



## Original article

## Are noise reduction interventions effective in adult ward settings? A systematic review and meta analysis



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## ABSTRACT

**Objective:** High levels of environmental noise in hospitals disturbs sleep. We aimed to identify, critically appraise and summarise primary research that reports studies that tested interventions to reduce night-time noise levels in ward-settings.

**Design:** Systematic review and meta-analysis in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.

**Data sources:** Key health-related and specialist acoustic databases (CINAHL, EMBASE, MEDLINE, The Cochrane Library, PsycINFO, NHS Evidence, Knovel, Journal of the Audio Engineering Society, Journal of the Acoustical Society of America, IEEE Xplore Digital Library, Acta Acustica and Acoustics in Practice) were searched from their inception to April 2017, with no language restrictions.

**Review methods:** Experimental, quasi-experimental and observational study designs assessing the effect of noise reduction interventions on patient outcomes and/or environmental noise levels were included. Two reviewers independently conducted a quality appraisal using a published framework.

**Results:** In total, 834 records were identified with nine studies meeting inclusion criteria. Quality appraisal showed that the level of evidence was generally weak. A range of noise reduction interventions were identified: one study implemented a single intervention, whilst the remainder were complex, multi-faceted interventions. Findings from individual studies showed mixed results but preliminary evidence suggests that noise reduction interventions can reduce environmental noise levels in ward settings and improve patients' sleep ratings. Quantitative data from 6 studies were pooled. A random effects meta-analysis determined that a synthesised estimate for the standardised mean difference in total hours sleep (no intervention – intervention) was  $-0.11$  h (95% CI  $-0.46$  to  $0.25$  h;  $p = 0.556$ ), with moderate statistical heterogeneity. A random effects meta-analysis determined that a synthesised estimate for the standardised mean difference in awakenings per night (no intervention – intervention) was  $0.05$  (95% CI  $-0.20$  to  $0.29$ ;  $p = 0.715$ ), with negligible statistical heterogeneity. A random effects meta-analysis determined that a synthesised estimate for the odds ratio for disturbed nights (no intervention: intervention) was  $0.75$  (95% CI  $0.55$  to  $1.01$ ;  $p = 0.059$ ), with low statistical heterogeneity.

**Conclusions:** Individual studies show that noise reduction interventions are feasible in ward settings and suggest they have potential to improve patients' in-hospital sleep experiences. However meta-analyses show insufficient evidence to support the use of such interventions at present. There is a lack of appropriately designed studies to test intervention effectiveness. Robust studies are required to identify the most effective interventions to address this significant and ubiquitous problem.

**What is known about the topic:**

- Noise levels in hospital impact on quantity and quality of sleep and patient experience.

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- Disturbed sleep can have a detrimental impact on health and extend patient recovery.
- Noise reduction interventions do not receive the priority they deserve.

*What this paper adds:*

- A comprehensive review of noise reduction interventions used in general ward settings.
- Noise reduction interventions show the potential to reduce environmental noise and improve patient sleep ratings.
- Appropriately designed studies are required to provide definitive evidence to demonstrate the effectiveness of noise reduction intervention in ward settings.

## 1. Introduction

Ideally, hospitals should provide a quiet and calm environment to promote rest, healing and well-being for patients. However, in reality, hospitals across the world tend to have high levels of environmental noise with levels at night which often exceed World Health Organisation (WHO) recommendations for optimising sleep: < 30 dB (A) for continuous background noise and < 45 dB(A) for individual noise events (Choiniere, 2010; Kahn et al., 1998; WHO, 2009). WHO further recommend noise levels in hospital do not exceed 35 dBA during the day and 30 dBA at night. Levels of 30–40 dB impact on self-reported sleep disturbances and arousals. When levels reach 40–55 dB, noise starts to have adverse health effects (Hume, Brink, & Basner, 2012). Excessive noise can lead to increased stress, poor sleep and even learned helplessness (Hatfield et al., 2002, Zaharna, 2010).

Environmental noise levels in hospital settings have increased over the last 45 years (Busch-Vishniac et al., 2005). Not surprisingly quality of care complaints from patients about their hospital stay often refer to noise disturbances at night (Fillary et al., 2015). Excessive environmental noise contributes to poor quality sleep (Freedman, Gazendam, Levan, Pack, & Schwab, 2001, Hume et al., 2012, Lei et al., 2009). Between 30 and 50% of people admitted to hospital suffer from significant sleep disturbance or reduced sleep patterns during their hospital stay (Doğan, Ertekin, & Doğan, 2005; Lane & East, 2008). Yoder demonstrated that noise in hospital was markedly higher than recommended levels and clearly evidenced a link to sleep loss for patients (Yoder, Staisiunas, Meltzer, Knutson, & Arora, 2012).

The physiological responses to noise and stress are similar, with detrimental effects such as causing autonomic arousals from sleep accompanied by increased heart rate and vasoconstriction, or neutral arousals from sleep characterised by a K-complex, an increase in the frequency of the brain activity and typically body movements (Edholm & Weiner, 2012). The secondary effects of sleep deprivation include low mood and performance, although any long-term cardiovascular consequences are still unclear (Overman Dube et al., 2008).

Over time, sleep disturbance has a detrimental impact on physical health and recovery rates (Choiniere, 2010; Overman Dube et al., 2008). Sleep is essential for physical healing and the maintenance of mental health and wellbeing (Fillary et al., 2015; Lei et al., 2009; Freedman et al., 2001). Lack of sleep or interrupted sleep is a significant problem and can have a major impact on psychological health and increased stress levels, particularly for the vulnerable in our society including children, older people and those with long-term illness (Hume et al., 2012; Morrison, Haas, Shaffner, Garrett, & Fackler, 2003).

As well as having a negative impact on patient experiences in hospitals, high noise levels also have an impact on annoyance, stress and potentially burnout of hospital staff (Joseph & Ulrich, 2007; Morrison et al., 2003). As a result, high noise levels may have a detrimental impact on patient safety through increase noise-induced distractions (Taylor-Ford, Catlin, LaPlante, & Weinke, 2008).

Environmental noises for in-patient settings fall broadly into two categories. Firstly, environmental noise produced by 'people', which includes other patients, visitors and staff: Christensen (2005) demonstrated a positive relationship between the number of staff on duty and an increased recorded level of noise. Secondly, environmental noise

from 'Hospital equipment', which includes monitor alarms, telephones, TVs and computers (Fillary et al., 2015; Montague, Blietz, & Kachur, 2009; Wiese & Wang, 2011). Hospital activity is typically constant regardless of time of day, with noise from wheelchairs, trolleys, deliveries, cleaning activities and footsteps all contributing to environmental noise levels and associated high acoustics, leading to sleep disruption (Overman Dube et al., 2008). Moreover, the increasing clinical acuity levels of hospital in-patients with complex conditions requiring close monitoring using advanced technology has an associated cacophony of alarm systems. In fact, patients also identified environmental noise from medical equipment to be of primary concern and a key cause of fragmented sleep (Fillary et al., 2015; Wiese & Wang, 2011). Yoder et al. (2012) concurs, reporting sources of environmental noise disturbances by hospital in-patients to include staff conversation (reported by 65% of patients), other patients/roommates (54%), alarms (42%), intercoms (39%), and pagers (38%). Different frequencies of noise are linked to sleep disturbance, with higher intensity noises, rather than lower intensity being responsible for interrupted sleep (Muzet, 2007).

Noise management and staff knowledge of the issues associated with reduced sleep and care requirements is poor (Fillary et al., 2015; Christensen, 2005). Both patients and staff would benefit from quieter environments to enhance patient outcomes. Sleep promotion is part of the nurses' role, but to date has received little attention. Practitioners and hospital managers/administrators alike need to identify ways to reduce noise in ward environments to improve patients' sleep experience.

Following a detailed search of the literature, to our knowledge, this is the first systematic review and meta-analysis with the specific aim to identify primary research studies designed to test the effectiveness of noise reduction interventions in general wards settings.

## 2. Methods

A systematic review of published literature informed by reporting guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA, 2015) was performed. The review protocol is available from the corresponding author on request.

### 2.1. Eligibility criteria

Studies were selected according to the following criteria:

#### 2.1.1. Study designs

We included experimental studies (randomised controlled trials, controlled trials), cross-sectional, cohort, case control studies or quasi-experimental studies with a pre and post measures design. Qualitative studies were excluded.

#### 2.1.2. Participants and setting

The target population was adults (over 18 years) who were hospital patients from any acute and mental health in-patient settings. In line with international convention for sleep studies, patients must have had an overnight stay in hospital with admission before 22:00. Due to their specialist nature and different staff skills mix and staff patient ratios,

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