

Effect of Implementing Safety Bundle Regarding Alarm Fatigue on Nurses' Perception and Practices in Cardiac Care Units

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Abstract

Background: Nurses work in complex environments with high numbers of alarms, including nuisance alarms and other factors. Alarm-related adverse events are common. **Aim:** Evaluate the effect of implementing safety bundle regarding alarm fatigue on nurses' perception and practices in cardiac care units. **Design:** A quasi-experimental design used in this study. **Setting:** The study carried out at the Cardiac Care Units (CCU) at Tanta University Hospital. **Subjects and Method: Subjects:** All nurses (50) of both sex working at CCU at Tanta University Hospital. **Tools:** Three tools were utilized. **Tool I:** Critical Care Nurses' Questionnaire. **Tool II:** Nurse s' Alarm Fatigue Level Questionnaire. **Tool III:** Nurses' Alarm Fatigue Management Observational Checklist. **Results:** There was statistically significant positive correlation between perception of clinical alarms, alarm fatigue level and alarm fatigue management pre and post implementation of alarm safety bundle. **Conclusion:** It was concluded that there were statistically significant differences between nurses' perception and practices categories indicating good knowledge and practice after the nurses implementing safety bundle regarding alarm fatigue, compared with poor perception and practice pre- implementing safety bundle regarding alarm fatigue p value (0.005*). **Recommendation:** It is recommended to develop a standardized tool that assesses nurses' perception of clinical alarms and alarm management guidelines. In service training implementing safety bundle regarding alarm fatigue should be conducted for nurses regarding alarm management and increase nurses' awareness of the presence of alarm fatigue. Future study should be made to implement fundamental universal alarm management guidelines all across the world.

Keywords: - Alarm Fatigue, Cardiac Care Units, Nurses' perception & practices, Safety bundle.

Introduction

Nurses work in complex environments with high numbers of alarms, including nuisance alarms and other factors. Alarm-related adverse events are common (Karahana et al., 2023). Excessive alarms can lead to alarm fatigue, a condition wherein healthcare professionals become desensitized by a high frequency of false alarms and alarms' sounds, resulting in negative patient outcomes (American

Association of Critical Care Nurses (AACN) (2018).

Nurses work in intricate settings with lots of alerts, including annoyance alarms and other things. Adverse occurrences associated with alarms are frequent (Karahana et al., 2023). The American Association of Critical Care Nurses (AACN) (2018) states that too many alerts can cause alarm

fatigue, a condition in which medical personnel grow desensitized to a high frequency of false alarms and alarm noises, with detrimental effects on patients.

Alarm fatigue is a type of human error defined by the emergency care research institute as the emotional stress that caregivers face as a result of sounds (Ashrafi, Mehri, & Nehrir, 2017). Every day, intensive care nurses are irritated by the burdensome reaction of subduing or shutting them off completely. As a result, critical signals that require action may be overlooked. The monitoring devices may be detrimental to the patient if they malfunction, are misused, or have the wrong alert set (Bourji et al., 2020).

The emergency care research institute defines alarm fatigue as a form of human error as the psychological strain that caregivers experience due to noises (Ashrafi, Mehri, & Nehrir, 2017). Intensive care nurses deal with the frustrating response of being fully shut down or subdued every day. As a result, important signals that need attention could go unnoticed. In the event that the monitoring devices malfunction, are mishandled, or have the incorrect alert set, they could be harmful to the patient (Bourji et al., 2020).

Alarm safety in critical care units is harmed by several factors, including a lack of rules and procedures for alarm management, poor usability of physiologic monitors, a lack of established practices for alarm reduction measures, and nursing competency in the use of physiologic monitors. Factors such as bed to alarm ratio, purpose and length of alarm conditions, personnel levels, and high-risk patient ratio required rigorous monitoring in the environment and organizations where the alarms were positioned (Martin et al., 2020).

Numerous reasons contribute to alarm safety in critical care units, such as the absence of protocols and guidelines for managing alarms, the unreliability of physiologic monitors, the absence of proven methods for reducing alarms, and the incompetence of nurses in using physiologic monitors. In the setting and establishments where the alarms were placed, variables including the bed-

to-alarm ratio, the reason and duration of the alarm conditions, staffing levels, and the proportion of high-risk patients required close observation (Martin et al., 2020).

A bundle is a group of three to five evidenced-based interventions that render better outcomes when performed together rather than separately. All components of the bundle should be implemented on all patients at all times (Lewandowska et al., 2021). Communication, Electrodes, Appropriate, Setup and Education bundle (CEASE) is a type of bundle that is developing a systematic, coordinated, evidence-based approach to mitigate alarm fatigue (Lee et al., 2021).

A bundle is a collection of three to five evidence-based therapies that, when used in tandem instead of alone, produce superior results. According to Lewandowska et al., (2021) every patient should always have access to every component of the bundle. The Communication, Electrodes, Appropriate, Setup, and Education bundle (CEASE) is a bundle type that is creating an organized, methodical, and evidence-based strategy to reduce alarm fatigue (Lee et al., 2021).

Implementation of the CEASE Bundle is a first attempt by one hospital to understand its situation and develop a systematic, coordinated, evidence-based approach to mitigate alarm fatigue to meet the 2019 National Patient Safety Goal to reduce the harm associated with clinical alarm systems. Alarm fatigue is the lack of response due to excessive numbers of alarms resulting in sensory overload and desensitization. A clinical alarm system is intended to alert nursing staff to patient problems, but if alarm systems are not well managed, the system may compromise patient safety. Proper management of a clinical alarm system is a multifaceted problem (AACN, 2013).

The 2019 National Patient Safety Goal to reduce the harm associated with clinical alarm systems is being met in part by one hospital's first attempt to assess its circumstances and create a methodical, coordinated, evidence-based strategy to mitigate alarm fatigue: the CEASE Bundle. When too many sirens occur, the body becomes desensitized and

unable to react, which is known as alarm fatigue. Nursing staff should be informed of patient issues by clinical alarm systems; nevertheless, patient safety may be jeopardized if alarm systems are not properly maintained. It's a complex issue to properly maintain a healthcare alarm system (AACN, 2013). Moreover, CEASE bundle assessed the effectiveness of an established policy and procedure for managing alarms, which included clinically appropriate settings for alarm signals, when alarm signals can be disabled when alarm parameters can be changed, who in the organization has the authority to set and change alarm parameters and who in the organization has the authority to set alarm parameters to "off", monitoring and logging of alarm signals. Educating nursing personnel about the purpose and correct operation of alarm systems that they are accountable for was part of the CEASE Bundle's implementation (Bourji et al., 2020).

Furthermore, the CEASE bundle evaluated the efficacy of a defined policy and process for handling alarms, which included monitoring and logging of alarm signals, clinically appropriate alarm signal settings, when alarm signals can be disabled when alarm parameters can be changed, who in the organization has the authority to set and change alarm parameters, and who in the organization has the authority to set alarm parameters to "off". Part of the CEASE Bundle's implementation was teaching nursing staff the purpose and proper operation of alarm systems that they are responsible for (Bourji et al., 2020).

Significance of the study:

Monitoring the physiological condition of critically ill patients is a difficult task that often necessitates the deployment of many monitoring devices per patient. Nurses are the primary responders to alarms and managers of the many monitoring devices (Peet, Theobald, & Douglas, 2019). Cardiac care units have a higher proportion of false alarms than non-critical care units, nurses in cardiac care units respond to 150-400 alarms per patient each day on average. As a result, in these units, alarm safety is a top focus. This shows that cardiac care nurses may have different views on clinical alarms than nurses in other clinical

settings. Therefore, alarm awareness and nursing staff education are essential for the resolution or mitigation of alarm fatigue. Alarm weariness is complicated by nursing staff perceptions and attitudes concerning alarm occurrences (Ruskin & Hueske, 2020).

Critically ill patients require a lot of monitoring devices to be deployed because it is a challenging effort to keep an eye on their physiological status. As to Pet, Theobald, and Douglas (2019), nurses are the first responders to alarms and overseers of the numerous monitoring gadgets. An average of 150–400 false alarms are responded to by nurses in cardiac care units per patient each day, which is a larger percentage of false alarms than in non-critical care units. Consequently, alarm safety is given significant priority in these units. This indicates that nurses working in cardiac care may evaluate clinical alarms differently from nurses working in other clinical settings. Alarm fatigue can therefore be resolved or mitigated, and this requires nursing staff education and alarm awareness. The attitudes and views of nursing staff toward alarm occurrences complicate alarm tiredness (Ruskin & Hueske, 2020).

In one hospital's emergency departments in Finland, a study revealed that various medical equipment generated 28,176 alarms in one month or about 125 alarms per monitor each day. In South Korea, approximately 2184 clinical alarms were detected in ICUs over two days, i.e. 45.5 clinical alarms per hour, with 63.8% of these being false alarms (Cho et al., 2020).

Various medical equipment produced 28,176 alerts in one month, or roughly 125 alarms per monitor per day, according to research conducted in the emergency departments of one hospital in Finland. A total of 2184 clinical alarms, or 45.5 clinical alarms per hour, were found in ICUs in South Korea over the course of two days; 63.8% of these alarms were false (Cho et al, 2020).

Between January 2018 and June 2020, the Joint Commission on Accreditation of Healthcare Organizations received 98 alarm-related incidents; 80 of these incidents resulted in fatalities, in constant function loss, and five in unexpectedly

extended hospitalizations. The mean alarm score among Chinese critical care nurses was found to be 21.11 using the Alarm Fatigue Questionnaire (AFQ) and the mean alarm score among Iranian nurses was found to be 19.08, indicating a moderate rank of alarm fatigue (Nyarko et al., 2023).

Ninety-eight alarm-related occurrences were reported to the Joint Commission on Accreditation of Healthcare Organizations between January 2018 and June 2020; of these, eighty resulted in fatalities, five in unexpectedly prolonged hospitalizations, and one in persistent function loss. Utilizing the Alarm tiredness Questionnaire (AFQ), it was determined that the average alarm score for Chinese critical care nurses was 21.11, while the average alarm score for Iranian nurses was 19.08, suggesting a moderate level of alarm tiredness (Nyarko et al., 2023).

Every day, nurses in critical care units deal with 350 alarms per bed, 85–99% of which are not actionable. As a result, nurses often find themselves grappling with alarm fatigue, which affects their ability to react to alarms effectively and reduces their receptivity to these notifications. Alarm fatigue poses a significant risk for critical care nurses, who serve as the frontline healthcare providers interacting directly with patients and monitoring them around the clock. Critical care nurses are often subjected to excessively frequent and burdensome alarms, potentially impeding their ability to concentrate on tasks and responsibilities, leading to lapses in attention and increased likelihood of errors (McFarlane et al., 2020).

Aim of this study:

The aim of the study is to evaluate the effect of implementing safety bundle regarding alarm fatigue on nurses' perception, practices and patients' clinical outcomes in cardiac care units.

Research Hypothesis:

1. Cardiac care nurses' perception regarding fatigue alarm management post implementation of safety bundle expected to be better than pre implementation.
2. Cardiac care nurses' practice regarding alarm post implementation of bundle set expected to improve than pre implementation.

3. Cardiac care nurses had lower alarm fatigue level after implementation of safety bundle measured by number and duration.

Subjects and Method

Research Design:

A quasi-experimental design (pre/post-test design) was used in this study.

Setting:

The study was carried out at the Cardiac Care Units (CCU) at Tanta University Hospital. The CCUs consisted of 3 units, each one filled with 6 beds.

Subjects:

All nurses (50) of both sex working at CCU at Tanta University Hospital and providing direct patient care were included to achieve the aim of the present study.

Inclusion criteria: The sample of this study was selected according to the following criteria:

All nurses (50) who were available during the period of data collection in the previously mentioned setting, had at least 6 months of working experience in CCU and providing direct patient care.

Tools for Data Collection:

Three tools were used to collect the data according to the following:

Tool I: Critical Care Nurses' Questionnaire

This tool included two parts as follows:

Part one: Nurses Personal Characteristics, such as gender, age, educational level, total years of nursing experience in the CCU and previous training program regarding alarm fatigue.

Part Two: Nurses' Perception of Clinical Alarms:

This tool, which was put forth by Seifert, (2021) and modified by the investigator, examined how well cardiac care unit nurses identified medical device alarms. It included 23 items that were suitably chosen from 31 items and were verified by expertise-based reverse translation.

Scoring system:

The first part of the selected questionnaire consisted of 14 items concerning the recognition of medical device alarms on a 5-point scale: from 1, meaning 'strongly disagree', to 5, meaning 'strongly agree'.

The second part consisted of 9 items concerning obstacles to effective alarm management.

Scoring was calculated and classified as the following:

- High perception level → > 80% of the total score
- Moderate perception level → 60% - 80% of the total score
- Low perception level → < 60% of the total score

Tool II : Nurses' Alarm Fatigue Level Questionnaire

This tool was developed by Torabizadeh, (2017) and adapted by a researcher that used to measure alarm fatigue. This instrument consisted of 13 questions on a 5-point Likert scale with each item scored as always (0), usually (1), occasionally (2), rarely (3), or never (4). Questions 1 and 9 were scored reversely and ranged from always (4) to never (0).

Scoring system:

The overall score ranged from 8 (minimum) to 44 (maximum) with higher scores indicating a greater degree of alarm fatigue.

Scoring was calculated and classified as the following:

- High alarm fatigue level → > 80% of the total score
- Moderate alarm fatigue level → 60% - 80% of the total score
- Low alarm fatigue level → < 60% of the total score

Tool III: Nurses' Alarm Fatigue Management Observational Checklist

It consisted of two parts as the following:

Part one: The CEASE Bundle Checklist:

This tool was developed by American Association of Critical Care Nurses, (2013) to measured adherence to the CEASE Bundle (Communication (1item), electrode (3 items), Appropriate (2 items) setup (2 items), and education (1 item)).

Scoring system:

Every practical point scored on the base of "Completely done", "incompletely done", and "Not done".

- Done completely was attained (2 points).

- Done incompletely was achieved (1 point).

- Not done was scored (Zero).

The nurses' practice scores obtained for every step were aggregated to gain the whole score. Total scoring was organized into two classes as follow:

- Satisfactory practice level → ≥ 80% of the total score.
- Unsatisfactory practice level → < 80% of the total score.

Part two: Nurses' Alarm Fatigue Management Practice Checklist Compliance

This part was developed by the researcher after a strong literature review (Sowan et al., 2020) to evaluate the nurses' practice regarding alarm fatigue.

This checklist included:

Alarm system safety as a hospital priority, recognize the greatest imperative alarm signals their management

Monitor troubleshooting alarm, infusion pump troubleshooting alarm, and ECG troubleshooting alarms.

Certain patient care activities and procedures may produce false alarms or expected non-actionable alarms such as ambulation, suctioning secretions, or patient repositioning can create false or non-actionable alarms due to artifact and extra movement.

Scoring system:

Every practical point scored on the base of "Completely done", "incompletely done", and "Not done".

- Completely done attained (2 points).
- Incompletely done achieved (1 point).
- Not done attained (Zero).

The nurses' practice scores obtained for every step were aggregated to gain the whole score. Total scoring was organized into two classes as follow:

- Satisfactory practice level → ≥ 80% of the total score.
- Unsatisfactory practice level → < 80% of the total score.

Ethical considerations:

-Approval of the ethical committee was obtained code No (37/2/2022) from faculty of nursing and code No (35257/2/22) from faculty of medicine.

-Official permission to carry out the study is obtained from the responsible authorities in the study setting.

-Informed consent was obtained from every nurse included in the study after an explanation of the aim of the study.

-Confidentiality and anonymity were maintained by the use of code number instead of name and the right of withdrawal was reserved.

-The nature of the study didn't cause any harm to the participants.

-Tools I part (one) and (two) was developed by the researcher after a review of the relevant literature where part (three) was adapted by the researcher from Seifert, (2021). Tools II was adapted by the researcher from Torabizadeh, (2017). Tool III part (one) was developed by American Association of Critical Care Nurses, (2013) and part (two) was developed by the researcher after review of the relevant literature.

-The study tools were tested for content validity by a jury of five experts in the field of critical care nursing and cardiac care specialists at Tanta and Sohag University.

-The reliability test for tool one (Critical Care Nurses' Questionnaire), tool two (Nurses' Alarm Fatigue Level Questionnaire) and tool three (Nurses' Alarm Fatigue Management Observational Checklist) by using Cronbach's coefficient alpha ($r=0.783, 0.870$ and 0.934 respectively).

-A pilot study was carried out on (10%) of the study sample to test the clarity and applicability of the tools to identify obstacles and problems that encountered during data collection and necessary modification done.

The safety bundle was implemented including the assessment, planning, implementation, and evaluation phases. The present study was conducted in four phases as follows:

Assessment phase:

-During this phase, the researcher assessed the following: Nurses' Personal characteristics, the top three problematic physiologic monitor alarms assessment pre implementing safety bundle. Also, perception of clinical alarms and obstacles to

clinical alarm pre, immediately post, and after one month of implementing safety bundle using tool I.

- Nurse alarm fatigue was assessed by management pre, immediately post, and after one month of implementing the safety bundle using tool II.

- Safety bundle and Nurses' Alarm Fatigue Management Observational checklist was assessed management pre, immediately post, and after one month of implementing safety bundle using tool III.

Planning Phase:

This phase was articulated based on the assessment phase and the literature review. Priorities and expected outcome criteria were put into consideration when planning for patient care. The expected clinical outcome included:

-Improvement of nurses' perception regarding fatigue alarm management.

-Improvement of nurses' practice regarding alarm fatigue.

-Decreased alarm fatigue post implementation of the safety bundle.

III. Implementation phase:

-The researcher explained the alarm fatigue perception questionnaire, read some questions, and clarified the ambiguity. Every interview continued for 20-30 minutes, after that the researcher composed the sheets and checked unanswered questions.

-The researcher was evaluated nurses' practical level performed forthright surveillance; the researcher was perceived all during day shifts using tool II, the researcher was filled out the observational checklists and was recognized nurses' practices linked to alarm fatigue nursing management.

-Safety bundle regarding alarm fatigue management practice was provided through five consecutive days for each group of nurses, each session was taking around 40-60 minutes. The session time was between morning and afternoon shift or through morning shift after giving the routine care to the critically ill patients as the following:

-The practical sessions were delivered throughout 5 training sessions. Each practical session was taken around 40-60 minutes during the shift work in small

groups (for every 5 nurses) debating with them in the nurses' working area to assist the meeting.

The practical session focused on the following items:

Session one was focused on alarm system safety as a hospital priority, recognizing the greatest imperative alarm signals to manage it.

Session two consisted of monitor troubleshooting alarm and infusion pump troubleshooting alarm and ECG troubleshooting alarms.

Session three included alarm fatigue nursing management actions and alarm reports.

Session four focused on certain patient care activities and procedures that may produce false alarms or expected non-actionable alarms such as ambulation, suctioning secretions, or patient repositioning can create false or non-actionable alarms due to artifact and extra movement.

Session five included a set of 5 safety interventions which includes

1. Communication among colleagues regarding procedures and patient conditions.
2. Electrodes as ECG electrodes, preparing the skin, and dating ECG electrodes.
3. Appropriateness as needed pulse oximetry sensor changes for respiratory monitoring and monitoring only patients with appropriate clinical indications.
4. Setup alarm as customizing and checking alarm parameters at the beginning of each shift, customizing alarm parameter settings for patients by unit or hospital policy.
5. Continuing education.

Enough time was given for discussions, clarifications, and any questions regarding the practical skills. Every session was integrated displaying easy training videos and a colored booklet for practical skills linked to alarm fatigue nursing management using audiovisual aids. Additionally, demonstration and re-demonstration methods were used.

- Researchers used these videos and explained to the nurses in Arabic language.
- Pre and post perception questionnaire and pre-post observation checklists were done after

implementing the safety bundle regarding alarm fatigue nursing management.

- Data collection was collected within 6 months (from June 2022 to May 2023).

IV. Evaluation phase:

- Evaluation of nurses' perception regarding alarm fatigue management pre, immediately post, and after one month of implementing safety bundle using tool I.
- Evaluation of nurse s' alarm fatigue level, safety bundle, and nurses' alarm fatigue management observational checklist were assessed management pre, immediately post, and after one month of implementing safety bundle using tool II and III.

Results

Table (1) Illustrates percentage distribution of the studied nurses according to personal characteristics. It can be seen that less than three-quarters (72%) of the studied nurses were female and two-fifths (40%) of them in the age group of 20 < 30 years old. Regarding educational level, it was found that more than two-fifths (44%) of the studied nurses had an associated degree and more than one fifth (28.0% and 22.0%) of them had diploma and bachelor degree respectively. Also, nearly two-thirds (60%) of the studied nurses had less than 10 years of experience in the CCU. Additionally, the majority (80%) of the studied nurses didn't attend previous training program regarding alarm fatigue.

Figure (1) shows percentage distribution of the total studied nurses' level of perception regarding clinical alarms throughout the study periods. It was found that more than two-thirds (64%) of the studied nurses had lower level of perception regarding clinical alarms pre implementing of alarm safety bundle then it was declined to only (11% and 12%) during post and after one month of implementing alarm safety bundle respectively. On the other hand, more than two-thirds (64%) of studied nurses had lower level of perception regarding clinical alarms pre implementing of alarm safety bundle then it was increase to nearly three-quarters (73% and 62.5%) during post and after one month of implementing alarm safety bundle respectively.

Figure (2) shows percentage distribution of the studied nurses' level of practices regarding the CEASE bundle throughout the study periods. It was found that more than two-thirds (66.4%) of the studied nurses had unsatisfactory level of practices regarding the CEASE bundle pre implementation of

alarm safety bundle. On the other hand, more than three-quarters (82.7% and 77.20%) of the studied nurses had satisfactory level of practices regarding the CEASE bundle post and after one month implementation of alarm safety bundle respectively.

Figure (3) reveals percentage distribution of the studied nurses' level of practices regarding alarm fatigue management throughout the study periods. It can be seen that, more than three-quarters (76.5%) of the studied nurses had unsatisfactory level of practices regarding alarm fatigue management pre implementation of alarm safety bundle. On the other hand, the majority (86.6% and 80.1%) of the studied nurses had satisfactory level of practices regarding alarm fatigue management post and after one month implementation of alarm safety bundle respectively.

Table (2) shows the relation between the studied nurse's personal characteristics and the total mean scores of nurse's alarm fatigue level throughout the study periods. It was found that there were highly statistically significant differences between nurses' age, previous training program regarding alarm fatigue and in relation to their perception regarding clinical alarms pre, post and after one month of implementing alarm safety bundle $p=0.00$.

Table (3) shows the correlation matrix between nurses' study variables and patients' clinical outcomes through the pre and post of implementing alarm safety bundle. It was found that there was statistically significant positive correlation between perception of clinical alarms, alarm fatigue level and alarm fatigue management pre and post implementation of alarm safety bundle in relation to patients' clinical outcomes.

Table (1): Percentage distribution of the studied nurses according to nurses' personal characteristics (n=50)

Nurses' personal characteristics	No	%
Sex		
Male	14	28.0
Female	36	72.0
Age (years)		
20 < 30years	20	40.0
30< 40 years	18	36.0
>40 years	12	24.0
Educational level		
Diploma degree	14	28.0
Associated degree	22	44.0
Bachelor degree	11	22.0
Post associated degree	3	6.0
Years of nursing experience in the CCU		
>10 years	20	40.0
<10 years	30	60.0
Previous training program regarding alarm fatigue.		
Yes	10	20.0
No	40	80.0

CCU: Critical Care Unit.

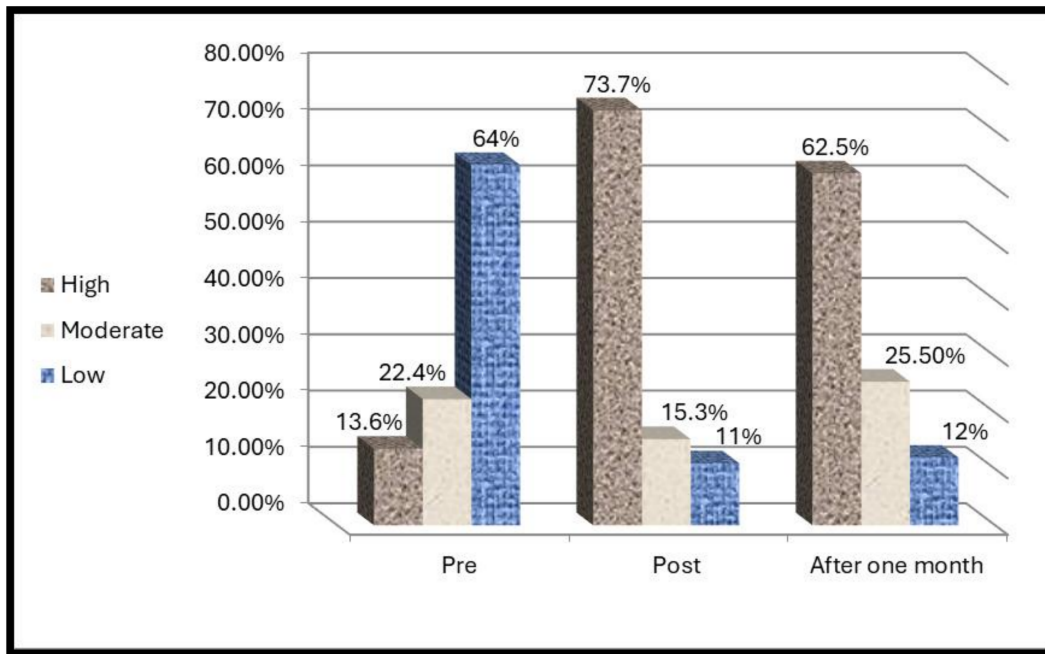


Figure (1): Shows percentage distribution of the total studied nurses' level of perception regarding clinical alarms throughout the study periods (n=50)

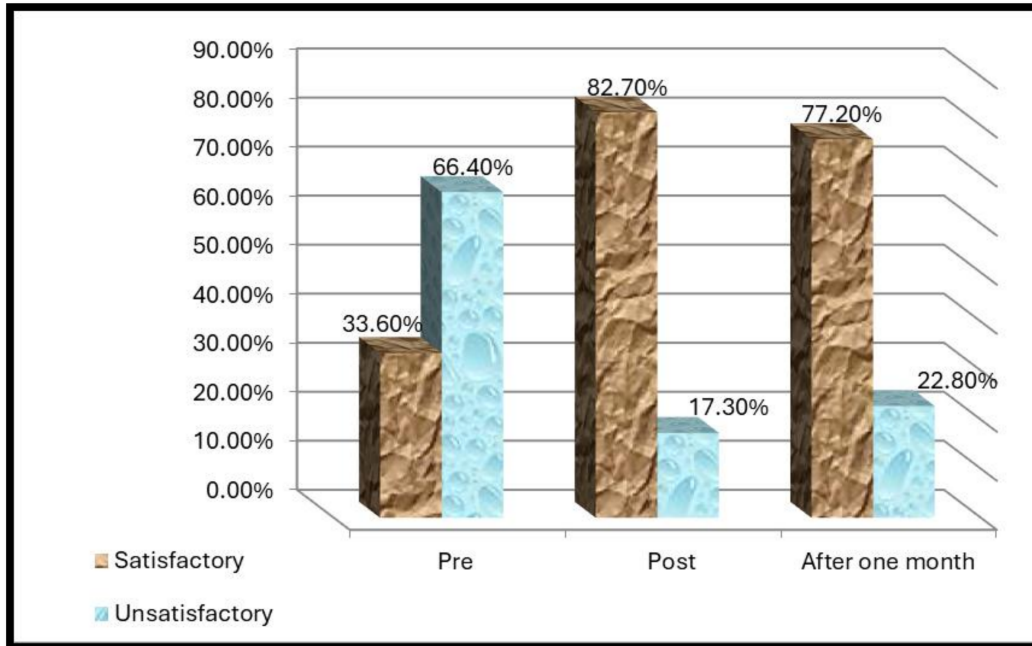


Figure (2): Shows percentage distribution of the studied nurses' level of practices regarding the CEASE bundle throughout the study periods

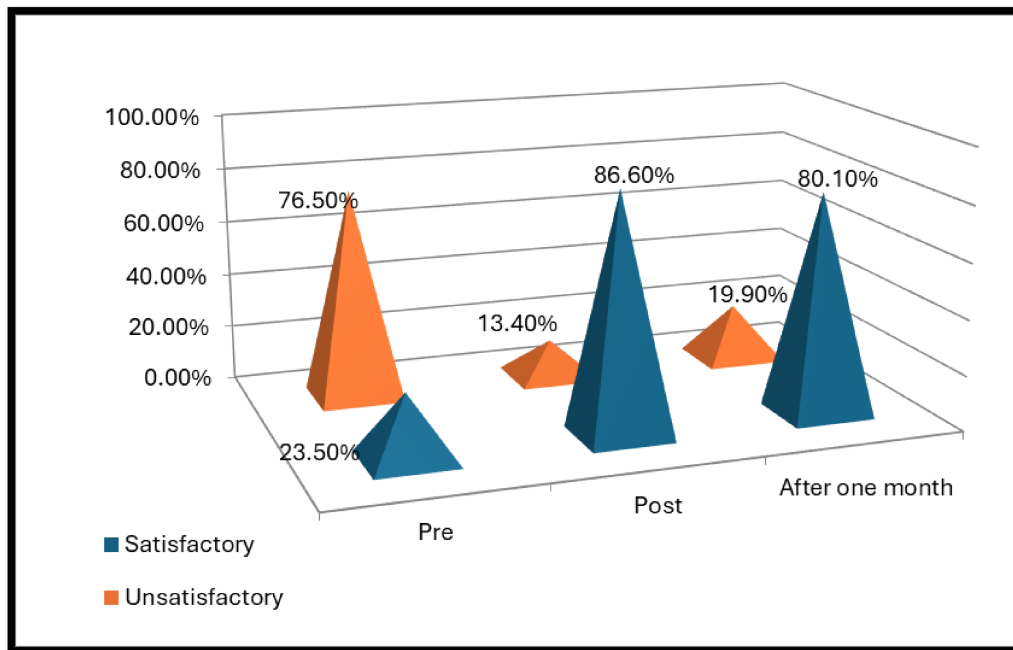


Figure (3): Reveals percentage distribution of the studied nurses' level of practices regarding alarm fatigue management throughout the study periods.

Table (2): Relation between the studied nurses' personal characteristics and the total mean score of nurses' alarm fatigue level throughout the study periods (n=50)

Nurses' Personal characteristics	Nurses alarm fatigue level			t (1)	P-Value	t (2)	P-Value	t (3)	P-Value
	Pre implementation	Post implementation	After one month						
	Mean± SD	Mean± SD	Mean± SD						
Sex	10.180±12.79	36.74±14.87	31.3±16.98	5.627	.000**	15.29	0.000**	14.8	.000**
Age (years)	10.72±12.98	37.28±16.45	31.84±14.27	5.838	.000**	16.02	0.000**	15.767	.000**
Educational level	11.08±12.61	37.64±16.95	32.2±14.73	6.208	.231	15.7	0.346	15.4	0.1571
Years of nursing experience in the CCU	11.0±12.9	37.56±16.70	32.12±14.57	6.027	1.46	15.89	0.330	15.58	1.202
Previous training program regarding alarm fatigue.	11.36±12.71	37.92±16.87	32.48±14.64	6.3	0.000**	15.8	0.000**	15.6	0.000**

** A highly statistically significant difference $P \leq 0.001$. t (1) paired t test between pre and post implementation. t (2) paired t test between pre and after one month implementation. t (3) paired t test between post and after one month implementation.

Table (3): Correlation matrix between nurses' study variables and patients' clinical outcomes through the pre and post implementation of the safety bundle (n=50)

Variables	Time assessment	Patients' clinical outcomes (Hemodynamic parameters monitoring and occurring of arrhythmia)	
		R	P
Perception of clinical alarms	Pre	1.600	0.005*
Alarm fatigue level		0.584	0.002*
Alarm fatigue management		0.272	0.012*
Perception of clinical alarms	Post	0.926	0.000**
Alarm fatigue level		0.482	.000**
Alarm fatigue management		0.835	0.000**

* Statistically significant correlation $P \leq 0.05$

** A highly statistically significant correlation $P \leq 0.001$.

Discussion

Medical device alarms, which were designed to draw medical staff's attention when a patient's condition goes beyond the proper range, are causing a new alarm hazard problem. The number of devices with alarms has multiplied exponentially in most hospital units. Monitors, ventilators, infusion pumps, and many other devices beep endlessly, demanding attention and causes alarm fatigue. Since alarm fatigue is directly related to patients' safety, the effective management of medical device alarms can reduce alarm fatigue and prevent potentially dangerous outcomes (**Regmi et al., 2023**). Therefore, the current study aimed to evaluate the effect of implementing safety bundle regarding alarm fatigue on nurses' perception, practices and patients' clinical outcomes in cardiac care units.

Alarm hazards are becoming more prevalent due to medical device alerts, which were intended to alert medical personnel when a patient's state deviates from the acceptable range. In most hospital units, the number of gadgets equipped with alarms has increased tremendously. Numerous gadgets, including infusion pumps, ventilators, and monitors, beep continuously, demanding care and leading to alarm weariness. Effective handling of medical device alarms can lessen alarm fatigue and avert potentially hazardous events, as there is a direct correlation between alarm tiredness and patient safety (**Regmi et al., 2023**). Thus, the purpose of the current study was to assess how nurses' perceptions, behaviors, and patients' clinical outcomes in cardiac care units might be affected by the

implementation of a safety bundle involving alarm fatigue.

Regarding percentage distribution of the studied nurses according to personal characteristics the current study illustrated that less than three quarters of the studied nurses were females and two fifths of them in the age group of 20 < 30 years old. Regarding educational level, it was found that more than two fifths of the studied nurses had an associated degree and more than one fifth of them had diploma and bachelor's degree. Also, three fifths of the studied nurses had <10 years of experience in the CCU. Additionally, the majority of the studied nurses did not have a previous training program regarding alarm fatigue. This may be due to the nursing institutes were accepting females only in the past years and there may be lack of conducted such training programs in CCU.

The current study demonstrated that, with respect to the percentage distribution of the investigated nurses based on personal characteristics, less than three quarters of the nurses were female, and that two-fifths of them were in the 20–30 age range. When it came to educational attainment, it was discovered that over two fifths of the nurses under study held an associate degree, and over one fifth held a bachelor's degree and diploma. Furthermore, less than 10% of the nurses in the study had less than ten years of CCU experience. Furthermore, most of the nurses in the study had never participated in an alarm fatigue training session before. This can be because there weren't enough of these training programs offered in CCUs or

because nursing schools used to only accept female applicants.

This result was supported by the study carried out by **(Bourji et al., (2020))**, which entitled "Evaluating the Alarm Fatigue and its Associated Factors among Clinicians in Critical Care Units" and revealed that more than half of participants were in the age group from 20 to 29 and more than three fifth of them were females. But, this result was different with the study performed by **(Lee et al., (2021))**, which entitled "Impact of Hospital Nurses' Perception on Clinical Alarms and Patient Safety Culture on Alarm Management Practice" and demonstrated that more than half of nurses in the age group 25–29, three quarters of them had hold Bachelor degree in nursing and more than one third of them worked on ICU and had <3 years of experience.

According to the total studied nurses' level of perception regarding clinical alarms throughout the study periods the current study found that nearly two thirds of the studied nurses had lower level of perception regarding clinical alarms pre implementation of alarm safety bundle then it was declined to only more than one tenth during post and after one month implementation of alarm safety bundle. On the other hand, less than two thirds of studied nurses had lower level of perception regarding clinical alarms pre implementation of alarm safety bundle then it was increased to be nearly three quarters of studied nurses had high level of perception regarding clinical alarms during post and after one month implementation of alarm safety bundle. This may be due to poor knowledge and lack of awareness

regarding the importance of clinical alarm perception before the beginning of the alarm fatigue management sessions.

This result was incompatible with the study conducted by **(Ding et al., (2023))**, which entitled "The Relationship between Alarm Fatigue and Burnout among Critical Care Nurses" data were collected from five hospitals in a inland China between January 2022 and March 2022, and showed that critical care nurses experienced moderate alarm fatigue levels. Additionally, this result was incongruent with the study carried out by **(Regmi et al., (2023))**, which entitled "Alarm Fatigue among Nurses Working in Critical Care Setting in a Tertiary Hospital, Nepal" and concluded that the alarm fatigue among nurses working in critical care settings was found to be higher in this study.

The current study found that there was a highly statistically significant improvement in the alarm fatigue domains of the nurses under study prior to, during, and following the one-month installation of the alarm safety package. This might be explained by the significance of alarm fatigue management and the researcher's informational materials' ease of understanding.

This result was in the same line with **(Bosma, (2022))**, who studied "Improving Clinical Alarm Fatigue and Alarm Management Competency among Critical Care Nurses by Implementing a Unit Based Alarm Management Bundle" and showed that there was a statistically significant decrease in self-reported alarm fatigue post project intervention, and the CEASE bundle

was found to be influential to nursing practice. Also, this result was compatible with (Cruz, (2020), who studied "Telemetry Nurses Knowledge of Alarm Fatigue and Interventions for Change: An Education Program Development" and demonstrated that educational intervention proved effective in increasing knowledge of alarm fatigue and interventions for prevention of alarm fatigue.

Concerning nurses regarding alarm fatigue level throughout the study periods, the present study found that nearly three quarters of the studied nurses had high level of alarm fatigue pre implementation of alarm safety bundle. On the other hand, it was found that less than two thirds of the studied nurses had lower level regarding alarm fatigue post and after one month implementation of alarm safety bundle. This may be due to nurses' low levels of education which affects their management of alarms.

This result was congruent with the study conducted by (Li et al., (2023), which entitled "The Effect of Intelligent Management Interventions in Intensive Care Units to Reduce False Alarms" and showed that different interventions for intelligent management of alarms were beneficial in reducing alarm fatigue levels among nurses. Additionally, this result was in the same line with (Bi et al., (2020), they studied "Effects of Monitor Alarm Management Training on Nurses' Alarm Fatigue" and demonstrated that Intensive care unit nurses' alarm fatigue was effectively decreased by the alarm management training program. But this result was different with the study conducted

by (Nyarko et al., (2023), they showed that educational intervention was beneficial for reducing the total number of alarms and false alarms. Furthermore, nurses' perceptions and knowledge improved, but the reduction in nurses' alarm fatigue is uncertain.

This outcome was consistent with a study by (Li et al., (2023), titled "The Effect of Intelligent Management Interventions in Intensive Care Units to Reduce False Alarms," which demonstrated that various intelligent management alarm interventions were helpful in lowering nurses' alarm fatigue levels. Furthermore, this finding was consistent with that of (Bi et al., (2020) study, "Effects of Monitor Alarm Management Training on Nurses' Alarm Fatigue," which showed that the alarm management training program was an effective way to reduce alarm tiredness in intensive care unit nurses. However, the findings of (Nyarko et al., (2023) demonstrated that educational intervention was helpful in lowering the overall number of alarms and false alarms. In addition, views and knowledge among nurses improved, however it's unclear if alarm fatigue among nurses decreased.

According to percentage distribution of the studied nurses' level of practices regarding the CEASE bundle throughout the study periods the present study founded that, two thirds of the studied nurses had unsatisfactory level of practices regarding the CEASE bundle pre implementation of alarm safety bundle. On the other hand, the majority of the studied nurses had satisfactory level of practices regarding the

CEASE bundle during pre, post and after one month implementation of alarm safety bundle. This may be due to easy knowledge presentation and effective methods of teaching used for nurses' program education.

This result was supported by **(Dee et al., (2022))**, they studied "Determining the Impact of an Alarm Management Program on Alarm Fatigue among ICU and Telemetry RNs: An Evidence Based Research Project" and revealed that after the nursing staff completed the educational intervention, there was a statistically significant increase in nursing knowledge about alarm management. Also, this result agreed with **(Bosma, (2022))**, who reported that nurse participants demonstrated improved alarm management competency after program implementation.

Concerning relation between the studied nurses' personal characteristics and the total mean score of nurses' alarm fatigue level throughout the study periods the present study showed that there was a highly statistically significant difference between nurses' sex, age, previous training program regarding alarm fatigue and in relation to their perception regarding clinical alarms pre, post and after one month implementation of alarm safety bundle. This may be due to the nature of response to stress and anxiety situation in both genders. In addition, the age and experience of nurses increased, and their responses became better.

This result agreed with the study conducted by **(Liao et al., (2022))**, which entitled "Nurses' Clinical Alarm-Related Behaviors

and Influencing Factors in China" and showed that the factors that influenced alarm perception included age, alarm-related training and willingness to participate in alarm-related training. This result was supported by the study carried out by **(Asadi et al., (2022))**, they studied "Alarm Fatigue and Moral Distress in ICU Nurses in COVID-19 Pandemic" and demonstrated that alarm fatigue in nurses who were trained in working with ventilators and alarm settings was significantly less than other nurses. This result was incompatible with the study performed by **(Regmi et al., (2023))**, they showed that there was no significant difference between alarm fatigue and selected socio-demographic (age, and previous training) and nurses' perception of alarm fatigue.

Regarding correlation matrix between nurses' study variables and patients' clinical outcomes through the pre and post implementation of the safety bundle. The current study showed that there was statistically significant positive correlation between study variables at pre implementation of alarm safety bundle. Also, it was found that there was highly statistically significant positive correlation between study variables at post implementation of alarm safety bundle. This may be attributed to the increased level of perception to alarms help them manage the undesired and false alarms which improves patient safety and decreases alarm fatigue.

This result was similar with the study conducted by **(Lewandowska et al., (2023))** entitled "Determining Factors of Alarm Fatigue among Nurses in Intensive Care

Units a Polish Pilot Study on 400 Polish ICU nurses" the study revealed that nurses' ability to manage alerts from monitoring equipment is a key component in lowering alarm fatigue. Also, this result was in the same line with the study performed by **Elbilgahy et al., (2023)**, they found that after implementing the educational intervention program, study nurses' knowledge scores regarding clinical alarms and alarm fatigue significantly improved when compared to their pretest scores.

Additionally, the results of this study showed that there was a statistically significant difference between the categories of knowledge held by nurses before and after the intervention program, showing improved knowledge following the program. Moreover, this study was compatible with the study done by **Nyarko, et al., (2023)**, which entitled "The Effect of Educational Interventions in Managing Nurses' Alarm Fatigue" and suggested that following alarm management training based on action planning theory, there has been evidence that alarm fatigue among ICU personnel has decreased.

Conclusion

It was concluded that there were statistically significant differences between nurses' perception and practices categories indicating good perception and practice after the nurses implementing safety bundle regarding alarm fatigue, compared with poor perception and practice pre- implementing safety bundle regarding alarm fatigue.

Recommendations

Based on results of the present study, the following can be recommended:

-It is recommended to develop a standardized tool that assesses nurses' perception and practices of clinical alarms and alarm management guidelines.

-In-service training implementing safety bundle regarding alarm fatigue should be conducted for nurses regarding alarm management and increase nurses' awareness of the presence of alarm fatigue.

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