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Evaluating the Impact of a Clinical Alarm Management Program on Nurses' Knowledge, Practice, and Patient Outcomes in the Intensive Care Unit: A Study at a Selected Hospital

Leya Mwenge Noe[1], Sangwa Muyumba Fidele[2]

[1]Professor, GM. Nursing Education and Training Yashoda Hospitals, Hyderabad, Telangana, India
leyamwenge@yashodamail.com

[2]Nurse Educator Yashoda Hospitals, Hyderabad, Telangana, India
sangwamuyu@gmail.com

Abstract: ***Background*: To Improving Clinical Alarm Management in Intensive Care Units (ICUs) for nurses. The Clinical alarms in ICUs can lead to alarm fatigue, compromising patient safety. Major Objectives of the program include Investigating the effectiveness of a clinical alarm management intervention program in improving nurse's knowledge, practice, and patient outcomes. *Materials and Methods:* The methodology focused on optimizing alarm signals, categorizing alarms, customizing alarm thresholds, ensuring proper equipment placement, and regularly reviewing alarm settings. *Expected Outcomes:* Enhanced nurses' understanding of alarm systems, optimized response times, reduced alarm fatigue, improved patient safety, and enhanced overall ICU care quality.***

Keywords: Alarm management, nurses' knowledge, nursing practice, patient outcomes, and alarm fatigue.

1. Introduction

Clinical alarms in intensive care units (ICUs) are a double-edged sword [1]. On one hand, they provide critical warnings to nurses about potential threats to patients. On the other hand, the high frequency of false and non-actionable alarms can lead to alarm fatigue [2], causing nurses to become desensitized and potentially compromising patient safety [3].

Effective Alarm Management in ICUs

Managing clinical alarms is a critical responsibility for ICU nurses[4]. To optimize alarm management, nurses should consider the following strategies:

- Optimize alarm signals: Use a combination of auditory and visual signals to ensure alarms are noticeable.
- Categorize alarms: Prioritize alarms based on severity, including crisis, system failure, warning, and advisory alarms [5].
- Customize alarm thresholds: Adjust alarm settings based on individual patient needs to minimize false alarms.
- Ensure proper equipment placement: Verify that the ventilator, syringe pump, and other device alarms are properly placed and functioning correctly.
- Regularly review and adjust alarm settings: Continuously assess and refine alarm management [6].

2. Objectives of the Study

This study aims to investigate the effectiveness of a clinical alarm management intervention program in improving:

- Nurses' knowledge: Enhance understanding of alarm systems and management best practices.
- Nurses' practice: Optimize response times, reduce alarm fatigue, and improve adherence to alarm management protocols.
- Patient outcomes: Improve patient safety, reduce adverse events, and enhance overall ICU care quality.

3. Background Study

Alarm management in ICUs is influenced by multiple factors, including institutional culture, nursing practices, and technological advancements. The primary goal is to create a safe and efficient monitoring environment that minimizes alarm fatigue and optimizes patient care. Clinical alarms are essential for alerting nurses to critical patient conditions, yet their excessive frequency can lead to desensitization, potentially endangering patients [7], [8].

A descriptive observation study was conducted of patient monitoring data gathered over a 1-month time frame during April 2019. Data from the Philips Healthcare Intelius. Patient Monitoring systems were extracted. After classifying the alarms into types (clinical or technical) and levels of urgency (lower or higher priority), further descriptive analysis was conducted to quantify the most prevalent alarms. (2024)

A retrospective study was conducted on 70,000 ICU patients of Critical alarm threshold values and threshold modification frequencies were examined. The link between these alarm threshold settings and 30 patient variables was then explored by a random Tree Forest model, fitted with patient variables and alarm settings. Alarm threshold values and alarm threshold modification frequencies exhibited the same trend: they were influenced by the vital signs monitored, but rarely by the patient's overall health status being stable (2024)

A descriptive study was a 24-hour continuous nonparticipant observation study conducted in the ICU. Observers observed and recorded the occurrence time, and detailed information when electrocardiogram monitor alarms were triggered. A cross-sectional study was conducted among ICU nurses by convenience sampling, using the general information questionnaire and the Chinese version of the clinical alarms survey questionnaire for medical devices (2023)

The cohort study Intensive care units (ICU) are often over-flooded with alarms from monitoring devices which constitutes a hazard to both staff and patients, they suggested solutions to excessive monitoring alarms have remained on a research level. We aimed to identify patient characteristics that affect the ICU alarm rate to propose a straightforward solution that can easily be implemented in ICUs. Alarm logs from eight adult ICUs of a tertiary care university hospital in Berlin, (2022)

4. Research Methodology

Alarm fatigue is indeed a significant concern in ICUs, where the high frequency of false alarms can lead to sensory overload among nurses, causing them to become desensitized to alarms. This can have serious consequences, including delayed responses to critical alarms, which can compromise patient safety.

The "Clinical Alarm Safety" awareness and education program conducted at selected Hospital in Hyderabad, in the month of January 2025, is a great step towards addressing this issue. By educating nurses and healthcare professionals about the importance of alarm safety and how to manage alarms effectively, the program aims to reduce alarm fatigue and improve patient safety.

Some strategies used to mitigate alarm fatigue include:

a) Standardizing alarm settings: Ensuring that alarm settings are standardized and tailored to individual patient needs can help reduce false alarms.
b) Implementing alarm management protocols: Developed and implemented alarm management protocols to ensure that alarms are responded to promptly and effectively.
c) Providing Education and Training: Planned training and education to nurses and healthcare professionals about alarm safety and management and helped them develop the skills and knowledge needed to manage alarms effectively.
d) Using technology to reduce alarms: Implementation of technologies that can help reduce alarms, such as smart alarm systems, can also be effective in mitigating alarm fatigue.

- Daily Audits and Hourly Rounds – Implemented to monitor compliance with alarm management protocols. Use of Clinical Alarm Assessment Tool – introduced standardized tool to evaluate patient conditions and alarm responses.
- Shift-wise Briefings – Conducted to reinforce alarm management practices in each shift.
- Leadership Oversight – Unit leaders, and middle-level leaders, ensured compliance with best practices in all 3 shifts.

Data Collection Tools

1) **Structured Knowledge Questionnaire** – Pre- and post-test knowledge assessment of nurses on Alarm management.
2) **Clinical Alarm Management Observational Checklist** – Evaluates adherence to protocols.
3) **Nurses' Perception of Alarm Fatigue Survey –**
4) **Patient Assessment Tool** – To Measure patient outcomes.

5. Major Results

Significant Improvement in Clinical Alarm Compliance

The "Clinical Alarm Safety" program has yielded impressive results:

Study Findings

- Alarm Frequency: 2,184 alarms rang for 48 patients over 48 hours, averaging 45.5 alarms/patient/hour.
- False Alarms: 63.8% of alarms were false (1,394/2,184), including 369 non-technical and 1,025 technical alarms.
- Alarm-Setting Status: Nurses personally set alarm ranges reflecting patient conditions in only 18.8% of cases.
- Nurse Perceptions: Most nurses (85.2%) agreed that sensitivity to alarms and quick response times were useful for alarm management.

Impact of Education

- Alarm Fatigue: 85% of nurses reported alarm fatigue before education, decreasing to 20% after education.
- Knowledge and Skills: Education improved nurses' knowledge (95%) and skills (90%) in clinical alarm management.
- Compliance rate: Improved from 25% in November 2024 to 90% in January 2025, reducing non-compliance by 65%.
- Alarm management compliance: 100% of nurses showed compliance post-education, up from 50% pre-intervention.
- Patient outcomes: Reduction in unnecessary alarms led to enhanced patient monitoring and improved outcomes.

Conclusion

The study highlights the importance of addressing alarm fatigue and improving clinical alarm management in ICUs. Education and training programs continuous audits, and leadership involvement can significantly enhance compliance with alarm management protocols, ultimately improving patient safety.

6. Discussion

Clinical alarm systems are integral in ICUs, serving as critical safety tools [9]-[11]. However, their excessive use without proper management leads to alarm fatigue, which can negatively impact patient care [12]. This study highlights the need for structured training and intervention programs to improve nurses' knowledge and practice in alarm management [13].

Despite prior awareness of alarm systems, many ICU nurses were unaware of best practices for minimizing nuisance

alarms. Implementing education programs and structured monitoring systems significantly enhances alarm safety, reducing errors and improving patient outcomes [14].

7. Conclusion

Alarm management is a vital aspect of ICU care, requiring a balance between effective patient monitoring and minimizing alarm fatigue. This study demonstrates that with structured education, Hospitals must continue to implement and refine alarm management strategies to ensure nurses are well-equipped to handle alarms effectively. Medical devices should aid, not replace, nurses' clinical judgment, emphasizing the importance of ongoing training and policy development.

8. Recommendations

Implement and refine alarm management strategies
Prioritize ongoing training and education for nurses
Develop and enforce alarm management policies
Foster a culture of safety and continuous improvement

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