Contents lists available at ScienceDirect

Intensive & Critical Care Nursing

journal homepage: www.sciencedirect.com/journal/intensive-and-critical-care-nursing

Review Article

Noise reduction interventions in intensive care units: a systematic review

Eugene Han [a], Haeun Kang [b], Yeonsoo Jang [c,*]

[a] College of Nursing, Yonsei University, Intensive Care Unit, Division of Nursing, Severance Hospital, Yonsei University Health System, Seoul, Republic of Korea
[b] College of Nursing, Yonsei University, Seoul, Republic of Korea
[c] College of Nursing, Yonsei University, Mo-Im Kim Nursing Research Institute, Seoul, Republic of Korea

ARTICLE INFO

Keywords:
Intensive care unit
Noise
Intervention
Psychological well-being
Systematic review

ABSTRACT

Objectives: This systematic review aimed to examine the impact of noise reduction interventions on objectively measured noise levels, as well as associated clinical and perceptual outcomes for patients and healthcare professionals (HCPs) in intensive care units (ICUs).
Methods: A systematic search of six electronic databases (PubMed, CINAHL, EMBASE, Web of Science, Cochrane Library, and Scopus) was conducted for studies published between January 2015 and December 2024. The review followed the Cochrane Handbook for Systematic Reviews and adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses reporting guidelines, and eligible studies were independently evaluated for quality assessment.
Results: Of the screened publications, 12 met the inclusion criteria, including randomized controlled trials (RCTs) (n = 2) and quasi-experimental studies (n = 10). Various interventions have been implemented to mitigate ICU noise, which are classified into three categories: patient-directed interventions (e.g., earplugs), environmental modifications (e.g., soundproofing), HCP-oriented interventions (e.g., education, behavioral changes), and multi-component interventions. The intervention period ranged from less than one day to four months. Outcome variables included noise level, sleep quality, physiological response, and HCP perception.
Conclusions: ICU noise reduction interventions showed variable effectiveness, with multi-component approaches to address multiple noise sources. While interventions reduced noise levels and improved patient outcomes, noise levels often remained above the World Health Organization (WHO) standards. Evaluations of effectiveness have primarily been short-term, limiting analysis of sustained effects. To create a more conducive ICU environment for both patients and HCPs, future studies should focus on long-term effectiveness and include well-designed RCTs to strengthen the evidence base for noise management.
Implications for clinical practice: Implementing noise reduction interventions, including HCP education, environmental modifications, and multi-component approaches, can improve ICU patient care and HCP well-being. Healthcare organizations should prioritize sustainable noise management strategies and conduct ongoing monitoring to ensure long-term effectiveness in ICUs.

Introduction

Noise, defined as unwanted or harmful sounds, negatively affects human health [1]. Noise pollution in hospitals is a serious issue affecting both patients and healthcare professionals (HCPs) [2]. Noise disrupts sleep, triggers stress responses, and increases the risk of health problems, such as hypertension and cardiovascular diseases [3,4]. These adverse effects impact both the physical and emotional aspects of human health, complicating patient recovery and negatively affecting patient health outcomes [3]. Noise adversely affects the performance and health of HCPs including nurses [2]. Noise reduces concentration, hinders communication, and diminishes job satisfaction while increasing the risk of medical errors, stress, and burnout among HCPs [4–7]. Effective noise management is essential for improving both patient care and the well-being of HCPs.

The World Health Organization (WHO) has warned that high noise levels in hospitals increase patient stress and slow recovery. The WHO advises that hospital noise should average below 35.0 dBA and not

* Corresponding author at: College of Nursing, Yonsei University, Mo-Im Kim Nursing Research Institute, 50-1 Yonsei-ro, Seodaemun-gu, Seoul, 03722, Republic of Korea.

E-mail address: ysjang517@yuhs.ac (Y. Jang).

https://doi.org/10.1016/j.iccn.2025.104234
Received 2 April 2025; Received in revised form 31 July 2025; Accepted 3 September 2025
Available online 19 September 2025

exceed a maximum of 40.0 dBA [1]. However, noise levels in hospitals have risen, ranging from 37 to 88.6 dBA during the day and 38.7 to 68.8 dBA at night [2]. Noise levels in intensive care units (ICUs) have been reported to range from 40 to 138.9 dBA, considerably exceeding the standards set by WHO [8–11].

ICUs, which operate 24 h a day for continuous monitoring and life-sustaining treatment, are constantly exposed to high levels of noise [11]. Major noise sources in ICUs include medical alarms, HCP conversations, and phones ringing, with alarms being the primary contributor [9,12,13]. These alarms, resembling human screams and baby cries, effectively capture nurses' attention but disrupt patient rest and comfort [9]. High noise levels also increase patient anxiety and worsen sleep quality [3], which in turn may lead to secondary complications such as delirium [14]. Notably, the sequelae of delirium may persist for months or even years beyond the ICU stay, particularly in critically ill patients [15]. The increasing use of medical devices has made noise a persistent problem in ICUs [11].

Noise reduction interventions have been studied across various hospital settings, including general wards, operating rooms (ORs), and neonatal intensive care units (NICUs). A systematic review of general wards suggested that such interventions could reduce noise and improve patient sleep [16]. Another systematic review of ORs identified various strategies to mitigate distractions affecting surgical performance, emphasizing noise as a critical factor that requires targeted intervention [17]. In NICUs, noise reduction studies have primarily aimed to protect neonates' auditory and neurodevelopmental outcomes, often focusing on specialized equipment such as incubators [18,19]. However, the unique patient characteristics and environmental conditions in NICUs limit the direct applicability of these findings to other ICU populations or settings.

Despite widespread acknowledgment of ICU noise as a significant issue, existing research has been limited in its capacity to comprehensively evaluate interventions that fully account for the complex noise characteristics inherent to ICU environments. A previous systematic review of noise reduction interventions in ICUs has demonstrated that noise levels are significantly influenced by the characteristics of the interventions implemented. The review has also suggested that different types of interventions can effectively reduce noise, as evidenced by differences in noise levels across different strategies. However, no results have been presented on the patient impact of noise reduction [20]. Therefore, noise interventions should adopt a multidimensional approach that extends beyond environmental and acoustic indicators to identify broader impacts on both patients and healthcare providers, encompassing all affected stakeholders [21].

To accurately evaluate the effectiveness of ICU noise reduction strategies, it is essential to integrate objective acoustic measurements with secondary outcomes, such as clinical and perceptual effects. This approach facilitates a comprehensive understanding of the intervention's performance characteristics. Therefore, this systematic review aims to examine the impact of noise reduction interventions on objectively measured noise levels, as well as associated clinical and perceptual outcomes for patients and HCPs in ICUs.

Methods

Study design

We conducted this systematic review using the *Cochrane Handbook for Systematic Reviews of Interventions* and reported the findings according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist [22]. The search strategy for the review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with registration number CRD42025631614.

Eligibility criteria

We included all peer-reviewed articles on intervention studies published in English and Korean from each database. The systematic literature search was guided by the PICOST framework (Problem or Population, Intervention, Comparison, Outcome, Study Design, Timeframe) [23–26].

The following PICOST inclusion criteria were used: a) problem: studies addressing noise issues in the ICU across various clinical specializations (e.g., medical, surgical, mixed, neurological); b) intervention: interventions aimed at reducing or controlling noise levels in the ICU (i.e., any structured or unstructured intervention aimed specifically at minimizing auditory disturbances in ICU settings, such as patient-centered tools [e.g., earplugs, music therapy], environmental redesign [e.g., architectural modifications, renovations to facility design, and construction projects targeting noise control], and HCPs-directed measures [e.g., training and education programs targeting noise reduction]); c) comparison: studies comparing outcomes between groups with and without noise reduction interventions, using any comparator (e.g., standard care); d) outcome: studies examining the effects of noise reduction interventions. Outcomes included environmental noise levels, patient-related outcomes (e.g., sleep quality, anxiety, physiological parameters) and HCPs-related outcomes (e.g., knowledge, perception) [27]. In cases where objective measurements of environmental noise levels were not available, studies were still included if the intervention explicitly aimed to reduce noise and its effects were assessed through relevant patient- or HCP-related variables; e) study design: experimental studies evaluating the effects of noise reduction interventions, including randomized controlled trials (RCTs) and NRS; f) timeframe: studies published from January 1, 2015 to December 3, 2024. The starting point was determined based on the 2014 establishment of an international task force by the World Federation of Societies of Intensive Care Medicine, which aimed to define and standardize intensive care practices globally. This initiative led to the publication of key international guidelines that promoted technological innovations and reshaped ICU workflows [28]. Therefore, this timeframe was selected to ensure that the review captures developments reflecting contemporary ICU practices. The following exclusion criteria were used: a) studies with unavailable full texts; b) non-peer-reviewed articles and gray literature; c) publications in languages other than English or Korean; d) studies conducted exclusively in neonatal ICUs, due to fundamental differences in patient characteristics, equipment profiles, and environmental design that may limit the generalizability of findings to ICU settings; e) non-experimental studies, including observational or descriptive studies that did not involve interventions and quality improvement projects; f) study objective not focused on noise reduction and without reported noise outcomes.

Search strategies

We conducted a systematic literature search using the following six databases: PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), EMBASE, Web of Science, Cochrane, and Scopus. To identify suitable studies, Medical Subject Headings (MeSH) or EMBASE subject headings were used to identify the relevant keywords: Noise, Intervention, Intensive Care Units. Examples of search terms include: ("Noise" OR "Noise"[MeSH] OR "Noise pollution" OR "Sound pollution" OR "Sound" OR "Acoustic" OR "Acoustics" OR "Alarm") AND ("Intensive care unit" OR "Critical care" OR "ICU" OR "Intensive Care Units"[MeSH] OR "Critical Care"[MeSH]) AND ("Intervention" OR "Interventions" OR "Intervention"[MeSH] OR "Training" OR "Training"[MeSH] OR "Education" OR "Education"[MeSH] OR "Evidence-based practice" OR "Evidence-Based Practice"[MeSH] OR "Noise control" OR "Reduction" OR "Reduce" OR "Reduction"[MeSH] OR "Facility design" OR "Construction"). The complete search strategy is described in Supplementary Appendix 1.

Search selection

All citations and abstracts identified by the search strategy were uploaded to the reference management software (Endnote 21.0) for selection. Two reviewers (E. H. and H. K.) independently screened and selected the studies. Duplicate articles were removed. In the first step of the initial search, the titles and abstracts of these studies were reviewed, and ineligible studies were removed based on the eligibility criteria. In the second phase, the researchers independently retrieved and assessed the full texts of all studies that passed the title and abstract screening. Any disagreements between the two authors regarding the inclusion of studies were resolved through discussion with a third senior researcher (Y. J.).

Data synthesis

The two researchers (E. H. and H. K.) independently extracted all the relevant information from the included articles, and the results were cross-verified by Y.J. The data sheet contained the following information from each selected study: author, publication year, country of publication, study design, type of ICU, participants and sample size, aim of the study, program content, and results. All the researchers (E.H., H. K., and Y.J.) assessed the extracted data for consistency. Discrepancies were resolved through discussion among the researchers. Due to heterogeneity in study designs and outcomes, a *meta*-analysis was not feasible. Instead, narrative synthesis was employed using vote counting based on the direction of the effect, and descriptive summaries of noise level changes were reported when available. Therefore, a narrative synthesis was conducted in accordance with the Synthesis Without Meta-analysis (SWiM) guideline [29].

Quality assessment

The quality of the studies was assessed using the Risk of Bias 2 (ROB2) and Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I V2) tools. The ROB2 tool evaluates bias in RCTs, including adaptations to crossover trials [30,31]. The ROBINS-I V2 tool enhances bias assessment in NRS through refined algorithms and expanded criteria [32,33]. Two researchers (E. H. and H. K.) independently conducted quality assessments, and any disagreements were resolved by consultation with a third researcher (Y. J.).

Results

Search results

A total of 6,823 studies were retrieved from the databases and 2,149 duplicates were removed. After title and abstract screening of 4,674 articles, 4,625 were excluded for reasons such as being unrelated to noise interventions, being conducted outside ICU settings, or utilizing non-experimental designs. The full texts of 49 studies were reviewed, and 37 were excluded based on criteria such as study design and relevance to the review. Ultimately, 12 studies were included in this systematic review. The comprehensive selection process is illustrated in Fig. 1.

Quality assessment

Among the two RCTs, both demonstrated a low risk of bias in key domains, particularly randomization [34,35]. However, some concerns were raised regarding deviations from the intended interventions, missing outcome data, and outcome measurements [35]. In another

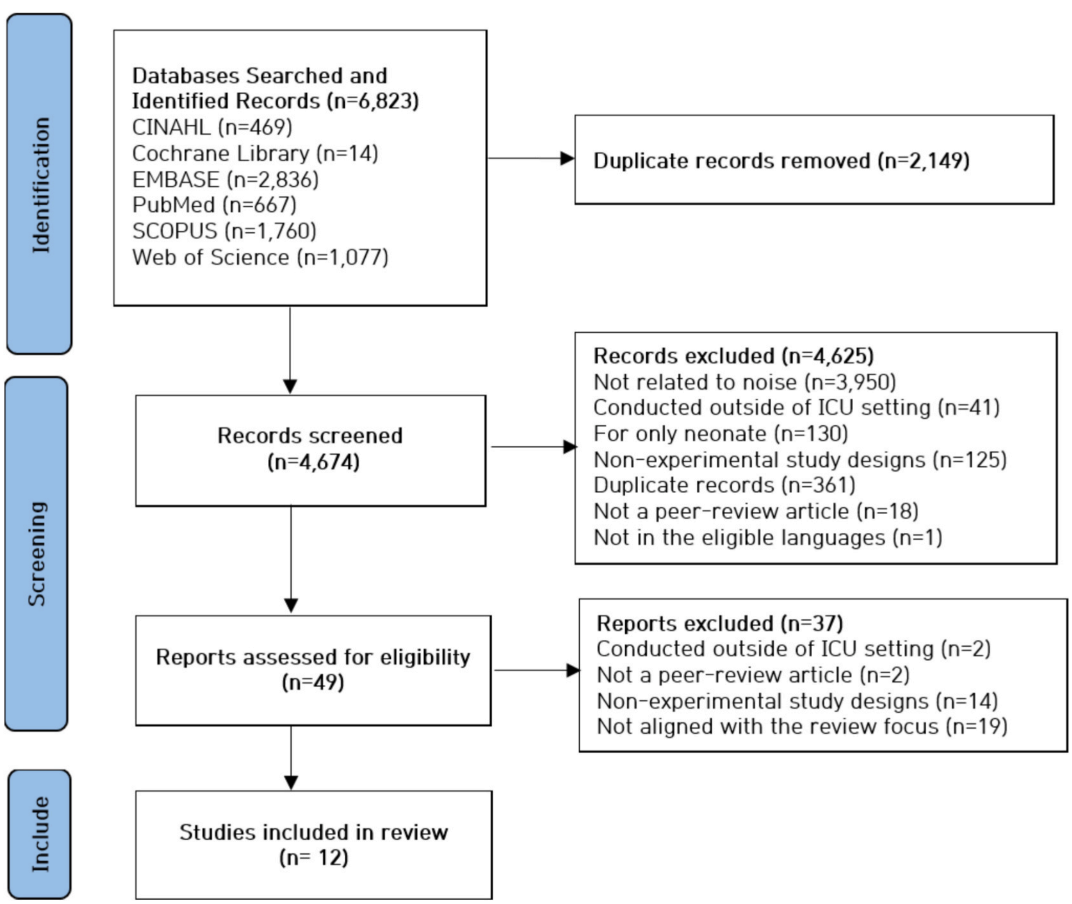

Fig. 1. PRISMA flow diagram – Process of study selection.

study, concerns were related to period and carryover effects [34]. Two studies were rated as having “some concerns” overall, based on the identified risks.

For the NRS assessed using ROBINS-I V2, the results indicated that most studies had a low risk of bias across the seven domains. However, the risk of bias assessment suggested that some studies had moderate concerns in specific domains, particularly confounding [36–40] and measurement of outcomes [14,41,42]. Despite these concerns, no study was rated as having a high risk of bias [14,36–44], supporting the reliability of the findings. Detailed results are shown in Fig. 2.

General characteristics of included studies

Twelve studies were included in the review [14,34–44]. Ten studies employed a quasi-experimental design [14,36–44], two were RCTs [34,35] and one was an RCT with a crossover design [34]. Among the quasi-experimental studies, seven adopted a repeated measures design, using pre-intervention data as the comparison group to assess intervention effects [14,36–39,41,44]. Although most of the included studies primarily targeted noise reduction, one study was included despite its primary focus on improving sleep quality [34], as it implemented a structured noise reduction intervention and reported objective measurements of environmental noise. The participants in the included studies were patients, HCPs, or ICU units. Three studies included only patients as participants [14,35,42], while four focused solely on ICUs [36,37,39,43]. The remaining five studies included over two types of participants [34,38,40,41,44]. The sample sizes varied across studies. Studies involving patients varied in sample size from 17 [34] to 421 [14] participants, whereas studies conducted with HCPs included as many as 179 participants [41]. Some studies implemented unit-based interventions aimed at reducing noise levels in ICUs [36,37,39,43]. The duration of the interventions varied significantly, ranging from less than one day [35] to four months [37]. A summary of the characteristics of the selected studies is presented in Table 1.

Contents and outcome variables of interventions

Across the twelve studies, noise reduction interventions varied considerably in design and scope but could be classified into three main aspects: patient, environmental, and HCPs. Two studies targeted the patient aspect intervention alone [35,42], one focused on environmental factors [37], and one focused on HCPs [39]. Additionally, four studies implemented interventions combining two aspects (environment and HCPs) [36,38,41,43], and four studies incorporated all three aspects [14,34,40,44]. Two studies evaluated patient outcomes [40,42], four studies assessed environmental outcomes [36,37,39,43], one study focused on HCPs [41], while three studies explored both patient and environmental aspects [14,34,42], and two studies examined all three areas [38,44]. A summary of the content and outcome variables of the selected studies is shown in Table 2.

Patient aspect

Interventions targeting patients primarily involved noise-blocking tools such as earplugs, noise-canceling headphones, and white noise devices [14,34,35,40,42,44]. Music therapy was also used to distract patients from ambient noise [42]. Among the seven studies evaluating patient-focused outcomes [14,34,35,38,40,42,44], two were mainly assessed through physiological outcomes, such as reductions in heart rate (HR), blood pressure (BP), and respiratory rate (RR), both of these studies reported reduction in HR and BP [40,42]. Improvements in sleep quality were observed in two of five studies [40,44], while the remaining three reported insignificant findings [14,34,42]. Reduced anxiety was reported in two of the three studies [40,42], while one study reported no significant change [35].

Environmental modification

Environmental interventions aimed at reducing noise levels in ICU settings have included operational policies as well as structural and technological modifications. Operational strategies included regular environmental checks and maintenance (e.g., inspecting rubber door seals, computer keyboard noise and servicing medical devices) [36,44]. Structural strategies included architectural changes, such as soundproofing, the introduction of single-patient rooms, and the installation of noise-shielding furniture [36,43]. Technological adjustments involved real-time noise awareness systems (e.g., SoundEar) and the reconfiguration of alarms to reduce their volume and frequency [14,34,36–38,40,41,44]. The outcomes of the environmental aspects were assessed using sound levels [14,34–39,43,44]. Noise reduction levels ranged approximately from 3.6 to11.5 dB following the interventions [36,37,39,44].

HCPs aspect

Interventions targeting HCPs primarily focused on education and behavioral modifications. Noise awareness training, behavioral changes such as reducing unnecessary conversations, and managing alarm settings were key components [14,34,36,38–41,43,44]. The impact of HCPs aspect was primarily assessed through changes in HCPs knowledge and attitudes toward noise control, as well as subjective perceptions of noise-related strain [38,41,44]. Two studies reported significant improvements in knowledge regarding noise management [38,44]. Notably, one of these studies also reported improvements in both perceptions and performance related to noise management [44]. One study reported no significant change in subjective noise-related strain [41].

Discussion

This systematic review aimed to examine the impact of noise reduction interventions in ICUs. This systematic review evaluated 12 studies that met the aims of this research. Two key findings were identified in this review: (1) noise reduction interventions were implemented in relation to three aspects: patient, environment, and HCPs, and (2) methodological limitations hindered the ability to derive conclusive evidence on the effectiveness of noise reduction interventions.

The findings of this review indicate that various noise reduction interventions have been implemented in ICUs, including patient-focused, environmental-, and HCP-directed strategies. These findings are consistent with those of previous systematic reviews on hospital noise reduction, particularly those conducted in general wards and ORs [16,17]. Similar to general ward and OR interventions, patient-focused interventions in ICUs primarily utilized noise-blocking devices such as earplugs and noise-canceling headphones, as well as music therapy to alleviate noise-induced distress. Furthermore, the present study demonstrated that noise interventions not only reduced noise levels but also improved sleep quality and physiological stability in patients. This finding provides valuable empirical evidence that noise reduction can directly enhance health outcomes, thereby expanding upon existing research that predominantly focused on minimizing noise levels in ICUs [20]. However, the observed inconsistency in the relationship between noise reduction and emotional health outcomes, such as anxiety, aligns with findings from studies in general ward settings [16]. This suggests that while patient-centered approaches may effectively mitigate noise disturbances, they alone may be insufficient to comprehensively address the complex challenges of noise in ICU environments. Consequently, a multifaceted strategy may be necessary to more effectively improve both physiological and psychological health outcomes in ICUs.

The interventions aimed at reducing noise in ICUs have been implemented at the environmental level, including soundproofing, alarm reconfiguration, and establishment of noise awareness systems in this review. Our findings align with previous research on noise

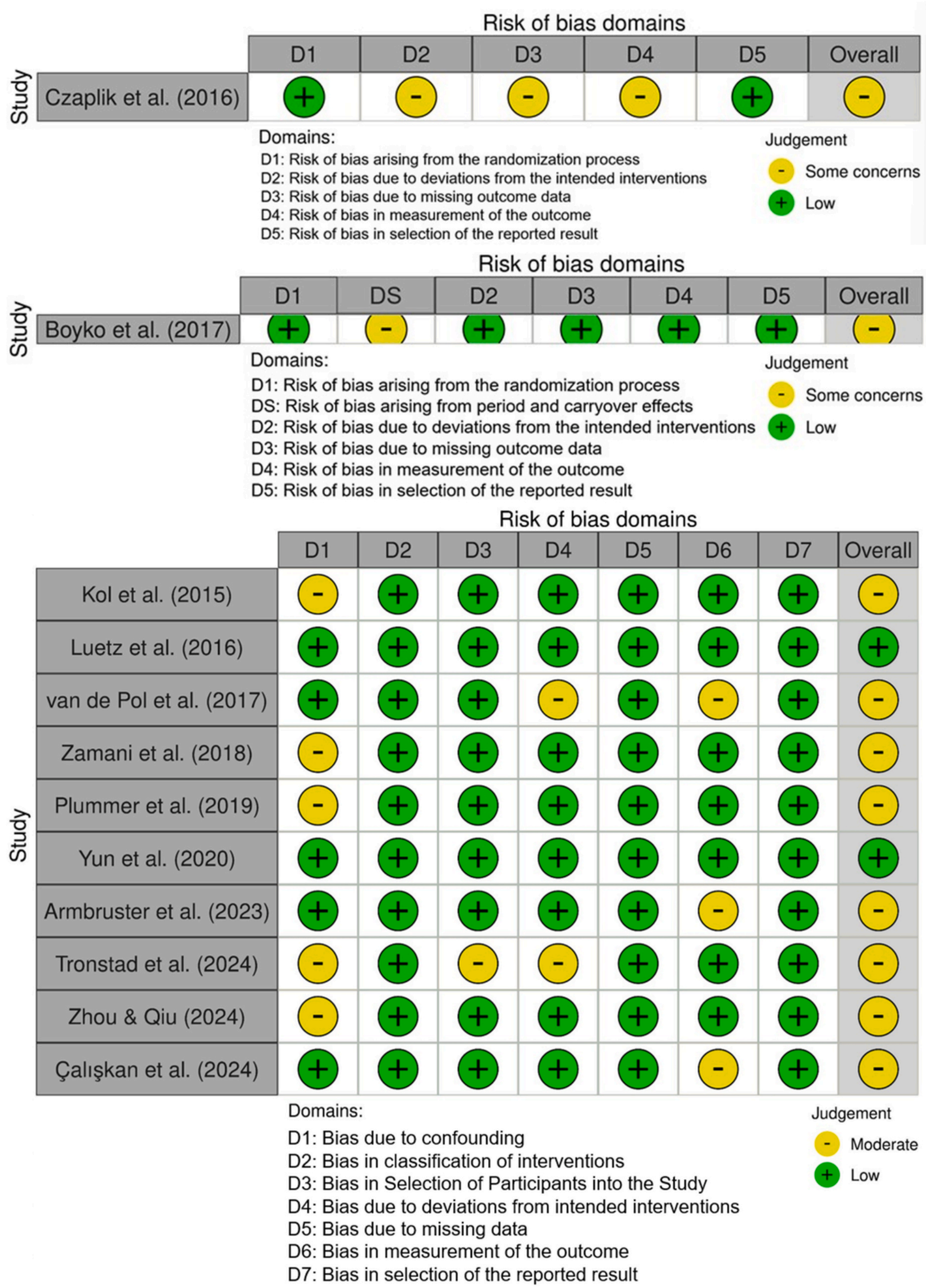

Fig. 2. Quality assessment of Included studies.

Table 1
General Characteristics of Included studies (N = 12)

Author(Year)	Country	Research Design	Type of ICU	Participants and Sample Size	Duration	Provider
Czaplik et al. (2016)	Germany	RandomizedControlled Trial	Adult ICU	• Patient N = 144 • (2 subsequent clinical studies, each studies' N = 72 • : IG (1) 24 / IG (2) 24 / CG 24, • total 6 groups, 24 per group)	• < 1 day	• Research Team
Boyko et al. (2017)	Denmark	RandomizedControlled Trial (cross-over)	Mixed ICU (Medical-Surgical ICU)	• Patient N = 17 • (IG 7 / CG10, cross-over IG10 / CG 7) • Unit N = 1	• 3 months	• Nurse
Kol et al. (2015)	Turkey	Quasi-experimental	Thoracic Surgery ICU	• Unit N = 1(Pre-Post measures)	• 3 months	• HCPs • Research Team
Luetz et al. (2016)	Germany	Quasi-experimental	Adult ICU	• Unit N = 1(Intervention room 1 / standard room 1)	• 3 months	• HCPs • Research Team • Architect
van de Pol et al. (2017)	Netherlands	Quasi-experimental	Mixed ICU(Medical-Surgical ICU)	• Patient N = 421 • (Pre-Post measures; Post-intervention Group 210 / Pre-intervention Group 211)	• 1 month	• HCPs
Zamani et al. (2018)	Iran	Quasi-experimental	Adult ICU	• Unit N = 1 • (Pre-Post measures)	• 2 weeks	• Research Team
Plummer et al. (2019)	United Kingdom	Quasi-experimental	Mixed ICU(Medical-Surgicaland neuroscience ICU)	• Unit N = 1 • (Pre-Post measures)	• 4 months	• Modified Environment
Yun et al. (2020)	Korea	Quasi-experimental	Neurocritical Care Unit	• Patient N = 68 • (Pre-Post measures; IG 34 / CG 34) • HCPs N = 47(Pre-Post Measures) • Unit N = 1 • (Pre-Post measures)	• 10 weeks	• Nurse • Research Team
Armbruster et al. (2023)	Germany	Quasi-experimental	Anesthesiological ICUNeonatological ICUNeurological ICU	• HCPs N = 179 • (Pre-Post measures) • Unit N = 3 • (Pre-Post measures)	• 12 weeks	• Nurse • HCPs • Modified Environment
Tronstad et al. (2024)	Australia	Quasi-experimental	Adult ICU	• Patient N = 68 • (IG (1) 14 / IG (2) 36 / IG (3) 18) • HCPs N = 100 • (Pre-Post Measures; IG (1)) • Unit N = 1	• 5 weeks	• HCPs • Research Team • Modified Environment
Zhou & Qiu (2024)	China	Quasi-experimental	Adult ICU	• Patient N = 150 • (IG 77 / CG 73) • Unit N = 1	• 10 days	• HCPs
Çalışkan et al. (2024)	Turkey	Quasi-experimental	Anesthesiology and reanimation ICU	• Patient N = 24 • (Repeated Measures; at Baseline, 30 min, 60 min)	• < 1 day	• Research Team

ICU, intensive care unit; IG: intervention group; CG: comparison group; HCPs: healthcare professionals

interventions in general wards and ORs, which similarly emphasize the role of structural and technological modifications in noise reduction [16,17]. However, the feasibility of implementing such changes varies owing to resource constraints and infrastructural limitations [10]. Importantly, the recent 2024 Society of Critical Care Medicine (SCCM) guidelines on adult ICU design underscore the significance of environmental factors—including lighting and noise control—as part of patient-centered ICU planning, although the strength of the relevant evidence remains low [13]. These guidelines reinforce the relevance of our findings and highlight the growing recognition of ICU design as a determinant of patient outcomes. Although environmental interventions in ICUs contribute to noise reduction, their long-term effectiveness and sustainability remain unclear and require further research. ICU environments pose unique challenges because of their diverse and continuous noise sources, which stem from multiple medical devices and alarms [9]. Given these complexities, future studies should explore ICU-specific environmental strategies tailored to the acoustic challenges in critical care settings.

In this review, the HCP-led interventions, particularly those focused on education and behavioral training, enhance awareness and responsiveness to noise disturbances. Similar approaches have been widely implemented in general wards and ORs, where educational programs for HCPs have effectively reduced noise levels [39]. However, these interventions assessed short-term outcomes, and the sustainability of behavior-based interventions presents a challenge due to factors such as employee turnover and fluctuations in compliance. Unlike environmental modifications that provide lasting noise control, behavior-focused strategies require continuous reinforcement to sustain their effectiveness [41]. This highlights the importance of integrating HCP training with environmental and technological interventions to achieve sustained noise reduction in ICUs. A comprehensive approach may be essential to facilitate immediate and long-term improvements in the acoustic conditions of ICUs.

Notably, even after implementing various noise reduction interventions, several studies reported post-intervention noise levels that remained above 40 dB [14,34–39,43,44], exceeding the WHO's recommended threshold for hospital environments. This persistent discrepancy highlights the structural and systemic limitations of current ICU environments and suggests that existing interventions alone may be insufficient to achieve optimal noise conditions. In fact, a comparison with earlier reviews reveals that the overall landscape of ICU noise interventions has not substantially changed over time [20]. Recent studies continue to employ familiar strategies—such as education, noise warning devices, and environmental modifications—rather than introducing fundamentally new approaches. Addressing the gap between observed noise levels and WHO standards remains essential through more targeted and multifaceted noise mitigation strategies.

This review had several limitations in evaluating the effectiveness of noise reduction interventions. Only two RCTs were included and both had small sample sizes, which limited their ability to draw robust

Table 2
Contents and Outcome Variables of Intervention in Included Studies (N = 12)

Author (Year)	Intervention			Outcome		
	Patient	Environment	HCPs	Patient	Environment	HCPs
Czaplik et al. (2016)	• Clinical study 1 • IG (1): Better earplugs • IG (2): Worse earplugs • CG: Providing nothing	–	–	• Clinical study 1 • Stress • (IG(2) < CG < IG (1)) • Anxiety (Insignificant) • Depression (Insignificant)	• Clinical study 1 • Night (↓) • "loud" and "very loud" events after 3:00 a.m. (↑)	–
	• Clinical study 2 • IG (1): Noise reduction earphones on • IG (2): Noise reduction earphones on and additional sound-masking • CG: Noise reduction earphones off	–	–	• Clinical study 2 • Stress • (CG < IG (1) < IG (2)) • Anxiety • (CG-IG(2): (Insignificant), • IG (1): (↑)) • Depression • (CG-IG(1): (Insignificant), • IG (2): (↓))	• Clinical study 2 • Noise level (dB (A)) • Night (↓) • "loud" and "very loud" events after 3:00 a.m. (↑)	–
Boyko et al. (2017)	• IG: Earplugs	• IG • : No visits after 10 PM • : Reduced alarm sounds • : Only strictly necessary diagnostic or treatment procedures	• IG • : No conversations in patient rooms • : At observation post	• Sleep quality (Insignificant)	• Noise level (dBA) • (Insignificant)	–
	• CG • : Usual routine activities	• CG • : Usual routine activities	• CG • : At observation post/ bedside			
Kol et al. (2015)	–	• IG • : Rearrangement of a room in the unit • : Movement away from an area previously allotted for treatment in the patient area and isolated by a door • : Device overhaul and repair • : Cart overhaul and wheels repair • : Non-activation of alarms unnecessarily and adjustment of alarms to a moderate volume • : Signs indicating that sound levels are being measured	• IG • : Educational session on noise and noise reduction • : Informed about the sources of noise and noise levels in the study unit	–	• Noise level (dBA) (↓)	–
Luetz et al. (2016)	–	• IG • : Architectural modifications • : Including soundproofing • : Noise-shielding furniture • : Technical corridor installation • : Closed working space • : Double door system • : Automatic closing door • ; Workflow adjustments	• IG • : Education programs for door closed and silence at night	–	• Noise level (dB) (↓) • Distinct variation of day-night sound level (Significant)	–
	–	• CG: Standard room	• CG • : Education programs for keeping door closed and silence at night			
van de Pol et al. (2017)	• IG: Earplugs	• IG • : Adequate alarm settings at patient level and minimizing alarm volume • : Closing the door	• IG: Avoiding non-clinical discussions around patient spaces • : Instructions of specific equipment	• Delirium (↓) • Sleep quality (Insignificant) • Using sleep-inducing medication (↓) • Patient perceived nocturnal noise level (↓)	• Noise level (dB (A)) • : Median 41.2 • and 52.1, over 35	–
Zamani et al. (2018)	–	–	• IG • : Indirectly training through the provision of educational pamphlets, posters and etc. about noise pollution outcomes and its reduction methods	–	• Noise level (dB) (↓)	–

(continued on next page)

Table 2 (*continued*)

Author (Year)	Intervention Patient	Environment	HCPs	Outcome Patient	Environment	HCPs
Plummer et al. (2019)	–	• IG: *SoundEar* • (Displaying ambient sound levels to provide a visual representation of noise levels)	–	–	• Noise level (dB) (↓)	–
Yun et al. (2020)	• IG • : Earplugs when needed • : White noise when needed	• IG • : Monthly improvement of environment (facility) including check the rubber strip on the door, the device to close the door slowly, whether silent garbage cans are used, and the status of the computer keyboard • : Monthly monitor/medical device inspection and repair • : Daily adjust and check alarms and ringtones	• IG • : HCPs training at all times • : Provide information about noise to patients and caregiver at each patient admission • : Daily modify an individual's habits or behavior (caution to noise occurring, be careful in conversation)	• Perceived noise level (↓) • Response to noise (↓) • Satisfaction with noise management (↑) • Sleep quality (↑)	• Noise level (dBA) (↓)	• Perceived noise level (↓) • Response to noise (↓) • Satisfaction with noise management (↑) • Noise-related knowledge (↑) • Perception and performance of noise management (↑)
	• CG: Usual routine activities	–	–			
Armbruster et al. (2023)	–	• IG: Visualizing the thresholds of sound pressure level • : Individual alarm management • : Adjustment of work processes	• IG: Conversations outside the patient rooms • : Collegial advice during loud conversations • : Educational informative materials	–	–	• Subjective noise-related strain (Insignificant) • Perception of noise*
Tronstad et al. (2024)	–	• IG(2): Visual sound-level alerts • IG(3): Monitor alarm reconfigurations	• IG (1): Noise awareness education	• The most frequently mentioned sources of sound that bothered patients across all interventions • : Alarms, sounds associated with patient care, and equipment sounds • The activities most frequently indicated to disrupt sleep • : light and excessive sound levels and noise, with sounds associated with medical instruments and alarms	• Noise level(dBA) (Insignificant) • Alarm frequency (↓)	• HCPs knowledge (↑)
Zhou & Qiu (2024)	• IG: Reminded to lower voices	• IG • : Establishing a noise Management team • : Taking noise elimination measures for the facilities and conditions of the ward • : Adjust the alarm volume to the appropriate range and repair • : Managing ward call ringing • : Restricted visitors' sound	• IG: HCPs training to improvement for noise understanding and operation methods • : Sticking the "Quiet Ward" logo on the walls of the ward • : Restricted conversation	• Sleep quality (↑) • Negative emotion • Anxiety (↓) • Depression (Insignificant) • Stress (↓) • HR (↓)/BP (↓) • Cortisol level (↓) • Quality of life (↑)	–	–
	• CG: Usual routine activities	• CG: Usual routine activities	• CG: Usual routine activities			
Çalışkan et al. (2024)	• Music therapy group (1) : Earphone with western classical music • Music therapy group (2) : Earphone with Turkish classical music • Sound isolation group: A special headphone	–	–	• BP (↓)/PR (↓)/RR (↓) • Oxygen saturation (↑) • Expiratory minute volume (↓) • Perceived pain (↓) • Consciousness (Insignificant) • Agitation (↓) • Anxiety (↓) • Sleep (Insignificant) • Patient-ventilator synchrony (Insignificant)	–	–

IG, intervention group; CG: comparison group; HCPs: healthcare professionals; *: Inconsistent results in subcategories conclusions regarding the effectiveness of the interventions. Additionally, substantial variability in outcome measures prevented us from conducting a *meta*-analysis. The reliance on quasi-experimental designs across most of the included studies further restricted causal inference regarding intervention effectiveness. Similar challenges have been observed in previous studies conducted in ICUs [20] and ORs [17]. Moreover, the lack of standardized outcome measures further complicates the evaluation of intervention effectiveness. While general ward reviews have attempted *meta*-analyses of noise reduction interventions focusing on sleep-related outcomes [16], their findings have been inconclusive owing to limited sample sizes and study heterogeneity. This emphasizes the challenges associated with synthesizing data in this field, primarily because of the limited number of RCTs and the variability in study designs and outcome measures. Our findings underscore the need for high-quality large-scale RCTs with standardized outcome measures to comprehensively evaluate noise reduction strategies in ICUs.

Furthermore, the studies included in this review were evaluated over relatively short durations, ranging from one day to four months, without addressing the long-term sustainability of the interventions. This result was consistent with the previous study in ICU [20]. Given the persistent nature of ICU noise, future research should focus on evaluating the sustained impact of noise-reduction interventions over extended periods. Considering the multifaceted nature of ICU noise, interventions targeting a single aspect may have limited efficacy. Therefore, a multifaceted approach that integrates patient-centered, environmental, and HCP-directed strategies is required to address the complex acoustic challenges in ICUs. Although previous studies have proposed multicomponent approaches, the heterogeneity of interventions and outcome measures makes it difficult to draw definitive conclusions about their effectiveness. These findings suggest that further studies are necessary to assess the effectiveness of noise management interventions and evaluate their sustainability over longer durations.

Limitations

This systematic review had some limitations. First, only studies published in English or Korean were included, which may have led to language bias and exclusion of relevant research published in other languages. Second, studies conducted in NICUs were excluded from the analysis in this study because NICUs may differ from adult ICUs due to their unique environments, such as the use of incubators, and the developmental characteristics of the patients. Consequently, the findings of this study did not address the unique noise problems and intervention effects of the NICU environment. Third, this review was limited in its capacity to thoroughly evaluate the effectiveness of the interventions. The inability to access the original data from the included studies constrained the analysis. Furthermore, several essential statistical metrics, such as p-values and confidence intervals, were not consistently reported, which hindered the precise estimation of effect sizes. Additionally, the limited number of RCTs, small sample sizes, and the prevalent use of quasi-experimental designs among the included studies posed further challenges in establishing definitive causal relationships.

Conclusion

Noise reduction in ICUs is a critical factor in enhancing patient outcomes. Existing evidence underscores the necessity of implementing multifaceted interventions that address patient-specific factors, environmental modifications, and HCPs' behaviors. Evaluating the efficacy of noise management strategies should extend beyond measuring reduction in external noise levels to also assessing their impact on patient health and well-being. We recommend the development of sustainable, context-specific noise reduction protocols that incorporate practical interventions such as HCPs training on noise awareness, providing patients with earplugs, and implementing feasible environmental adjustments. Addressing the persistent discrepancy between current noise levels and the WHO standards remains essential through targeted noise mitigation efforts. Future research should prioritize large-scale, high-quality RCTs with standardized outcome measures and long-term follow-up, to establish robust evidence for effective interventions. Additionally, exploring tailored, multifactorial approaches that integrate patient-centered strategies, environmental enhancements, and HCP engagement will be vital. Investigations into context-specific noise reduction interventions across diverse ICU settings hold substantial potential to facilitate the creation of a quieter and more therapeutic environments for both patients and HCPs.

Funding source information

This work was supported by a 2024 Faculty-Student Research grant from the Yonsei University College of Nursing (6-2024-0159).

Ethics statement

This study did not require IRB approval.

CRediT authorship contribution statement

Eugene Han: Writing – review & editing, Writing – original draft, Visualization, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Haeun Kang:** Visualization, Project administration, Methodology, Formal analysis, Data curation. **Yeonsoo Jang:** Writing – review & editing, Visualization, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iccn.2025.104234.

References

[1] Berglund B, Lindvall T, Schwela DH. New WHO guidelines for community noise. Noise Vibration Worldwide 2000;31:24–9. https://doi.org/10.1260/0957456001497535.
[2] de Lima AE, da Cunha ESDC, de Lima EA, de Oliveira RA, Zannin PHT, Martins ACG. Environmental noise in hospitals: a systematic review. Environ Sci Pollut Res Int 2021;28:19629–42. https://doi.org/10.1007/s11356-021-13211-2.
[3] Aydın Sayılan A, Kulakaç N, Sayılan S. The effects of noise levels on pain, anxiety, and sleep in patients. Nurs Crit Care 2021;26:79–85. https://doi.org/10.1111/nicc.12525.
[4] Hodges S, Riley L, Dickson T, Mitchell A. A systematic literature review of noise and nurse stress levels in intensive care units. J Educ Society Behav Sci 2018;27:1–7. https://doi.org/10.9734/JESBS/2018/44648.
[5] Kebapcı A, Güner P. "Noise Factory": a qualitative study exploring healthcare providers' perceptions of noise in the intensive care unit. Intensive Crit Care Nurs 2021;63:102975. https://doi.org/10.1016/j.iccn.2020.102975.
[6] Schmidt N, Gerber SM, Zante B, Gawliczek T, Chesham A, Gutbrod K, et al. Effects of intensive care unit ambient sounds on healthcare professionals: results of an online survey and noise exposure in an experimental setting. Intensive Care Med Exp 2020;8:34. https://doi.org/10.1186/s40635-020-00321-3.
[7] Terzi B, Azizoğlu F, Polat Ş, Kaya N, İşsever H. The effects of noise levels on nurses in intensive care units. Nurs Crit Care 2019;24:299–305. https://doi.org/10.1111/nicc.12414.
[8] Jung S, Kim J, Lee J, Rhee C, Na S, Yoon JH. Assessment of noise exposure and its characteristics in the intensive care unit of a tertiary hospital. Int J Environ Res Public Health 2020;17. https://doi.org/10.3390/ijerph17134670.
[9] Darbyshire JL, Müller-Trapet M, Cheer J, Fazi FM, Young JD. Mapping sources of noise in an intensive care unit. Anaesthesia 2019;74:1018–25. https://doi.org/10.1111/anae.14690.

[10] Verderber S, Gray S, Suresh-Kumar S, Kercz D, Parshuram C. Intensive care unit built environments: a comprehensive literature review (2005-2020). HERD 2021;14:368–415. https://doi.org/10.1177/19375867211009273.
[11] Konkani A, Oakley B. Noise in hospital intensive care units : a critical review of a critical topic. J Crit Care 2012;27:522. https://doi.org/10.1016/j.jcrc.2011.09.003.
[12] Petersen EM, Costanzo CL. Assessment of clinical alarms influencing nurses' perceptions of alarm fatigue. Dimens Crit Care Nurs 2017;36:36–44. https://doi.org/10.1097/dcc.0000000000000220.
[13] Hamilton DK, Gary JC, Scruth E, Anderson 3rd HL, Cadenhead CD, Oczkowski SJ, et al. Society of critical care medicine 2024 guidelines on adult ICU design. Crit Care Med 2025;53(3):e690–700. https://doi.org/10.1097/ccm.0000000000006572.
[14] van de Pol I, van Iterson M, Maaskant J. Effect of nocturnal sound reduction on the incidence of delirium in intensive care unit patients: an interrupted time series analysis. Intensive Crit Care Nurs 2017;41:18–25. https://doi.org/10.1016/j.iccn.2017.01.008.
[15] Mart MF, Williams Roberson S, Salas B, Pandharipande PP, Ely EW. Prevention and management of delirium in the intensive care unit. Semin Respir Crit Care Med 2021;42:112–26. https://doi.org/10.1055/s-0040-1710572.
[16] Garside J, Stephenson J, Curtis H, Morrell M, Dearnley C, Astin F. Are noise reduction interventions effective in adult ward settings? a systematic review and meta analysis. Appl Nurs Res 2018;44:6–17. https://doi.org/10.1016/j.apnr.2018.08.004.
[17] Ayas S, Armstrong BA, Wong S, Gordon L, Kishibe T, Grantcharov T, et al. Mitigating operating room distractions: a systematic review assessing intervention effectiveness. Hum Factors Health 2022;2:100013. https://doi.org/10.1016/j.hfh.2022.100013.
[18] Bertsch M, Reuter C, Czedik-Eysenberg I, Berger A, Olischar M, Bartha-Doering L, et al. The "Sound of Silence" in a Neonatal Intensive Care Unit-Listening to Speech and Music inside an Incubator. Front Psychol 2020;11:1055. https://doi.org/10.3389/fpsyg.2020.01055.
[19] Sibrecht G, Wróblewska-Seniuk K, Bruschettini M. Noise or sound management in the neonatal intensive care unit for preterm or very low birth weight infants. Cochrane Database Syst Rev 2024;5(5):Cd010333. https://doi.org/10.1002/14651858.CD010333.pub4.
[20] Vreman J, Lemson J, Lanting C, van der Hoeven J, van den Boogaard M. The effectiveness of the interventions to reduce sound levels in the ICU: a systematic review. Crit Care Explor 2023;5:e0885.
[21] Raghuwanshi NK, Yadav SK, Jayaswal P, Parey A. Noise effects, analysis and control in hospitals-a review. Noise Vibr Worldwide 2024;55(3):123–34.
[22] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. https://doi.org/10.1136/bmj.n71.
[23] Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 2009;339:b2700. https://doi.org/10.1136/bmj.b2700.
[24] Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al. Cochrane Handbook for Systematic Reviews of Interventions version 6.5 (updated August 2024). Cochrane; 2024. https://training.cochrane.org/handbook; [accessed 28 January 2025].
[25] Feldner K, Dutka P. Exploring the evidence: generating a research question: using the PICOT framework for clinical inquiry. Nephrol Nurs J 2024;51(4):393–5.
[26] International Liaison Committee on Resuscitation. Science Advisory Committee Guidance and Templates. 2025. https://ilcor.org/documents/continuous-evidence-evaluation-guidance-and-templates; [accessed 23 July 2025].
[27] Konkani A, Oakley B. Noise in hospital intensive care units–a critical review of a critical topic. J Crit Care 2012;27(5):522. https://doi.org/10.1016/j.jcrc.2011.09.003.
[28] Chander S, Kumari R, Sadarat F, Luhana S. The evolution and future of intensive care management in the era of telecritical care and artificial intelligence. Curr Probl Cardiol 2023;48(10):101805. https://doi.org/10.1016/j.cpcardiol.2023.101805.
[29] Campbell M, McKenzie JE, Sowden A, Katikireddi SV, Brennan SE, Ellis S, et al. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. BMJ 2020;368:l6890. https://doi.org/10.1136/bmj.l6890.
[30] Higgins JP, Li T, Sterne J. Revised Cochrane risk of bias tool for randomized trials (RoB 2) Additional considerations for crossover trials. 2021. https://www.riskofbias.info/; [accessed 28 January 2025].
[31] Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 2019;366:l4898. https://doi.org/10.1136/bmj.l4898.
[32] Sterne J, Higgins J. Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) Version 2. 2024. https://www.riskofbias.info; [accessed 28 January 2025].
[33] Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ 2016;355:i4919. https://doi.org/10.1136/bmj.i4919.
[34] Boyko Y, Jennum P, Nikolic M, Holst R, Oerding H, Toft P. Sleep in intensive care unit: the role of environment. J Crit Care 2017;37:99–105. https://doi.org/10.1016/j.jcrc.2016.09.005.
[35] Czaplik M, Rossaint R, Kaliciak J, Follmann A, Kirfel S, Scharrer R, et al. Psychoacoustic analysis of noise and the application of earplugs in an ICU: a randomised controlled clinical trial. Eur J Anaesthesiol 2016;33:14–21. https://doi.org/10.1097/EJA.0000000000000313.
[36] Kol E, Demircan A, Erdoğan A, Gencer Z, Erengin H. The effectiveness of measures aimed at noise reduction in an intensive care unit. Workplace Health Saf 2015;63(12):539–45. https://doi.org/10.1177/2165079915607494.
[37] Plummer NR, Herbert A, Blundell JE, Howarth R, Baldwin J, Laha S. SoundEar noise warning devices cause a sustained reduction in ambient noise in adult critical care. J Intensive Care Society 2019;20:106–10. https://doi.org/10.1177/1751143718767773.
[38] Tronstad O, Patterson S, Zangerl B, Flaws D, Holdsworth R, Irvine L, et al. The introduction of a sound reduction bundle in the intensive care unit and its impact on sound levels and patients. Aust Crit Care 2024. https://doi.org/10.1016/j.aucc.2024.02.011.
[39] Zamani K, Asgharnia HA, Yazdani J, Taraghi Z. The effect of staff training on the amount of sound pollution in the intensive care unit. J Nurs Midwifery Sci 2018;5:130–3. https://doi.org/10.4103/JNMS.JNMS_38_18.
[40] Zhou H, Qiu Y. Retrospective study on the value of intensive care unit noise reduction management in elderly patients with chronic renal failure in the uremic phase. Noise Health 2024;26:376–82. https://doi.org/10.4103/nah.nah_70_24.
[41] Armbruster C, Walzer S, Witek S, Ziegler S, Farin-Glattacker E. Noise exposure among staff in intensive care units and the effects of unit-based noise management: a monocentric prospective longitudinal study. BMC Nurs 2023;22:460. https://doi.org/10.1186/s12912-023-01611-3.
[42] Çalışkan S, Akın E, Uyar M. Effect of music therapy and sound isolation on the comfort of mechanically ventilated patients. J Turk Intens Care 2024. https://doi.org/10.4274/tybd.galenos.2023.86648.
[43] Luetz A, Weiss B, Penzel T, Fietze I, Glos M, Wernecke K, et al. Feasibility of noise reduction by a modification in ICU environment. Physiol Meas 2016;37:1041. https://doi.org/10.1088/0967-3334/37/7/1041.
[44] Yun SH, Kwak NY, Yoo YS. Development and application of an intervention for noise reduction in intensive care units. Korean J Adult Nurs 2020;32:584–98. https://doi.org/10.7475/kjan.2020.32.6.584.