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SYSTEMATIC REVIEW

Sleep Bundles in the Intensive Care Unit: A Systematic Review

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Abstract

Background: Sleep quality is essential for critically ill patients, both for recovery and maintaining overall health. Sleep facilitates healing, bolsters immune function, and aids in managing stress and pain. Numerous studies have explored various interventions to enhance sleep quality, including both single and "bundled" approaches. These bundled interventions, as defined by the Institute for Healthcare Improvement, are combinations of evidence-based practices that are more effective collectively than individually. Despite the recognized importance of sleep and the investigation into these interventions, there has yet to be a literature review assessing the effectiveness of bundled sleep interventions specifically for critically ill patients.

Objective: This review aims to examine the components, implementation, and outcomes of sleep bundles on patient sleep quality in critical care settings.

Research Methodology: A systematic literature search in PubMed, CINAHL, and Embase followed the PRISMA guidelines. Studies were evaluated using the Johns Hopkins Nursing Evidence-Based Practice models and scored based on study type and quality. Primary interest focused on sleep quality, with secondary outcomes being ICU and hospital length of stay. Included studies were conducted in intensive care units and featured sleep quality as a primary or secondary outcome. Literature reviews and pediatric patient studies were excluded.

Results: Eleven studies, encompassing 1560 patients, met the inclusion criteria. Four studies demonstrated sleep quality improvement, while seven did not. Despite considerable heterogeneity in sleep bundle interventions, four studies with significant sleep quality improvement shared five non-pharmacologic interventions: providing eye masks and earplugs, adjusting light, controlling environmental noise, and re-timing patient care activities. Notably, studies featuring pharmacologic interventions in sleep bundles did not yield significant sleep quality improvement. Due to heterogeneity in sleep bundle components, outcomes, ICU environments, patient populations, and implementation strategies, a meta-analysis was not conducted.

Discussion: This review's results might suggest that bundled sleep interventions are ineffective; however, this conclusion is potentially misleading due to the methodological limitations of the studies These limitations include significant heterogeneity, reliance on subjective sleep questionnaires instead of objective polysomnography in ten of the eleven studies, and the predominance of quasi-experimental pre-post designs. Further studies should be conducted before reaching a definitive conclusion.

Introduction

ICU patients often experience significant alterations in sleep patterns which may be characterized by highly disrupted sleep, disturbances in circadian rhythm, increased time taken to fall asleep, frequent arousals during the night, and decreased efficiency of nighttime sleep [1]. Extended periods of time spent in an Intensive Care Unit (ICU) can engender deleterious physical and mental health consequences for patients [2]. Among the multifarious factors that heighten the probability of adverse outcomes, sleep quality surfaces as a determinant [2]. Lack of sleep is expected in the ICU and has been documented as a risk factor for delirium, decreased immune function, and longer recovery time [3]. The quality of sleep in ICUs can be influenced by factors such as noise, light, pain, and care activities that disrupt sleep [3]. Lewandowska, et al. [4] pinpointed pain as cause of sleep disturbance in ICUs related to surgical procedures and invasive devices.

Empirical studies have underscored that the ICU environment can be contributory to sleep disturbances. High nocturnal light levels in ICUs are known to affect melatonin secretion and circadian rhythm regulation [5]. In addition, the literature has highlighted that noise in ICUs can reach as high as 80 decibels, which

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is far higher than the United States Environmental Protection agency's recommended 35 to 45 decibels [6]. Consequently, patients, already critically ill, navigating these impediments to adequate sleep quality in the ICU are predisposed to additional complications.

Numerous studies have explored interventions to ameliorate sleep quality in the ICU, both individually and as part of multicomponent intervention packages, commonly referred to as a "bundle." A bundle is characterized as a collection of three to five evidence-based interventions whose collective implementation yields superior results compared to individual interventions [7]. Bundles have been utilized in the ICU environment for various purposes to include infection prevention [8].

Despite the widespread utilization of "sleep bundles" within ICUs, there exists substantial heterogeneity in the interventions employed within these bundles, without any universally accepted sleep bundle strategy. These bundles tend to consist of several interventions, some of which are pharmacological, some non-pharmacological, or often, a combination of both. In general, sleep bundles typically include measures to modify the physical environment such as readjusting light and noise levels, promoting sleep hygiene, modifying bedding, or using sleep aids like white noise. However, the diverse range of interventions included in these bundles presents a challenge when attempting to ascertain the individual efficacy and practicality of each intervention. This variability also poses a challenge for systematic assessment and comparability between studies.

Within the existing literature, there seems to be an absence of a comprehensive review that evaluates sleep bundles and their associated interventions in the ICU setting specifically. This literature review serves the purpose of critically examining these varied sleep bundles, analyzing the effectiveness of the interventions for improving sleep quality in ICU patients. By identifying shared characteristics among successful interventions and spotlighting currently unexplored areas of research, this review underpins the importance of developing and implementing evidence-based and effective sleep bundles within ICU settings. The aim of comprehensive review not only provides a detailed analysis of existing approaches but also establishes a foundation for future investigations, that may improve sleep quality for patients in intensive care units.

Methods

A systematic review was conducted to answer the question, "Do bundle sleep interventions and sleep protocols improve sleep quality in adult, critically ill patients in intensive care unit (ICU) settings compared to usual care? The study protocol was registered in Prospero (ID: 344864). The findings from the review are reported using the Preferred Reporting Items for Systemic Reviews and Meta-Analysis (PRISMA) [9].

Search Strategy

A comprehensive search was conducted using Embase, CINAHL Plus, and PubMed databases. A priori, search terms were segmented under four distinct concepts: sleep, critical-care, bundle, and protocols. The term 'protocol' was included as some protocols align with the Institute for Healthcare Improvement (IHI) definition of a bundle - an evidence-based, structured methodology for enhancing patient outcomes and care processes through the implementation of three to five procedures [7]. Combinations of Boolean operators "AND" and "OR" were utilized during the search, and these operators were modified to capture relevant studies. In addition, search strategies involved the use of MeSH terms as well as searches for free-text terms in titles and abstracts (Table 1).

Inclusion and Exclusion Criteria

Inclusion criteria for articles incorporated studies featuring adults (over the age of 18) admitted to ICUs, with sleep quality as a primary or secondary outcome, and bundled sleep interventions as an independent variable. Systematic reviews, scoping reviews, literature reviews, meta-analyses, dissertations, conference proceedings, articles not written in English, and studies solely focusing on pharmacologic interventions were excluded. Systematic, scoping, and literature reviews, meta-analyses, and dissertations were excluded to avoid potential bias or redundancy. Similarly, conference proceedings were not included due to their often-preliminary nature and lack of detailed methodology. Non-English articles were excluded to ensure uniform understanding, and studies focusing solely on pharmacologic interventions were omitted to concentrate on the impacts of collective, non-pharmacologic interventions on sleep quality.

Search Results and Critical Appraisal

This search yielded 14,901 studies, which were screened by title and abstract using the defined inclusion and exclusion criteria. Of these, 139 articles were selected for a comprehensive full-text review, ultimately resulting in 13 eligible articles. Studies were screened by a minimum of two independent reviewers (RP, AP, & KS), with a third reviewer (OK) resolving any conflicts in both the title and abstract screening and full-text review. The 'Johns Hopkins Nursing Evidence-Based Practice Levels of Evidence guide' was employed to evaluate the quality and evidence level of the articles [10]. The quality of articles was judged based on sample size, bias, confounding, and the presence of significant flaws in the study by two reviewers, and a third reviewer assisted with reaching a consensus.

Table 1: Study characteristics.

Author,	Country	ICU Setting	Study design	Total Sample Size	Evidence Levels	Quality Levels
Beltrami, 2021 [1]	Brazil	General ICU	Quasi-Experimental: Pre-Post Study Design	113	2	B
Boyko, 2017 [19]	Denmark	Medical ICU	Randomized Control Trial	17	1	B
Chen, 2022 [12]	China	Cardiac ICU	Quasi-Experimental: Pre-Post Study Design	67	2	B
Darby, 2022 [13]	United States	Medical ICU	Quasi-Experimental: Pre-Post Study Design	162	2	B
Jinglin, 2019 [14]	Canada	Medical ICU	Pilot Study Pre-post Design	82	2	C
Kamdar, 2013 [15]	United States	Medical ICU	Quasi-Experimental: Pre-Post Study Design	300	2	B
Locihova, 2020 [16]	Czech Republic	General ICU	Quasi-Experimental: Pre-Post Study Design	40	2	C
Patel, 2014 [17]	United States	Medical & Surgical ICU	Quasi-Experimental: Pre-Post Study Design	59	2	B
Tonna, 2021 [2]	United States	Surgical ICU & Cardiovascular ICU	Quasi-Experimental: Pre-Post Study Design	646	2	B
Topcu, 2022 [18]	Turkey	Medical ICU	Quasi-Experimental: Pre-Post Study Design	74	2	B

Data Extraction

Extracted data encompassed a variety of aspects including study characteristics, participant characteristics, type of intervention, instruments used to measure outcomes, and outcome measures (sleep quality, sleep duration, ICU length of stay, and hospital length of stay). In regards to the definition of sleep quality studies have suggested sleep quality consist of four components: sleep efficiency, sleep duration, wake after sleep onset, and sleep duration [11]. The various studies utilized both subjective and objective measures. One author extracted the data, while a second person reviewed to ensure the accuracy of the data extracted, and a third person resolved any conflicts (Table 2).

Data Synthesis

The characteristics of the studies, participants, intervention types, and instruments employed are systematically organized in tabular format and explicated through a narrative method. Studies were classified according to various criteria, such as the sleep bundle's constituent interventions and the nature of the ICU environment (e.g., Neurological, Cardiac, Medical). Additionally, studies were categorized based on their research design (e.g., quasi-experimental, observational, and randomized control trial). A meta-analysis could not be conducted in this instance.

Results

This review resulted in ten studies published between 2012-2022. Nine studies utilized a quasi-experimental pre-post design, while one was a randomized control trial. The selected Quasi-Experimental Studies involved a cumulative total of 1543 patients [1,2,12-18]; while the experimental study had 17 patients. All the studies were conducted in Intensive Care Units (ICU). However, there was heterogeneity in the types and specialties of ICU, including medical, surgical, and cardiac. There was heterogeneity in the location of the studies as well as four studies took place in the United States [2,13,15,17], while others took place in either Brazil, Canada, Czech Republic, China, Denmark or Tukey [1,12,14,16,18,19].

Patient Characteristics

Patient demographics and characteristics varied across the reviewed studies, with a median age difference not exceeding six years, except in the study by Darby, et al. [13]. Male participants dominated the sample population, comprising 56% of the total. Most studies did not include patients' races, and only 2 recorded the percentage of non-white patients. There was significant heterogeneity in patient comorbidities and inclusion criteria across the studies. However, the representation of racial groups was not uniformly reported across all of the studies. A significant disparity was observed in patient comorbidities and inclusion criteria among the studies, affecting the potential for generalizing the outcomes. For example, Chen, et al. [12] only included patients who had undergone cardiac surgery for the first time. Inclusion and exclusion criteria varied drastically among the studies, from patients who were required, to a score of 11 or above on the Glasgow coma scale [16,18], to studies only including patients who are intubated (Table 3).

Instruments Used to Measure Sleep Quality

To assess sleep quality a variety of tools were used across the studies. Most commonly, the Richard Campbell Sleep Questionnaire (RCSQ), which consists of 5 questions has been validated in both English

Table 2: Participant Characteristics.

Author, year	Intervention	Sample Size	Age	Sex	Race	Comorbidities
Beltrami, 2022 [1]	Pre	58	Mean: 58.7	Male: 38 (65.5%) Female 20 (35.5%)	White: 51(87.9%)	Hypertension, Heart Failure, Diabetes, Ischemic Heart Disease
	Post	55	Mean: 62.6	Male: 40 (72.7%) Female: 15(27.3%)	White: 47 (85.5%)	Hypertension, Heart Failure, Diabetes, Ischemic Heart Disease
Boyko, 2017 [19]	Control	17	Mean: 67	Male: 9(53%) Female: 8(47%)	Not Reported	Pneumonia, COPD, hemorrhage, Sepsis, Neurologic Disease
	Intervention	17	Mean: 67	Male: 9(53%) Female: 8(47%)	Not Reported	Pneumonia, COPD, Hemmorhage, Sepsis, Neurologic Disease
Chen, 2022 [12]	Pre	37	Mean: 66.78	Male: 27(73%) Female: 10(27%)	Not Reported	Hypertension Coronary Artery Disease, all patients had undergone surgery for the first time.
	Post	30	Mean: 64.97	Male: 22(73.3%) Female: 8(26.7%)	Not Reported	Hypertension Coronary Artery Disease, all patients had undergone surgery for the first time.
Darby, 2022 [13]	Pre	78	Median: 69	Male: 43(55.1%) Female: 35(44.9%)	Caucasian - 40(51.3%) African American - 23(29.5%) Asian - 1(1.3%) Other - 14(17.9%)	Respiratory Failure, Gastrointestinal, Non pulmonary Sepsis Cardiovascular, Other
	Post	84	Median: 58	Male: 40(47.6%) Female: 44(52.4%)	Caucasian - 44(52.4%) African American - 28(33.4%) Asian - 1(1.2%) Other - 11(13.1%)	Respiratory Failure, Gastrointestinal, Non pulmonary Sepsis Cardiovascular, Other
Jinglin, 2019 [14]	Pre	34	Mean: 66.7	Male: 18 (52.9%) Female: 16 (47.1%)	Not Reported	Patients Hospitalized for various conditions including: CNS, Respiratory, Cardiovascular, Gi/ GU
	Post	38	Mean: 60.6	Male - 21(43.8%) Female -27(56.3%)	Not Reported	Patients Hospitalized for various conditions including:CNS, Respiratory, Cardiovascular, Gi/ GU
Kamdar, 2013 [15]	Pre	122	Mean: 54	Male = 68(55.7%) Female = 54(44.3%)	White-49(40.2%)	Not Reported
	Post	178	Mean: 54	Male = 85(47.7%) Female = 93(52.3%)	White-82(46.1%)	Not Reported
Locihova, 2020 [16]	Pre	40	Mean: 65.7	Male: 9 (45%) Female: 11(55%)	Not Reported	Not Reported
	Post	40	Mean: 66.2	Male: 11(55%) Female: 9 (45%)	Not Reported	Not Reported
Patel, 2014 [17]	Pre	167	Mean: 60	Male = 85(51%) Female = 85(49%)	Not Reported	Respiratory, Cardiovascular, General Surgery, Urology, Neurosurgery
	Post	171	Mean: 60.6	Male = 91(53%) Female = 80(47%)	Not Reported	Respiratory, Cardiovascular, General Surgery, Urology, Neurosurgery
Tonna, 2021 [2]	Pre	332	Mean: 58	Male = 214 (64%) Female = 118 (36%)	Caucasian- 274(83%) Hispanic/ Latino ethnicity- 24(7%)	General surgery, cardiac surgery, trauma surgery
	Post	314	Mean: 58	Male = 206 (66%) Female = 108 (34%)	Caucasian-261(83%) Hispanic/Latino ethnicity- 25(8%)	General surgery, cardiac surgery, trauma surgery

Topcu, 2022 [18]	Pre	37	Mean: 68.9	Male = 22(55%) Female = 18(45%)	Not Reported	Not reported however roughly 50% of participants had hearing or visual impairments.
	Post	37	Mean: 73.3	Male = 23(60%) Female = 15(40%)	Not Reported	Not reported however roughly 50% of participants had hearing or visual impairments.

Table 3: Outcomes.

Author, year	Intervention	Mean ± SD RCSQ	P-Value	ICU LOS	P-Value	Hospital LOS	P-Value
Beltrami, 2022 [1]	Pre	66.5	0.002				
	Post	83					
Boyko, 2017 [19]	Control		0.7				
	Intervention						
Chen, 2022 [12]	Pre						
	First night	80.73 ± 9.75					
	Second night	82.28 ± 7.18					
	Post						
	First night	88.49 ± 2.49	<0.001				
	Second night	87.59 ± 2.46	<0.001				
Darby, 2017 [13]	Pre	Median: 59.4	0.2	Median: 5.5	0.1	Median: 13	0.05
	Post	Median: 61.2		Median: 4		Median: 8	
Jinglin, 2019 [14]	Pre	58.9 ± 24.3	0.106	2 ± 3	0.002		
	Post	66.6 ± 18.1		5 ± 9.8			
Kamdar, 2013 [15]	Pre	54.5 ± 27.1	0.46	5.4 ± 9.5	0.6	15 ± 14.6	0.74
	Post	53.2 ± 27.3		4.3 ± 6.8		13.4 ± 17	
Locihova (2020) [16]	Pre	47.6 ± 25.0	0.693				
	Post	51.1 ± 25.2					
Patel (2014) [17]	Pre	60.8 ± 3.5	0.001				
	Post	75.9 ± 2.24					
Tonna (2021) [2]	Pre	Median: 52	0.43				
	Post	Median: 55					
Topcu (2022) [18]	Pre	51.5	0.001	4.3			
	Post	68.4		6.1			

and non-English populations was utilized in multiple studies [1,2,12,13,14,15,16,17,18]. Notably the only randomized control trial (RCT) utilized polysomnography which is considered to be the gold standard in sleep quality information [19]. Additionally, Locihová, et al. [16] utilized sleep actigraphy alongside the RCSQ. Chen, et al. [12] utilized a Chinese translation of the RCSQ which demonstrated a Cronbach Alpha of 0.874 and a Content Validity Index of 0.84. Two studies utilized the Sleep in the Intensive Care Unit Questionnaire (SICUQ) in addition to the RCSQ [1,17]. It is important to acknowledge that when analyzing sleep quality, both subjective and objective measures indicate a discrepancy; subjective measures do not closely align with objective methods like polysomnography and sleep actigraphy, as highlighted by Girschik, et al. [20].

Sleep Quality

Though sleep quality is a term that is often used there is no concrete definition. Nelson, et al. [11], conduct a concept analysis posited that sleep quality consists of four components: Sleep efficiency, sleep duration, wake after sleep onset, and sleep duration. Some of these measures can be seen in the RCSQ which usually sleep depth, sleep latency, awakenings, return to sleep, and overall sleep quality [16]. Four studies found a significant improvement in sleep quality after implementing sleep bundles [1,12,17,18]. Chen, et al. [12] collected data from patients for two nights and found significant improvement in sleep quality (Night 1: 80.73 ± 9.75 vs. 88.49 ± 2.49 p-value < 0.001, Night 2: 82.28 ± 7.18 vs. 87.59 ± 2.46 p-value <0.001) for both nights. Though Beltrami, et al. [1], found significant improvement in sleep quality according to the sum of the RCSQ (66.5 vs. 83 p-value 0.002), they did not find a significant improvement according to the SICUQ. By contrast, Patel, et al. [17] found a significant increase in sleep quality in both the RCSQ (60.8 ± 3.5 vs. 75.9 ± 2.24 p-value: 0.001) and on three parameters of the SIQU (noise: 7 vs. 2 $p < 0.001$; light 5.5 vs. 1, $p = 0.011$ and nursing interventions 4 vs. 1, $p = 0.043$).

Six studies found no significant differences in sleep quality [2,13-16]. Kamdar, et al. [15] conducted multivariable regression analysis and found no significant differences between the pre-post groups regarding sleep quality. In addition to the RCSQ,

Locihová, et al. [16] also utilized sleep actigraphy which showed no significant difference as measured by the sleep quality (SEI).

Boyko, et al. [19], conducted a RCT using a "quiet time" protocol in an ICU over the course of two nights. The sample size involved 17 mechanically ventilated patients who were randomized to receive the intervention either on the first or second nights in the ICU [19]. This study utilized polysomnography which is an objective tool for measuring sleep quality and is considered the "gold standard" for measuring sleep quality [21]. Researchers for this RCT used a scoring system based American Academy of Sleep Medicine (AASM) scoring criteria (N1, N2, N3, REM, & Wake) [22]. Of the 17 patients, only nine (53%) were found to have identifiable sleep patterns according to AASM criteria. The results did not show any significant difference in sleep quality [19].

Length of Stay

Jinglin, et al. 14] reported that the length of stay in the ICU increased post-sleep bundle implementation, with the average length of stay pre-implementation being 2 ± 3 days, increasing to 5 ± 9.8 days post-implementation (P-Value = 0.002). However Jinglin, et al. [14] noted that the post implementation group also included a more mechanically ventilated patients which could lead to possible confounding. Darby, et al. [13] did not find a significant difference in the ICU length of stay with a median of 5.5 days pre-implementation and 4 days post-implementation (P-Value = 0.1), but they did note a substantial decrease in hospital length of stay, from a median of 13 days pre-implementation to 8 days post-implementation (P-Value = 0.05). Kamdar, et al. [15] found no significant change in either ICU or hospital length of stay, with the ICU length of stay averaging 5.4 ± 9.5 days pre-implementation and 4.3 ± 6.8 days post-implementation (P-Value = 0.6), and the hospital length of stay averaging 15 ± 14.6 days pre-implementation and 13.4 ± 17 days post-implementation (P-Value = 0.74).

Components of Sleep Bundle

The common interventions among the sleep bundles were earplugs, and eye masks controlling noise and adjusting the lighting. While sleep bundles across the studies varied on whether pharmacologic interventions were included, five non-pharmacological interventions were found in common among the four studies which showed improvement in sleep quality. These interventions involve offering eye masks, earplugs, adjusting light, controlling environmental noise, and re-timing patient care activities. Seven studies reported either discussing sleep during patient care rounds or receiving input from a physician or pharmacist, or respiratory therapist about sleep quality [1,12-15,19]. Four studies utilized pharmacological interventions which include either a single or combination of melatonin, opioids, haloperidol, zolpidem, and sedatives [1,13-15,19]. Beltrami, et al. [1], gave hypnotic medication if indicated by physician. Three studies utilized limited caffeine after 1500 in their sleep bundles however none those bundles were effective in improving sleep quality [2,13,15]. Chen, et al. [12] utilized an adaptive mode of ventilation (specifically pressure support). Interestingly four studies reported conducting pain assessments before sleep as this is a regular activity in most ICUs [1,15-17]. Two studies reported promoting daytime wakefulness and activities to encourage nighttime sleeping [2,17].

Implementation Strategy

The results of this review showed a wide array of approaches in the strategies to implement the sleep bundles. While some research did not specifically state implementation strategies while others varied from assigning nurse mentors, implementing daily checklist, and multi-week training periods [2,13,14,16,17]. The most comprehensive sleep bundle implementation education and training was done by Darby, et al. [13] who implemented an eight week education and training period for their sleep protocol which included turning on lights and opening window blinds during daytime, promoting mobilization during daytime, avoiding caffeine after 1500, turning off lights and TV when patient is ready for sleep, provide earplugs, and eye masks if preferred by the patient, promoting daily awakening and spontaneous breathing trials for intubated patients, and ensuring pain and confusion assessments are done regularly.

Discussion

Our review provides insight into the complexities and nuanced efficacy of sleep bundles in enhancing sleep quality for critical care patients. Notwithstanding the positive outcomes observed in some of the bundled interventions, the evident heterogeneity in the forms of the interventions and the demographics of the patient populations underscore the importance of context-specific approaches. The varied implementation strategies, from comprehensive training to singular briefs, amplify the need for more standardized protocols. Despite these discrepancies, the recurrent theme in our findings champions the utility of sleep bundles as a valuable for advancing sleep quality in the ICU, aiding in the integration of feasible, non-pharmacological strategies tailored to the critical care environment.

Components of Sleep Bundles

In addressing the components of sleep bundles, our review shows that basic measures-such as providing earplugs and eye masks, managing noise, and optimizing lighting remain essential. The ease of implementation of these interventions into the ICU environment, which has

been multiply attested [23-25], solidifies their standing as optimal interventions. It is important to recognize that these interventions are designed to mitigate the disruptive effects of the ICU setting, a well-documented source of poor sleep quality [26]. While the application of pharmacological interventions remains variable among studies, prevailing trends advise a prudent approach to their use considering possible negative impacts on sleep quality a concern also highlighted in the context of caffeine usage by Kerpershoek, et al. [27]. Though some studies have shown the negative impact of caffeine on sleep quality the three studies that specifically stated they limited caffeine intake did not show any improvement in sleep quality. This is surprising considering that caffeine is a known detriment to sleep quality, thereby warranting a closer investigation into the contributing variables and the complex relationship between caffeine intake and sleep dynamics among ICU patients. Given these considerations, future research should prioritize delineating the causal mechanisms by which these non-pharmacological interventions exert their beneficial effects, as well as optimizing the judicious use of pharmacological agents. This would enable the development of more targeted sleep bundles, refined through a precision medicine approach, to enhance patient recovery and overall outcomes in the ICU. Given these considerations, future research should prioritize delineating the causal mechanisms by which these non-pharmacological interventions exert their beneficial effects, as well as optimizing the judicious use of pharmacological agents. This would enable the development of more targeted sleep bundles, refined through a precision medicine approach, to enhance patient recovery and overall outcomes in the ICU (Table 4).

Furthermore, the collaborative efforts among healthcare professionals have been previously acknowledged as a critical component in promoting improved patient sleep outcomes [28]. However, our review unveils that these integrative practices are not uniformly adopted; only a fraction of the studies examined incorporated inter-professional consultations within their daily patient care regimens or utilized them in evaluating sleep-enhancing interventions [1,12-15,19]. Interestingly, only one study reported positive sleep outcomes explicitly recognized the role of interdisciplinary collaboration as part of their sleep bundle [12].

This suggests the prospect that the most substantial improvements in sleep quality may be realized through interventions tailor-made to counteract the specific challenges posed by the ICU environment. As such, future sleep bundle designs should be crafted, taking into consideration the interplay of clinical care practices as well as the environment, with an emphasis on fostering collaborative efforts among ICU healthcare providers to maximize the therapeutic potential of sleep interventions.

Patient Characteristics

Our analysis revealed a considerable degree of heterogeneity within the study populations, prompting reflections on the applicability of sleep intervention outcomes across diverse patient groups. Such variability, while potentially problematic for the broad extrapolation of research findings, enriches our understanding of the differential effectiveness of sleep bundles when applied to distinct patient subsets. The study conducted by Chen, et al. [12] specifically targeting those post-off bypass coronary artery surgery, is notably significant. Their positive outcomes are particularly pertinent given the frequent incidence of suboptimal sleep quality reported in the postoperative phase, a problem which, if ameliorated, may correlate with enhanced recovery trajectories for patients post operatively.

Contrastingly, the research conducted by Tonna, et al. [2] in a mixed surgical and cardiovascular surgical ICU population did not replicate these positive results, positing a nuanced relationship between the nature of the patient cohort and the efficacy of the sleep intervention. The presence of trauma and general surgery patients in their control group may have introduced confounding variables, thereby moderating the effect of the implemented sleep bundles. Further distinction was observed in the population for the study by Chen, et al. [12] which included patients intubated for brief durations, potentially influencing the intervention's impact due to variations in patient acuity and morbidity. Moreover, Patel, et al. [17] whose study context extended to medical and surgical settings, demonstrated positive outcomes mirroring the non-pharmacologic modalities employed by Chen, et al. [12]. The concordance in intervention approaches between these separate investigations suggests that the strategic inclusion of non-pharmacological measures could be instrumental in optimizing postoperative patient recovery across a heterogeneity of patient populations.

Critical examination of these findings highlights the necessity to prioritize research in the domain of sleep disturbances post-surgery. It postulates that an interdisciplinary effort to innovate and implement targeted non-pharmacologic sleep interventions could constitute a transformative step in refining the convalescence process and augmenting patient recuperation across surgical and intensive care contexts.

Implementation strategy

In analyzing sleep bundle interventions, it becomes apparent that the methodologies of implementation are as critical as the interventions themselves. Our review uncovers a broad spectrum of strategies, from simplistic

Table 4: Interventions.

Intervention	Beltrami, 2022 [1]	Boyko, 2017 [19]	Chen, 2022 [12]	Darby, 2022 [13]	Jinglin, 2019 [14]	Kamdar, 2013 [15]	Locihov, 2020 [16]	Patel, 2014 [17]	Tonna, 2021 [2]	Topcu, 2022 [17]
Sleep discussed during rounds				×						
Consultation with pharmacist		×			×	×				
Physician input on improving sleep quality	×									
Education provided to staff	×	×	×	×				×		
Consultation with Respiratory Therapist			×						×	×
Eye Masks	×	×	×	×	×	×	×	×	×	×
Earplugs	×	×	×	×	×	×	×	×	×	×
Adjust Lighting	×	×	×	×	×	×	×	×	×	×
Control environmental noise to include conversations and alarms	×	×	×	×	×	×	×	×	×	×
Aromatherapy										
Alternative Treatment										
Massage			×							
Sedative				×	×					
Melatonin		×		×	×					
Opioid		×			×					
Zolpidem						×				
Haloperidol						×				
Caffeine limited after 1500				×		×			×	
adaptive ventilation mode			×							
retiming patient-care interventions. (Glucose checks, medication administration, labs, assessments)	×		×				×	×		×
managing noise from IV pump	×									×
light music			×							
Pain Assessment before bed	×					×	×	×		
Offer nicotine patch	×									
Antipsychotic Medication				×						
Promoting Daytime wakefulness						×		×	×	
Encourage family visits at nighttime									×	
Discouragement of Medications known to alter sleep						×				
Hypnotic	×									
Restrict glucose checks between (2200-0600)	×									
Perform medication review for patients who slept poorly or had positive CAM								×		

Category	Intervention	Beltrami, 2022 [1]	Boyko, 2017 [19]	Chen, 2022 [12]	Darby, 2022 [13]	Jinglin, 2019 [14]	Kamdar, 2013 [15]	Locihova, 2020 [16]	Patel, 2014 [17]	Tonna, 2021 [2]	Topcu, 2022 [18]
Professional Collaboration and Education	Sleep discussed during rounds			×							
	Consultation with pharmacist	×			×	×					
	Physician input on improving sleep quality	×									
	Education provided to staff	×	×	×	×				×		
	Consultation with Respiratory Therapist			×						×	×
Non-Pharmacological Interventions	Eye Masks	×	×	×	×	×	×	×	×	×	×
	Earplugs	×	×	×	×	×	×	×	×	×	×
	Adjust Lighting	×	×	×	×	×	×	×	×	×	×

	Control environmental noise	×	×	×	×	×	×	×	×	×	×
	Aromatherapy										
	Alternative Treatment								×		
	Managing noise from IV pump	×									×
	Light music			×							
	Retiming patient-care interventions	×		×				×	×		×
	Promoting Daytime wakefulness									×	×
	Encourage family visits at nighttime										×
Pharmacological Interventions	Sedative				×	×					
	Melatonin	×			×	×					
	Opioid	×			×						
	Zolpidem									×	
	Haloperidol									×	
	Caffeine limited after 1500				×		×			×	
	Hypnotic	×									
	Antipsychotic Medication				×						
Pain and Medication Management	Pain Assessment before bed	×				×	×	×			
	Offer nicotine patch	×									
	Perform medication review									×	
	Discouragement of Medications known to alter sleep									×	
	Restrict glucose checks	×									
Specialty Interventions	Adaptive ventilation mode			×							

educational sessions to more comprehensive 21-day staff training programs. Intriguingly, in three out of the four studies that demonstrated considerable improvements in sleep quality, the common denominator was the active participation of nursing staff in rolling out the interventions. The singular study lacking in this respect was that of Chen, et al. [12] which did not provide sufficient detail on the implementation strategy, casting light on the necessity for clear reporting in this research domain. Ensuring transparent and detailed descriptions of the tactics employed to implement sleep interventions is crucial for both reproducibility and the advancement of standardization within the field. Subsequent research must focus on identifying which strategies are not only effective in improving sleep outcomes but also economically viable, to inform and streamline their use in diverse medical settings.

Limitations

There are limitations in interpreting the results of this review. A primary concern is the marked heterogeneity observed both in the sleep-enhancing interventions and in the participant profiles across the included studies. Notable examples include the work of, Beltrami, et al. [1] and Locihová, et al. [16] which were limited to conscious, non-sedated individuals, juxtaposed with Boyko, et al. [19] which focused solely on mechanically ventilated patients, and Chen, et al. [12] whose research was confined to first-time cardiac surgery recipients. Consequently, the ability to generalize these findings across a broader ICU population is significantly constrained.

Concerning the measurement of sleep quality, several studies leaned on subjective assessments completed by

nurses [13,15] a method susceptible to measurement bias, although Kamdar, et al. [15] attempted to mitigate this by introducing a statistical interaction term, finding that the reporting personnel seemingly had no substantial effect on outcomes. Nonetheless, the potential for confounding variables is amplified when considering differing baselines; for instance, Jinglin, et al. [14] acknowledged a comparatively more critical condition amongst post-implementation patients, while Patel, et al. [17] dealt with a pre-implementation cohort with a higher prevalence of gynecological and urological disorders known to disrupt sleep.

The tendency to favor subjective measurement tools like the Richard-Campbell Sleep Questionnaire over objective counterparts such as sleep actigraphy or polysomnography further entrenches the risk of inaccuracies in sleep quality evaluation. This concern is validated by the fact that the two investigations which employed objective measures reported negligible effects on sleep quality [16,19]. Finally, the diversity in clinical settings-from specialized cardiac ICUs to general or medical ICUs introduces additional variation that may compromise the external validity of the findings. These cumulative limitations highlight critical areas for improvement in future research design and underscore the importance of cautious interpretation when applying these results to patient care protocols in intensive care settings.

Conclusion

In summing up the insights gleaned from this comprehensive review, several considerations come to the forefront. While there are indications that sleep bundles could hold potential for enhancing sleep quality in ICU settings, the extensive variability in intervention types, participant profiles, and implementation strategies encountered across the studies introduces a significant degree of uncertainty. This diversity, along with methodological limitations such as a reliance on subjective rather than objective measures of sleep quality, and the potential for confounding factors, means that caution must be exercised when interpreting the results.

The findings underscore the importance of a standardized approach to both the design of sleep interventions and their measurement. Moreover, additional research is required to firmly establish the effectiveness of sleep bundles and to discern which components most significantly improve sleep quality for critically ill patients. Future investigations should aim to address the gaps identified in this review, with a particular focus on rigorous methodological design, the use of objective sleep measures, and the careful delineation of patient cohorts, to provide clarity on this important aspect of ICU patient care. Future investigations must go beyond the immediate impact of sleep bundles, by exploring the long-term influences of sleep bundles, thus enabling greater clarity around their enduring effectiveness in the ICU setting.

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