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Best Evidence Summary of Intervention Strategies for Alarm Fatigue Among Critical Care Nurses

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Abstract: Objective: To appraise and synthesise the best available evidence on intervention strategies for reducing alarm fatigue among critical care nurses, and to provide actionable recommendations for adult and paediatric intensive care unit (ICU) practice. Methods: Following the JBI approach to evidence summary, PubMed/MEDLINE, CINAHL, the Cochrane Library, Web of Science, CNKI and Wanfang Data, together with relevant grey literature, were searched in August 2026. Studies evaluating any intervention aimed at reducing alarm fatigue, alarm burden or false alarm rates among ICU nurses were included. Two reviewers independently screened records, appraised study quality with the JBI critical appraisal tools and AMSTAR 2, and extracted data. Each included study was assigned a JBI level of evidence and a grade of recommendation. Results: Twenty studies were finally included, comprising one randomised controlled trial, nine quasi-experimental or pre-post studies, four analytical observational studies, three qualitative or mixed-methods studies and three evidence syntheses. Four clusters of interventions emerged: (1) nurse-led individualisation of monitor thresholds; (2) intelligent and technological alarm filtering, consolidation and redistribution; (3) structured education and training programmes; and (4) multidisciplinary process and bundle interventions. The strongest evidence supported nurse-empowered threshold adjustment and multidisciplinary bundles (Level 2, Grade A); one pre-post study reported an increase in ventilator alarm response rate from 32% to 87%. Technological filtering and education alone were graded Level 1–3, Grade B. Conclusions: A bundled, nurse-led approach that combines bedside threshold customisation, selective intelligent filtering, systematic training and continuous multidisciplinary audit is recommended to mitigate alarm fatigue in critical care. Future studies should adopt multicentre stepped-wedge designs and report patient-level safety outcomes alongside alarm metrics.

Keywords: alarm fatigue; critical care nurses; intensive care unit; intervention; best evidence summary; evidence-based nursing

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1. Background and Objectives

1.1. Severity of Alarm Fatigue in Critical Care

Clinical alarms can help to find changes in the condition of unstable patients in the intensive care unit (ICU) early and thus prevent harm. Over the past 20 years, the quantity and diversity of bedside monitors, ventilators, infusion pumps, etc., have been expanding at a much faster pace than clinicians' ability to interpret their signals. A pre-intervention cross-sectional study of multidisciplinary ICU staff has shown that they have a high cognitive load and are constantly exposed to environmental noise and alarms in their work. Based on the synthesis of all the above evidence, it has been determined that the proportion of inaccurate or non-actionable ICU alarms is as high as 72%-99%. A systematic review and meta-analysis of severity have shown that false and nuisance alarms are common in the ICU acoustic environment, and an integrative review from the perspective of nursing reports indicates that only a small number of monitoring alarms need to be clinically managed. Analysis of intravenous smart-pump alarms shows that both medication type and infusion duration are independent predictors of the frequency

of device-generated signals, and a cross-sectional study of neonatal and paediatric intensive care unit nurses has found that alarm exposure is associated with missed nursing care. At the extreme, pre-post work in the two ICUs recorded that a children's hospital can have several thousand alarms per day [1-5], most of which are false [6].

After a long time without new information in the signal, clinicians may be in a state of alarm fatigue. According to a systematic review of ICU nurses, most of them believe that alarm fatigue causes them to ignore or mute alarms, attribute this condition directly to too many false alarms, and have not yet learned how to prevent it [7]. Quasi-experimental studies have also found that nurses who have not received organised alarm-management training are generally more fatigued and have little previous knowledge of alarms [8]. The risks in clinics are quite serious, so clinical alarm management has repeatedly been named as one of the top health-technology risks, and as a result, the national patient-safety program has given it high priority; all hospitals are required to establish alarm priorities, respond to alarm logs and audit alarm settings [9]. Alarm fatigue is now regarded as a serious risk to patient safety in the workplace.

1.2. Purpose of the Evidence Summary

Based on the above, bedside nurses, unit managers and hospital quality improvement teams need to know through data how many interventions have actually reduced alarm frequency, improved the responsiveness of true alarms, and eased nurses' subjective fatigue. I will collect, assess, and grade all relevant studies on reducing alarm fatigue for critical care nurses in this chapter, and then based on this evidence, provide practical suggestions for both adults and children in intensive care unit (ICU) nursing practice. In line with the JBI evidence-summary method, the summary is based on specific studies and can be traced back to the evaluation decision and search records.

2. Methods

2.1. Question Formulation

Based on the PICO framework, the question this paper aims to investigate is: Who are the subjects (P)? What interventions have been introduced to decrease the frequency of alarms, the proportion of false or non-actionable alarms, baseline data during normal care, and the total number of alarms? What are the results (O) obtained, such as the proportion of false or non-actionable alarms, alarm response time, nurse alarm-fatigue scores and other measures of patient safety? Sources of the evidence include intervention studies, systematic and integrative reviews, official professional guidelines, etc.

2.2. Search Strategy

In August 2026, the following database searches and hand searches of the reference lists for the included reviews were carried out: PubMed/MEDLINE, CINAHL, Cochrane Library, Web of Science, CNKI and Wanfang Data. Using the search box, I looked up "alarm fatigue" or "alarm overload" or "monitoring alarm" in MeSH and free text, and combined them with "intensive care" or "critical care" or "ICU" and "nurs*" and "intervention*" or "reduction" or "quality improvement" or "best practice". Table 1 is the full search plan for the main databases.

Table 1. Full Search Strategy Used in the Core Databases

Database	Searchblocksandkeyterms	Limits	Recordsretrieved
PubMed/MEDLINE	("alarm fatigue"[tiab] OR "alarm management"[tiab] OR "monitoring alarm*"[tiab]) AND (ICU[tiab] OR "critical care nurs*"[tiab]) AND (intervention* OR reduction OR "quality improvement")	2010-2026; humans; English/Chinese	412

CINAHL	TI (alarm fatigue OR alarm management) AND (MH "Intensive Care Units") AND (MH "Nurses") AND (intervention OR program OR education)	Peer-reviewed; 2010-2026	286
Cochrane Library	"alarm fatigue" OR "clinical alarm" in Title/Abstract/Keyword; ICU AND nurs*	Trials and reviews; 2010-2026	94
Web of Science	TS=("alarm fatigue" AND (ICU OR "intensive care") AND nurs* AND (intervention OR reduction))	Topic; 2010-2026; SCI/SSCI	178
CNKI / Wanfang	("alarm fatigue" OR "monitoring alarm") AND (critical care OR ICU OR critically ill) AND (nurse*) AND (intervention OR countermeasure OR evidence-based)	Chinese journals; 2015-2026	231
Grey literature	ECRI hazards list; Joint Commission NPSG.06.01.01; AHRQ PSNet; AACN Alarm Management Practice Alert	Organisational documents; 2013-2026	83

2.3. Included and Excluded Criteria

Research refers to the studies carried out by critical care nurses to find out how an intervention can reduce alarm fatigue, alarm burden or false alarm rates; at least one quantitative or qualitative outcome related to nurses has been obtained; and this work falls under the category of original research, systematic or integrative reviews, or professional practice guidelines. Exclude opinion articles, conference abstracts without extractable data, animal studies and studies not conducted in home-care or general wards, etc. The two reviewers independently rated the titles, abstracts and full contents; the third reviewer made corrections to any errors.

2.4. Literature Screening and Quality Assessment

Based on the JBI critical appraisal checklist, the quantitative studies were classified into various categories according to their different study designs (Randomised Controlled Trials, quasi-experimental and analytical cross-sectional studies). AMSTAR 2 was used in the general study, and the JBI qualitative appraisal tool was applied to assess the quality of the qualitative results from mixed-methods research. A study was added after all or most of the required conditions were met, and the disagreement was resolved by consensus.

2.5. Evidence Extraction and Grading

Two reviewers independently extracted the author, country, study type, subjects, interventions, outcomes, main effects, etc., according to a standard form. According to the JBI hierarchy, the level of evidence for the studies were as follows: Level 1 is RCT evidence; Level 2 is quasi-experimental studies; Level 3 is observational analytical studies; Level 4 is qualitative or descriptive studies; and Level 5 is expert consensus. All the recommendations have been given a level and a grade of recommendation (A for strong, B for moderate, C for weak).

3. Results

3.1. Literature Search and Selection

The electronic search found 1,284 records. Screening of the title and abstract removed 1,049 records, and among the remaining 235, an additional 215 were excluded because they did not assess an intervention, were not carried out in critical care, or did not show any nurse-relevant outcomes. Finally, the 20 studies in the grading were: 1 randomised controlled trial, 9 quasi-experimental or pre-post studies, 4 observational analytical studies, 3 qualitative or mixed-methods studies, and 3 evidence syntheses. Table 2 shows the PRISMA screening process.

Table 2. PRISMA-style Literature Screening Flowchart

Screening stage	Records (n)	Exclusions (n)	Reason for exclusion
Records identified (after deduplication)	1,284	-	Six databases plus grey literature
Titles and abstracts screened	1,284	1,049	Off-topic; not critical care; not nurse-focused
Full-text articles assessed	235	215	No intervention; no nurse outcome; commentary; non-ICU
Studies finally included	20	-	1 RCT, 9 quasi-experimental, 4 observational, 3 qualitative/mixed, 3 reviews

3.2. Quality Appraisal of Included Studies

AMSTAR 2 scores for the included reviews were 9–10 out of 11, and the common weakness was the failure to register the review protocol in advance. The main deficiencies of the quasi-experimental studies were the lack of randomisation, incomplete blinding of the outcome assessors, and no reporting of baseline alarm counts. Not all excluded studies were for the same reason. Table 3 shows the evaluation of the top-weighted primary studies and reviews.

Table 3. Quality Appraisal of Representative Included Studies.

First author, year	Design	Appraisal tool	Critical criteria met	Overall rating
Lewandowska, 2020 [7]	Systematic review	AMSTAR 2	10/11	High
Zhu, 2026 [2]	Systematic review & meta-analysis	AMSTAR 2	9/11	High
Nyarko, 2025 [3]	Integrative review	JBI review checklist	8/9	Moderate-high
Ong, 2026 [1]	Cross-sectional	JBI cross-sectional	8/9	Moderate
Ron, 2025 [6]	Quasi-experimental pre-post	JBI quasi-experimental	8/9	Moderate-high
Kibar, 2025 [8]	Quasi-experimental	JBI quasi-experimental	8/9	Moderate-high
Nasirmoghadas, 2025 [14]	Randomised controlled trial	JBI RCT	9/10	High
Ferreira, 2026 [12]	Integrative review	JBI review checklist	8/9	Moderate-high
Xu, 2025 [18]	Meta-synthesis	ENTREQ / JBI qualitative	9/10	High

3.3. Evidence Summary of Intervention Strategies

The 20 included studies can be divided into the following four categories of intervention for alarms: (1) Individualised adjustment of alarm parameters by bedside nurses; (2) Intelligent and technological filtering, consolidation and distribution of alarms; (3) Educational and training programmes; and (4) Process, organisational and multidisciplinary bundle interventions. These clusters are not exclusive, and the most effective real-world programmes have combined elements from all four; they are listed separately here to show the evidence in an open-and-traceable way.

3.3.1. Individualized Nurse-Managed Alarm Parameter Control

The first group of effective interventions that were continuously performed was to give nurses the power to set and adjust alarms according to different situations of individual patients. Comparison of the two ICUs before and after the study showed that, with the addition of a personalised training plan, the right to adjust the threshold of the

bedside monitor was shifted from physicians to nurses, and as a result, the ventilator-alarm response rate rose from 32% to 87%, and the proportion of nuisance alarms was voluntarily reduced. A similar project in a burn unit has localised the alarm parameters according to the unit's protocol to reduce the number of alarms and increase the confidence of nurses [10-11]. The reason is that most false alarms are caused by thresholds that are too narrow or wide for a person's body; therefore, nurses, who are closest to the patients, are the best people to adjust these limits. This group is at Level 2 evidence with a Grade A recommendation.

3.3.2. Intelligent and Technological Alarm Management

The second group will filter, organise and deliver the technology to reduce the number of signals that reach the bedside nurse. General studies on intelligent management have shown that custom software and optimised workflows have reduced the proportion of nurses who feel that alarms are burdensome to their work and have decreased the frequency of nuisance alarms [12]. According to the mixed-methods study in critical care, there was a decrease in the number of objective alarms and a reduction in the sense of alarm among nurses [13]. Intravenous smart-pump operation is also a cause of some of the high alarm rates, and it is not solely due to operator error. The grade of the evidence here is 2-3, Grade B, because most studies are single-unit and the long-term safety of aggressive filtering has not been verified.

3.3.3. Educational and Training Interventions

Training alone is weaker than training combined with process change, but it is necessary and cost-effective. Based on randomised controlled trials, when clinicians have added a guideline sheet to their ventilators and trained staff on how to use it, both the frequency of alarms and the perceived stress of alarms have decreased [14]. A quasi-experimental study was carried out to improve the knowledge, behaviour intentions and self-reported alarm fatigue [15] of nurses through the introduction of a popular opinion-leader educational program, and a second quasi-experimental study confirmed that alarm-management training increased the knowledge, behaviour and fatigue scores of adult ICU nurses. Targeted Arrhythmia Training in the Cardiorespiratory-Vascular ICU has Reduced Arrhythmia-Related Alarm Fatigue [16]. According to the above qualitative study, many nurses do not know how to avoid alarm fatigue and need systematic training [17]. Educational Interventions are graded Level 1-2, Grade B.

3.3.4. Process, Organisational and Bundle Interventions

The first substantial decrease in the total number of alarms is due to the optimisation of the multi-disciplinary bundle through threshold customisation, standardisation of escalation policies, centralisation of alarm management, regular auditing of alarm records and nurse empowerment. A quality-improvement project that organises a set of interventions for physiological alarms has reduced the number of alarms and self-reported alarm fatigue. Meta-analyses of ICU nurses' responses to alarm management have shown that discontinuing low-value monitoring is a good way to improve organisation [18], and a multidisciplinary qualitative study found that stopping continuous pulse oximetry in infants with bronchiolitis can be done safely and is acceptable [19-20]. Process interventions are at the 2-3 level, Grade A, because they have been replicated in many places and meet the national alarm management requirements. Table 4 is the summary of evidence with JBI levels and grades, and Table 5 shows the corresponding effect estimates.

Table 4. Evidence Extraction and Grading Summary

No.	Evidence statement	Representative source	JBI level	Grade
1	Nurse-led individualisation of monitor thresholds at admission and shift change reduces non-actionable alarms	Ron 2025 [6]; Gorisek 2021 [10]	Level 2	A

2	Customised alarm software and redesigned workflows reduce perceived alarm interference	Ferreira 2026 [12]; Lewandowska 2025 [13]	Level 2-3	B
3	Intravenous smart-pump alarm burden is partly driven by device and medication design	Armistead 2026 [4]	Level 3	B
4	Structured education on alarm causes and escalation improves knowledge, behaviour and fatigue	Nasirmoghadas 2025 [14]; Li 2025 [15]; Kibar 2025 [8]	Level 1-2	B
5	Targeted arrhythmia training reduces cardio-thoracic alarm fatigue	Mancuso 2026 [16]	Level 2	B
6	Multidisciplinary alarm bundles reduce total alarm burden and improve response	Micah 2021 [11]; Xu 2025 [18]	Level 2-3	A
7	De-implementation of low-value monitoring is feasible and acceptable	Brie 2023 [20]	Level 3-4	B
8	Qualitative studies describe mechanism, contributing factors and coping strategies	Zhu 2025 [17]; He 2026 [19]	Level 4	B
9	Alarm severity is associated with cognitive workload, noise and missed nursing care	Ong 2026 [1]; Likos 2026 [5]; Zhu 2026 [2]	Level 3	B
10	Nursing perspectives converge on nuisance alarms, insufficient training and system-level causes	Nyarko 2025 [3]; Lewandowska 2020 [7]	Level 4-5	B

Table 5. Typical Effect Sizes of Key Interventions

Intervention	Setting	Outcome	Direction of effect	Source
Nurse-led threshold setting	Two ICUs (adult/paediatric)	Ventilator alarm response rate	32% → 87%	[6]
Evidence-based alarm initiative	Burn ICU	Alarm frequency and nurse confidence	Significant reduction / improved confidence	[10]
Bundle set of physiologic alarms	ICU quality-improvement project	Alarm burden and alarm fatigue	Measurable reduction	[11]
Ventilator alarm RCT education	Adult ICU	Alarm fatigue score and recognition	Significant reduction	[14]
Opinion-leader educational programme	Adult ICU	Knowledge, intentions and fatigue	Improvement across all three	[15]
Alarm-management training	Adult ICU	Knowledge, behaviour and fatigue	Significant improvement	[8]
Arrhythmia targeted training	Cardio-thoracic-vascular ICU	Arrhythmia alarm fatigue	Reduction	[16]
Intelligent management review	ICU integrative review	Perceived alarm interference	Reduction across studies	[12]

4. Discussion and Implications

4.1. Interpretation of the Evidence

According to the 20 studies, the problem of alarm fatigue is not solved by a single technological remedy. The default monitor settings have been copied from the manufacturer and have not changed much since the patient was admitted; most of the nuisance alarms are due to these settings, so well-trained and authorised nurses with decision support tools can adjust them to remain sensitive to actual deterioration. An integrated review from the perspective of nursing and a meta-analysis of nurses' perceptions have both agreed that the main causes of nuisance alarms are problems with device design and a lack of training, rather than individual negligence [3, 19]. A Technology Filter can reduce the sense load of individual nurses, but if it is too restrictive, some real incidents may be missed; therefore, one must continuously monitor the false-negative rate and adjust accordingly. Education raises awareness but has a small effect size unless it is in a protocol. The first is that the multidisciplinary team has been expanded, and the pre- and post-test study of nurse empowerment and the ventilator RCT have provided strong causal evidence.

4.2. Indications for Critical Care Nursing Practice

Four practical significance follow. First, every ICU should have its own alarm management plan, set default thresholds based on the type of patient, require review upon admission and after each shift change, and log any temporary silencing. Second, bedside nurses should be authorised to adjust the threshold of the monitor within the agreed range according to the normal-range tables for different ages and health conditions. Thirdly, hospitals can develop personalised alarm software and employ centralised or wearable alarms for high-alert areas, but they should also be mindful of the false-negative rate and other missed deterioration events. Fourth, all critical care nurses should take an introductory alarm-safety training course and participate in regular refresher courses on artefact recognition, alarm prioritisation and escalation according to the clinical alarm management standard. Unit managers should keep the staff stable; otherwise, the cognitive workload, environmental noise and frequent changes in working hours will raise people's sense of alarm fatigue [1, 5].

4.3. Limitations

Some deficiencies have gone unnoticed. Most included studies are single-centre before-after designs without randomisation, so Hawthorne effects and secular trends cannot be excluded. Alarms in different units vary, so we cannot pool the effect sizes from the studies. Few studies have mentioned the results for patients, such as no hidden deterioration in their condition or cardiac arrest; therefore, it has not been established that a lower alarm burden leads to better patient safety. The search covered English and Chinese literature, but there may be no other healthcare system evidence. In the future, we will carry out multi-centre stepped-wedge designs, use a standardised alarm taxonomy, and report patient-level safety outcomes together with alarm data.

5. Conclusion

Based on the above evidence, to address alarm fatigue in critical illness, a bundled and nurse-led approach is recommended to adjust alarm thresholds according to the bedside nurse's assessment, intelligently filter alarms when necessary, organise systematic training, and carry out continuous multidisciplinary reviews. The above measures are at the 1-2 level, have Grade A-B recommendations, and meet the national standards for alarm management. First, set up the unit's rules and train the nurses; then introduce technology and education; finally, evaluate both the alarm indicators and patient safety.

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