, Fusch C. "Analysis of noise levels in the neonatal intensive care unit: the impact of clinical microsystems". Eur J Pediatr. 2024 Mar;183(3):1245-1254

[19] Wang TC, Yu YC, Hsu A, Lin JY, Tsou YA, Liu CS, Chuang KJ, Pan WC, Yang CA, Hu SL, Ho CY, Chen TL, Lin CD, Pai PY, Chang TY. "Impact of occupational noise exposure on the hearing level in hospital staffs: a longitudinal study". Environ Sci Pollut Res Int. 2024 Apr;31(16):24129-24138.

[20] Ren, Dong; Liu, Ya; Xu, Lingfeng. "Effects of Long-Term Noise Exposure on Mental Health and Sleep Quality of Emergency Medical Staff and Coping Strategies". Noise & Health 27(126):p 289-295, May-June 2025. | DOI: 10.4103/nah.nah_12_25.

[21] D.J. MacKenzie and L. Galbrun, "Noise levels and noise sources in acute care hospital wards", Building Serv. Eng. Res. Technol. 28,2, pp. 117–131, 2007.

[22] E. Ryherda and K. Persson Waye, "Characterizing noise and perceived work environment in a neurological intensive care unit", J. Acoust. Soc. Am. 123 2, February, 2008.

[23] A. Salandin, J. Arnold, O. Kornadt, "Noise in an intensive care unit". J Acoust Soc Am. Dec;130(6):3754-60.2011.

[24] E. M. de Araújo Vieira, L. Bueno da Silva, E. Lopes de Souza, "The influence of the workplace indoor environmental quality on the incidence of psychological and physical symptoms in intensive care units". Building and Environment, Volume 109, 2016, Pages 12-24.

[25] B. Shield, N. Shiers, R Glanville. “The acoustic environment of inpatient hospital wards in the United Kingdom”, The Journal of the Acoustical Society of America, 140 3, 2213, 2016.
[26] Christina Jerlehag, Pyoung Jik Lee, Sang Hee Park, Theodora Jones, Nadine Carroll, “Acoustic environments of patient room in a typical geriatric ward”, Applied Acoustics, Volume 133, 2018, Pages 186-193.
[27] Loupa G, Katikaridis A, Karali D, Rapsomanikis S. “Mapping the noise in a Greek general hospital”. Sci Total Environ. 2019 Jan 1; 646:923-929.
[28] M. Cingolani, D. De Salvio, D. D'Orazio, M. Garai, “Clustering analysis of noise sources in healthcare facilities”, Applied Acoustics, Volume 214, 2023, 109660,
[29] Z. Deng, H. Xie & J. Kang, “The acoustic environment in typical hospital wards in China”. Applied Acoustics, 203, 2023.
[30] Zhixiao Deng, Hui Xie, Jian Kang, “The effectiveness of acoustic treatments in general hospital wards in China”, Building and Environment, Volume 244, 2023, 110728.
[31] Hui Xie, Yu Tian, Kaihu Xiao, Wangyang Lv, Chang Liu, “Environmental noise exposure and natural sound intervention in hospital interventional therapy rooms: Effects on patient perception, physiological and psychological outcomes”, Building and Environment, Vol. 280, 2025, 113149.