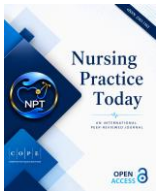
Tehran University of Medical Sciences

Nursing Practice Today

2026; Volume 13, No 3, pp. 246-263



Review Article

Effectiveness of nurse-implemented nonpharmacologic interventions on delirium incidence in cardiac surgical ICU patients: A systematic review and meta-analysis

Dikki Saputra[1]*, Muhammad Luthfi[1], Hafizul Makruf[2]

[1]Department of Nursing, Faculty of Medicine, Universitas Tanjungpura, Indonesia
[2]Sekolah Tinggi Ilmu Kesehatan Medika Seramoe Barat, Meulaboh, Indonesia

ARTICLE INFO

Received 14 February 2026
Accepted 13 April 2026

Available online at:
http://npt.tums.ac.ir

Keywords:
delirium;
cardiac surgical procedures;
nursing care;
critical care;
systematic review;
meta-analysis

Corresponding Author:
Dikki Saputra, Department of Nursing, Faculty of Medicine, Universitas Tanjungpura, Indonesia.
E-mail: dikkisaputra@ners.untan.ac.id

DOI: 10.18502/npt.v13i3.22127

ABSTRACT

Background & Aim: Delirium is a common, serious postoperative complication in cardiac surgery. This study evaluated the impact of nurse-implemented multimodal nonpharmacologic bundles on delirium incidence and severity in adult cardiac surgery ICU patients.

Methods & Materials: A systematic review and meta-analysis were conducted. A systematic literature search was performed across PubMed, Scopus, ScienceDirect, and the Cochrane Library from inception to September 15, 2025. Data from eligible studies were extracted for narrative synthesis and meta-analysis. Pooled Odds_Ratios and 95% Confidence Intervals were calculated to evaluate delirium incidence, and statistical heterogeneity was assessed using the I^2 statistic.

Results: Thirteen studies were included, with eight studies (N=3,831) suitable for meta-analysis. Nurse-implemented bundles were associated with a reduced incidence of delirium (OR 0.56; 95% CI: 0.41–0.75; I2=14%). Narrative synthesis of five additional studies indicated that interventions such as early mobilization and sensory-based bundles (eye masks/earplugs) may mitigate delirium severity. Furthermore, physical frailty was identified as a significant risk factor (Adj. OR 1.61), and Scenario-Based Learning was found to be a viable approach for enhancing nurse competency.

Conclusion: Nurse-implemented multimodal non-pharmacological bundles contribute to reducing delirium incidence in cardiac surgery ICUs. These findings suggest that such protocols serve as a relevant secondary prevention strategy. However, given the diversity of intervention components and geographical settings, these results should be interpreted with caution. Clinical protocols should consider integrating frailty screening and environmental modifications, while future research should prioritize standardized continuous outcomes like Delirium-Free Days.

Introduction

Delirium is a serious complication commonly experienced by patients after cardiac surgery in intensive care units (ICUs), with reported incidence ranging from 20% to 52%, depending on patient characteristics, diagnostic criteria, and surgical complexity (1-3). This condition has significant clinical implications, as it is associated with prolonged mechanical ventilation, longer ICU and hospital stays, higher healthcare costs, long-term cognitive impairment, and increased mortality (4,5).

Pharmacological approaches for delirium prevention and management have shown limited effectiveness and are often accompanied by adverse drug effects (6,7). Consequently, greater attention has shifted toward nonpharmacological strategies, particularly multimodal bundles that target modifiable risk factors. These interventions generally include early mobilization, orientation protocols, sleep hygiene, cognitive stimulation, and family involvement. Nurses, as providers of continuous bedside care, play a central role in implementing these strategies and ensuring adherence and consistency (8,9).

Recent evidence indicates that nurse-implemented multimodal bundles can reduce delirium incidence and improve patient outcomes in ICU settings. For example, a

Please cite this article as: Saputra D, Luthfi M, Makruf H. Effectiveness of nurse-implemented nonpharmacologic interventions on delirium incidence in cardiac surgical ICU patients: A systematic review and meta-analysis. Nursing Practice Today. 2026; 13(3): 246-263.

quasi-experimental study among post-cardiac surgery patients reported a decrease in delirium incidence from 21.9% in the control group to 9.4% following protocol implementation (10). Nevertheless, the findings remain heterogeneous. Previous systematic reviews across broader ICU populations have shown mixed results; some demonstrated reductions in delirium incidence and ICU length of stay, while others found no significant effect on delirium duration (11). Crucially, these general reviews may not fully capture the unique physiological stressors of cardiac surgery, such as the inflammatory response to cardiopulmonary bypass and postoperative hemodynamic instability, which may influence patient response to preventive strategies.

Furthermore, while prior reviews exist, they often combine pharmacologic and nonpharmacologic approaches or lack a specific focus on nursing-led care. Given the high burden of delirium and the variability in practice, a focused synthesis of nurse-implemented strategies specifically within the cardiac surgical context is necessary to provide clear guidance for bedside practice. Therefore, this study aims to evaluate the effectiveness of nurse-implemented nonpharmacologic interventions on delirium incidence in adult patients admitted to cardiac surgical intensive care units. Secondary objectives include synthesizing evidence on delirium duration, ICU and hospital length of stay, short-term mortality, and functional recovery compared with usual care.

Methods

Study design

This study was designed as a systematic review and meta-analysis and was conducted in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. The completed PRISMA 2020 checklist is provided in Figure 1. The protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD420251150387 (available at: https://www.crd.york.ac.uk/PROSPERO/view/CRD420251150387)

Eligibility criteria

The inclusion criteria for this review were developed using the PICO (Population, Intervention, Comparator, and Outcomes) framework. The population considered included adult patients (≥18 years) admitted to cardiac surgical intensive care units following procedures such as coronary artery bypass grafting, valve replacement, or combined surgeries. The intervention of interest focused on nurse-implemented nonpharmacologic interventions. To address potential clinical heterogeneity, the review included both multimodal bundles and single-component interventions (e.g., sleep promotion, early mobilization, reorientation, and sensory optimization), with planned subgroup analyses to distinguish their effects. Studies incorporating elements of the ABCDEF (Assess, Prevent, and Manage Pain; Both Spontaneous Awakening and Breathing Trials; Choice of analgesia and sedation; Delirium: Assess, Prevent, and Manage; Early mobility and exercise; and Family engagement and empowerment) bundle were also eligible, provided they were compared with standard or usual ICU care. Regarding outcomes, although delirium-free days were initially stated as the primary outcome in the protocol, delirium incidence was adopted as the operational primary outcome for the meta-analysis due to inconsistent reporting of delirium-free days across the included studies. Secondary outcomes included delirium duration, ICU and hospital length of stay, short-term mortality (ICU, hospital, or 30-day), functional recovery, and adverse events.

Studies were excluded if they reported aggregated data for mixed ICU populations (e.g., combined medical, general surgical, and cardiac patients) without providing separate, extractable data for the cardiac surgical subgroup. Regarding interventions, studies focusing solely on pharmacologic sedation or analgesia protocols without a distinct nonpharmacologic component were excluded. To clearly define "nurse-led," we excluded interventions that were strictly physician-initiated or where nursing autonomy in protocol delivery and titration was absent. Additionally, study designs lacking a control

group (e.g., case reports, case series), as well as editorials, commentaries, conference abstracts, dissertations, and non-peer-reviewed publications, were not considered. Articles not published in English were also excluded.

Searching strategy

A literature search was conducted systematically across multiple databases, including PubMed, Scopus, ScienceDirect, and the Cochrane Library. Each database was searched from inception to September 15, 2025. The search strategy was adapted for each database using a combination of relevant keywords and controlled vocabulary (e.g., MeSH terms), which encompassed concepts such as "delirium," "delirium-free days," "cardiac surgical intensive care unit," "nursing care," "critical care nursing," and "nonpharmacologic interventions" (e.g., sleep hygiene, mobilization, reorientation, family involvement, ABCDEF bundle). The detailed search strategy is provided in Supplementary File 1.

All identified articles were imported into Covidence, where duplicates were automatically removed. The remaining records were then screened independently by two reviewers (DS and ML). Title and abstract screening was followed by a full-text review based on predefined eligibility criteria, all conducted within the Covidence platform. Any disagreements were resolved through discussion with a third reviewer (HM).

Quality assessment

To ensure methodological rigor, the risk of bias of the included studies was appraised independently by two reviewers (DS and ML) using design-specific tools. For Randomized Controlled Trials (RCTs), the Cochrane Risk of Bias 2 (RoB 2) tool was utilized. For quasi-experimental and observational cohort studies, the Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) tool was applied. Any disagreements between reviewers were resolved through discussion or consultation with a third reviewer (HM). This rigorous quality assessment directly guided the decision to pool comparable RCTs into the meta-analysis while appropriately allocating non-randomized and heterogeneous studies into the narrative synthesis.

Data extraction

Data from the included studies were extracted independently by two reviewers using a standardized data extraction form. Extracted information included key study characteristics such as author and year of publication, country, study design, and intervention. Details of the intervention, including the components, duration, and frequency of the nurse-implemented multimodal nonpharmacologic bundles, were collected along with information on the comparator group. Outcomes of interest, including delirium-free days during ICU stay, delirium incidence, duration of delirium, ICU and hospital length of stay, mortality (ICU, hospital, or 30-day), and other relevant clinical endpoints, were also recorded.

For the outcomes of interest, data were collected either as the number of events and total participants per group, or as reported effect measures, including odds ratios (ORs) or hazard ratios (HRs) with their respective confidence intervals. Data extraction was performed independently by three reviewers (DS, ML, HM) to ensure accuracy and consistency.

Statistical analysis and certainty assessment

Statistical analyses were conducted using RevMan software. Given the clinical and methodological diversity of the included interventions, a Mantel-Haenszel random-effects model was employed for the meta-analysis to pool dichotomous outcomes (delirium incidence), with effect sizes expressed as odds ratios (ORs) and 95% confidence intervals (CIs). Continuous outcomes and hazard ratios were not pooled directly with ORs; where statistical pooling was not feasible due to substantial clinical or statistical heterogeneity (e.g., continuous outcomes with varied measurement scales), the data were synthesized narratively.

Heterogeneity was assessed using the I^2 statistic and Cochran's Q test, with I^2

statistic and Cochran's Q test, with $I^2 \geq 50\%$ or $p < 0.05$ indicating substantial heterogeneity. Sensitivity analyses were conducted to assess the robustness of the findings using two approaches: (1) a leave-one-out procedure to test the influence of individual large trials, and (2) an analysis restricted only to studies with a lower risk of bias, thereby assessing the impact of study quality on the pooled estimates. Publication bias was not formally assessed via funnel plots as the number of included meta-analysis studies was less than 10, rendering such tests underpowered.

Results

Study selection

Figure 1 shows that a total of 295 records were retrieved from the database searches (Scopus= 38, PubMed= 145, ScienceDirect= 60, and CochraneLibrary= 52). After removing 14 duplicates and 22 records identified as ineligible by automation tools, 259 records were screened. Of these, 202 records were excluded for being irrelevant. The remaining 57 reports were assessed for full-text eligibility, leading to the exclusion of 44 reports due to wrong outcomes (n= 28), wrong patient population (n= 4), wrong intervention (n= 9), and wrong study design (n= 3). Finally, 13 studies fulfilled the inclusion criteria and were incorporated into the review.

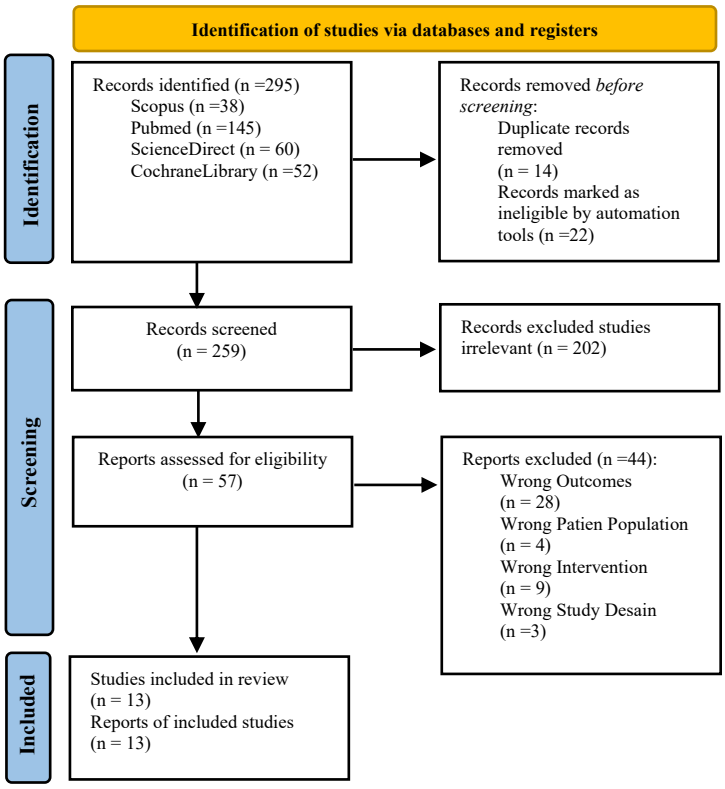


Figure 1. PRISMA diagram of included studies

Study characteristic

A total of 13 studies met the inclusion criteria, comprising randomized controlled trials (RCTs), quasi-experimental studies, and observational cohorts. Of these, 8 studies provided dichotomous outcome data on delirium incidence suitable for quantitative meta-analysis. The remaining 5 studies, although relevant to the topic, were included only in the narrative synthesis due to incompatible data formats, non-randomized designs, or significant statistical heterogeneity.

Table 1. Characteristics of the study

No	Author (Year)	Country	Design	Intervention
1	Askarkafi et al. 2020 (12)	Iran	Single-blind, randomized controlled trial	• Massage with aromatic oil (rose oil 4% in sweet almond base), twice daily × 3 sessions (post-op day 1 to day 3), Brown massage technique. • Massage without aroma (sweet almond oil only), same procedure and schedule.
2	Cheng et al. 2024 (13)	China	Retrospective cohort study (observational)	Frail group (MFI ≥3, Modified Frailty Index)
3	Deeken et al. 2022 (14)	Germany	Stepped-wedge cluster randomized controlled trial	Multifaceted non-pharmacological delirium prevention program (AKTIVER): • Cognitive, motor, sensory stimulation • Meal companionship • Accompaniment during diagnostic procedures • Stress relaxation, sleep promotion • Delivered by trained delirium prevention team + staff education
4	Fazlollah et al. 2021 (15)	Iran	Randomized controlled trial	Foot reflexology massage (20 min per session, once daily × 2 days, both feet, post–CABG surgery)
5	Gómez Tovar et al. 2024 (16)	Colombia	Double-masked randomized controlled trial	Dynamic Delirium (DyDel) – multicomponent nursing intervention based on the Dynamic Symptom Model and evidence-based bundles (ABCDEF, HU-CI). Activities included reorientation, family participation, cognitive stimulation, environmental control, pain management, sensory aids, etc., delivered every shift until ICU discharge.
6	Jahanbazi et al. 2022 (17)	Iran	Quasi-experimental, pretest–posttest study	Scenario-Based Learning (SBL) workshop (2 days × 6h/day) with case scenarios, NICE guideline-based teaching, group analysis of delirium cases, and training on delirium prevention/management.
7	Milz et al. 2024 (18)	Germany	Prospective system-based quality improvement	Implementation of a 4-component delirium prevention bundle: • Preoperative delirium risk stratification • Consistent post-anesthesia rounds with delirium screening until POD3 (CAM-ICU) • Multidisciplinary education of staff on guidelines • Written memory aids (flyers) Non-pharmacological measures included: early mobilisation, avoiding benzodiazepines, daily pain assessment, adequate nutrition, use of hearing/visual aids, and noise reduction.
8	Shorofi et al. 2024 (19)	Iran	Single-blind randomized controlled trial	• Routine ICU care plus; Eye masks (Paksaman Co.) and Foam earplugs (3M Classic, noise reduction 29 dB) • Applied nightly from 21:00–07:00 for 3 consecutive nights, starting POD2. • Nurses supervised compliance.
9	Söylemez et al. 2024 (10)	Türkiye	Quasi-experimental (nonrandomized)	• Nurse training + implementation of "Postoperative Delirium Prevention, Diagnosis, and Intervention Protocol." • Protocol developed from guidelines and literature, validated by experts. • Included: CAM-ICU, GCS, RASS assessments; prevention and nursing interventions; daily monitoring checklist. • Training booklet and 2-hour session for ICU nurses.
10	Zhang et al. 2025 (20)	China	Randomized controlled study	• Observation group: Graded nursing management based on the delirium prediction model. • Risk stratification: low-risk (0–20%), medium-risk (20–40%), high-risk (40–60%), extremely high-risk (>60%). • Nursing measures according to risk group: Low-risk: routine pain assessment (NRS/CPOT), sedation assessment (RASS), CAM-ICU twice daily, sleep management, environmental adjustments, Medium-risk: + functional training (heel raises, wall squats, stair training), High-risk: + psychological support, family involvement, Extremely high-risk: + pharmacological prevention (e.g., dexmedetomidine 0.2–0.7 μg/kg/h with monitoring).
11	Zhao et al. 2024 (21)	China	Retrospective cohort study	• Observational study; patients with delirium (POD group) compared to the non-POD group. • Focused on identifying perioperative risk factors; proposed nursing interventions.
12	Lin et al. 2024 (22)	China	Single-blind randomized controlled trial	• Family intervention during ICU visits: education of family caregivers on ICU infection prevention and delirium; active family involvement, including psychological support, orientation (5W1H), cognitive stimulation, prevention of sensory deprivation, and participation in basic ICU care; implemented daily from post-operative day 1 until ICU discharge (max 7 days)
13	Shirvani et al. 2020 (23)	Iran	Double-blind randomized controlled trial	• Early planned mobilization protocol applied during the first 2 days after CABG surgery compared with routine postoperative care

Quality assessment

The methodological quality and risk of bias of the 13 included studies were appraised using standardized Cochrane tools. Randomized controlled trials (n=8) were assessed using the Risk of Bias 2 (RoB 2) tool (Supplementary Figure S1), while non-randomized studies (n=5) were evaluated using the Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) tool (Supplementary Figure S2). Overall, the majority of RCTs demonstrated a low risk of bias, though some raised 'some concerns' primarily due to deviations from intended interventions. For non-randomized studies, the risk of bias ranged from moderate to serious, predominantly due to confounding factors. To directly address reviewer feedback regarding the practical application of these scores, these rigorous assessments were subsequently used to categorize study quality (e.g., high vs. low quality) and directly informed the sensitivity analyses to ensure the robustness of the meta-analysis findings. Detailed risk of bias judgments for each domain and overall scores are provided in the Supplementary Materials.

Meta-analysis

Dichotomous outcomes (Delirium incidence)

The pooled analysis for the dichotomous outcome (delirium incidence) incorporated eight studies, comprising a total sample size of 3,831 patients (1,921 in the experimental group and 1,910 in the control group). The statistical synthesis, consistently conducted using a Mantel-Haenszel random-effects model, demonstrated that nurse-implemented multimodal nonpharmacologic bundles significantly reduced the incidence of delirium when compared to standard ICU care. The overall Odds Ratio (OR) was 0.56, with a 95% Confidence Interval (CI) ranging from 0.41 to 0.75 ($P = 0.0001$). This finding indicates that patients receiving the nursing intervention bundle had 44% lower odds of developing postoperative delirium.

Importantly, the heterogeneity analysis revealed a low level of statistical heterogeneity among the included studies ($Tau^2 = 0.03$; $Chi^2 = 8.18$, $df=7$, $P=0.32$; $I^2 = 14\%$). This low I^2 value suggests an acceptable and expected level of clinical variance across different study populations and intervention formats, acknowledging that true homogeneity is rare in clinical trials involving complex nursing interventions. In conclusion, this meta-analysis provides strong and compelling evidence that the implementation of nonpharmacological bundles by nurses is an effective strategy for the prevention of delirium occurrence (secondary prevention) in critically ill post-cardiac surgery patients (Figure 2).

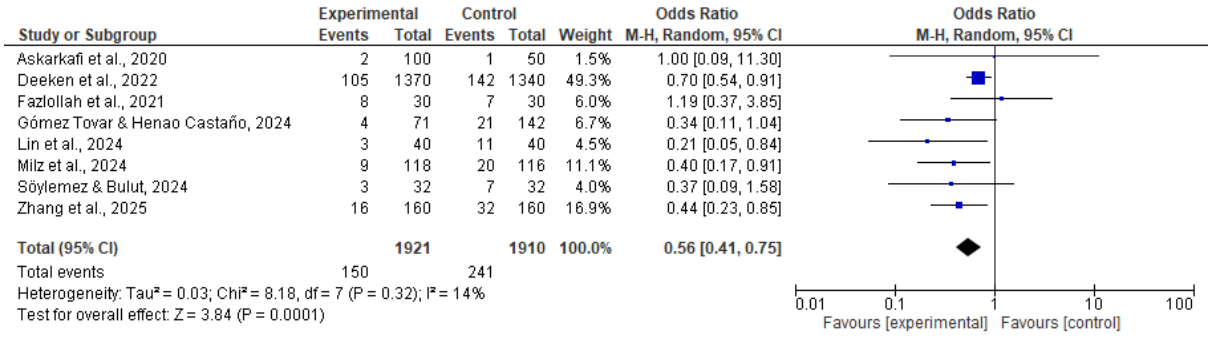


Figure 2. Forest plot of dichotomous outcomes–delirium incidence

Sensitivity analysis

Influence of individual studies

A sensitivity analysis was performed to evaluate the robustness of the primary meta-analysis finding, which reported a pooled OR of 0.56 with low heterogeneity (I^2= 14%). The testing focused on the influence of individual studies on the overall pooled estimate. Our primary result was intentionally derived using the Mantel-Haenszel Random-effects model to account for the anticipated clinical diversity among the included studies. To test the stability of this

finding, we performed a leave-one-out analysis to ensure that the result was not unduly dominated by the largest trial, Deeken et al. (2022), which contributed 49.3% of the total weight. Notably, when Deeken et al. (2022) were excluded, the intervention's protective effect remained robust, and the result remained highly statistically significant. Crucially, the sequential removal of any single trial neither abolished the statistical significance nor reversed the direction of the overall effect.

Influence of study quality (Risk of bias)

To evaluate the impact of methodological quality on the overall findings, an additional sensitivity analysis was conducted based on the risk of bias assessments (RoB 2 and ROBINS-I). The meta-analysis was re-evaluated by excluding studies categorized as having a higher risk of bias, specifically, those with "Some concerns" for RCTs (Askarkafi et al., 2020; Fazlollah et al., 2021; Zhang et al., 2025) and "Serious" risk for non-randomized studies (Milz et al., 2024). When the analysis was restricted strictly to the four studies with a lower risk of bias (Deeken et al., 2022; Gómez Tovar & Henao Castaño, 2024; Lin et al., 2024; and Söylemez & Bulut, 2024), the pooled effect size remained consistent and statistically significant (OR = 0.48; 95% CI: 0.28–0.85; P=0.01; Supplementary Figure S3).

Conclusion of sensitivity analyses

These sensitivity analyses conclusively demonstrate that the primary finding is highly reliable and stable. The results are neither controlled by a single large study nor disproportionately driven by studies with methodological limitations. Therefore, our conclusion that nurse-implemented nonpharmacologic interventions consistently and significantly reduce delirium incidence in cardiac surgical ICU patients is strongly supported.

Narrative review results

Five studies (Cheng et al., 2024; Jahanbazi et al., 2022; Zhao et al., 2024; Shirvani et al., 2020; Shorofi et al., 2024) were excluded from the primary meta-analysis due to incompatible data formats, non-randomized designs, or significant statistical heterogeneity. These studies provide critical complementary insights into the effectiveness of multimodal nursing interventions and the perioperative risk factors for delirium in cardiac surgery patients.

Regarding delirium severity, two studies (Shirvani et al., 2020; Shorofi et al., 2024) evaluated cognitive status using the NEECHAM Confusion Scale. Although both studies demonstrated statistically significant improvements in cognitive function (P<0.0001), statistical pooling revealed substantial heterogeneity (I^2 = 87%), likely due to the fundamental differences in the clinical interventions provided (early mobilization versus sensory-based bundles). Shirvani et al. (2020) reported that an early planned mobilization protocol significantly improved cognitive function on the second postoperative day compared to routine care (MD 4.33; 95% CI 3.49–5.17). Similarly, Shorofi et al. (2024) found that the use of earplugs and eye masks significantly enhanced cognitive status, with an improvement of 2.66 points over standard care (95% CI 1.85–3.47).

Furthermore, other narrative findings emphasized the role of nurse education and risk factor identification. Jahanbazi et al. (2022) demonstrated that Scenario-Based Learning (SBL) significantly improved nurses' knowledge and performance in delirium management (P<0.001). Additionally, evidence from Cheng et al. (2024) and Zhao et al. (2024) identified physical frailty (Adj. OR 1.61) and prolonged mechanical ventilation as key predictors of delirium, highlighting them as essential targets for preventive nursing care.

Table 2. Summary of studies included in the narrative review

No	Author (Year)	Design	Intervention	Control	Outcome	Key Findings
1	Cheng et al. 2024 (13)	Retrospective cohort study (observational)	Frail group (MFI ≥3, Modified Frailty Index)	Non-frail group (MFI 0–2)	Primary: Postoperative delirium incidence (assessed with CAM-ICU and nursing notes) Secondary: Pressure injury	Frailty significantly increased the risk of postoperative delirium (29.2% vs 16.4%; Adj. OR 1.61, 95% CI: 1.23–2.10, p<0.001) and was also associated with a higher prevalence of pressure injury (11.1% vs 4.8%).
2	Jahanbazi et al. 2022 (17)	Quasi-experimental, pretest-posttest study (N=36 nurses in cardiac surgery ICUs).	Scenario-Based Learning (SBL) workshop (2 days × 6h/day) with case scenarios, NICE guideline-based teaching, group analysis of delirium cases, and training on delirium prevention/management.	No control group (single-group pre-post design).	Nurse knowledge and performance on delirium diagnosis and management (knowledge questionnaire, performance checklist).	Scenario-Based Learning (SBL) significantly improved nurses' performance and knowledge in delirium care, with scores increasing immediately after and remaining higher three weeks post-training (p<0.001). The study recommends SBL as an effective training method for cardiac surgery ICU nurses.
3	Zhao et al. 2024 (21)	Retrospective cohort study (n=320)	• Observational study; patients with delirium (POD group) compared to the non-POD group. • Focused on identifying perioperative risk factors; proposed nursing interventions.	Non-POD patients (n=227).	Primary: Incidence of POD (CAM-ICU, DSM-5, RASS ≥ -3). Secondary: Perioperative risk factors (surgery time, CPB, ICU stay, ventilation, pain).	Postoperative delirium occurred in 29.1% of cardiac surgery patients. Significant risk factors included demographic and intraoperative variables. The study highlights these risk factors as the clinical basis for targeted nursing interventions guided by behavior change theory to improve delirium prevention and management.
4	Shirvani et al. 2020 (23)	Double-blind randomized controlled trial (n=92)	Early planned mobilization protocol: structured ambulation started on postoperative days 1-2.	Routine nursing care only; no early mobilization.	Neurological status by NEECHAM Confusion Scale; Intubation time.	Early mobilization significantly improved cognitive function (NEECHAM score 26.82 vs 22.49, p=0.001) and shortened intubation time (p=0.020).
5	Shorofi et al. 2024 (19)	Randomized controlled trial (n=114)	Sensory-based intervention bundle: use of earplugs and eye masks in the ICU.	Standard nursing care without sensory aids.	Cognitive status measured by the NEECHAM Confusion Scale.	The intervention group showed a significant improvement in cognitive status compared to the control group (MD 2.66; 95% CI: 1.85–3.47; p < 0.00001).

Discussion

This systematic review synthesized evidence from 13 studies that met the eligibility criteria, reflecting a broad spectrum of methodological designs tailored to the complex ICU environment. The included literature comprised randomized controlled trials (RCTs), including single-blind, double-masked, and stepped-wedge cluster designs, alongside quasi-experimental research and retrospective observational cohorts. Of these, eight studies provided sufficient dichotomous data on delirium incidence for quantitative meta-analysis. The remaining five studies were synthesized narratively, as they either focused on specific risk factors, utilized educational interventions for staff, or presented data in formats unsuitable for statistical pooling.

Regarding methodological quality, the assessment using the Cochrane Risk of Bias 2 (RoB 2) and ROBINS-I tools indicated a generally acceptable level of rigor across the evidence base. While several RCTs demonstrated a low risk of bias, some were noted for "some concerns" or "moderate" risk, frequently stemming from the inherent challenges of blinding nursing interventions in a critical care setting. By shifting from a general scoring system to domain-specific assessments, this review provides a more nuanced understanding of how study quality, particularly in areas of confounding and intervention adherence, might influence the observed outcomes.

The interventions under investigation were predominantly nurse-led and nonpharmacological, emphasizing a proactive approach to delirium management. These strategies ranged from multifaceted protocols, such as tiered nursing management and evidence-based bundles (e.g., AKTIVER and DyDel), to targeted comfort-focused interventions including massage, aromatherapy,

foot reflexology, and sleep-promotion aids like eye masks and earplugs. Furthermore, educational strategies such as scenario-based learning (SBL) were identified as critical components for ensuring protocol fidelity among nursing staff.

Geographically, the evidence was notably concentrated in Asian countries, particularly Iran and China, with significant contributions from Germany, Colombia, and Turkey. This geographic distribution suggests that while the principles of nurse-led delirium bundles are globally recognized, their implementation is adapted to diverse clinical cultures and staffing models. The variation in study designs and intervention components underscores the necessity of the sensitivity analyses performed, ensuring that the synthesis of these diverse studies yields a stable and applicable conclusion for cardiac surgery ICUs.

The meta-analysis, incorporating eight studies with a total sample size of 3,831 patients, indicates that nurse-implemented nonpharmacologic interventions are associated with a significant reduction in delirium incidence among cardiac surgical ICU patients. The statistical synthesis, conducted using a Mantel-Haenszel random-effects model, yielded a pooled Odds Ratio (OR) of 0.56 (95% CI: 0.41–0.75; P= 0.0001). These findings suggest that patients receiving the nursing intervention bundles had 44% lower odds of developing postoperative delirium compared to those receiving standard care.

Heterogeneity analysis revealed a low level of statistical variance among the included studies (I^2 = 14%; P= 0.32), which represents an acceptable and expected degree of clinical diversity in complex nursing interventions across varied study populations. From an epidemiological perspective, these results support the implementation of nonpharmacologic bundles as an effective secondary prevention strategy. This classification is appropriate as the interventions aim to mitigate the onset of an acute complication (delirium) in a high-risk population already hospitalized and exposed to the physiological stressors of major cardiac surgery and cardiopulmonary bypass.

Multimodal non-pharmacological nursing interventions are effective in reducing the incidence of delirium among patients in intensive care settings, including those undergoing cardiac surgery. Several studies reported that the implementation of multicomponent strategies reduced delirium incidence by 27% to 54% in older adults (24-26). Furthermore, nurse-led interventions significantly lowered the risk of delirium compared to standard care, with a risk ratio of 0.74 ($p<0.001$) (27). The effectiveness of these interventions is also reflected in their impact on other clinical outcomes related to delirium. Evidence suggests that multicomponent strategies not only reduce delirium incidence but also contribute to shorter hospital stays and improved cognitive function following intensive care (24,25). However, findings regarding their effect on the duration and severity of delirium remain inconsistent, as some studies reported no significant improvement in these aspects (24,28).

Nurses play a central role in the primary prevention of delirium, extending beyond screening to active involvement in intervention. Evidence from various studies demonstrates that nurse-led non-pharmacological interventions are effective in reducing the incidence of delirium. The strategies applied include environmental modification, sleep promotion, cognitive assessment, patient orientation, and early therapeutic interventions, which are typically implemented within structured protocols to minimize the risk of delirium (29,30).

The effectiveness of these interventions is further enhanced when delivered through a multidisciplinary approach. Nurses, family members, and other healthcare professionals collaborate in implementing comprehensive care plans. Such interprofessional collaboration is essential, as delirium is a multifactorial condition that requires integrated interventions (31). Findings from this meta-analysis indicate that nurse-implemented multimodal non-pharmacological interventions contribute to the prevention of acute complications among hospitalized patients. This evidence highlights that nurses not only play a role in early detection but also directly contribute to reducing delirium incidence through evidence-based interventions integrated within the multidisciplinary healthcare team. By

managing modifiable risk factors in patients already exposed to major surgery, these nursing strategies serve as an essential component of secondary prevention within the cardiac surgical environment.

The primary meta-analysis demonstrated a consistent protective effect of nurse-implemented multimodal bundles, with a pooled OR of 0.56 (95% CI: 0.41–0.75; P=0.0001) and low heterogeneity (I^2=14%). To evaluate the robustness of these findings, a series of sensitivity analyses was conducted. The leave-one-out analysis confirmed that the results were not unduly dominated by the largest trial (Deeken et al., 2022), which contributed 49.3% of the total weight. Even upon its exclusion, the protective effect remained statistically significant, suggesting that the effectiveness of these nursing interventions is consistent across different study settings. Furthermore, when the analysis was restricted to studies with a lower risk of bias, the pooled effect size remained stable (OR 0.48). This stability indicates that the primary finding is not disproportionately driven by methodological limitations in individual studies. The consistency between the primary analysis and these sub-analyses reinforces the reliability of multimodal non-pharmacological interventions as an effective strategy for the prevention of acute delirium complications, serving as a critical component of secondary prevention in the cardiac surgical ICU.

This phenomenon can be further explained through the concept of the small study effect and other methodological factors that influence pooled estimates. The small study effect refers to the tendency for smaller studies to report larger and more favorable effect estimates compared to larger studies (32). In contrast, larger studies often provide more conservative estimates or "dilute" the pooled effect (33). This aligns with the leave-one-out findings in the present meta-analysis, where removing the largest study (14) resulted in an increased protective effect of the intervention, suggesting that the effectiveness of multimodal nonpharmacological bundles may be stronger than indicated by the initial pooled estimate.

Simulation studies have shown that small sample sizes can yield valid and accurate effect estimates comparable to larger samples, although this is context- and intervention design-dependent (34). Additionally, smaller studies are more susceptible to publication bias, in which significant results are more likely to be published, potentially leading to an overestimation of intervention effects (35). Combining studies with varying sample sizes and designs can also introduce heterogeneity, which may influence the pooled estimate (36). The choice of statistical model, whether fixed-effect or random-effects, further affects the pooled estimate; random-effects models often provide more balanced estimates by assigning relatively more weight to smaller studies (37).

Taking all these factors into account, the sensitivity analysis indicates that the results of the meta-analysis are not only stable and reliable but also demonstrate consistency across study scales and the potential for even stronger protective effects of the intervention. These findings reinforce the robustness of nurse-implemented multimodal nonpharmacological interventions in preventing delirium and support their generalizability across different study designs and populations.

Five studies (Cheng et al., 2024; Jahanbazi et al., 2022; Zhao et al., 2024; Shirvani et al., 2020; Shorofi et al., 2024) were synthesized narratively, as they provided critical insights into risk stratification, clinical implementation, and delirium severity that could not be pooled quantitatively. Regarding risk stratification, the association between frailty and delirium incidence (Adj. OR 1.61) reported by Cheng et al. (2024) indicates a necessary shift in perioperative care focus. (13)These findings clearly imply that screening with the Modified Frailty Index (MFI) should be integrated into routine pre- and perioperative risk assessments in cardiac surgery ICUs. The integration of the Modified Frailty Index (MFI) into pre- and perioperative risk assessments in cardiac surgery ICUs helps identify patients at high risk of delirium (38,39). Early identification allows nurses to implement targeted, intensive non-pharmacological multimodal interventions, including environmental modifications, sleep promotion, cognitive assessments, and family involvement (40,41). This is particularly relevant given that intraoperative variables such as surgery duration and cardiopulmonary bypass (CPB)

further increase the clinical foundation for targeted nursing care (21).

Furthermore, a notable contribution of this narrative synthesis is the evidence regarding delirium severity. Nurse-led interventions, such as early mobilization (Shirvani et al., 2020) and sensory bundles (Shorofi et al., 2024), were associated with improved cognitive status as measured by NEECHAM scores. Although these outcomes were excluded from the meta-analysis due to substantial statistical heterogeneity (I^2 = 87%), they provide a relevant clinical message: the effectiveness of an intervention should not be evaluated solely by the presence or absence of delirium. These findings suggest that nursing strategies may also play a role in mitigating the severity of acute cognitive dysfunction, which is closely associated with clinical outcomes such as prognosis and functional decline.

Finally, the successful application of these bundles in clinical practice is closely linked to nursing competency. The effectiveness of the Scenario-Based Learning (SBL) method demonstrated by Jahanbazi et al. (2022) indicates that case-driven training may significantly improve nurses' knowledge and performance in delirium management. These findings emphasize that ensuring the success of multimodal nonpharmacological bundles requires an effective educational program. Jahanbazi et al. (2022) (17) Scenario-Based Learning (SBL) is recommended as a superior training method, providing a practical, scenario-driven learning environment that bridges the gap between theoretical guidelines and nurses' clinical practice (42).

Meta-analysis findings (OR 0.62, I^2=0%) confirm that nurse-implemented multimodal nonpharmacologic bundles effectively reduce delirium risk by up to 38%, emphasizing the central role of nurses in primary prevention. Nurses should move beyond screening (e.g., CAM-ICU) to actively implementing interventions, including early mobilization, orientation, and sleep promotion, using structured bundle protocols such as ABCDEF. Environmental and risk management strategies are crucial. Frailty screening (e.g., MFI) should be integrated into routine assessments to identify high-risk patients, and simple interventions like earplugs and eye masks should become standard practice to reduce delirium severity.

Successful bundle implementation also relies on nursing competency. Scenario-Based Learning (SBL) is recommended to bridge theoretical knowledge and daily practice, and nurses should be trained to tailor interventions according to specific perioperative risk factors, maximizing patient outcomes in cardiac surgery ICUs.

Limitations and recommendations

This systematic review and meta-analysis have several limitations. First, evidence for continuous outcomes, such as delirium duration and Delirium-Free Days, remains limited. Although two studies (Shirvani et al., 2020; Shorofi et al., 2024) reported data on delirium severity using the NEECHAM scale, a meta-analysis for these outcomes could not be conducted due to high statistical heterogeneity and differences in intervention protocols. Second, the bundled nature of the interventions prevents isolating the specific effect of individual components, making it difficult to determine which single strategy is most effective. Third, the majority of the included studies were conducted in Asia, which may limit the generalizability of the findings to other geographical regions with different healthcare systems. Finally, while the meta-analysis included eight studies, this number is relatively small, which limits the power to conduct a formal statistical assessment of publication bias.

Future research should prioritize standardized reporting of continuous outcomes, including Delirium-Free Days and validated severity scores, and consider component-specific trials to identify the "active ingredients" of multimodal bundles. Larger, high-quality RCTs in diverse international settings are also needed to improve external validity. Clinically, the integration of simple environmental interventions, such as earplugs and eye masks, should be considered as part of standard care in cardiac surgery ICUs. Furthermore, educational programs utilizing Scenario-Based Learning (SBL) are recommended to ensure consistent implementation of these bundles. Finally, routine frailty screening and the monitoring of intraoperative risk factors should be used to

guide targeted secondary prevention for high-risk patient clusters.

Conclusion

Evidence from this meta-analysis indicates that nurse-implemented multimodal non-pharmacological bundles contribute to reducing the risk of delirium among cardiac surgical ICU patients (OR 0.56; 95% CI: 0.41–0.75). These findings suggest that such interventions serve as a viable component of secondary prevention for managing acute complications in hospitalized patients. Simple nursing strategies, including the use of eye masks and earplugs, may also play a role in mitigating delirium severity, while the identification of frailty appears essential for implementing more targeted care. Additionally, nurse-led nonpharmacologic protocols and tailored interventions remain essential for optimizing patient outcomes in specialized cardiovascular intensive care environments (43).

Clinically, these results suggest that ICU protocols should consider the integration of risk screening and environmental modifications into routine practice. However, given that the majority of current evidence is derived from studies in specific geographic regions and involves diverse intervention bundles, the findings should be interpreted with caution. Future research is recommended to focus on standardized continuous outcomes, such as Delirium-Free Days, and to conduct component-specific studies and multi-center RCTs across diverse locations to further establish the external validity and optimal design of these nursing interventions.

Acknowledgments

The authors sincerely thank all the primary study authors whose work was synthesized in this systematic review and meta-analysis. We recognize that this research builds upon the solid foundation of evidence they established. Their contributions to the field of nurse-implemented nonpharmacologic delirium prevention in cardiac surgery patients were instrumental in allowing us to draw comprehensive conclusions about the effectiveness of these interventions.

Conflict of Interest

The authors declare no conflict of interest related to this study.

Funding

This research did not receive any specific funding, grants, or financial support from public, commercial, or nonprofit funding agencies.

Author contribution

Data extraction was independently performed by three reviewers (DS, ML, and HM) to ensure accuracy and consistency. DS led the study, including conceptualization, methodology, study screening, quality assessment, statistical analysis, and drafting the manuscript. ML assisted in data acquisition, study screening, quality assessment, and independently verified data extraction, contributing to critical revisions. HM contributed to drafting the Introduction and assisted in data extraction. All authors read and approved the final manuscript.

References

1. Mattimore D, Fischl A, Christophides A, Cuenca J, Davidson S, Jin Z, et al. Delirium after Cardiac Surgery—A Narrative Review. Brain Sciences. 2023;13(12). doi:10.3390/brainsci13121682
2. Fu M, Yuan Q, Yang Q, Song W, Yu Y, Luo Y, et al. Risk factors and incidence of postoperative delirium after cardiac surgery in children: A systematic review and meta-analysis. Italian Journal of Pediatrics. 2024;50(1):1–16. doi:10.1186/s13052-024-01603-2 PubMed PMID: 38331831.
3. Ordóñez-Velasco L, Hernández-Leiva E. Factors associated with delirium after cardiac surgery: A prospective cohort study. Annals of Cardiac Anaesthesia. 2021;24(2):183–9. doi:10.4103/aca.ACA_43_20 PubMed PMID: 33884974.
4. Wang Y, Wang B. Risk factors of delirium after cardiac surgery: a systematic review and meta-analysis. Journal of Cardiothoracic Surgery. 2024;19(1):1–9. doi:10.1186/s13019-024-03156-1 PubMed PMID: 39707458.
5. Staicu RE, Vernic C, Ciurescu S, Lascu A, Aburel OM, Deutsch P, et al. Postoperative Delirium and Cognitive Dysfunction After Cardiac Surgery: The Role of Inflammation and Clinical

Risk Factors. Diagnostics. 2025;15(7):1–20. doi:10.3390/diagnostics15070844
6. Echeverría M de LR, Schoo C, Paul M. Delirium. NCBI Bookshelf. A service of the National Library of Medicine, National Institutes of Health. 2022.
7. Chen H, Mo L, Hu H, Ou Y, Luo J. Risk factors of postoperative delirium after cardiac surgery: a meta-analysis. Journal of Cardiothoracic Surgery. 2021;16(1):1–11. doi:10.1186/s13019-021-01496-w PubMed PMID: 33902644.
8. Diao Y, Yu X, Zhang Q, Chen X. The predictive value of confusion assessment method-intensive care unit and intensive care delirium screening checklist for delirium in critically ill patients in the intensive care unit: A systematic review and meta-analysis. Nursing in Critical Care. 2024 Nov 27;29(6):1224–35. doi:10.1111/nicc. 13064
9. Sahawneh F, Boss L. Non-pharmacologic interventions for the prevention of delirium in the intensive care unit: An integrative review. Nursing in Critical Care. 2021 May 20;26(3):166–75. doi:10.1111/nicc.12594 PubMed PMID: 33474830.
10. Söylemez GK, Bulut H. The effectiveness of postoperative delirium prevention, diagnosis, and intervention protocol in patients monitored in the intensive care unit after cardiac surgery: a quasi-experimental study. BMC Nursing. 2024 Dec 18;23(1):904. doi:10.1186/s12912-024-02547-y
11. Zhang S, Han Y, Xiao Q, Li H, Wu Y. Effectiveness of Bundle Interventions on ICU Delirium: A Meta-Analysis. Critical Care Medicine. 2021 Feb 16;49(2):335-46. doi:10.1097/CCM.0000000000004773 PubMed PMID: 33332818.
12. Askarkafi F, Rayyani M, Dehghan M. The Effect of Massage With and Without Aromatic Oil on Delirium After Open-Heart Surgery: A Randomized Controlled Trial. Journal of Chiropractic Medicine. 2020 Mar 1;19(1):49-57. doi:10.1016/j.jcm.2019.08.001
13. Cheng H, Ling Y, Li Q, Li X, Tang Y, Guo J, et al. Association between modified frailty index and postoperative delirium in patients after cardiac surgery: A cohort study of 2080 older adults. CNS Neuroscience & Therapeutics. 2024 Jun 1;30(6). doi:10.1111/cns.14762 PubMed PMID: 38924691.
14. Deeken F, Sánchez A, Rapp MA, Denkinger M, Brefka S, Spank J, et al. Outcomes of a Delirium Prevention Program in Older Persons after Elective Surgery: A Stepped-Wedge Cluster Randomized Clinical Trial. JAMA Surgery. 2022 Feb 1;157(2):E216370. doi:10.1001/jamasurg.2021.6370 PubMed PMID: 34910080.
15. Fazlollah A, Babatabar Darzi H, Heidaranlu E, Moradian ST. The effect of foot reflexology massage on delirium and sleep quality following cardiac surgery: A randomized clinical trial. Complementary Therapies in Medicine. 2021 Aug 1;60. doi:10.1016/j.ctim.2021.102738 PubMed PMID: 34029674.
16. Gómez Tovar LO, Henao Castaño AM. Dynamic delirium – Nursing intervention to reduce delirium in critically ill patients, a randomized controlled trial. Intensive and Critical Care Nursing. 2024 Aug 1;83. doi:10.1016/j.iccn.2024.103691 PubMed PMID: 38518455.
17. Jahanbazi A, Jokar F, Kheirollahi N. The Effect of Scenario-Based Learning on the Performance of Nurses Regarding Delirium in Cardiac Surgery Intensive Care Units. Iranian Journal of Nursing and Midwifery Research. 2022 Jul;27(4):260–5. doi:10.4103/ijnmr.ijnmr_28_21
18. Milz S, Holaubek C, Siebel J, Hulde N, Wefer F, Fruend A, et al. Implementation of Evidence-Based International Recommendations Reduces Postoperative Delirium Rate in Patients Undergoing Cardiac Surgery or Interventions: A System-Based Quality Improvement Study. Reviews in Cardiovascular Medicine. 2024;25(10). doi:10.31083/j.rcm2510369
19. Shorofi SA, Dadashian P, Arbon P, Moosazadeh M. The efficacy of earplugs and eye masks for delirium severity and sleep quality in patients undergoing coronary artery bypass grafting in cardiac intensive care units: A single-blind, randomised controlled trial. Australian Critical Care. 2024 Jan 1;37(1):74-83. doi:10.1016/j.aucc.2023.08.003 PubMed PMID: 37802695.
20. Zhang H, Wang Q, Feng P. Significance Analysis of the Improvement in Postoperative Recovery of Cardiac Surgery Patients Based on the Graded Management Established Using the Delirium Prediction Model. Alternative Therapies in Health and Medicine. 2025 Jan;31(1):338–42. PubMed PMID: 38607204.
21. Zhao Y, Guo S, Wang Z, Dong Y, Wei W, Su Z. Clinical investigation into risk factors for delirium post-cardiac surgery and its implications for nursing intervention guided by behavior change theory. Journal of Cardiothoracic Surgery. 2024 Dec 1;19(1). doi:10.1186/s13019-024-03021-1 PubMed PMID: 39420396.
22. Lin L, Peng Y, Huang X, Li S, Chen L, Lin Y. A family intervention to prevent

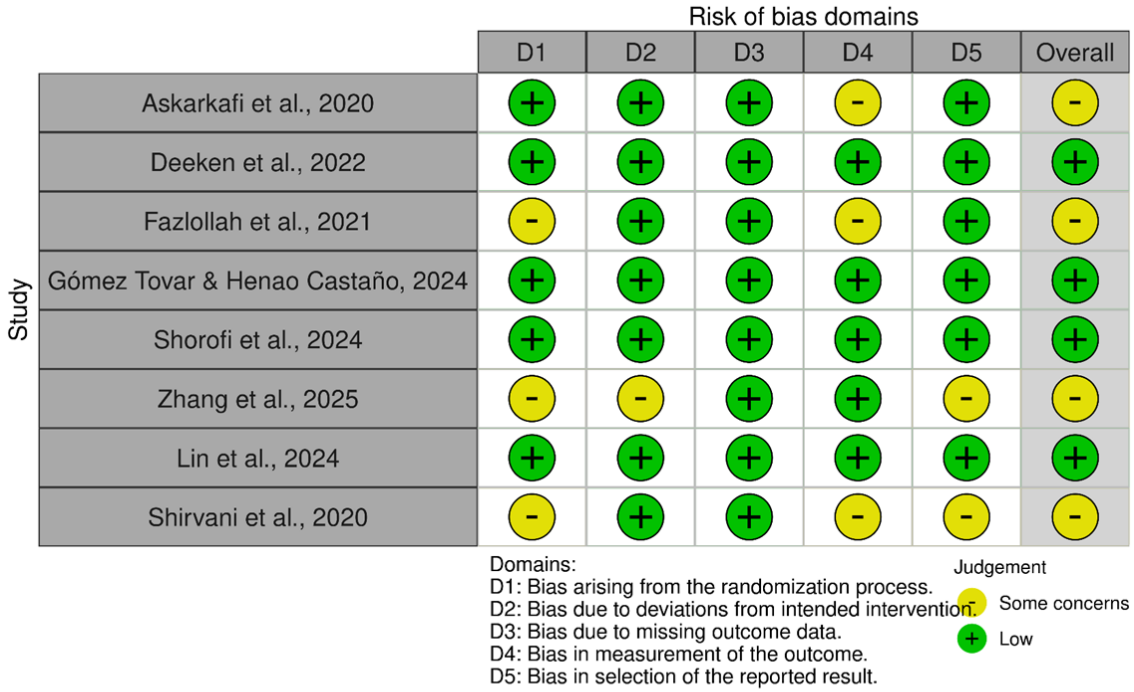
postoperative delirium in patients undergoing cardiac valve surgery: A randomized controlled study. Heart & Lung. 2024 Jan;63:1–8. doi:10.1016/j.hrtlng.2023.09.002
23. Shirvani F, Naji SA, Davari E, Sedighi M. Early mobilization reduces delirium after coronary artery bypass graft surgery. Asian Cardiovascular and Thoracic Annals. 2020 Nov 5;28(9):566–71. doi:10.1177/0218492320947230
24. Zhao Q, Liu S, Zhao H, Dong L, Zhu X, Liu J. Non-pharmacological interventions to prevent and treat delirium in older people: An overview of systematic reviews. International Journal of Nursing Studies. 2023;148. doi:10.1016/j.ijnurstu.2023.104584
25. Abraha I, Trotta F, Rimland JM, Cruz-Jentoft A, Lozano-Montoya I, Soiza RL, et al. Efficacy of non-pharmacological interventions to prevent and treat delirium in older patients: A systematic overview. The SENATOR project ONTOP series. PLoS One. 2015;10(6). doi:10.1371/journal.pone.0123090
26. Vos CF, van Diem-Zaal IJ, Pop-Purceleanu M, van den Boogaard M. Prevention of delirium in the Intensive Care Unit. Nederlands Tijdschrift voor Geneeskunde [Internet]. 2023;167(28). Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85165629141&partnerID=40&md5=80bb29f0bda36411f45dd4950bc9945d
27. Wang J, Lu Y, Chen X, Wu Y. Effectiveness of nurse-led non-pharmacological interventions on outcomes of delirium in adults: A meta-analysis of randomized controlled trials. Worldviews on Evidence-Based Nursing. 2024;21(5):514–27. doi:10.1111/wvn. 12739
28. Bannon L, McGaughey J, Verghis R, Clarke M, McAuley DF, Blackwood B. The effectiveness of non-pharmacological interventions in reducing the incidence and duration of delirium in critically ill patients: a systematic review and meta-analysis. Intensive Care Medicine. 2019;45(1). doi:10.1007/s00134-018-5452-x
29. Oliveira C, Garnacho Martins Nobre CF, Dourado Marques RM, Madureira Lebre Mendes MM, Cruz Pontífice Sousa P. O papel do enfermeiro na prevenção do delirium no paciente adulto/idoso crítico. Revista Cuidarte. 2022 Jun 23. doi:10.15649/cuidarte. 1983
30. Vallés-Fructuoso O, Rodríguez-Mondéjar JJ, Alonso-Crespo D, Robleda-Font G, López-López C, Gil-Castillejos D, Acevedo-Nuevo M. 10 key issues for prevention, monitoring and non-pharmacological treatment of delirium in critically ill patients. Enfermería Intensiva (English ed.). 2025 Apr 1;36(2):100499. doi:10.1016/j.enfi.2024.05.004
31. Hirsch C. Prevention of delirium in the medical wards. In: Delirium: Prevention, Symptoms and Treatment [Internet]. 2017. p. 49–69. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85034960325&partnerID=40&md5=8925914815ff031ae1a923f023e6d38a
32. Lu L, Phua QS, Bacchi S, Goh R, Gupta AK, Kovoor JG, et al. Small Study Effects in Diagnostic Imaging Accuracy: A Meta-Analysis. JAMA Network Open. 2022;5(8):E2228776. doi:10.1001/jamanetworkopen. 2022.28776
33. Evans DK, Yuan F. How Big Are Effect Sizes in International Education Studies? Educational Evaluation and Policy Analysis. 2022;44(3):532–40. doi:10.3102/01623737221079646
34. Hutchins SS, Brown C, Mayberry R, Sollecito W. Value of a small control group for estimating intervention effectiveness: Results from simulations of immunization effectiveness studies. Journal of Comparative Effectiveness Research. 2015;4(3):227–38. doi:10.2217/cer. 15.11
35. Vasques C, Magalhães P, Cortinhas A, Mota P, Leitão J, Lopes VP. Effects of intervention programs on child and adolescent BMI: A meta-analysis study. Journal of Physical Activity and Health. 2014;11(2):426–44. doi:10.1123/jpah.2012-0035
36. Cordero CP, Dans AL. Key concepts in clinical epidemiology: detecting and dealing with heterogeneity in meta-analyses. Journal of Clinical Epidemiology. 2021;130:149–51. doi:10.1016/j.jclinepi.2020.09.045
37. Kanters S. Fixed- and Random-Effects Models. In: Methods in Molecular Biology [Internet]. 2022. p. 41–65. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85116115951&doi=10.1007%2f978-1-0716-1566-9_3&partnerID=40&md5=98d4c865e662807df33ce893a55b77f8 doi:10.1007/978-1-0716-1566-9_3
38. Moss W, Zhang R, Carter GC, Kwok AC. A Case for the Use of the 5-Item Modified Frailty Index in Preoperative Risk Assessment for Tissue Expander Placement in Breast Reconstruction. Annals of Plastic Surgery. 2022;89(1):23–7. doi:10.1097/SAP.0000000000002771
39. Connolly MJ, Ahmed A, Worrall A, Williams N, Sheehan S, Dowdall J, et al. Reliability of the modified Frailty Index (mFI) for intervention and continued surveillance in elective infrarenal abdominal aortic aneurysm (AAA). The

Surgeon. 2023;21(4):250-5. doi:10.1016/j.surge.2022.10.002
40. Byrnes T, Woodward J. Implementing a Delirium Risk Stratification Tool and Rounds to Identify and Prevent Delirium in Hospitalized Older Adults. Journal of Nursing Care Quality. 2023;38(2):158–63. doi:10.1097/NCQ.0000000000000676
41. Ku YL, Tang MH, Chen SM, Kuo WY, Huang KT. Delirium Care by Intensive Care Unit Nurses: Focus Group Studies in a Medical Center of Southern Taiwan. Dimensions of Critical Care Nursing. 2023;42(5):255–62. doi:10.1097/DCC.0000000000000568
42. Hustad J, Johannesen B, Fossum M, Hovland OJ. Nursing students' transfer of learning outcomes from simulation-based training to clinical practice: a focus-group study. BMC Nursing. 2019 Dec 8;18(1):53. doi:10.1186/s12912-019-0376-5
43. Abbasinia M, Babaii A, Nadali Z, Pakzaban S, Abbasi M, Shamali M. The effects of a tailored postoperative delirium prevention intervention after coronary artery bypass graft: A randomized controlled trial. Nursing Practice Today. 2021;8(3):226-33. https://doi.org/10.18502/npt.v8i3.5937.

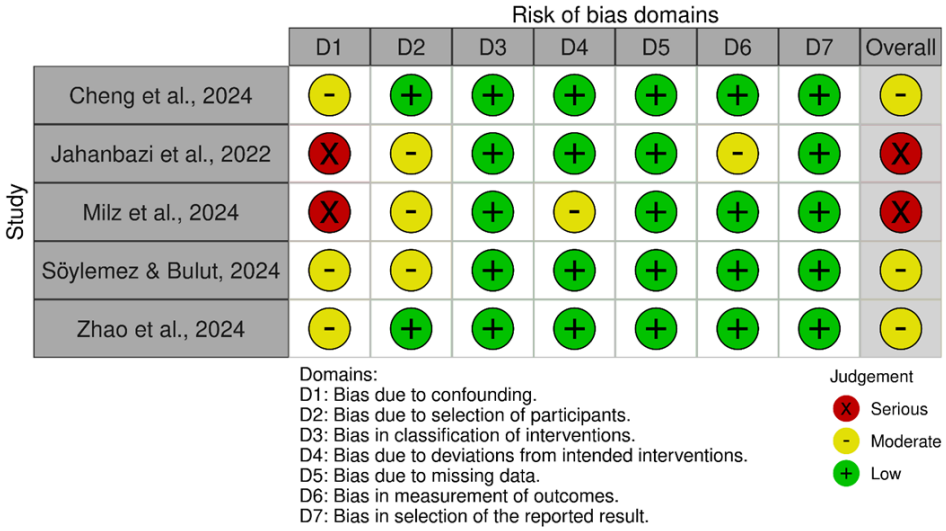
Supplementary file 1. Search strategy

Databases	Search strings
PubMed	"Delirium"[Mesh] OR delirium OR "delirium-free days" AND "Cardiac Surgical Procedures"[Mesh] OR "cardiac surgery" OR "heart surgery" OR "postoperative cardiac" AND "Intensive Care Units"[Mesh] OR ICU OR "cardiac ICU" AND "Nursing Care"[Mesh] OR "Critical Care Nursing"[Mesh] OR nurse-led OR nurse-implemented AND nonpharmacologic OR "non-drug" OR "multicomponent intervention" OR "multimodal bundle" OR "ABCDEF bundle" OR "bundle care" OR "delirium prevention program"
Scopus	(TITLE-ABS-KEY (cardiac surgery OR "heart surgery" OR "cardiac ICU" OR "postoperative cardiac") AND TITLE-ABS-KEY (delirium OR "acute confusion" OR "cognitive dysfunction") AND TITLE-ABS-KEY (nurse OR nursing OR "nurse led" OR "nurse implemented" OR "nursing care" OR "nursing intervention") AND TITLE-ABS-KEY (bundle OR "care bundle" OR ABCDEF OR "nonpharmacologic" OR "non drug" OR "intervention" OR mobilization OR "early mobilization" OR sleep OR "sleep promotion" OR reorientation OR family OR "family engagement")
ScienceDirect	delirium AND ("cardiac surgery" OR "heart surgery") AND ("nursing care" OR "critical care nursing") AND (nonpharmacologic OR bundle OR intervention)
Cochrane Library	("cardiac surgery" OR "heart surgery" OR "coronary artery bypass" OR CABG OR "valve replacement" OR "cardiac intensive care" OR CSICU OR CVICU OR "post-cardiac" OR "postoperative cardiac") AND (delirium OR "acute confusion" OR "postoperative delirium" OR "cognitive dysfunction" OR agitation OR "ICU psychosis") AND (nurse* OR nursing OR "nurse-led" OR "nurse-initiated" OR "critical care nursing") AND (nonpharmacologic OR "non-pharmacologic" OR bundle OR multimodal OR multicomponent OR ABCDEF OR sleep OR mobilization OR reorientation OR family OR sensory OR "eye mask" OR earplug OR massage OR music OR relaxation OR environment)

Supplementary figure S1: Risk of Bias Assessment of Included RCTs (RoB 2)



Supplementary figure S2: Risk of bias assessment of non-randomized studies (ROBINS-I)



Supplementary figure S3: The pooled effect size of four studies with a lower risk of bias (Deeken et al., 2022; Gómez Tovar & Henao Castaño, 2024; Lin et al., 2024; and Söylemez & Bulut, 2024)