Original Scientific Paper

NOISE LEVELS IN OPERATING ROOMS: A QUANTITATIVE ANALYSIS AND EVALUATION OF NOISE SOURCES

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DOI: https://doi.org/10.65241/wh.9.2.8

For citation: Babic S, Atlagic K, Tuweg Pejak L, Vratan N. Noise levels in operating rooms: A quantitative analysis and evaluation of noise sources. World of Health. 2026:2(9):61-66. https://doi.org/10.65241/wh.9.2.8

Received: 15 June 2026 Revised: 11 August 2026 Accepted: 19 August 2026

ABSTRACT

Background: Noise in operating rooms is a common environmental factor that may negatively affect communication, concentration, staff performance, and patient safety. Despite recommendations that noise levels in hospital environments requiring high concentration should not exceed 35 dB, operating room noise often surpasses these limits.

Methods: A quantitative observational study was conducted on 30 elective surgical procedures from five surgical specialties: general surgery, gynaecology and obstetrics, otorhinolaryngology, neurosurgery, and urology. Noise levels were measured using a calibrated SoundEar 3 device during induction, intubation, and extubation. Potential noise sources, including staff activities, communication, equipment use, and operating room occupancy, were systematically recorded. Data were analysed using descriptive statistics, one-way ANOVA, Pearson correlation, and a one-sample t-test.

Results: Thirty elective procedures were analysed, including 6 general surgical, 6 gynaecological and obstetric, 6 otorhinolaryngological, 6 neurosurgical, and 6 urological procedures. Mean operating room noise levels differed significantly between specialties (one-way ANOVA: $F(4, 13) = 17.68$, $p = 0.0001$, $\eta^2 = 0.702$). Overall mean noise was 61.38 dB (95% CI 59.83-62.92) and exceeded the WHO reference value of 35 dB by 26.38 dB (one-sample t-test: $t(17) = 36.03$, $p < 0.0001$, Cohen's $d = 8.49$). Peak values approached 95 dB. The number of staff present showed a positive correlation with maximum recorded noise levels ($r = 0.293$, 95% CI -0.218-0.678, $p = 0.2538$).

Conclusions: Operating-room noise consistently exceeded recommended thresholds and was primarily associated with human and organisational factors. Further evaluation of targeted noise-reduction strategies is warranted.

Keywords: *Patient safety, noise, sources of noise, work quality, operating room noise level.*

INTRODUCTION

Noise in operating rooms represents a significant but often overlooked problem in modern healthcare systems, with potentially serious consequences for the quality of medical staff performance and patient safety (1). The operating room is a highly demanding work environment in which concentration, precise communication, and rapid decision-making are crucial. However, the presence of various noise sources can disrupt these key factors and negatively affect surgical outcomes.

According to World Health Organization guidelines, the recommended noise level in hospital environments requiring a high level of concentration, such as operating rooms, should not exceed 35 dB (2). Despite these recommendations, numerous studies indicate that actual noise levels in operating rooms are often significantly higher, which may increase stress levels, reduce team efficiency, and raise the risk of errors (3).

Noise sources in operating rooms are numerous and diverse. They include medical equipment such as monitors and anaesthesia machines, surgical instruments, ventilation and air-conditioning systems, device alarms, and communication among team members (4,5). Additional factors such as the use of radios, phones, and movement of auxiliary equipment also contribute to the overall noise level (5). Such a complex acoustic environment can hinder clear communication, reduce

concentration, and increase the mental and physical workload of healthcare professionals.

Noise in operating rooms can significantly affect healthcare workers, particularly the anaesthesia team, whose work requires continuous monitoring of patients' vital functions and timely responses in critical situations. Increased noise levels are associated with reduced concentration, higher stress and anxiety, poorer communication, and decreased ability to make fast and accurate decisions. In addition, prolonged exposure to noise may lead to mental fatigue, physical exhaustion, hearing damage, and an increased risk of professional burnout (3,6).

At the hospital center where the research was conducted, general noise protection measures are implemented in accordance with the Ordinance on the Protection of Workers from Exposure to Noise at Work (Official Gazette No. 148/2023). These measures include risk assessment, regular maintenance of medical equipment, staff education, and organisational measures aimed at reducing unnecessary noise exposure. However, a specific system for the continuous monitoring and management of noise levels in operating rooms has not been established. The aim of this study was to quantify noise levels across surgical specialties, identify dominant noise sources, and determine factors associated with peak noise exposure in the operating room.

METHODS

A quantitative study was conducted in which numerical data on noise levels in operating rooms were collected. The study was non-interventional, meaning that the researchers only observed and recorded data without influencing the course of surgical procedures or the behaviour of healthcare staff.

The study included surgical procedures from five clinical specialties, covering a broad spectrum of surgical interventions and working conditions. Measurements were performed in operating rooms of the Department of Surgery, the Department of Gynaecology and Obstetrics, the Department of Otorhinolaryngology and Head and Neck Surgery, the Department of Neurosurgery, and the Department of Urology. The study was conducted on 30 elective surgical procedures during the period from May to October 2025.

DATA COLLECTION

Noise levels were measured using the SoundEar 3 device, which enables continuous real-time monitoring of sound levels in decibels (dB). The SoundEar 3 device was factory-calibrated, and its accuracy was periodically verified using a class 1 acoustic calibrator at 94 dB, 1 kHz prior to data collection. The device was positioned at strategic locations within the operating rooms, including areas near the anaesthesia workstation and the surgical table. Measurements were conducted during key phases of anaesthesia: induction, intubation, and extubation. The device continuously recorded noise levels at defined time intervals, allowing detailed insight into changes in acoustic exposure during surgical procedures. In parallel with acoustic measurements, potential noise sources were identified and recorded using a structured direct observation protocol. Noise sources were assessed through systematic observation performed simultaneously with sound measurements. Recorded variables included the number of personnel present in the operating room, phone calls, staff entry and exit, changes in team members, communication not directly related to the procedure, consultations and teaching activities, use of radios and other audio devices, medical equipment alarms, intraoperative instrument preparation, equipment checks, and door status (open/closed) and opening events. The observation protocol included predefined categories of noise events and clear operational definitions for each variable to ensure consistent data collection across all measurement periods and observers.

STATISTICAL ANALYSIS

Data were analysed using IBM SPSS Statistics software. Descriptive statistics were used to summarize noise levels, including mean, minimum, and maximum values, as well as frequencies and percentages for categorical variables describing noise sources. One-way analysis of variance (ANOVA) was performed to compare mean noise levels between different surgical specialties. When applicable, post-hoc comparisons were used to identify differences between groups. The relationship between the number of staff present in the operating room and maximum recorded noise levels was assessed using Pearson's correlation coefficient. A one-sample t-test was used to compare the observed mean noise levels with the World Health Organization recommended threshold of 35 dB for hospital environments.

ETHICAL APPROVALS

The study was approved by the Ethics Committee of University Hospital Centre Sestre milosrdnice, Zagreb, Croatia.

RESULTS

Mean noise levels varied depending on the type of surgical procedure. The lowest average values were recorded during laparoscopic surgical procedures in general surgery, with mean noise levels ranging between 54 and 56 dB. Similar values were observed in gynaecological laparoscopic procedures, where mean noise levels ranged between 55 and 58 dB. The highest mean noise levels were recorded during urological procedures, with values reaching 64–67 dB. Elevated noise levels were also observed during otorhinolaryngology (ENT) procedures (63.5 dB), as well as neurosurgical procedures,

where mean values were approximately 63 dB (Figure 1).

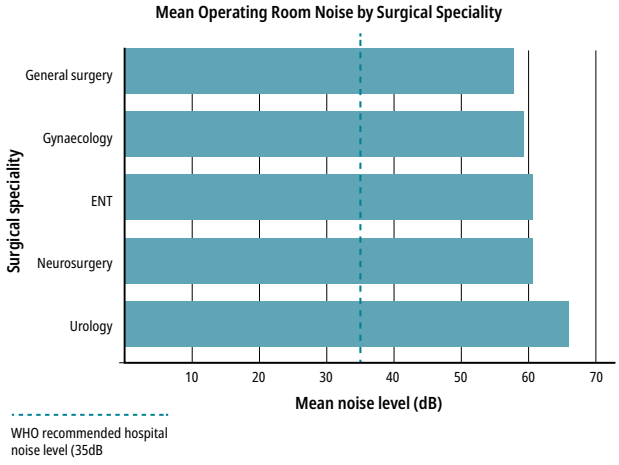

Figure 1. Mean operating room noise by surgical specialty.

During induction and intubation, operating-room noise levels ranged from 39.4 dB to 94.66 dB, with a mean value of 60.28 dB. During extubation, noise levels were consistently higher across all summary measures, ranging from 43.05 dB to 95.12 dB and averaging 61.75 dB. Although the differences between phases were modest, extubation was associated with slightly greater minimum, mean, and maximum noise levels, suggesting increased acoustic activity during the final phase of anaesthesia management (Figure 2).

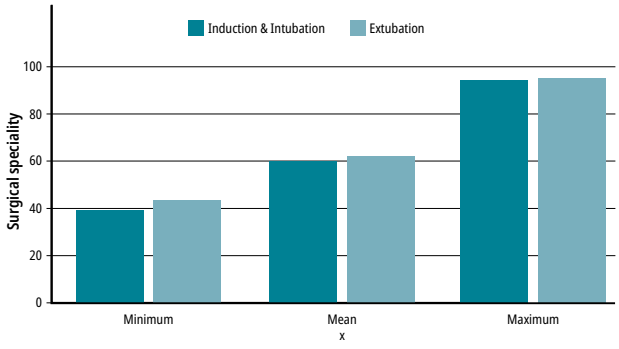

Figure 2. Minimum, mean, and maximum operating-room noise levels recorded during induction and intubation compared with extubation.

Overall, 93.8% (n = 28/30) of observed procedures exceeded the World Health Organization recommended noise threshold of 35 dB. To improve interpretation of the observed noise sources, individual activities were grouped into three broader categories: human factors, organisational factors, and equipment-related factors. Human factors included staff entry and exit from the operating room, non-procedure-related communication, consultations, and educational activities. Organisational factors included instrument preparation, equipment checks, staff changes, and door-opening events. Equipment-related factors included medical equipment alarms, radio use, and telephone calls. Human and organisational factors accounted for most observed noise-generating activities, whereas equipment-related sources were observed less frequently.

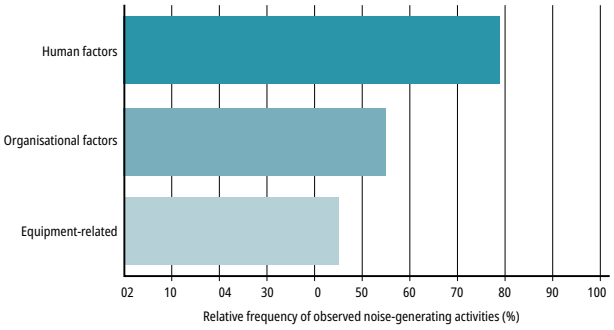

Figure 3. Frequency of observed operating-room noise-source categories. Human factors comprised staff movement, communication, consultations, and educational activities; organisational factors comprised instrument preparation, equipment checks, staff changes, and door-opening events; equipment-related factors comprised alarms, radio use, and telephone calls.

The graph shows a positive association between the number of people in the operating room and the maximum recorded noise level. As staff numbers increased, peak noise levels also tended to increase. However, the association did not reach statistical significance (r = 0.293, 95% CI -0.218 to 0.678, p = 0.2538) (Figure 4).

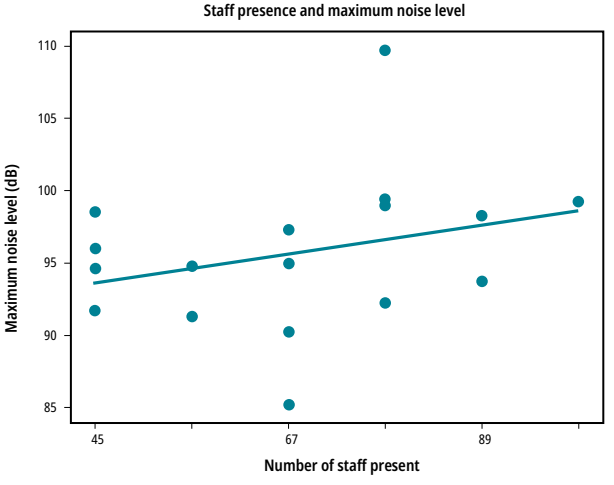

Figure 4. Association between operating-room occupancy and maximum recorded noise level (r = 0.293, 95% CI –0.218 to 0.678, p = 0.2538).

DISCUSSION

The results of this study confirm that noise levels in operating rooms are consistently elevated and, in most cases, exceed recommended limits for hospital environments. Mean noise levels during induction and intubation (approximately 60.28 dB) and during extubation (approximately 61.79 dB) are consistent with previous studies reporting typical operating room noise levels between 60 and 65 dB (7, 8). Similar findings were reported by Hasfeldt et al., who emphasized that operating rooms frequently exceed recommended acoustic thresholds throughout all phases of surgical procedures (7).

This study also recorded peak noise levels approaching 100 dB, consistent with findings by Wallace et al., who reported that short-term acoustic peaks in operating rooms can reach levels comparable to industrial noise environments (8).

Differences in noise levels were observed depending on the type of surgical procedure. The lowest mean values were recorded during gynaecological and general laparoscopic procedures, while the highest levels were measured during urological and ENT procedures. These results confirm that procedure type, duration, and intensity of equipment use significantly influence noise levels. Similar findings were reported by Katz et al., who noted that technically more complex procedures and increased use of devices such as lasers, suction devices, and electrocautery significantly increase overall noise levels in the operating room (9).

The observed differences between surgical specialties are likely explained by variations in procedure complexity, equipment utilisation, team size, and workflow requirements. Urological and otorhinolaryngological procedures often involve greater use of powered instruments, suction systems, and frequent staff interaction, all of which may contribute to elevated noise levels. In contrast, laparoscopic procedures performed in general surgery and gynaecology are typically conducted in a more controlled environment with fewer instrument exchanges and less movement within the operating room. These findings suggest that procedural characteristics, rather than specialty alone, are important determinants of operating-room noise exposure.

Analysis of noise sources showed that human and organizational factors were dominant contributors. The positive relationship observed between staff numbers and peak noise levels is biologically and operationally plausible. Larger teams inevitably generate more verbal communication, movement, instrument handling, and interactions between personnel. Although the correlation between occupancy and maximum recorded noise levels did not reach statistical significance in the present study, the direction of the association is consistent with the hypothesis that increasing room occupancy contributes to a more acoustically demanding environment. The lack of statistical significance may be explained by the relatively small sample size and the limited variability in the number of staff present across procedures.

Categorisation of noise sources further demonstrated that human and organisational activities occurred more frequently than equipment-related sources, suggesting that operating-room noise is primarily influenced by workflow and staff interactions rather than by medical equipment alone.

The most frequent sources included staff entering and leaving the operating room, non-procedure-related communication, and handling of instruments and medical equipment. Similar conclusions were reported by Healey et al., who emphasized that staff communication is one of the main contributors to elevated noise levels in operating rooms (10).

Comparison across anaesthesia phases showed that noise levels during extubation were slightly higher and more variable compared to induction and intubation. Similar findings have been reported in the literature, indicating that noise levels increase during the final phases of surgery due to increased staff activity, communication, and preparation for patient transfer (11,12).

Although extubation demonstrated slightly higher minimum, mean, and maximum noise levels than induction and intubation, the magnitude of these differences was modest. Consequently, the findings may be more clinically indicative of increased staff activity during the conclusion of surgery than evidence of a substantial change in acoustic risk. Nevertheless, even small increases in noise may be relevant during extubation, a phase that requires careful patient monitoring, communication, and coordinated team actions.

Not all studies have reported comparable levels of operating-room noise. Some investigations have identified lower average noise levels or weaker associations between human activity and acoustic exposure. Differences between studies may reflect variation in operating-room design, hospital policies, measurement methodologies, surgical case mix, and local workplace culture. Furthermore, some studies have focused on selected phases of surgery or specific procedure types, making direct comparisons challenging. These methodological differences should be considered when interpreting discrepancies across the literature.

All measured mean values in this study substantially exceeded World Health Organization recommendations (WHO, 1999; WHO, 2018), which recommend noise levels below 35 dB for hospital environments (2,13). These findings confirm that operating room noise is a persistent and systemic issue across healthcare settings.

The clinical significance of the observed noise levels should be interpreted in the context of both sustained exposure and short-term peak events. Mean noise levels of approximately 60 dB are comparable to normal conversational speech and may contribute to cognitive fatigue, communication difficulties, and distraction when maintained throughout lengthy procedures. In contrast, peak noise levels approaching 95–100 dB, although brief, may interfere with verbal communication, increase stress responses, mask safety-critical auditory signals, and

reduce situational awareness during key procedural moments. Therefore, both average noise exposure and noise peaks are important considerations when evaluating operating-room safety.

Prolonged exposure to elevated noise levels may negatively affect concentration, communication, and stress levels among healthcare personnel, and may potentially compromise patient safety (14).

Therefore, the results of this study highlight the need for targeted interventions aimed at reducing noise levels. These may include standardized communication protocols in the operating room, reduction of unnecessary staff movement, technical optimization of equipment, and staff education regarding the impact of noise on clinical outcomes. Multiple authors emphasize that a combination of organizational and technical interventions is most effective in reducing noise levels (7,10).

From a practical perspective, the findings suggest several opportunities for noise reduction within operating rooms. Interventions focused on limiting unnecessary staff movement, reducing non-essential conversations, optimising workflow processes, and improving awareness of environmental noise may represent relatively low-cost approaches to improving the acoustic environment. Hospitals may also consider incorporating noise-monitoring systems and educational initiatives into patient-safety programmes. Importantly, such interventions should be designed to preserve effective team communication while reducing avoidable sources of distraction.

STUDY LIMITATIONS

This study has several limitations that should be considered when interpreting the findings. First, the sample size was relatively small, comprising 30 procedures, which may have reduced statistical power to detect weaker associations. Second, the study was conducted at a single tertiary-care centre, potentially limiting the generalisability of the results to other hospitals and healthcare systems. Third, because staff were aware that observations were being conducted, an observer effect cannot be excluded. Fourth, the analyses did not adjust for procedure duration, surgical complexity, or other procedural characteristics that may influence acoustic exposure. Finally, differences in organisational practices, operating-room design, and staffing patterns may limit the applicability of these findings to other clinical settings.

CONCLUSION

The results of this study demonstrate that operating-room noise levels remain elevated across different surgical specialties and anaesthesia phases, exceeding recommended levels for healthcare environments. Mean noise levels were approximately 60 dB, with short-term peak values approaching 100 dB, indicating substantial acoustic exposure during surgical procedures. Operating-room noise also consistently exceeded the World Health Organization recommended threshold and varied between surgical specialties. Human and organisational factors, including staff movement, communication, consultations, and workflow-related activities, were identified as dominant contributors to elevated noise levels. Although a positive association was observed between operating-room occupancy and maximum noise exposure, this relationship did not reach statistical significance. These findings support the conclusion that operating-room noise is a measurable and clinically relevant environmental factor that warrants continued monitoring and further investigation.

ETHICS STATEMENT

The study was approved by the Ethics Committee of University Hospital Centre Sestre milosrdnice, Zagreb, Croatia.

AUTHORS CONTRIBUTION

Authors declared that all contributed equally. All authors approved the submitted version.

FUNDING

The authors declare that no financial support was received for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

GENERATIVE AI STATEMENT

The authors used a generative AI tool to assist with language editing, formatting, and journal-specific manuscript preparation. All AI-assisted output was critically reviewed, revised, and verified by the authors, who take full responsibility for the final content. No AI tools were used for data collection, analysis, or interpretation.

ACKNOWLEDGMENTS

None

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