

Nurses Competency in Alarm Protocol and Its Management in Critical Care Setting: A Systematic Review

Sweta Kumari¹, Dr. Sanjay Kumar Singh²

¹PhD Scholar, ²Professor, Department of Medicine
Rajendra Institute of Medical Sciences, Ranchi

1. INTRODUCTION

In critical care units, alarm rates are known to be the highest. The high number of false alarms has led to alarm fatigue. Alarm fatigue is basically a sensory overload when health workers are exposed to an excessive number of false alarms, which result in desensitization to alarms as well as missed alarms. Based on the literature findings, between 76% to 99% of alarms are considered clinically insignificant by nurses. (Chambrin, 2001; Funk & Cvach, 2012) (1). Patient safety and regulatory agencies have focused on the issue of alarm fatigue, and it is a 2014 Joint Commission National Patient Safety Goal. (2,3)

Due to the technological advancement, the nursing profession demands gaining more knowledge and skills and clinical alarm protocol knowledge and its management competency is one of the knowledge and skills that must be acquired among nurses in the Critical Care Units. Nursing professionals are expected to take independent decisions in health care activities on daily basis. The modern knowledge acquired by the nurses gives them ability to make those decisions with right attitude and experience, that provide the needed skill, which together may be referred to as health care competency.

1.1. Background

Implementation of process improvement interventions as proper patient selection, electrode management etc. causes significant reduction in false alarms (Gazarian and Morano, 2014). Many published literatures on alarm management and reduced alarm fatigue includes overview summaries of research and performance improvement project reports (Cvach, Currie, 2013; Funk & Cvach, 2012; Graham 2010; Guardia-LaBar et al.)

Less than a handful of review articles have been published, on effectiveness of alarm management strategies and nursing behaviour related to this. (Bonafide et al., 2017; Gazarian, 2014; Gorges et al., 2009; West et al., 2014) Their focus has been on nursing perspectives, alarm effects on personnel and patients, and alarm management strategies, but at the same time, these studies have not addressed the effectiveness of the implemented practices (Cvach, 2012; Konkani, Oakley, & Bauld, 2012;) At the time of this study, there were no nursing-related systematic reviews or meta-analyses that provide information on the effectiveness of implemented alarm management strategies and improvement in alarm protocol knowledge.

Interventions based on limited levels of evidence have reduced 46-68% of these alarms (Cvach et al., 2013; Whalen et al., 2013). However, the ratio of false to true alarms remains high, and nurses continue to exhibit behaviours of alarm fatigue (Baillargeon, 2013; Bonafide et al., 2015; Konkani et al., 2012). Due to regulatory requirements from the Joint Commission, clinical and administrative decisions that have fiscal and nursing workflow impact are being made based on inconsistent conclusions and knowledge gaps regarding the effectiveness of nurses' alarm management strategies (Gazarian, 2014; Gross, Dahl, & Nielsen, 2011; GuardiaLaBar et al., 2014).

This systematic review was conducted to analyse the level of evidence for the research on physiological alarm management strategies and to identify gaps in knowledge in designing more robust research on alarm management, nurses' physical and cognitive responses to alarms, and prevent alarm fatigue.

2. THE REVIEW

2.1. Aims

The primary aim was to identify, appraise and synthesize the evidence on the critical care nurses.

Secondary aims-:

- (1) To determine the various interventions employed by nurses in the management of clinical alarms in the care of critically ill patients at the CCU
- (2) To reduce noncritical and false alarm
- (3) To have sufficient knowledge about the alarm protocol
- (4) To determine whether particular educational intervention on alarm protocol works and improve outcomes.

2.2. Design

A systematic review, without meta-analysis, in seeking studies published post-2010 and appraising outcomes. The systematic review of the literature was carried out according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) guidelines. The content of PubMed, Google Scholar, EMBASE ctri.gov and Cochrane Library was searched. A written protocol of the review was drafted. and the protocol was registered in (PROSPERO) in conjunction with the 2020 PRISMA checklist to promote transparency.

2.3. Search Strategy

The keywords used in the literature search were: “critical care nurses,” “nursing staff”, “Cardiac alarm protocol,” “electrocardiographic alarm protocol”, “knowledge within the nurses,” efficiency with nurse and alarm protocol.” In the course of the search, single words were used or their combinations with AND/OR or both. The number of articles obtained during every search test was limited to researches carried out “between” 2010–2022. Strict inclusion and exclusion criteria were applied. Seven publications were included in the study at the final stage. The detailed search process is presented in Figure 1.

2.4. Study Selection

Inclusion criteria:

- Articles in English,
- Research carried out among nurses working at adult critical care units/ acute emergency care unit
- Studies with adult patients,

Exclusion criteria:

- Articles in a language other than English,
- Research where a study group consisted of members other than medical personnel, moreover, articles were eliminated that focused on the perception of alarms generated by multiple devices (e.g., injection pumps or a pulse oximeter, ventilator)
- Studies concerning paediatric intensive therapy units

2.5. Study Quality Assessment

All studies taken into account were assessed based on the NIH quality assessment tool and most of the study selected included in this review was fair enough to consider.

2.6. Data Extraction

Two reviewers assessed the studies independently, using a formalized form of data collection, which included, but was not limited to, the following data: the first author, the year of publication, the place of study, the study group, the type of study, and the method of assessing the alarm protocol efficiency. All disagreements were resolved by means of consensus and in consultation with another author. Seven articles were included in the descriptive analysis. In addition, quantity data from the above-mentioned articles were synthesized and analysed by another researcher.

2.7. Data Analysis

Descriptive data were presented in the form of a table showing: the author and the year of publication, the country of study, the setting of the study, the study group, the type of research, the method of assessing the efficiency of alarm protocol, and the conclusion (Table 1)

2.8. Data synthesis

The key characteristics and results of each study were charted, described and synthesized according to the primary outcomes. No studies were discarded because of their quality rating, but weak rated studies are highlighted in the text with the superscript*. Only studies that explicitly aimed to show the critical care nurses’ efficiency of alarm protocol and its management were included in effectiveness analyses.

3. RESULTS

3.1 Search outcomes

Electronic database searches identified 166 references (Figure 1). After duplicates were removed, 133 records were screened by title and abstract for relevance and the full texts of the 51 remaining documents identified by reference tracking, were independently assessed against the inclusion/exclusion criteria. This resulted in 7 included studies.

The studies came from different countries, including United States, Egypt and Arab countries. In all, 1473 nurses were studied from the following units: intensive care units and coronary care units

Two studies were found with pre-post design and five had the form of a descriptive, cross-sectional survey including four using the knowledge questionnaire created by the author.

All studies described the efficiency of nurses based on the knowledge questionnaire. For intensive care nurses’ clinical alarms was found to be burdensome and too frequent, which interfere with the caring of patients. They lack knowledge about alarm protocol and its management and there is no clear system and exist well defined protocol for managing the alarms of monitoring devices.

The results from this review shows that the respondents in this study usually have a lack of knowledge and alarm management efficiency. Appropriate intervention improves their efficiency and capacity, therefore, respondents in this review need frequent and regular educational intervention to keep them updated.

Moreover, nurses suggest that more than half of alarms result from the absence of nurses at a patient's bedside. In the quality studies, nurses present a sense of responsibility for the correct and individualized setting of alarms [18, 19]. However, an excessive number of duties very often makes alarm management a task of low priority.

3.2. Risk of Bias

Risk of bias assessment was done based on the Cochrane risk of bias assessment tool.

Table 1. Descriptive analysis of articles included in the systematic review

S. N.	Author and year of Publication	Count ry	Setting	Study group	Type of research	Method of assessing alarm efficiency protocol	Conclusions
1	Zeinab et.al (2019)	Egypt	ICU	40 Nurses	Quasi experimental	-Structured Knowledge Questionnaire- pre-& post test -Clinical Alarm Management Observational Checklist	Good knowledge and satisfactory practice after the intervention program, compared with poor knowledge and unsatisfactory practice level pre intervention program. Pre education, all nurses agreed that they feel anxious due to clinical alarms compared to 50% of nurses who agreed on post-education
2	Mahmoud. S. 2017	Egypt	ICU/CU	50 Nurses	Descriptive, cross sectional	A questionnaire composed (31) questions on nurses knowledge about clinical alarm	Only small percentage of nurses and hospitals report alarm improvement initiatives.
3	James.C. W. 2021	Arizona (U.S)	Critical Care Units	20 Nurses	Descriptive cross sectional	13 open-ended questions related to alarms encountered in their prospective units	Critical care nurses encounter numerous alarms and apply various strategies to troubleshoot these alarms.
4.	Lucy W. Menganyi, 2014	Kenya	Critical Care Unit (CCU)	87 Nurses	Descriptive cross sectional	A structured self-administered questionnaire in a Likert scale in relation to the actions the nurses would take in the management of clinical alarm.	Gaps was found in the management of clinical alarms.
5	Marjorie Funk,2021	Florida	Acute Care Units	1136 Nurses	Descriptive cross sectional	Questionnaire on monitor watcher use, nurses' knowledge of electrocardiographic monitoring, and arrhythmia detection.	The use of monitor watchers was not independently associated with electrocardiographic monitoring knowledge (p=.083). The presence of monitor watchers was also not significantly associated with the accuracy of arrhythmia detection (p=.935) Nurses on units with monitor watchers scored significantly lower on the test of electrocardiographic monitoring knowledge compared with nurses on units not using monitor watchers (46.7±10.6 with monitor watchers vs. 48.2±12.7 not using monitor watchers; p = .040).

6	Ali Salam Obeid 2021	Arabian Country	Critical Care Units	80 Nurses	Quasi experimental study	Structured knowledge questionnaire	Nurses' responses of 54.31% of experimental group knowledge about the causes of monitor device alarm at pre- test and 100% at post-test, The control group knowledge related to causes of monitor device alarm was still at same level in pre and post-test which of 54.32%,
7	Samantha Cruz2018	Arabian Country	Critical Care Unit	60 Nurses	Pre-test, educational intervention, and a post-test design.	Tests were used to evaluate the nurses' knowledge improvement related to the educational intervention.	Pre- test scores: 51.2% Post-test scores: 92%

4. DISCUSSION

4.1. Theoretical Implications

In this literature review, the focus was on publications that present the opinions and feelings of nurses' efficiency about clinical alarms. After the analysis of results from studies conducted based on the knowledge questionnaire, a simple conclusion can be drawn. Nurses from different parts of the world needs in service education program and educational intervention to improve their knowledge and efficiency of alarm protocol that can manage burdensome alarms occurring too frequently.

The false alarm disturbs their care of patients, and reduce their trust in alarm system. The study conducted by Cho et al., the number of alarms generated by an ICU over 48 h was 2184, 36.2% of which were significant, while the remaining 63.8% were false. Being overburdened with numerous duties in caring for patients, they do not want to be solely responsible for reacting to alarms. The involvement of a whole team in managing clinical alarms might contribute to the reduction of excessive and tiresome alarms. On the other hand, in the quality study carried out by Poncette et al., in Germany, nurses thought that the introduction of additional technology, such as tablets or mobile phones, might improve patient safety. Owing to the ability to cancel clinically irrelevant alarms from any location, stress might be reduced and satisfaction with performed work might be increased [25].

As described in the studies by Ruppel et al., carried out in the United States, the use of modern technologies may be problematic for older nurses. On the other hand, nurses with advanced clinical knowledge and experience usually showed greater comfort in adjusting alarms, and the level of noise during their duties was lower. This was related to better knowledge of physiological changes, recognizing certain "types" of patients and the ability to forecast different situations (23). The AACN (American Association of Critical-Care Nurses) published guidelines concerning alarm management. One of the recommendations was induction and continuous training [12]. An essential role in alarm management should be played by the education of nurses and the implementation of individual nursing internships. Such dynamically developing technology requires training. Other essential recommendations of the AACN concern, among others, suitable preparation of the skin for the daily exchange of electrodes (ECG), the change of pulse oximeter sensors if necessary, monitoring only those patients who have clinical recommendations, and creating a team responsible for the alarm system [6,22].

In 2018, the same organization published a new protocol based on evidence and ready strategies in order to solve problems related to alarm management. Based on such guidelines, it was also observed that the respondents began to be more conscious of the rules of alarm management and more frequently discussed the issues of monitoring patients with their co-workers [13]. The total number of competences included 54 basic and 5 advanced functions. The author emphasizes that only regular training guarantees the safe and proper use of monitors and reduces alarm fatigue. Training should be comprehensive and encompass not only basic but also more advanced functions [7]. Summarizing the analyzed studies, we can say that nurses are exposed nurses are overwhelmed by the introduction of new technologies and many years of experience of the nursing staff allow for the recognition of dangerous situations with the patient, but

it does not help to prevent fatigue with alarms. Finally, it is worth focusing on ongoing training for nurses to increase the level of knowledge about alarm management in CCU conditions

This therefore shows that no alarm protocols are available in the institution as echoed by some of the respondents. The fact that no research has been undertaken on alarm management in the country also plays a role as it shows how little attention has been paid to alarm management.

The nurses aged 36–44 years scored the highest as compared to those aged between 25 and 35 years. This should probably be looked into in future studies. The younger nurses could be ignoring to assess the cause of the alarm beep because of the assumption that it is a false alarm and the older ones from experience could ignore because they can use the patient's physiological status to detect whether they need to respond or not.

4.2. Practical Implications

In practice, efforts should be made to develop common universal principles for alarm management in all critical care units around the world. Due to the variety of equipment, each ICU/ CCU should have procedures dedicated to each unit, including compulsory training for nurses joining the profession. At each stage of education relating to the ICU, training programs should be supplemented with content around the development of new technologies, thus adapting to the global needs of ICU/ CCU branches and the existing market needs.

Nurses in the unit carry out the standard nursing interventions on clinical alarms and, respond to alarms of all durations and do not fill alarm checklists. Alarm protocols should therefore be developed in the hospital, the nurses should be trained on management of clinical alarms and more nurses employed.

Perceived alarm urgency contributes to the nurse's alarm response but nurses use additional strategies to determine response including the criticality of the patient, signal duration, rarity of alarming device and workload. A caregiver shall respond to an alarm if he or she perceives it to be true. "If an alarm system is perceived to be 90% reliable, the response rate shall be about 90%, if the alarm system is perceived to be 10% reliable, the response rate shall be about 10%. Nurses respond to alarms for different reasons, not just the fact that the alarm sounds [18]."

Various devices in the CCU have alarms whose various goals are: to detect life threatening situations, detect imminent danger, diagnose (diagnostic alarms, indicate a pathophysiological condition e.g. shock), detection of life threatening device malfunction e.g. disconnection from the patient, occlusion of the connection to the patient, disconnection from power, gas etc. and detection of imminent device malfunctions [2].

Nurses adjust the order of their activities by evaluating alarm urgency in relation to the patients' condition and have a greater tendency to react to alarms of longer duration and considered rare,. As workload complexity increases, alarm response and task performance deteriorates. Thus signal duration is an important influence to the nurses' response but workload, patient condition and task complexity may lead to other reaction strategies. Adjusting alarms to patient's actual needs ensures that alarms are valid and provides an early warning to potential critical situations [1].

Nurses are at risk of becoming desensitized to the alarms that are meant to protect patients when the frequency of alarms is high. Nurses in the CCUs in the North eastern academic medical center in the USA stated that the primary problem with alarms is that they are continuously alarming and that the largest contributor to the number of false alarms in the CCUs is the pulse oximetry alarm [3].

According to the American Association of Critical Care Nurses (AACN, 2012) practice alerts, alarm fatigue develops when a person is exposed to an excessive number of alarms of which most could be false alarms. This may result in sensory overload, which may cause the person to become desensitized to the alarms [4]. Patient deaths have been attributed to alarm fatigue [4]. The AACN therefore has suggested several strategies to improve patient safety in the event of reducing the number of false alarms [5].

4.3. Limitation

The main limitation of this review was the small number of articles meeting the criteria, which forced the researchers to include both quantitative and quantitative studies in the review. An experienced research team made an attempt to systematize the data. It turned out to be problematic to match the appropriate tool to assess the quality of the studies included in the review due to their diversity. More research into alarm protocol efficiency is needed, hence global research by researcher around the world will allow guidelines to be developed based on scientific evidence.

5. CONCLUSIONS

(1) The growing technology makes the number of clinical alarm grow drastically, and this will undoubtedly increase in the future as well. Therefore, it is necessary to introduce standard protocol of alarm management as soon as possible.

(2) Nursing personnel feel overburdened with demanding duties and a continuous wave of clinical alarms.

(3) Nurses often do not perceive the need for education regarding alarms, which is an important element of any alarm management strategy.

- (4) In the future, it is worth focusing on assessing the level of alarm fatigue. This would help provide safety both to patients and nursing personnel and verify the effectiveness of strategies that are introduced
- (5) The results of this review cannot be used to make concrete conclusions. In the future, observational comparison studies geared towards these particular variables should be undertaken to support whether any associations do exist.
- (6) Alarm protocols should also be established in the unit and the element of alarm checklists should be introduced. Finally, more research should be undertaken on alarm management where all the nurses, doctors and biomedical personnel should be included.

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