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Different nursing interventions on sleep quality among critically ill patients

A systematic review and network meta-analysis

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Abstract

Background: Critically ill patients in intensive care often struggle with disrupted sleep, a prevalent issue in this population. However, the question of which non-pharmacological intervention is most effective in enhancing sleep quality remains unanswered. This study was conducted to comprehensively evaluate and compare the efficacy of various non-pharmacological interventions aimed at improving sleep quality among critically ill individuals.

Methods: We conducted a search of PubMed, Embase, and the Cochrane Library (Cochrane Central Register of Controlled Trials) without language restrictions to identify articles published until July 15, 2023. Randomized controlled trials (RCTs) that investigated various nursing interventions designed to improve sleep quality in critically ill patients were included in this network meta-analysis. All analyses were performed using R software (version 3.4.3) with the "gemtc" package.

Results: A total of 2036 patients from 31 RCTs were included in the network meta-analysis, involving 11 different nursing interventions (routine care, relaxation combined with imagery (RI), nursel, music + earplugs + eye masks, music, eye masks, earplugs + eye masks, earplugs, aromatherapy, Warm footbath combined with acupoint exercise (WFA), Virtual reality meditation (VR)). Eye masks and earplugs + eye masks were associated with improved sleep quality compared to routine care intervention ($P < .05$).

Conclusions: In summary, eye masks and earplugs + eye masks stand out as the most effective interventions for enhancing sleep quality in critically ill patients. Therefore, critical care nurses should consider incorporating the use of eye masks alone or combining music with eye masks into the sleep care regimen for critically ill patients.

Abbreviations: RCTs = randomized controlled trials.

Keywords: critically ill patients, network meta-analysis, nursing interventions, sleep quality

1. Introduction

Adequate rest plays a crucial role in maintaining homeostasis, particularly during the recovery phase from an illness. Nevertheless, research has underscored the prevalence of sleep disruptions and inadequate rest among patients in intensive care units.[1–3] These disruptions manifest as suboptimal sleep quality, difficulties in falling asleep, fragmented sleep patterns, frequent nocturnal awakenings, and diminished periods of deep, slow-wave sleep.[4,5]

Disturbed sleep has been associated with compromised immune function, prolonged stays in critical care units, an elevated risk of delirium among critically ill patients, and increased mortality rates within this population.[6,7] Furthermore, inadequate sleep can persist for up to 6 months after discharge from the critical care unit, significantly impacting individuals' quality of life.[8] Several factors contribute to disrupted sleep in the critical care setting, including postoperative pain, medical or nursing interventions, as well as environmental disturbances such as noise and light.[9]

While pharmacological approaches have been extensively used to enhance subjective or objective sleep quality in critically ill individuals, there has been no systematic comparison of the effects of these pharmacological agents,[10] leaving their effectiveness uncertain.[11] Non-pharmacological interventions primarily target modifiable risk factors, such as sensory deprivation, sleep deprivation, and immobilization, and are recommended for addressing sleep disturbances in critical care unit patients.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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To date, only one meta-analysis has explored the efficacy of non-pharmacological interventions, such as the use of eye masks, earplugs, relaxation techniques, and music, in alleviating sleep disruptions among critically ill individuals.[12] However, this analysis was limited by the inclusion of a small number of studies and substantial heterogeneity among them. Nonetheless, it did find evidence suggesting that the use of earplugs or eye masks, or both, can extend total sleep duration.

Traditional pairwise meta-analyses have limitations as they only directly compare 2 interventions, making it challenging to simultaneously assess the comparative effectiveness of all available interventions—an essential consideration in clinical practice. Consequently, selecting the optimal non-pharmacological intervention, whether a single approach or a combination, for managing sleep disturbances in critically ill patients remains a complex task for healthcare professionals.

To address this disparity, a network meta-analysis methodology can be employed to combine both direct and indirect evidence while concurrently evaluating numerous treatment options.[13] This approach serves to inform clinical decision-making. Therefore, the study aimed to conduct a comprehensive comparison of the effects of various non-pharmacological interventions on sleep quality among critically ill patients in need of intensive care.

2. Methods

The current study, a systematic review and network meta-analysis, strictly adhered to the reporting guidelines set forth in the Preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA) extension statement, which focuses on the reporting of systematic reviews that incorporate network meta-analyses.[14] Ethical approval was not deemed necessary for this study, as it involved a meta-analysis of existing articles, thus eliminating the requirement for handling individual patient data.

2.1. Search strategy

randomized controlled trials (RCTs) that compared different nursing interventions on sleep quality among critically ill patients were searched in electronic databases including

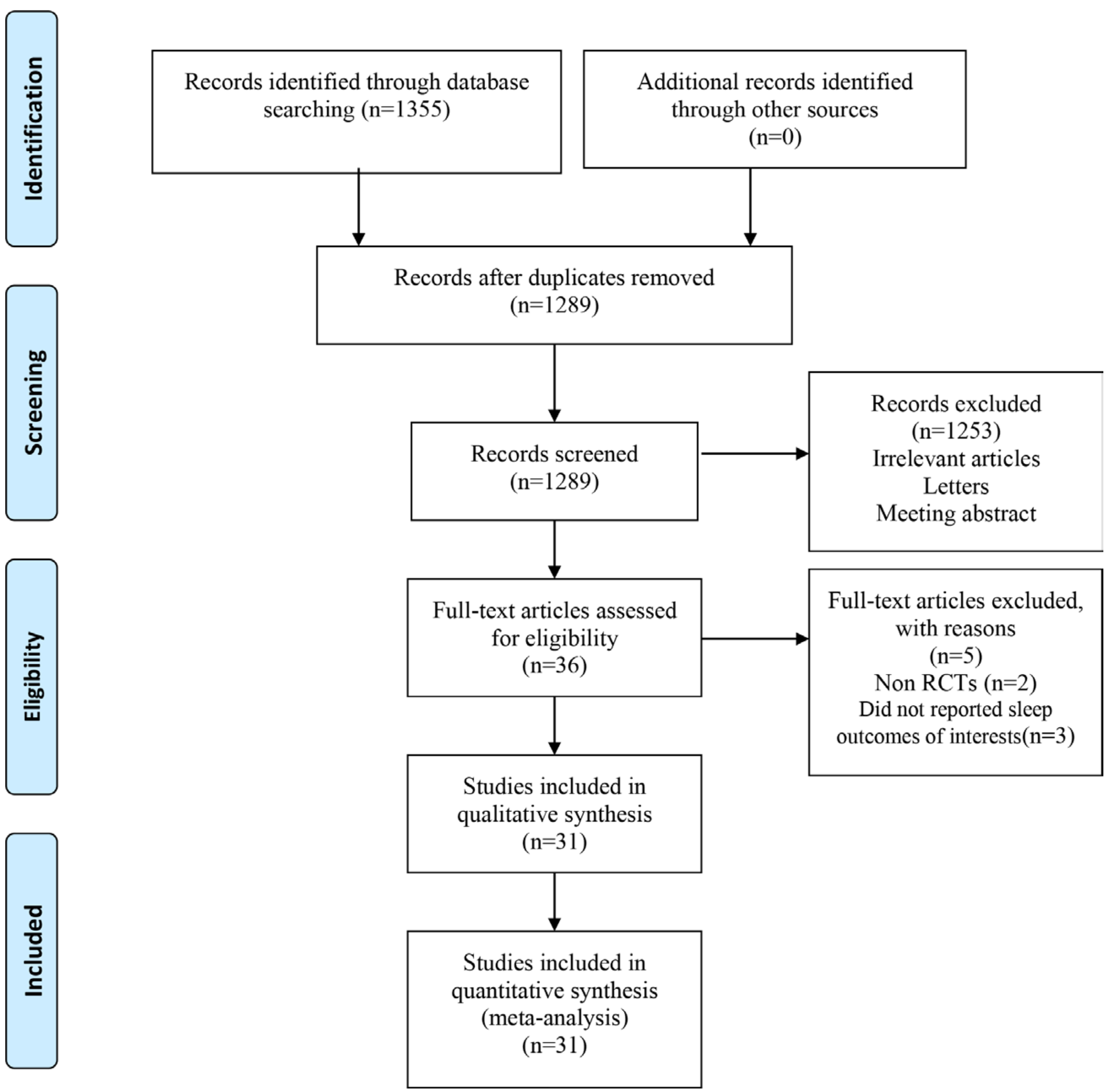

Figure 1. Flow diagram of the literature selection process.

Table 1

General characteristic of the included studies.

Author	Countries	Design	Intervention	Control	Frequency (h/night)	Lasting days	Measurement
Arttawejkul 2020	Thailand	Parallel	EE	Routine care	9 h/night (10:00 PM–7:00 AM)	5	RCSQ
Borromeo 1998	USA	Cross-over	Aromatherapy	Routine care	Aromatherapy or Water to used 9 h/night (9:00 PM–6:00 AM)	2	RCSQ
Obanor 2021	USA	Parallel	EE	Routine care	NR	Until ICU discharge	RCSQ
Chaudhary 2020	India	Parallel	EE	Music	Earplugs and eye mask used 9 h/night (10:00 PM–7:00 AM) Music used 30 min/night (9:15 PM–9:45 PM)	4	PSQI
Daneshmandi 2012	Iran	Cross-over	Eye mask	Routine care	NR	4	PSQI
Demoule 2017	France	Parallel	EE	Routine care	10 h/night (10:00 PM–8:00 AM)	Upon ICU discharge	VAS of sleep
Díaz-Alonso 2018	Spain	Parallel	Nursel	Routine care	10–15 min/once	1	RCSQ
Hajibagheri 2014	Iran	Parallel	Aromatherapy	Routine care	8 h/night (10:00 PM–6:00 AM)	4	PSQI
Hansen 2018	Denmark	Parallel	Music	Routine care	30 min/night	1	RCSQ
Hu 2015	China	Parallel	MEE	Routine care	Music used 30 min/night Earplugs and eye mask used 9:00 PM until the next morning	Until ICU discharge	RCSQ
Karadag 2017	Turkey	Parallel	Aromatherapy	Routine care	3 h/night (9:00 PM–12:00 PM)	15	PSQI
Lee 2020	South Korea	Parallel	VR	Routine care	30 min/night	1	Korea sleep scale A
Litton 2017	Australia	Parallel	Earplugs	Routine care	8 h/night (10:00 PM–6:00 AM)	1	RCSQ
Mahran 2020	Egypt	Parallel	Eye mask	Routine care	10 h/night (9:00 PM–7:00 AM)	3	RCSQ
Moeini 2010	Iran	Cross-over	Aromatherapy	Routine care	9 h/night (9:00 PM–6:00 AM)	3	SMHSQ
Richardson 2003	USA	Parallel	RI	Routine care	3 h/night (17:00 PM–19:00 AM)	2	VSH
Ryu 2012	South Korea	Parallel	MEE	EE	Music used 53 min/night (10:00 PM–10:53 PM)	1	VSH
Sha 2013	China	Parallel	Music	Routine care	Earplugs and eyemask used 7 h/night (10:00 PM–5:00 AM)	1	PSQI
Su 2013	Taiwan	Parallel	Music	Routine care	45 min/night	1	VSH
Zhou 2017	China	Parallel	WFA	Routine care	1 h/night	1	PSQI
Altintaş 2023	Turkey	Parallel	Eye mask	Routine care	10 h/night (9:00 PM–7:00 AM)	2	PSQI
Akpinar 2022	Turkey	Parallel	Earplugs + eye masks	Routine care	9 h/night (9:00 PM–6:00 AM)	2	PSQI
Babaii 2015	Iran	Parallel	Eye mask	Routine care	10 h/night (9:00 PM–7:00 AM)	1	VSH
Baghaie 2018	Iran	Parallel	Earplugs	Routine care	NR	1	
Bajwa 2015	India	Parallel	Earplugs + eye masks	Routine care	9 h/night (9:00 PM–6:00 AM)	1	VSH
Dave 2015	India	Parallel	Earplugs + eye masks	Routine care	45 min/night	2	PSQI
Kiliç 2023	Turkey	Parallel	Earplugs + eye masks	Routine care	After 22:00–23:00 after the nurses' treatment hours	3	PSQI
Lin 2022	Taiwan	Parallel	Earplugs + eye masks	Routine care	10 PM and 7 AM	3	RCSQ
Mashayekhi 2013	Iran	Parallel	Eye masks	Routine care	NR	1	VSH
Menger 2018	Austria	Parallel	Earplugs	Routine care	NR	2	RCSQ
Yazdannik 2014	Iran	Parallel	Earplugs + eye masks	Routine care	Earplugs and eye masks used 7 h/night (10:00 PM–5:00 AM)	Until ICU discharge	VSH

C = control group, E = experiment group, EE = earplugs combined with eyes mask, MEE = music combined with earplugs and eye mask, NR = not report, Nursel = nurse intervention, PSQI = Pittsburgh Sleep Quality Index, RCSQ = Richards-Campbell Sleep Questionnaire, RI = relaxation combined with imagery, SMHSQ = St Mary's Hospital Sleep Questionnaire (SMHSQ), VAS = visual analogue scale, VR = virtual reality meditation, VSH = Verran and Snyder-Halpern sleep scales, WFA = warm footbath combined with acupoint exercise.

Table 2

General characteristic of the included studies.

Author	n (E/C)	Age (year, E/C)	Male (%, E/C)	ICU type	ICU days	Sedation use	MV use	APACHE-II
Arttawejkul 2020	8/9	67/76	25/44	MICU	NR	Yes	NR	14–15
Borromeo 1998	13/12	62	72	CCU	NR1.61-1.66	NR	NR	NR
Obanor 2021	44/43	51.4/50.7	0/0	SICU	2.13–2.23	NR	NR	13.3–14.3
Chaudhary 2020	30/30	52.7/49.7	40/63.3	MICU	NR	NR	No	NR
Daneshmandi 2012	30/30	55.9	53.3/43.3	CCU	NR	No	NR	NR
Demoule 2017	30/31	64/65	67/58	ICU	NR	Yes	NR	42–45
Díaz-Alonso 2018	20/20	NR	60/60	ICU	NR	Yes	No	<25–>25
Hajibagheri 2014	30/30	61.4/63.9	53.3/30	CCU	3	No	NR	NR
Hansen 2018	18/19	60/65	27/27	MICU	53 h	No	Yes	NR
Hu 2015	20/25	56.6/56.8	55/64	ICU	NR	NR	NR	20.1–21.2
Karadag 2017	30/30	53.3/47.36	66.7/66.7	CCU	2.79	No	NR	NR
Lee 2020	24/24	69.46/63.38	62.5/70.8	ICU	3-4	No	No	14.3
Litton 2017	20/20	70/66	70/85	CSICU	4.32	Yes	No	14
Mahran 2020	31/35	48.03/46.91	74/31	CCU	NR	No	NR	NR
Moeini 2010	32/32	55.7/52.8	65.6/59.4	MICU	NR	NR	NR	NR
Richardson 2003	17/12	53.3/62.4	19.4/27.8	CCU	NR	No	NR	NR
Ryu 2012	29/29	61.2	32.8/32.8	ICU	NR	NR	NR	NR
Sha 2013	107/112	56.48/56.69	66.3/66.96	MICU	NR	Yes	NR	NR
Su 2013	14/14	62.43/60.93	57.1/64.3	ICU	NR	No	Yes	18.57
Zhou 2017	57/56	NR	NR	ICU	NR	Yes	No	NR
Altintaş 2023	64/64	NR	63.87	ICU	NR	No	Yes	12.5
Akpinar 2022	42/42	NR	NR	ICU	NR	No	No	11.8
Babaii 2015	30/30	51.6/65.7	15.9/20.3	ICU	NR	No	No	NR
Baghaie 2018	50/50	NR	NR	ICU	NR	Yes	NR	NR
Bajwa 2015	50/50	56.48/56.69	68.9	ICU	NR	No	Yes	NR
Dave 2015	25/25	NR	NR	ICU	NR	No	Yes	NR
Kiliç 2023	30/30	58.9	53.3/43.3	ICU	NR	No	Yes	12–15
Lin 2022	32/32	55.7/52.8	NR	MICU	NR	Yes	NR	NR
Mashayekhi 2013	30/30	56.34/56.41	12/11	MICU	NR	No	NR	NR
Menger 2018	27/36	56.15/56.21	15/18	ICU	NR	Yes	NR	15.76
Yazdannik 2014	25/25	NR	NR	ICU	NR	No	NR	NR

CCU = coronary care unit, CSICU = cardiac surgical intensive care unit, ICU = intensive care unit, MICU = medical intensive care unit, MV = mechanical ventilation, NR = not reported.

PubMed, Embase and Cochrane Library (Cochrane Central Register of Controlled Trials) databases. All relevant RCTs will be collected from the inception of each database to July 15, 2023. We will use the MeSH/Emtree terms, combining free-text words that were properly adjusted for the different databases in all of the search strategies. Search terms used were ICU, intensive care unit, critically ill OR critical illness AND (relaxation combined with imagery (RI) OR nursel, music + earplugs + eye masks, music, eye masks, earplugs + eye masks, earplugs, aromatherapy, Warm footbath combined with acupoint exercise (WFA), Virtual reality meditation (VR)). Ongoing trials or unpublished studies were also searched in ClinicalTrials.gov. Two reviewers (D.H. and Y.L.) independently read titles and abstracts for preliminary screening and reviewed full-text eligibility. Any disagreements were resolved by discussion with a third party or by consultation with the investigator (Y.L.).

2.2. Inclusion criteria and exclusion criteria

Studies were included if the following inclusion criteria (PICOS) were met: Population (P): Critically ill patients; Interventions (I): RI, nursel, music + earplugs + eye masks, music, eye masks, earplugs + eye masks, earplugs, aromatherapy, WFA, VR; Control (C): routine care; Outcomes (O) sleep quality; Study (S): All relevant randomized controlled trials were included. Exclusion criteria were as follows: case reports and comments; studies with insufficient data; reviews or meta-analyses studies; studies with only case group; and no follow-up after discharge.

2.3. Data extraction

Two authors (J.Y. and C.L.) independently screen literature, extract data, and cross-check them. In case of disagreements, a third reviewer is consulted to assist with the judgment, and any missing information is supplemented by contacting the author as much as possible. When screening literature, the title and abstract are read first, and after excluding obviously irrelevant literature, the full text is further read to determine whether it should be included. The main content of data extraction includes: first author and publication year, country, design, intervention, control, frequency, lasting days, measurement, number of the patients, age of the patients, male patients, ICU type (cardiac surgical intensive care unit (CSICU), coronary care unit (CCU), medical intensive care unit (MICU), surgical intensive care unit (SICU) and ICU days, sedation use, mechanical ventilation (MV) use and Acute Physiology and Chronic Health Evaluation-II (APACHE-II) score.

2.4. Quality assessment

The risk of bias in RCTs was assessed by 2 reviewers (D.H. and Y.L.) using the Cochrane Collaboration's risk of bias tool as depictive in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins JPT, Green S. Cochrane handbook for systematic reviews of interventions, version 5.1.0), which comprised items such as random sequence generation, allocation concealment, blinding of participants and outcome assessors, incomplete outcome data, reporting bias, and other bias. Each domain was assessed as low, unclear and high according to the instruction. In case of any discrepancies in the evaluations between the 2 reviewers, a third reviewer (Y.L.) was consulted to resolve them.

2.5. Statistical analysis

A Bayesian network meta-analysis with a random-effect model was performed using gemtc package in R, version 3.6

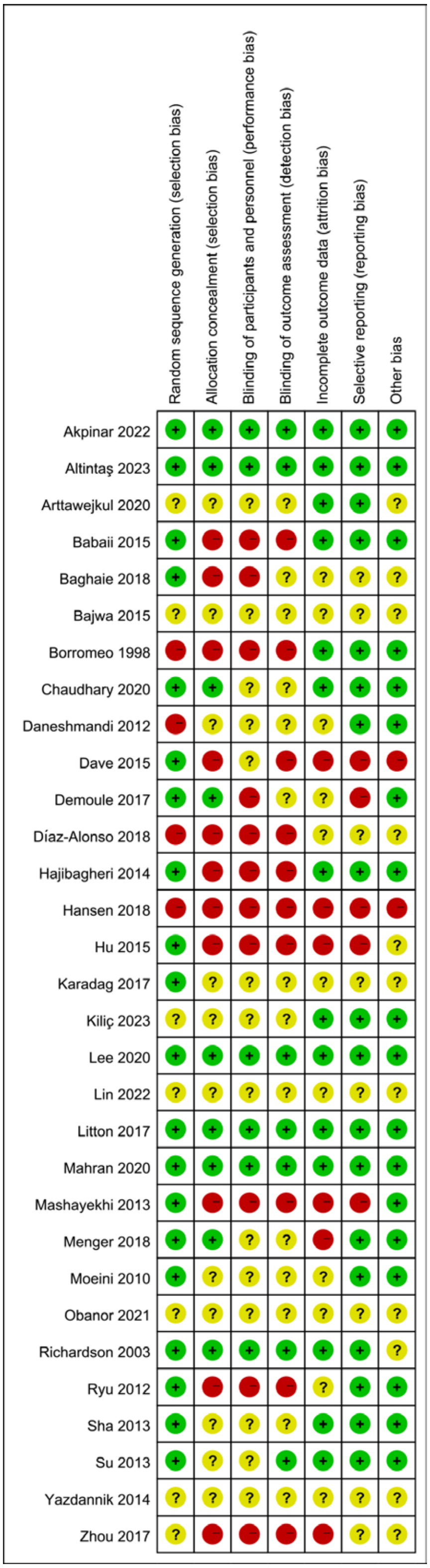

Figure 2. Risk of bias summary of the included studies.

(R Foundation for Statistical Computing) and rjags package. Simulations were allowed to burn-in for 10,000 Markov Chain Monte Carlo (MCMC) iterations (using the WinBUGS default Gibbs sampling method), which in our study were sufficient for all parameter estimates to stabilize and converge between 2 chains with different initial values. A burn-in phase of 20,000 iterations was followed by 50,000 updates, where the number of burn-in iterations was chosen according to the Brooks-Gelman-Rubin method for convergence checks. Median values from the posterior distribution were used to calculate estimated outcomes, represented as standard mean differences (SMDs), along with their corresponding 95% credible interval (CrI). Statistically significant differences were considered when the 95% CrI did not encompass 0 for mean differences. The significance level was set at $P < .05$. Furthermore, surface under the cumulative ranking curve (SUCRA) values were employed to rank the different interventions, where higher SUCRA values indicated more effective interventions. To evaluate heterogeneity, the I^2 test was used, with a threshold of 50% indicating low heterogeneity. Global inconsistency was assessed by comparing the fit of consistency and inconsistency models using the deviance information criterion (DIC), with similar DIC values across different models indicating good consistency. For local inconsistency, node-splitting analysis was utilized, and a P value greater than .05 suggested no significant inconsistency between the direct pairwise results and the indirect results. We conducted a Bayesian hierarchical framework network meta-regression with random-effects using the gemtc package in R. This package automatically assigns uninformative prior distributions to all parameters in our model, a common practice in NMA. Comparison-adjusted funnel plots were performed by Stata 14.2 (Stata Corp, College Station, TX) to assess publication bias for network meta-analyses.

3. Results

3.1. Study selection

Of the 855 relevant publications that were identified through the electronic search and additional sources, 202 were excluded because they were duplicates. After the title and abstract were screened, further 638 studies were excluded. After verifying the remaining 15 full-text reports, 31 RCTs met the inclusion criteria and were included in the network meta-analysis.[7,15–44] The study selection process is shown in Figure 1.

3.2. Study characteristics

The included studies were published between 1998 and 2023. Three studies were originated from USA, 1 from Thailand, 3 from India, 7 from Iran, 4 studies originated from Turkey, one originated from France, 2 originated from China, 2 originated from South Korea, 2 originated from Australia, 2 originated from Taiwan and 1 study from Egypt. Twenty-eight studies were parallel studies and the rest studies were crossover studies. A total of 11 treatments (routine care, aromatherapy, ear plugs, ear plugs + eye mask, eye mask, music, music + ear plugs + eye mask, nursel, RI, VR, and WFA) were included in this network meta-analysis. The duration of ICU stay varied, spanning from 1 to 5 days. Sleep quality assessment included Richards-Campbell Sleep Questionnaire (RCSQ), Verran and Snyder-Halpern sleep scales (VSH), Pittsburgh Sleep Quality Index (PSQI), St Mary's Hospital Sleep Questionnaire (SMHSQ) Visual analogue scale (VAS). Number of patients ranged from 8 to 112. Mean age of the patients ranged from 46.9 to 76. And Male patients ranged from 0% to 74%. ICU type included MICU, CCU and SICU. ICU days ranged from 2.13 to 4.32 day. Detailed information can be seen in Tables 1 and 2.

3.3. Risk of bias

The risk of bias summary and risk of bias graph for the included trials is shown in Figures 2 and 3 respectively. Five trials were graded as having a low risk of bias, 10 trials were at an unclear risk of bias and the rest studies were rated as high risk of bias. Twenty included trials reported an appropriate random sequence generation. Nine studies were rated as low risk of bias for allocation concealment

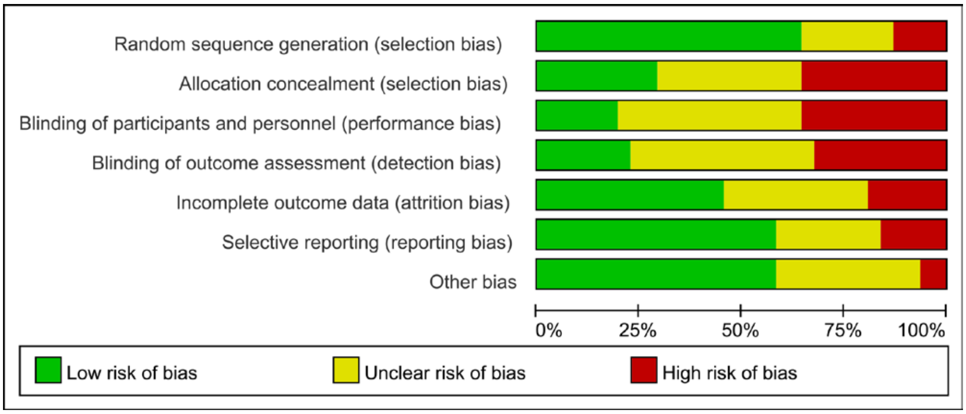

Figure 3. Risk of bias graph of the included studies.

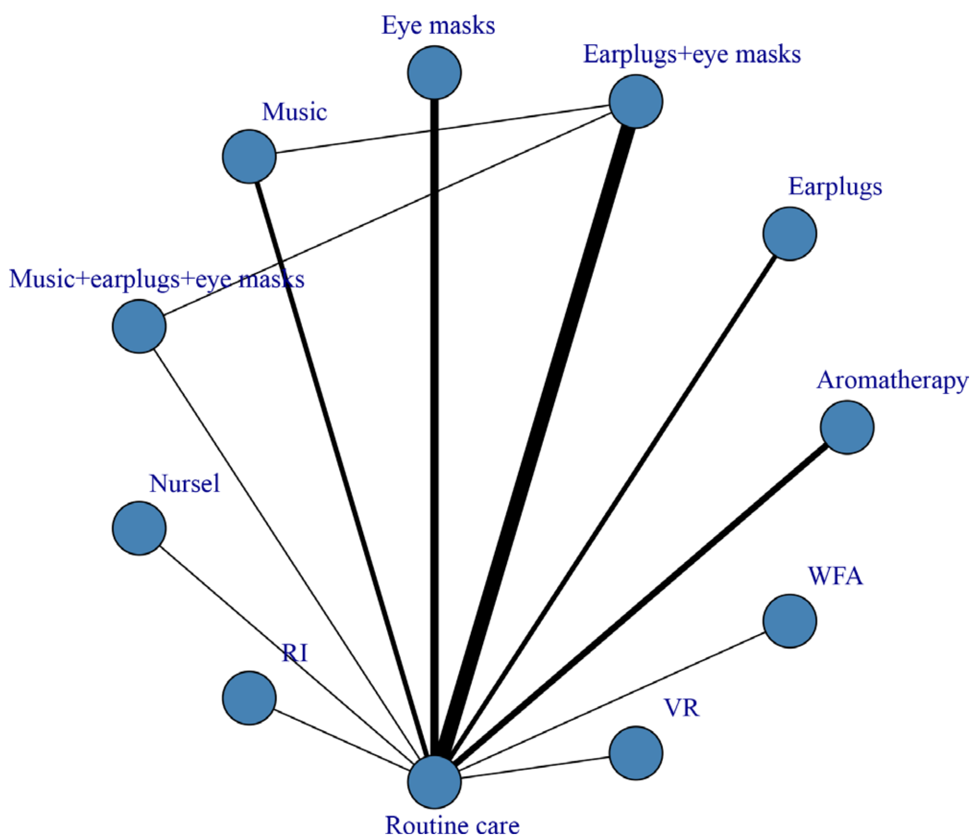

Figure 4. Network structure diagrams of sleep quality.

and 6 studies were rated as unclear risk of bias. Six studies were rated as low risk of bias for blinding of participants and personnel. Seven studies were at unclear risk of bias for blinding of outcome assessment. Fourteen studies were rated as low risk of bias for incomplete outcome data and selective reporting. Eighteen studies were rated as low risk of bias for other bias.

3.4. Sleep quality

Figure 4 illustrates a network plot of sleep quality. All included RCTs used two-arm study designs. The plot revealed 11 treatments in the 31 RCTs, namely the use of routine care, RI, nursel, music + earplugs + eye masks, music, eye masks, earplugs + eye masks, earplugs, aromatherapy, WFA, and VR. Two closed loops were formed in the network meta-analysis; thus, inconsistency testing was conducted in the 2 loops.

Network meta-analysis showed significantly heterogeneity with global (I^2 = 98.2%, Fig. 5). In head-to-head comparison, eye masks (SMD = 40.0, 95%CrI: 15.0–65.0, $P < .05$, Fig. 6; Table 3) and earplugs + eye masks (SMD = 34.0, 95%CrI: 16.0–51.0, $P < .05$, Fig. 6; Table 3) were associated with an increase of the sleep quality than routine care.

The SUCRA shows that eye masks ranked first (SUCRA, 84.6%), earplugs + eye masks ranked second (SUCRA, 77.7%), earplugs ranked third (SURCA, 63.8%) and aromatherapy ranked the last (SUCRA, 18.5%, Fig. 7). There was no indication of publication bias as shown by the symmetrical funnel plot (Fig. 8).

We used the node-splitting method and its Bayesian P value to report the inconsistency of our results. For the majority of

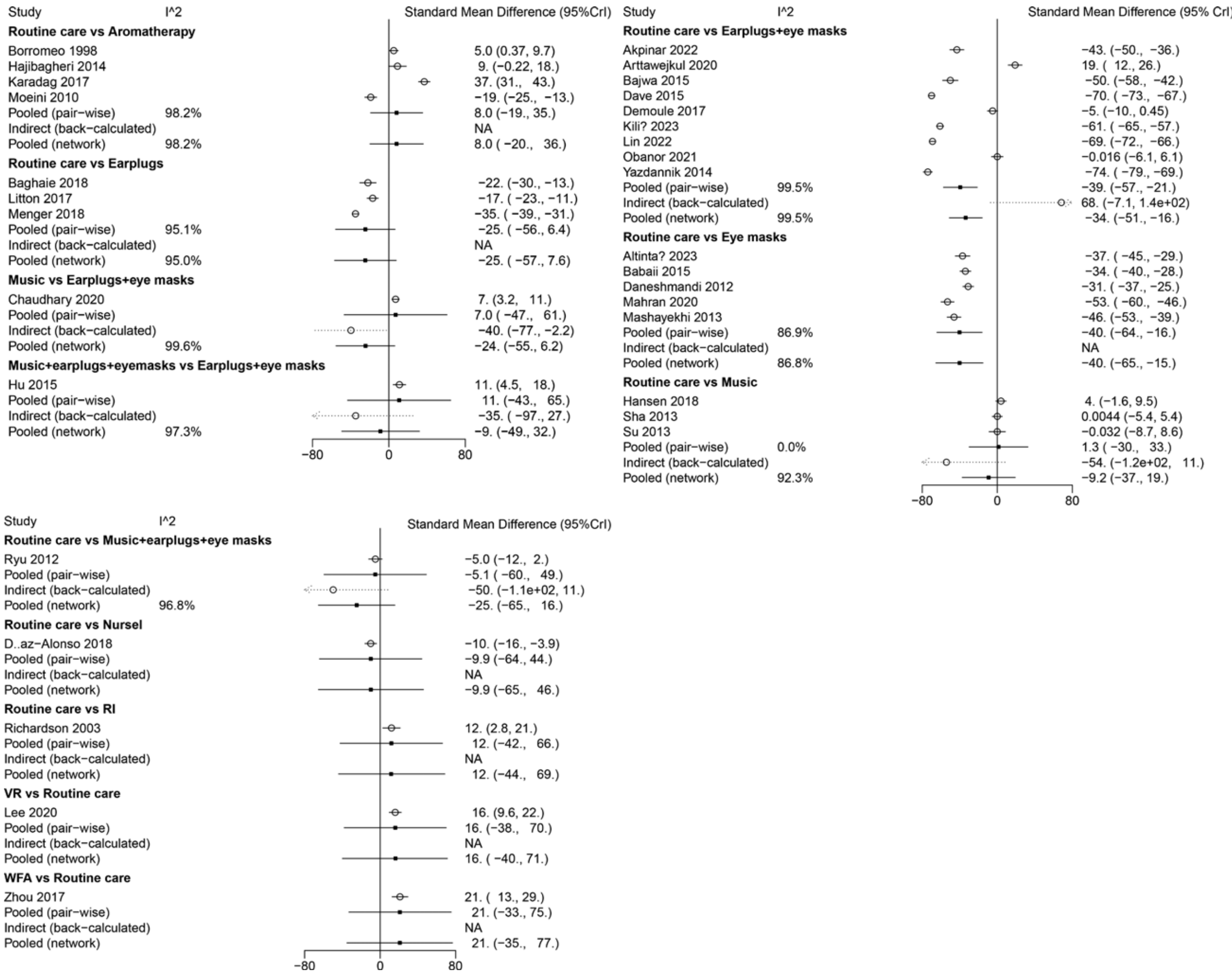

Figure 5. Heterogeneity analysis of the sleep quality.

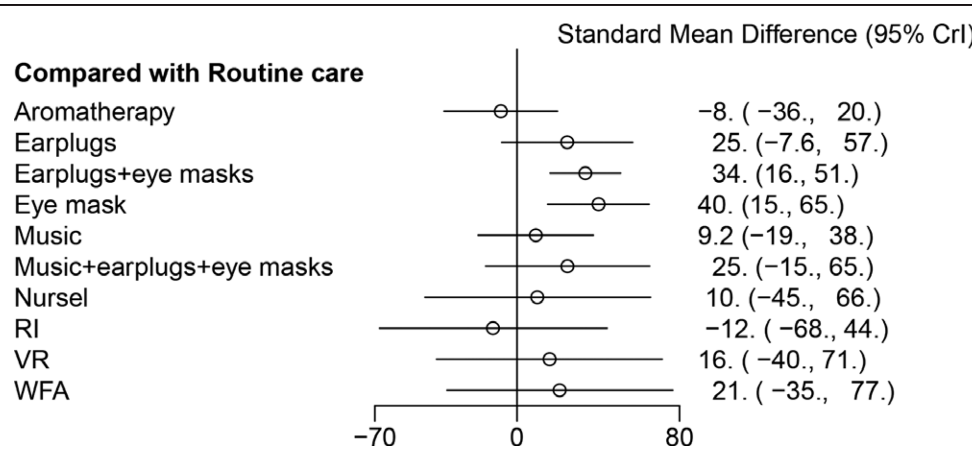

Figure 6. Forest plot of the sleep quality as compared with routine care.

our results, the confidence intervals from direct and indirect evidences are in general consistent, with minor differences (Fig. 9).

4. Discussion

4.1. Main finding

This study performed a network meta-analysis of 31 RCTs involving 2036 patients, which is based on the largest sample size to date, with an estimated sample size increase of 59.3% compared with the sample size in a previous meta-analysis (1207 patients).[12] Our findings revealed that eye masks (SMD = 40.0, 95%CrI: 15.0–65.0, $P < .05$) and earplugs + eye masks (SMD = 34.0, 95%CrI: 16.0–51.0, $P < .05$) were associated with an increase of the sleep quality than routine care. Moreover, eye masks ranked first (SUCRA, 84.6%), earplugs + eye masks ranked second (SUCRA, 77.7%), earplugs ranked third (SURCA, 63.8%), emerged as particularly effective

Table 3

Efficacy of different comparisons for sleep quality by SMDs and corresponding 95% CrIs.

Aromatherapy										
−32.77 (−75.22, 9.92)	Earplugs									
−41.63 (−74.59, −8.75)	−8.91 (−45.71, 27.79)	Earplugs + eye masks								
−48.15 (−85.45, −10.7)	−15.43 (−56.07, 25.29)	−6.52 (−36.9, 23.99)	Eye masks							
−17.27 (−57.01, 22.49)	15.44 (−27.55, 58.39)	24.39 (−6.53, 55.16)	30.83 (−6.8, 68.63)	Music						
−32.82 (−82.18, 16.31)	−0.02 (−51.79, 51.22)	8.84 (−31.61, 49.18)	15.35 (−32.24, 62.9)	−15.51 (−63.86, 32.94)	Music + earplug + eyemask					
−18.04 (−80.45, 44.17)	14.77 (−49.73, 78.63)	23.58 (−34.72, 81.74)	30.14 (−30.99, 90.6)	−0.84 (−63.12, 61.45)	14.76 (−54.16, 83.1)	NurseI				
3.76 (−58.74, 66.37)	36.52 (−28.23, 101.1)	45.46 (−13.32, 104.08)	51.99 (−9.45, 113.14)	21.08 (−41.75, 83.91)	36.59 (−32.24, 105.38)	21.8 (−57.06, 100.8)	RI			
−7.97 (−35.94, 19.9)	24.69 (−7.58, 56.94)	33.62 (16.25, 51)	40.14 (15.09, 65.01)	9.24 (−19.17, 37.57)	24.81 (−15.48, 65.29)	9.96 (−45.33, 65.72)	−11.85 (−67.69, 44.34)	Routinecare		
−23.98 (−86, 38.21)	8.62 (−55.46, 72.62)	17.62 (−40.49, 75.81)	24.09 (−36.57, 84.95)	−6.76 (−69.34, 55.72)	8.95 (−60.15, 77.52)	−5.96 (−84.67, 73.08)	−27.85 (−106.89, 51.27)	−16.03 (−71.47, 39.66)	VR	
−28.92 (−91.45, 33.14)	3.77 (−60.64, 68.25)	12.68 (−45.72, 71.05)	19.24 (−42.09, 80.14)	−11.7 (−74.39, 50.6)	4 (−65.15, 72.43)	−10.93 (−89.53, 68.4)	−32.73 (−111.91, 46.76)	−20.97 (−76.67, 34.51)	−4.9 (−83.91, 73.54)	WFA

interventions in enhancing sleep quality. Critical care nurses should consider integrating these evidence-based interventions into their daily care routines to address sleep issues in critically ill patients within intensive care units. Our approach incorporated data from studies that couldn't directly compare eligible interventions, resulting in more precise estimates of their effects.

4.2. Compared with previous meta-analysis

A previous network meta-analysis on the same topic was done by Shih et al[12] and published in 2011. In detail, the previous meta-analysis included 21 RCTs for analysis involving a total of 1207 subjects, and showed that the eye masks alone and music combined with earplugs and eye masks appear to be the most effective interventions for improving sleep quality in people who are critically ill. Our meta-analysis reinforces earlier results by including 10 recently published RCTs. These studies were high-quality and included an additional 829 patients. Another traditional meta-analyses suggested that using both eye masks and earplugs together could enhance sleep in critically ill individuals,[10,45,46] our study reveals a different perspective. Specifically, our findings indicate that the use of eye masks alone, rather than in conjunction with earplugs, holds promise for improving sleep quality in critical care units.

The potential discomfort associated with earplugs may account for the discrepancy between our findings and previous meta-analysis.[47] Factors such as discomfort, ear soreness, and anxiety stemming from the absence of background noise could contribute to the reluctance to use earplugs.[30,46,48] Consequently, our study supports the argument that using earplugs as a standalone intervention may not significantly enhance-and could even potentially impair – sleep quality in critically ill individuals when compared to standard care. In summary, our findings suggest that critically ill individuals who use earplugs during the night may experience poorer sleep quality.

The potential effectiveness of eye masks in improving sleep quality can be attributed to the interaction between the circadian rhythm and the diurnal-nocturnal cycle. In critical care settings, the lack of natural light due to the absence of windows and continuous exposure to artificial lighting both day and night are the primary triggers for sleep disturbances. Consequently, an altered light-dark cycle can disrupt the nocturnal release of melatonin from the pineal gland. Using an eye mask during the sleep period has the potential to increase melatonin levels, thereby contributing to an improvement in sleep quality.[49]

In view of these findings, it is advisable for critical care nurses to gauge the receptiveness of their patients toward the use of eye masks and earplugs. Furthermore, they should offer their expertise and support to help individuals choose the most suitable sleep-enhancing tool during their stay in critical care units. Future research initiatives should delve deeper into the hypothesis that eye masks might exhibit superior efficacy in improving the sleep quality of critically ill patients compared to earplugs.

A holistic approach to sleep care, designed to alleviate anxiety, reduce noise disruptions, and manage lighting conditions, has been proposed as a promising strategy for addressing sleep-related challenges in critical care environments.[50,51] Our study unveiled that a comprehensive treatment regimen, which included music, eye masks, and earplugs, particularly the combination of music with earplugs and eye masks, led to a noteworthy improvement in sleep quality when compared to standard care and select alternative interventions among adult patients in critical care units. Moreover, the efficacy of music as a non-pharmacological intervention to enhance sleep in critically ill individuals finds support in recent meta-analysis findings from 202.[52] These results align with our own investigation,

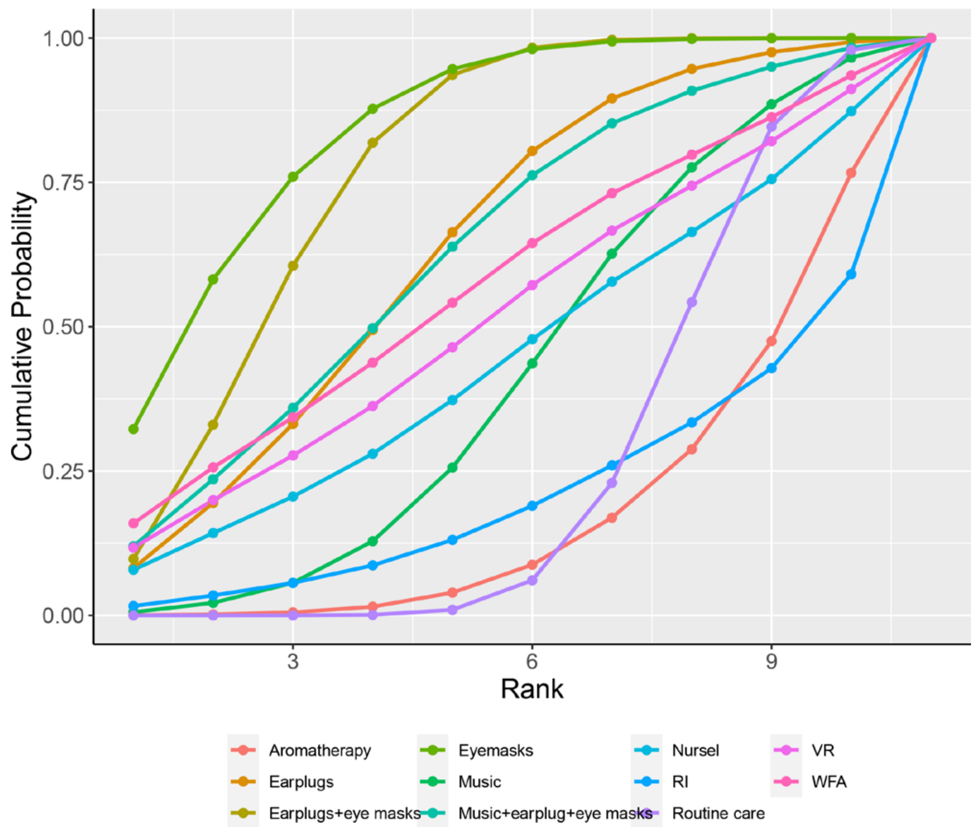

Figure 7. Surface under the cumulative ranking curve (SUCRA) probabilities of different treatments for sleep quality.

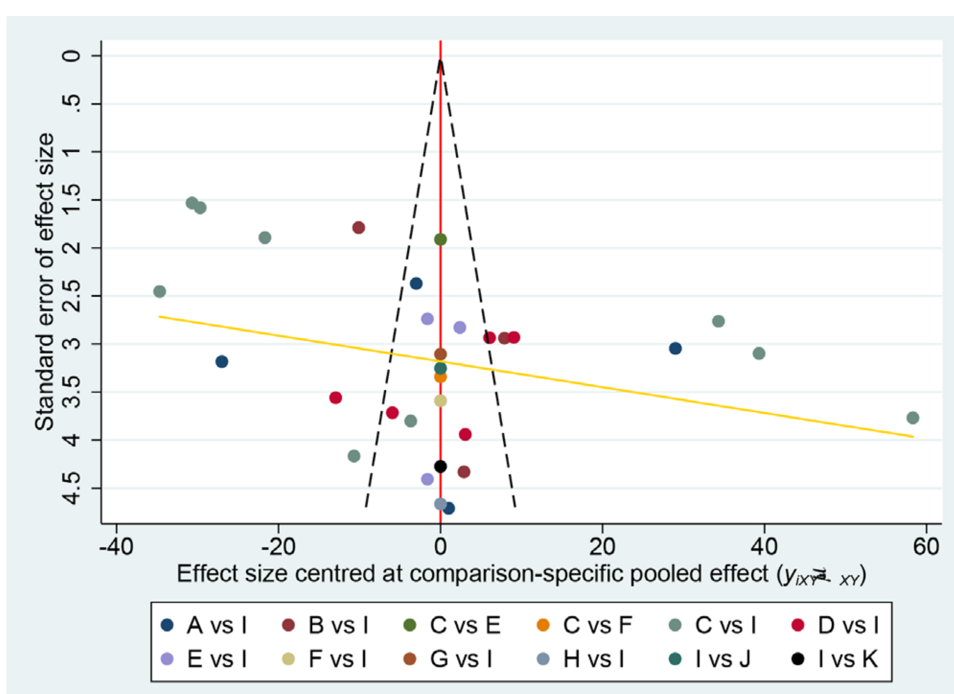

Figure 8. Funnel plot of the different treatments for sleep quality.

which highlighted the beneficial impact of music on sleep quality, even if it didn't reach statistical significance.

Several mechanisms have been proposed to explain the impact of music on sleep, which include relaxation, distraction, rhythmic entrainment, and masking.[53] The implementation of a sleep care bundle, encompassing music, eye masks, and earplugs, has demonstrated effectiveness in mitigating sleep disruptions in critical care units. The synergistic effects of this comprehensive approach are plausible. Our research findings suggest that both the integration of music with earplugs and eye masks and the

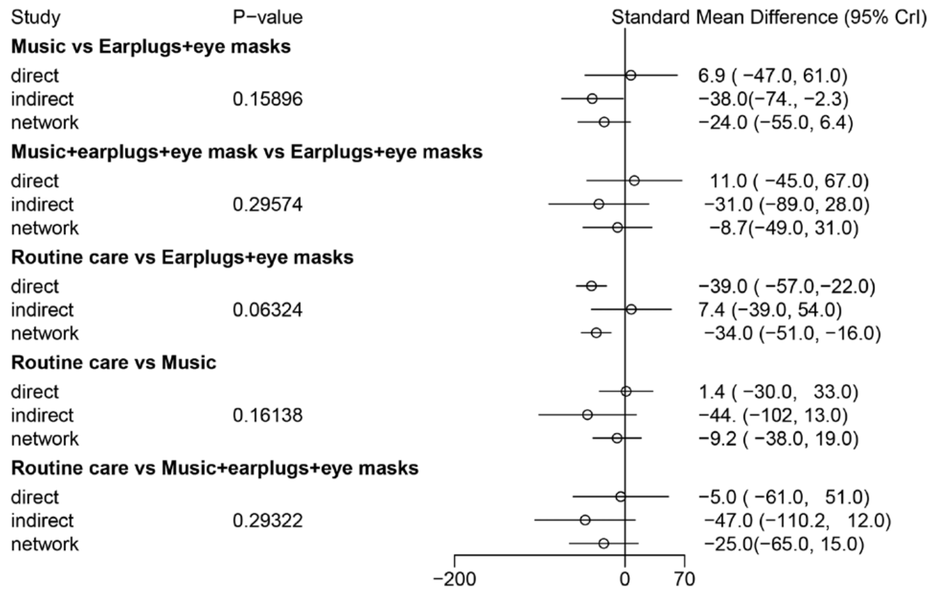

Figure 9. Node-split analysis of the different treatments for sleep quality.

use of eye masks alone have the potential to be effective strategies for addressing sleep disturbances in critically ill individuals. Notably, the integration of music with earplugs and eye masks represents a multifaceted intervention, while the use of eye masks alone can be viewed as a single-component approach. This raises the question of why both interventions yielded similar outcomes in improving sleep quality.

The introduction of earplugs as part of the combined intervention might potentially explain the observed phenomenon, as our research results indicate that earplugs had a counterproductive effect on enhancing sleep in critically ill patients when compared to standard care. Therefore, while both music and eye masks independently contribute to enhanced sleep quality, the inclusion of earplugs may attenuate the cumulative benefits, resulting in a scenario where using music in combination with earplugs and eye masks yields sleep improvements on par with those achieved with eye masks alone.

In light of our study's findings, it is worth highlighting the remarkable effectiveness of aromatherapy in improving the sleep quality of critically ill patients compared to standard care. It is plausible to suggest that the reduction in anxiety and stress levels may be a pivotal factor in explaining the positive impact of aromatherapy on sleep quality in this specific population. This assertion aligns with previous research demonstrating that lavender essential oil, a commonly used element in aromatherapy, significantly alleviates anxiety and stress levels in patients admitted to critical care units.[24,54]

The principle of transitivity, a fundamental assumption in network meta-analyses, shaped our research methodology.[55] To mitigate both within- and between-study heterogeneity, we implemented rigorous search strategies and inclusion criteria. While our study utilized a random-effects model to accommodate heterogeneity and assess inconsistencies, it is important to recognize the possibility of unmeasured effect modifiers that might impact the results of direct and indirect comparisons.

The interpretation of the findings derived from this network meta-analysis requires careful consideration of several noteworthy limitations. Primarily, as is common in meta-analyses, heterogeneity poses a substantial challenge. In our study, the presence of diverse participant characteristics, varied study attributes (encompassing a range of interventions and study designs), the inclusion of comparisons involving routine care, and relatively modest sample sizes within the randomized controlled trials we examined may potentially impact the internal validity of our results. Furthermore, it's essential to acknowledge that the quality of the data included heavily influences the efficacy of a study's findings. In the context of this specific network meta-analysis, a significant proportion of the randomized controlled trials (18 out of 20) displayed deficiencies in either adequately documenting or appropriately executing an allocation concealment procedure. Moreover, certain studies raised concerns or were considered to carry a substantial risk of bias regarding missing outcome data. They either did not utilize an intention-to-treat approach to address missing data or failed to adequately disclose the rationale behind data gaps. However, the incorporation of studies addressing these issues may pose a threat to the internal validity of our study. Furthermore, although our current network meta-analysis did not identify significant discrepancies, it did not provide sufficient evidence to unequivocally confirm the overall consistency of the network. Nevertheless, this analysis has highlighted the potential effectiveness of both music combined with earplugs and eye masks, as well as the use of eye masks alone, in enhancing sleep quality among critically ill patients in need of intensive care. Another significant finding from this study suggests that the use of earplugs may have adverse effects on sleep within critical care units.

Given that music combined with earplugs and eye masks, as well as eye masks alone, represent low-cost and highly feasible interventions, we propose that healthcare professionals consider these options as non-pharmacological strategies for enhancing sleep quality in critically ill patients. Such interventions have the potential not only to improve sleep but also to reduce the risk of delirium, shorten critical care unit stays, and decrease mortality rates among critically ill patients requiring intensive care.

5. Conclusions

In conclusion, eye masks and earplugs + eye masks are the most effective interventions for improving sleep quality in critically ill patients. We recommend that researchers design large-scale, high-quality randomized controlled trials, with a particular focus on implementing adequate allocation concealment and effective missing data management. These trials should further investigate the treatment effects of non-pharmacological interventions on sleep disturbances in critically ill individuals. Additionally, future research should explore the effects of combining music with eye masks to validate the inferences made in the present network meta-analysis.

Author contributions

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Supervision: Daijin Huang.
Validation: Chang Liu.
Visualization: Yumei Li, Chang Liu, Dongyan Shen, Yunhui Lv.
Writing – original draft: Yumei Li, Yunhui Lv.

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