Advances in Nursing Science & Research

doi: 10.39127/2574-7823/ANSR:1000106
Aparício C. Ad Nurs Sci Resear: ANSR-106

Research Article

The Sources of Noise in Hospital Settings and the Associated Adverse Health Effects to Patients and Staff

Carlos Aparício, MSc, BSc (Hon), DipHE, RN*

Doctoral Student - Faculty of Health, Education, Medicine and Social care, Anglia Ruskin University Young Street, CB1 2LZ Cambridge, UK

***Corresponding author:** Carlos Aparício, MSc, BSc (Hon), DipHE, RN, Doctoral Student - Faculty of Health, Education, Medicine and Social care, Anglia Ruskin University Young Street, CB1 2LZ Cambridge, UK.

Citation: Aparício C (2020) The Sources of Noise in Hospital Settings and the Associated Adverse Health Effects to Patients and Staff. Ad Nurs Sci Resear: ANSR-107.

Received Date: 09 December 2020; **Accepted Date:** 14 December 2020; **Published Date:** 20 December 2020

Introduction

A quiet environment in a hospital ward is essential to support patients' sleep as well as supporting Healthcare Professionals (HCPs) to do their work. For patients, sleep is crucial for recovering from their illnesses and for combating infection [1]. During sleep, the body produces growth hormone, which is very important for wound healing and boosting the immune system to fight infections [1]. However, the lack of sleep due to noise in the ward environment can inhibit growth hormone production.

Amongst other factors that can disturb patients sleep, for example, environmental factors, clinical care and clinical diagnostics, noise is at the top rank of the factors that responsible for the lack of patients' sleep in hospital settings [2]. Studies found that hospitals' noise levels are always exceeded the conducive levels that support sleeping [3,4]. This may potentially create negative health effect on patients and staff.

The consequence of exposing to a continuously high level of noise result in adverse health effects, because noise can cause annoyance, anxiety, stress and delirium in patients [3,4]. Noise also causes stress, annoyance, interfere with speech and concentration in HCPs in the hospital setting (WHO, 2009) [5]. This systematic literature review aims to summarise all evidence of noise sources in hospital settings and the adverse effects on both patients and HCPs.

Noise Level Units

Similar to sound, the unit used to measure noise is in decibel (dB); it ranges between below 0dB-above 140dB [6]. The human ear cannot hear any levels below 0dB (low pitch), and any levels above 140dB (high pitch) can cause permanent deafness [5,6,7]. To accurately measure the noise levels, a different version of weighted frequency is used. There are three different known weighted frequencies: A-weighted, C-weighted and Z-weighted. The most common used weighted frequency in studies is the A-weighted version or abbreviated as "dB(A)" to filter out low pitch and high pitch noises that cannot be tolerated by the human ear (NIH, 2019) [7].

Method

A database search of the literature was undertaken to identify studies for review. The identified studies were assessed for bias with Critical Assessment Skills Programme (CASP) before analysing the study results. The findings are presented in themes.

Study Selection

The search was conducted across three databases; CINHAL, MEDLINE and PubMed. In addition, the reference search was also conducted to obtain other relevant publications. A deductive approach was carried out using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart [8].

Both methods of searching yield an accumulation of 5,011 articles and following the application of limiters (see diagram 1), this was reduced to 175 articles. The titles and abstracts were screened for study relevancy, and then the full-text screening of the remaining articles was carried out. As a result, nine studies were found to be relevant for inclusion in this systematic review.

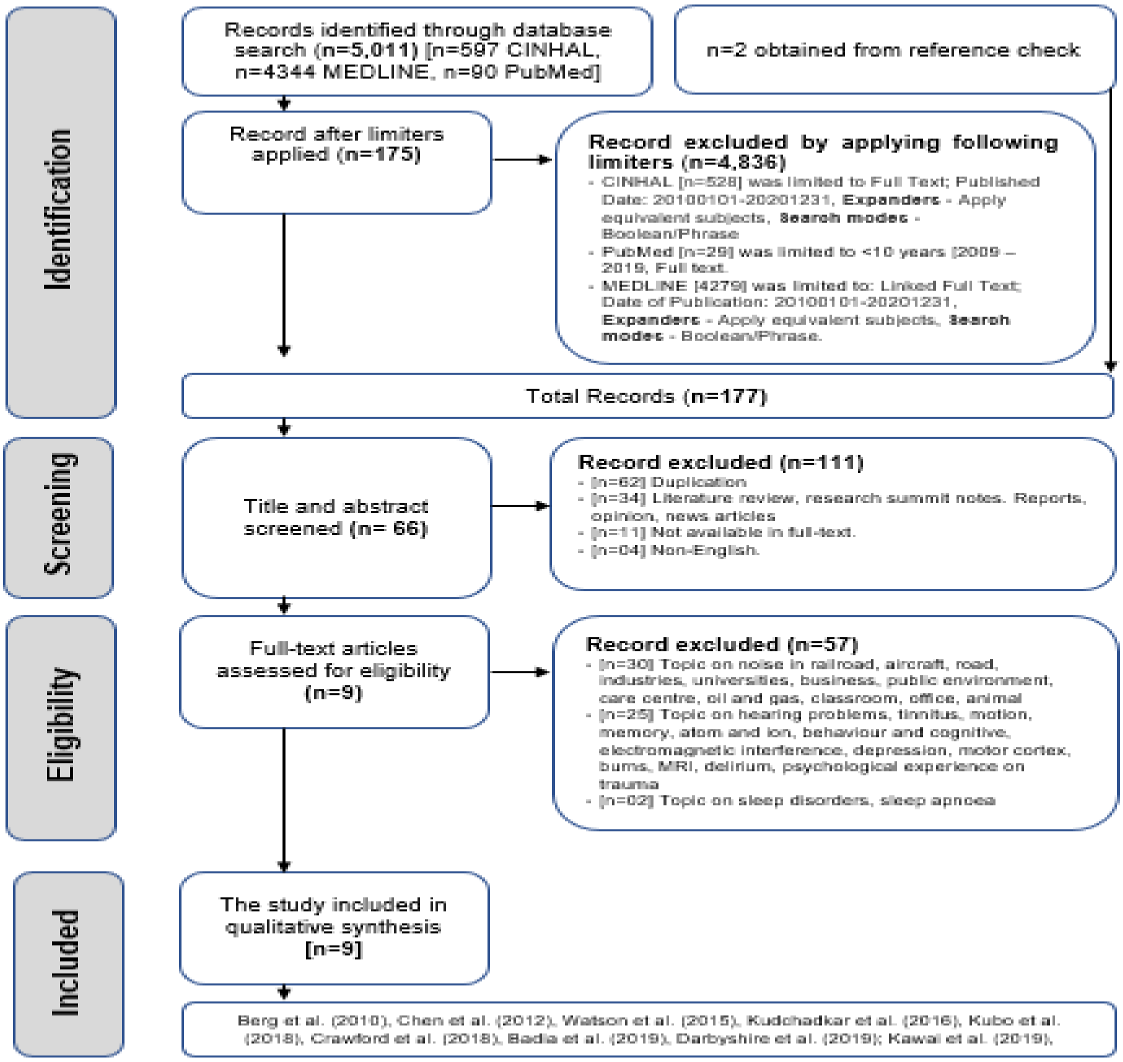

Diagram 1: Study deduction until final selection for review using PRISMA (Moher et al., 2009).

Risk of Bias Assessment

The studies included in this systematic review were assessed for bias with three different CASP checklist (Clisby and Charnok, 2000) [9]. CASP for cohort study was used to assess [10-15] and their score were 22, 20, 20, 22, 20 and 22 respectively (out of a possible score of 24). CASP for the trial was used to assess [16-17] and their score were 19 and 19 respectively (out of a possible score of 22). Finally, CASP for qualitative study was used for Kudchadkar et al. (2016) [18], and it scores 20 out of a possible score of 20.

Result

Following the qualitative analysis of the selected studies included in this systematic review (see table 1), four new themes emerged: (1). Noise levels exceeded the WHO's recommended levels, (2). Source of noise are from verbal conversations, monitors, alarms, medical equipment and environmental control system, (3). Noise adverse effects on patients and HCPs and (4) Recommendations for improving noise levels.

1. Noise Levels Exceed the WHO's Recommended Levels
   Similar to previous studies [3,4] this systematic review found that noise levels recorded in the selected studies were exceeded the noise level recommended by WHO (2009) [5]. This systematic review found a total of six out of nine studies recorded noise levels before their interventions [10,11,12,14-16].

Author (year) Country	Study Design	Intervention	Noise Levels	Noise Source	Adverse Effects	Limitation
Berg et al. [5] USA	Observational study	Records noise levels in 7 designated NICU areas for 24 hours per day over a week	>50dB(A) across all seven areas 56.96dB(A) is the mean average noise levels across Peak noise levels between 82-102 dB(A)	Monitors, alarms and medical equipment (exceeded 75 dB(A).	Routine noise monitoring to alert and sensitise the adverse effect of noise on the premature neonate	Small sample size
Chen et al. [11] USA	Environmental monitoring	Measuring full-shift personal noise exposure for two days while performing typical daily activities in the operating room	Sound levels >90dB(A). 76dB(A) – 95dB(A) during drill use 67dB(A) – 94dB(A) while playing music 69dB(A) – 90dB(A) during post-surgery clean-up activities	Surgery preparation Drilling Other powered surgical instruments Clean up after the operation music	Unwanted noise can interfere with operating room staff members' efficiency, productivity and ability to understand speech. Unwanted noise can be detrimental to comfort, health and well-being	Small sample size
Watson et al. [16] USA	A cross-sectional pilot study	Assessing noise levels and noise sources in 3 different speciality Pediatric intensive care units 15 nurses were observed for 4-hour sessions during the 24 hours The sound level was measured Heart rates were measured Stress rating was recorded	Cardiac ICU between 51-107 dB(A) Neonatal ICU between 53-102 dB(A) Pediatric ICU between 45-104 dB(A) Mean heart rate was 85.s/min	Noise from patient rooms Care activities Staff communication	91% nurse thought that noise could adversely affect their work environment 66% felt irritated and fatigue 43% admitted concentration problem and 40% experiences tension and headaches	Small sample size
Kudchadkar et al. [18] USA	Cross-sectional survey	Survey of nurses before and after the move to a new hospital building	N/A	Monitors, alarms Staff conversation	Nurses were less annoyed (33%) in single-patients rooms compare to 79% in multiple rooms	Small sample size
Kubo et al. [17] Japan	Environmental monitoring	Measuring noise levels of HFNC with or without filter	HNFC/Venturi when using modified T-piece can reduce noise levels from 70dB to 55dB. HFNC/Blender	Various types of oxygen therapy including HFNC	Noise can impair both physiologic and psychologic homeostasis of patients and staff	Small sample size
Badia et al. [13] USA	Cross-sectional quantitative and qualitative evaluation	Plan-do-study-act intervention Noise measurement Quality improvement initiative	Overnight mean decibel level decreased from 74dB – 44dB (6% reduction) Overnight noise spikes >60dB decreased from a mean of 865-463 (46%reduction)	Hallway noise Nurses gathering Noisy doors Trash pull In/out rooms	Sleep disruption negatively affects the healing process and recovery of the patient after transplant surgery. Sleep disruption affects the ability of caregivers to support their loved ones	Small sample size
Crawford et al. [12]	Quality Improvement	Train staff to keep noise	On flagged days the noise measurements	Heating, ventilation,	Noise reduction intervention was	Small sample size

USA		below 55dB(A) during the day and 50dB(A) during the night Noise measurement	are over 60dB(A) when HFR support devices were used	airconditioning system A high volume of respiratory-support devices	statistically significant but clinically irrelevant to reduce patients' exposure to potential adverse health effects.	
Darbyshire et al. [14] UK	An observational study	Noise measurement continuously for a year	Alarms noise level >50dB(A)	The loud sound originated from communication between patients, caring staff and visitors. A significant proportion of loud sound originated from equipment alarms, monitors and ventilators	Reduce speech comprehension in acute care High ambient sound levels also have a range of deleterious non-auditory health effects on staff	Small sample size
Kawai et al. [15] USA	Quality Improvement	Noise measurement	Max hourly sound was above 65dB(A) in occupied bed spaces. Median of all occupied bed spaces 48dB(A)	Alarms are modifiable noise source in PICU	High noise levels can put patients at risk of auditory and non-auditory health concern. Noise pollution increases the risk of delirium.	Small sample size

Table 1: Summary of studies on identifying noise sources and measuring noise levels and their health effects on patients and staff.

Although the lowest noise levels recorded were varied across the six studies, it was recorded at >50dB(A) and was reported in studies by Berg et al., (2010) [10] and Darbyshire et al. (2019) [14]. These findings also echoed in the previous study by Delaney et al. (2018) [19]. The researcher measured noise levels in 15 clinical areas before intervention which showed the mean noise levels was 36.7dB(A) and peak noise levels between 51.3dB(A) to 103.3dB(A). Which significantly above the recommended levels.

WHO (2009) [5] recommended that continuous noise levels in a hospital ward at night should not exceed 35dB(A) overnight, and individual noise peaks should not exceed 45dB(A) [6-13]. Put these noise levels into perspective [see Table 2], 30dB(A) is similar to soft music and whisper, and 70dB(A) is similar to a noisy restaurant [6-13]. When WHO receomended levels were compared to findings of studies in this systematic review, it was too low.

Decibel level	Equal to
140 dB(A)	Gunshot or jet engine take off
110 dB(A)	Jackhammer, loudest transient peak of change of shift
100 dB(A)	Portable X-ray
90 dB(A)	Motor cycle
80 dB(A)	Loud radio, garbage disposal
70 dB(A)	Hairdryer, noisy restaurant, washing machine
60 dB(A)	Busy street, alarm clock
50 dB(A)	Normal conversation
40 dB(A)	Moderate snoring
30 dB(A)	Soft music, whisper
20 dB(A)	Whisper
10 dB(A)	Normal Breathing
0 dB(A)	Limit of human hearing

Table 2: Example of noise produced by the decibel levels (Cmiel et al. 2004; Badia et al. 2019).

2. Noise Sources

2.1. Verbal Communication Raises Noise Levels

Verbal communication or conversation is a fundamental part of HCPs jobs and is one of the core competencies that staff must-have. With this competency, professionals can communicate patients' data, diagnosis and plan of care to other professionals. It will be a problem when conversations become uncontrollable and become one of the factors that disturb patients' sleep (Aparício and Panin, 2020) [2].

Four studies in this systematic review found that verbal communication and conversation between professionals raise the ward's noise levels. For example, Berg et al. (2010) [10] recorded a 24-hour noise levels in seven designated Neonatal-ICU over one week to examine and monitor the sources of noise. They found that the conversation during the ward round and conversations at the nursing stations always exceeded 75dB(A). This noise source was also reported in Watson et al. (2015) [16] and Kudchadkar et al. (2016) [18]. Watson et al. (2015) [16] found that noise from staff conversations was amongst the three most frequently occurring noise sources. This was also highlighted in a previous study by Fillary et al. (2015) [20] as one of the factors that contributed to noise levels, especially during shift changes.

Futhermore Darbyshire et al. (2019) [14] carried out an observational study to explore the principal source of noise in an Adult-ICU. They recorded noise levels continuously for a year by installing four arrays of sixteen microphones into the ward's ceilings. They concluded that a high level of noise found in a place where the conversation and discussion were commonly taking place.

The verbal communication issue in this systematic review corresponds with a literature review by Aparício and Panin (2020) [2]. They compared sleep-promotion interventions between ICU and acute ward settings to explore similarities and differences of strategies. They found that conversation by staff at nursing stations was the primary sleep-disturbing factor. This was further reported by Walker and Karl (2019) [21]. The researchers surveyed staff noise perception and identified that 90.91% noise on the unit was from staff conversation.

2.2. Noise from Alarms and Monitors

In the critical care setting alarms and monitors are vital to all interventions to save lives. It is so essential that alarms and monitors are often taken for granted, and less attention paid to noise that they produce, in many ways, it disturbs patients sleep [19]. Three studies in this systematic review identified alarms and monitors as a potential source of the noise. For example, Kawai et al. (2019) [15] assessed the degree of Paediatric-ICU noise levels, to develop a delirium bundle targets the noise levels reduction. The "delirium bundle" consisted of activities to normalise sleep cycle, improve orientation to environment, minimise sedation, increase mobility, reduce medication, and treat the pain. The researchers installed sensors in patients' bed spaces, hallways, and common areas to record noise. The researchers identified the alarms as the sources of noise which corresponds with Berg et al. (2010) [10] and Kudchadkar et al. (2016) [18]. Kudchadkar et al. (2016) [18] surveyed nurses' perceptions and experience of a paediatric environment after the ward was modified from multi-patient bay to a single patient's room to reduce noise. They surveyed 100 nurses with different years of experience working in the ward. The survey revealed that single rooms are more conducive to patients sleep, but monitors and alarms persisted affecting sound levels in the unit. These findings were similarly reported by Darbyshire et al. (2019) [19].

Furthermore, these findings also correspond to a cross-sectional study by Delaney et al. (2018) [19] who investigated the perceived duration and quality of patients sleep to identify any environmental factors associated with patient-reported poor sleep in the hospital. They interviewed 144 patients across 15 hospitals; they also collected 81 self-reported survey forms from nurses. The researchers found that patients' sleep duration and sleep quality reduced due to sleep inhibiting factor, which includes conversations, alarms, telephone calls and patients buzzers.

2.3. Noise from Oxygen Therapy and Surgical Instrument

Oxygen therapy, such as high flow oxygen is essential for saving lives, but it has been identified by two studies in this systematic review as potential sleep disturbance factors. For example, Crawford et al. (2018) [12] studied the effectiveness of a behaviour-based intervention to reduce noise and to identify noise sources in a Medical-ICU. Noise levels were recorded continuously and were compared by room position, occupancy status, and time of the day. They found that noise levels above 60dB(A) recorded in the use of high-flow respiratory devices compared to low-flow devices (OR= 5.3, 95% CI = 5.0–5.5). Similarly, Kubo et al. (2018) [17] evaluated three types of High Flow Nasal Cannula (HFNC) [HFNC/venturi, HFNC/blender, and HFNC/turbine] compared to two types with the filter attached for noise reduction. HFNCs were positioned at the centre of a hospital room, and the noise levels measured at the distance of 1-meter from the equipment at various total flows. Their study showed that noise levels were increased with HFNCs when total flow and oxygen concentration was increased. Noise levels decreased with the HFNCs when filters were applied.

In terms of medical equipment, Chen et al. (2012) [11] identified that powered surgical tools in theatres could be very noisy. For example, the noise produced from a surgical instrument such as surgical drill can reach up 76-95dB(A), and post-surgery clean up can reach between 69-90dB(A) [11]. However, the noise recorded was from a wearable recording device that attached to the staff's theatre gown; the noise levels may have been underestimated due to the microphone was covered by the gown. In addition, the second sound recording device was placed 3-meters away from the noise source, which may not accurately record the noise levels.

2.4. Noise from Hallway

One study found that the hallway at night can be very noisy. Badia et al. (2019) [13] implemented Quality Improvement to improve sleep quality in transplantation and cellular therapy patients. They collected a baseline noise levels using a sound meter, which was placed in the unit's hallway for ten days. While at the same time, a night-time nurse observed and documented the identifiable source of hallway noises. Noise spikes were compared with identifiable noise sources. The study identified unnecessary trash pulls by domestic staff at night, opening/closing door to patients' room, hallway equipment closets and wall-mounted workstations, found that these noise sources were transmitting noise into the patients' room. There was 6% reduction in night-time hallway noise [47dB(A)-44dB(A)], and 46% [865 spikes to 463 spikes] of noise peaks after the intervention. However, there was no subjective evaluation from patients which was considered as the limitation of this study. This result was also reported in a similar study by Filus et al. (2015) [22]. The researchers assessed the sound environment in an emergency ward. They observed when objects fell or when stretcher and tables were manipulated, when garbage cart was transported or when waste bin receptacle was opened or closed, the noise levels were reached up to 80dB(A).

2.5. Noise from Heating, Ventilation and Air-Conditioning (HVAC) System

Although the HVAC system is designed for environmental and temperature control in the hospital wards, they may produce noise that disruptive to patients sleep. Two studies in this systematic review identified HVAC system as the source of the noise. Badia et al. (2019) [13] found that the noise produced from this equipment can reach up to 38dB(A) at night. This level alone exceeds the continuous background noise levels of 35dB(A) as recommended by WHO (2009) [5]. The similar finding also echoed in the study by Crawford et al. (2018) [12]. The researcher identified that HVAC system contributed to high background noise in Medical-ICU. This source of noise corresponds to a previous study by Wiese and Wang (2011) [23]. The researchers carried out a pre and post-intervention noise levels measurement and concluded that HVAC was one of the top five sources of noise in the hospital.

2. Adverse Health Effects of Noise on Patients and HCPs

The adverse health effect of continuous exposure to the noisy environment on patients causes distress, disorientation [14], delirium, increase the risk to hospital-acquired infection (NHS Improvement, 2018) [24]. It also causes a lack of sleep in patients in hospitals. Similarly, it increases annoyance (WHO, 2009) [5], increase heart rate (Buxton et al., 2012) [25] and reduce concentration [11] in HCPs. The lack of concentration has been associated with surgical site infection postoperatively. A previous study by Kurmann et al. (2011) [26] evaluated noise levels in an operating theatre to detect any correlation between noise levels and subsequent surgical site infection. They measured noise levels during 35 elective abdomen procedures, and a standard questionnaire was used to evaluate the behaviour of the surgical team during the operation. The study found that intraoperative noise levels was associated with the infection rate. They concluded that this association was due to the lack of concentration from a stressful environment.

The adverse health effect also reported by Watson et al. (2015) [16]. The researchers explored and measured the source of noise and the effect of noise on the registered nurses using noise dosimeter [Quest Technologies] with a microphone attached to each participants lapel. They found that the mean noise levels were 71.9dB(A) (SD, 9.2), the mean heart rate [85.2/min] was significantly associated with noise.

3. Recommendations for Improving Noise Levels

Having identified the source of noise, and the adverse health effect on patients and HCPs, all studies included in this systematic review recommended ways to reduce noise levels. Berg et al. (2010) [10] recommended physical environment modification and education of HCPs and patients to monitor conversation level. This recommendation was also echoed in the study by Kawai et al. (2019) [15]. The researchers recommended behavioural modification using a simple bedside 'delirium bundle checklist' to reduce noise.

Similarly, Watson et al. (2015) [16] recommended behavioural modification as the means for noise reduction. At the same time, Crawford et al. (2018) [12] recommended a combination of physical environment modification as well as the behavioural modification to achieve optimum noise reduction. For instance, by installing sound-absorbing materials to the walls and the use of sound-absorbing tiles. Furthermore, Chen et al. (2012) [11], Crawford et al. (2018) [12], and Kawai et al. (2019) [15] recommended using of hearing protector such as earplug improve noise-related sleep disturbance.

In summary of the result section, there are two similarities in all studies included in this systematic review. The first similarity is the noise levels in those studies are always above WHO (2009) [5] recommended levels for daytime and night-time. The second similarity is that all studies have a small sample size which may limit the transferability of the study result in other settings [27].

Discussion

In hospital settings, high noise levels have always been the issue. This systematic review found that the minimum noise level is >50dB(A) which is significantly exceeds WHO noise levels recommendations for both daytime and night-time (Crawford et al., 2018; Kawai et al., 2019) [12,15]. The reason for this significance is because healthcare services are increasingly using technologies in medical interventions, which results in the increases in noise levels [20,28]. However, some researchers consider the WHO (2009) [5] recommended noise levels are too low and are not realistic in hospital settings and they have called for an urgent review to reflect the current increase of technologies used in medical interventions.

In terms of noise sources, this systematic review found that verbal communication between HCPs and between HCPs and patients was the most mentioned source of the noise in the studies included in this systematic review [10,14,16]. Although conversation raises noise levels, it is an integral part of HCPs roles. Because verbal communication is used to communicate patients' conditions, care plans, diagnostics between the multidisciplinary team, between HCP and patients/relatives, but it becomes an issue when conversation raises environmental noise levels. It interferes with speech perceptions, interferes with planned activities [28] and much worse; disturbs patients sleep [18,22,28].

Equally, this systematic review also found that monitors and alarms as the source of noise [12,15,18] and raise noise levels significantly [28]. Mostly noise that created by false alarms is the second most frequently occurred as a sleep-disturbing factor [14]. This systematic review also found noise sources from HFNC oxygen therapy in respiratory patients and HVAC systems. Although these sources generate low noises, it can reach up to 38dB(A) at night [13]. A continuous low-level noise overnight has been associated with sleep disturbance [17].

The traditional noise source from electronic devices such as telephones, patients' buzzer, intercoms, paging system, television and patients' mobile phones were not identified in the current systematic review. However, previous studies have reported these electronic devices as the source of noise that disturbs patients sleep in hospital settings especially at night [19,20].

The strength of this systematic review is the use of PRISMA to identify articles for review, and the use of CASP to assess the potential bias in the studies, however, there are limitations that the author would like to highlight. First, the narrow focus of this systematic review was on noise sources and the adverse health effects on patients and HCPs. It provides an incomplete summary of ways to improve patients sleep experiences, as noise reduction is one part of the broader interventions targeting sleep inhibiting factors. Second, the limitation of the database used to only three databases; it might have missed source of noise generates from electronics devices in the hospital. Finally, the result of this systematic review needs careful interpretation considering the sample sizes in the studies included in this systematic review were small, limiting the generalizability to the other settings within health sectors.

Acknowledgements

The author would like to thanks Hillary Bungay and Jo-Anne Johnson who spared their time for reviewing the manuscript before submission. The decision to write this systematic literature review and submit for publication was no involvement of anyone other than the author.

Conclusion

The majority of noise sources identified in this systematic review are coming from verbal communications, medical equipment, and HVAC systems. Although medical equipment and verbal communications are vital for patients' care, it is also essential to balance the noise levels produced by using noise reduction interventions. One way to improve noise levels is to promote interventions by targeting both physical environmental modification and HCPs' behavioural modification to achieve optimum noise reduction in hospital settings.

Statement of Significance

- Sleep is vital for patients in the hospital, but noise prevents patients from sleeping.
- Noise as the result of conversations of healthcare professionals can be the source of noise disturbing patients sleep.
- Monitors and alarms are essential for saving lives in ICU and recovery, but the noise produced by alarms and monitors can disturb patients' sleep.
- Behavioural change, coupled with physical environment modification is recommended to achieve optimum noise reduction.

Reference

1. Zakri, J., 2019. Stages of Sleep and Sleep Cycles. Available at: https://www.tuck.com/stages/. Accessed on 12th October 2020.
2. Aparício, C., and Panin, F. 2020. Interventions to improve inpatient's' sleep quality in the intensive care unit and acute ward settings: a literature review. *British Journal of Nursing* 29(13) pp770-776. https://doi.org/10.12968/bjon.2020.29.13.770
3. Patel J, Baldwin J, Bunting P, and Laha S. 2014. The effect of a multicomponent multidisciplinary bundle of interventions on sleep and delirium in medical and surgical intensive care patients. *Anaesthesia,* 69(6):540-549. https://doi.org/10.1111/anae.12638
4. Foreman B, Westwood A, Claassen J, and Bazil C. 2015. Sleep in the Neurological Intensive Care Unit: Feasibility of Quantifying Sleep After Melatonin Supplementation with Environmental Light and Noise Reduction. *J of Clinic Neuropathy,0* 32(1):66-74. DOI: 10.1097/WNP.0000000000000110
5. World Health Organization. 2009. *Night Noise Guidelines for Europe.* http://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf. Accessed on 18/04/2020.
6. Cmiel CA, Karr MD, Gasser DM, Oliphant LM, and Neveau JA. 2004. Noise Control: A Nursing Team's Approach to Sleep Promotion. *The American Journal of Nursing* 104(2), Pg.40-49. DOI: 10.1097/00000446-200402000-00019
7. National Institute of Health [NIH]. 2019. *How is Sound Measured?* Available at: https://www.noisyplanet.nidcd.nih.gov/have-you-heard/how-is-sound-measured. Accessed on 5th July 2020.

8. Moher D, Liberati A, Tetzlaff J, Altman GD. The PRISMA Group. 2009. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med* 6(7):1-6. DOI: https://doi.org/10.1136/bmj.b2535
9. Clisby N, and Charnock D. 2000. *DISCERN/CASP Workshops 2000 Final Project Report. Crit Appr Skills Prog*, Institute of Health Sciences: Oxford.
10. Berg, LA, Chavez, LT, and Serpanos CY. 2010. Monitoring Noise Levels in a Tertiary Neonatal Intensive Care Unit. *Contemp Iss in Comm Sci and Dis* 37:69-72. https://doi.org/10.1044/cicsd_36_S_69
11. Chen L, Brueck ET, and Niemeier TM. 2012. Evaluation of Potential Noise Exposure in Hospital Operating Rooms. *AORN J* 96(4):412-418. DOI: 10.1016/j.aorn.2012.06.001
12. Crawford JK, Barnes, AL, Peters MT, Falk J, and Gehlbach KB. 2018. Identifying Determinants of Noise in a Medical Intensive Care Unit. *Jour of Occup Envir Hyg* 15(12):810-817. DOI: 10.1080/15459624.2018.1515491
13. Badia P, Hickey V, Flesch L, Byerly M, Sensibaugh C, Potts K, Michel C, Drozd A, Curd F, Crosby L, Beebe D, Davies MS, and Dandoy EC. 2019. Quality Improvement Initiative to Reduce Night-time Noise in a Transplantation and Cellular Therapy. *Biologic Blood Marrow Transplant* 25:1844-1850. https://doi.org/10.1016/j.bbmt.2019.05.001
14. Darbyshire JL, Müller-Trapet M, Cheer J, Fazi FM, and Young JD. 2019. Mapping sources of noise in an intensive care unit. *Anaesthesia* 74:018-1025. https://doi.org/10.1111/anae.14690
15. Kawai Y, Weatherhead RJ, Traube C, Owens AT, Shaw EB, Fraser JE, Scott MA, Wojczynski RM, Slaman LK, Cassidy MP, Baker AL, Shellhaas AR, Dahmer KM, Shever LL, Malas MN, and Niedner FM. 2019. Quality Improvement Initiative to Reduce Paediatric Intensive Care Unit Noise Pollution with the Use of a Paediatric Delirium Bundle. *J of Intensive Care Med* 34(5):383-390. https://doi.org/10.1177/0885066617728030
16. Watson J, Kinstler A, Vidonish PW, Wagner M, Lin L, Davies GK, Kotowski ES, and Daraiseh MN. 2015. Impact of Noise on Nurses in Pediatric Intensive Care Units. *Am J of Crit Care*, 24(5):377-384. DOI: 10.4037/ajcc2015260
17. Kubo T, Nakajima H, Shimoda R, Seo T, Kanno Y, Kondo T, and Tamai S. 2018. Noise Exposure from High-Flow Nasal Cannula Oxygen Therapy: A Bench Study on Noise Reduction. *J of Resp Car*, 63(3):267-273. DOI: https://doi.org/10.4187/respcare.05668
18. Kudchadkar RS, Beers MC, Ascenzi AJ, Jastaniah E, and Punjabi MN. 2016. Nurses' Perceptions of Paediatric Intensive Care Unit Environment and Work Experience After Transition to Single-Patient Rooms. *Am J of Crit Care*, 25(5):98-107. DOI: 10.4037/ajcc2016463
19. Delaney JL, Currie JM, Huang CH, Lopez V, and Van Haren F. 2018. "They Can Rest at Home": An Observational Study of Patients' Quality of Sleep in an Australian Hospital. *BMC Health Serv Resea,* 18:524-533. https://doi.org/10.1186/s12913-018-3201-z
20. Fillary J, Chaplin H, Jones J, Thompson A, Holme A, and Wilson P. 2015. Noise at night in hospital general wards: a mapping of the literature. *Brit J of Nurs* 24(10):536-540. DOI: 10.12968/bjon.2015.24.10.536
21. Walker, L., and Karl, A.C., 2019. The Hospital (Not So) Quiet Zone: Creating an Environment for Patient Satisfaction Through Noise Reduction Strategies. *Health Environment Research* 12(4), Pg.197-202. DOI: 10.1177/1937586719839229
22. Filus W, De Lacerda BMA, and Albizu E. 2015. Ambient Noise in Emergency Rooms and Its Health Hazards. *International Arch Otorhinolaryngology* 19:205-209. DOI: 10.1055/s-0034-1387165
23. Wiese, C., and Wang, L.M., 2011. *Measured levels of hospital noise before, during, and after renovation of a hospital wing, and survey of resulting patients perception*. Architectural Engineering faculty publication 44. Available at: https://digitalcommons.unl.edu/archengfacpub/44/?utm_source=digitalcommons.unl.edu%2Farchengfacpub%2F44&utm_medium=PDF&utm_campaign=PDFCoverPages. Accessed on 23 November 2020.
24. NHS Improvement. 2018. *Guide to reducing long hospital stays*. Available at: https://improvement.nhs.uk/documents/2898/Guide_to_reducing_long_hospital_stays_FINAL_v2.pdf. Accessed on 9th July 2020.
25. Buxton O, Ellenbogen J, Wang W, Carballeira A, O'Connor D, Gordhan-das A, McKinney S, Solet JM. 2012. Sleep disruption due to hospital noise. *Annals Inter Med* 3:170–179. https://doi.org/10.7326/0003-4819-156-12-201208070-00472
26. Kurmann A, Peter M, Tschan F, Mühlemann K, Candinas D, Beldi G. 2011. The adverse effect of noise in the operating theatre on surgical-site infection. *Brit J of Surg* 98(7):1021-1025. DOI: https://doi.org/10.1002/bjs.7496.
27. Ajetunmobi, O., 2002. *Making Sense of Critical Appraisal*. Hodder Arnold an Imprint of Hodder Arnold Education – London. ISBN 978-0-340-80812-2
28. Oleksy, A., and Schlesinger, J.J., 2019. What's all that noise – Improving the hospital soundscape. Journal of Clinical Monitoring and Computing 33, Pg.557-562. https://doi.org/10.1007/s10877-018-0215-3.
29. Aveyard H, Payne S, and Preston N. 2016. *A Post-graduate's Guide to Doing a Literature Review in Health and Social Care*. Open University Press: England. ISBN 987-0-3352-6368-4.