

REVIEW ARTICLE

Systematic review of the effects of intensive-care-unit noise on sleep of healthy subjects and the critically ill

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Abstract

Intensive-care-unit (ICU) patients exhibit disturbed sleeping patterns, often attributed to environmental noise, although the relative contribution of noise compared to other potentially disrupting factors is often debated. We therefore systematically reviewed studies of the effects of ICU noise on the quality of sleep to determine to what extent noise explains the observed sleep disruption, using the Cochrane Collaboration method for non-randomized studies. Searches in Scopus, PubMed, Embase, CINAHL, Web of Science, and the Cochrane Library were conducted until May 2017. Twenty papers from 18 studies assessing sleep of adult patients and healthy volunteers in the ICU environment, whilst recording sound levels, were included and independently reviewed by two reviewers. We found that the numbers of arousals between the baseline and the ICU noise condition in healthy subjects differed significantly (mean difference 9.59; 95% confidence interval 2.48–16.70). However, there was considerable heterogeneity between studies (I^2 94%, $P < 0.00001$), and all studies suffered from a considerable risk of bias. The meta-analysis of results was hampered by widely varying definitions of sound parameters between studies and a general lack of detailed description of methods used. It is, therefore, currently impossible to quantify the extent to which noise contributes to sleep disruption among ICU patients, and thus, the potential benefit from noise reduction remains unclear. Regardless, the majority of the observed sleep disturbances remain unexplained. Future studies should, therefore, also focus on more intrinsic sleep-disrupting factors in the ICU environment.

Key words: Arousal; Intensive care units; Noise; Sleep

Key points

- The authors performed a systematic review and meta-analysis considering the effect of ICU noise levels on patients' quality of sleep.
- They found wide variation in studies, preventing them from making generalisable conclusions.
- However, sleep disturbance remains a clear problem, and the authors recommend further studies examining the issue.

Sleep is an important process that is essential for repair and survival.¹ Disrupted sleep is associated with impaired immune function and increased susceptibility to infections,^{2–4} alterations in nitrogen balance and wound healing,^{2,4} and diminished neurophysiological organisation and memory consolidation.³ In the intensive care unit (ICU), this may lead to delirium, prolonged admission, and increased mortality.³ Unfortunately, most patients in the ICU exhibit disturbed sleeping patterns^{1,2} characterized by severe fragmentation of sleep.⁵ As part of a pilot study, we too found severely fragmented sleep and EEG activity that suggest heightened arousal and signs of sleep deprivation.⁶

Patients admitted to an ICU are exposed to several intrinsic and extrinsic sleep-disrupting factors, which were described previously in more detail by Le Guen and colleagues.⁷ A multitude of these factors, most of them interdependent, likely causes the disrupted sleep observed in the ICU. The most important environmental factors are assumed to be temperature, light exposure, and noise, the latter of which is most often associated with disturbed sleep.^{8,9} Although the exact mechanism and the significance of sleep disruption by ICU noise amongst patients are still debated, workplace noise is known to have a negative effect on ICU staff causing irritation, fatigue, concentration problems, headaches, and even burnout.^{10–13}

The 1999 World Health Organization guidelines for community noise recommend a maximum of 35 decibels, adjusted for the range of normal hearing [dB(A)] overnight and 40 dB(A) during the day for hospital environments.¹⁴ However, this is not achievable in a modern ICU unless all equipment is switched off.¹⁵ As a result, sound levels in ICUs far exceed the recommended levels^{15–20} with average noise levels between 55 and 70 dB(A), accompanied by peak noise levels of more than 80 dB(A).²¹ The Society of Critical Care Medicine's guideline for ICU design even states that increased noise levels can disrupt sleep, although the cited sources do not provide data on ICU patients' sleep.²²

Consequently, an increasing number of studies focus solely on sleep disturbance by ICU noise specifically, disregarding other environmental and illness-related changes that accompany ICU admission. In order to know how to optimize ICU architecture, improve technology, and guide staff behaviour to promote sleep, it is crucial to know with a sufficient level of evidence how large the impact of ICU noise on the quality of sleep really is.^{12,22} The aim of our study was to systematically review the available evidence on the effects of ICU noise on the quality of sleep in healthy volunteers and ICU patients.

Methods

The Cochrane Collaboration method for non-randomized studies was used for this systematic review.²³

Eligibility criteria

We searched for studies assessing the sleep of adult patients and healthy volunteers in the ICU environment objectively, using methods, such as polysomnography (PSG), actigraphy, or patient self-reports whilst the patient was in the ICU, with simultaneous registration and recording of sound levels. Studies were excluded if they met at least one of the following criteria: included only neonates or children, and assessed sleep or sound levels using subjective observation only. Although a very informative method, the assessment of sleep by observation is known to significantly overestimate the total sleep time and sleep continuity, and is generally considered to provide an inaccurate estimation of the quality of sleep.²⁴ Finally, it is vital that sound levels are objectively measured using standard units to ensure that results from various studies can be compared and data can be pooled for meta-analysis.

Outcome

The primary outcome was the number of arousals per hour of sleep for different sound conditions. This outcome was chosen because it best represents sleep quality in a single measure and was, therefore, most commonly used in the reviewed articles.

Search strategy

A literature search was conducted using the following electronic databases: Scopus, PubMed, Embase, CINAHL, Web of Science, and the Cochrane Library. The search terms used in all of the databases were 'sleep and (noise or sound) and (ICU, intensive care, or critical care)'. The search was conducted without any article format, data, or language restrictions, and included studies published until May 2017.

Study selection

The titles for the articles retrieved from the search were manually reviewed by two authors. After the removal of letters to the editor, reviews, abstracts only, and non-article formats, the remaining abstracts were assessed for eligibility. Only abstracts of original investigations were included. The references of all included articles and those from selected reviews were checked for relevancy. The following data were extracted: year of publication, country in which the study was conducted, period of conduct of the study, inclusion and exclusion criteria, all outcomes, details on interventions, and characteristics of the studies.

Bias risk assessment

Two authors independently assessed the risks of bias of the studies following the domains from the Cochrane risk of bias assessment tool: for non-randomized studies of interventions.²⁵ The domains are bias attributable to confounding, bias in the selection of participants into the study, bias in measurement of interventions, bias attributable to departures from intended interventions, bias attributable to missing data, bias in measurement of outcomes, and bias in the selection of the reported results.

Statistical analysis

A meta-analysis on data from studies that measured the number of arousals per hour of sleep for multiple settings was

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