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Assessment of Critical Care Nurses' Knowledge and Perceptions Regarding Alarm Fatigue

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ABSTRACT

Background: In clinical practice, an extensive number of false alarms is still difficult to resolve, which causes nurses and other healthcare professionals to become overworked and exhausted. Therefore, one of the biggest problems that nurses face in clinical practice is excessive alerts**. Aim:** the aim of this study is to assess critical care nurses' knowledge and perceptions regarding alarms fatigue**. Method:** A descriptive exploratory research design was utilized. This study was carried out at Medical ICUs of Medical Specialized Hospital - Mansoura University, Egypt**. Sample type:** A convenient sample was chosen. A sample of 60 CCNs with more than one year of working experience in ICUs and were involved in patients' direct care. Nurses' Alarm Fatigue Questionnaire and CCNs' Alarm Fatigue Perception Questionnaire were used**. Results:** The current study showed that, 48.3% demonstrated good knowledge of alarm fatigue, 26.7% had average knowledge, and 25.0% exhibited poor knowledge. Among critical care nurses, 61.7% demonstrated a satisfactory perception of alarm fatigue, while 38.3% had unsatisfactory perception. Significant associations were found between nurses' educational background and knowledge level ($p < 0.001$). Also, more experienced nurses had satisfactory perceptions ($p < 0.001$). **Conclusion:** The data indicate that knowledge regarding alarm fatigue is generally good, nearly half of nurses demonstrating strong understanding. Perceptions of alarm fatigue also appear satisfactory among majority of nurses. There is a positive correlation between CCNs' knowledge regarding alarm fatigue and their perceptions (p<0.002). **Recommendation:** A regular assessments of alarm fatigue is important to determine training needs, and enhance nurses' alarm management skills and knowledge.

Keywords: *Alarm Fatigue, Critical Care Nurses, Knowledge, and Perceptions*.

Introduction:

Intensive care units (ICUs) are specialized spaces devoted to caring for patients `who are critically ill and need continuously observation and advanced medical assistance. To handle complex patient needs, modern ICUs are manned by multidisciplinary teams and equipped with modern technology. ICUs have changed significantly over time, implementing telemedicine, sophisticated predictive technologies, and better processes to improve patient outcomes **(Varon & Varon, 2021; Waydhas et al., 2023)**. Intensive care units are designed and operated to support patients with serious medical conditions by combining specialist care with technological advancements. In order to enable more individualized and successful interventions, dynamic prediction models have been established to track patient outcomes in real-time **(Lapp, Roper, Kavanagh, Bouamrane, & Schraag, 2023)**.

Furthermore, the use of advanced devices like ventilators, patient monitoring systems, and infusion pumps is necessary due to the increasing number of patients in critical care units; however, there is also a need for a trained care team with clinical expertise and experience in using such equipment **(Yahyaei, Khoddam, Alinaghimaddah, & Modanloo, 2023).** Therefore, medical professionals working in (ICUs) depend on alarms to notify them of potentially hazardous patient circumstances (like high blood pressure), syringe pump status (like drug syringe empty), or technical malfunctions of medical equipment (like battery empty). But today's ICUs have so many alarms that staff members are unable to respond to them all **(Poncette, et al., 2021)**.

In addition, since artifacts and mismeasurements can potentially create alarms, very few alarms are caused by situations that call for action. About 56% of all alarms are false or don't need to be responded to, this is according to a

recent survey that was distributed to employees in every ICU of a major university hospital in Germany **(Wunderlich, et al., 2023).** In clinical practice, an extensive number of false alarms is still difficult to resolve, which causes nurses and other healthcare professionals to become overworked and exhausted **(Storm & Chen, 2021)**. Therefore, one of the biggest problems that nurses face in clinical practice is excessive alerts, **(Lewandowska et al., 2020).** False alarms account for a large percentage of ICU alerts, frequently exceeding 70% in frequency, which causes stress for patients and caregivers, a reduction in staff responsiveness, and leading to alarm fatigue **(Sujimongkol, Daochai, Wichakhrueang, & Daochai, 2023)**.

"Alarm fatigue occurs when clinicians experience high exposure to medical device alarms, causing desensitization and leading to missed alarms or delayed responses" **(Woo &Bacon, (2020)**. According to **Karahan et al., (2023) and Lobo et al., (2024)**, alarm fatigue has a significant negative influence on clinicians' mental health since it impairs work performance and raises anxiety level. Addressing organizational problems and encouraging a safety culture are examples of sustainable solutions. There has been a lot of discussion about alarm fatigue as a possible patient safety concern. Burnout from alarm fatigue can have a major impact on patient safety **(Ding et al., 2023; Storm & Chen, 2021).** Alarm fatigue can be further avoided by efficiently reducing false alarms by increasing the specificity of the alarm **(Yue, 2021)**. Additionally, regular non-actionable alarms cause more disruptions to clinical duties, which reduces productivity and affects with workflow (**Jämsä, Uutela, Tapper, & Lehtonen, 2021**).

Many strategies to lower the number of false alarms has been documented by the Critical Care American Association **(Aysha & Ahmed, 2019)**. These strategies include using pulse oximetry machines to customize oxygen saturation, changing electrodes every day, and properly preparing cardiac monitoring electrodes. determines which alarms to sound, carefully switches the patient to mechanical breathing, and makes that the syringe pump is positioned and fastened appropriately **(Aysha & Ahmed, 2019)**. Additionally, regular training and educational interventions designed to increase nurses' understanding of alarm systems shown benefits in clinical procedures and patient safety outcomes, albeit the direct effects on perceptions of alarm fatigue differed **(Nyarko, Nie, Yin, Chai, & Yue, 2022).**

Comprehensive techniques that incorporate training, system optimization, and legislative approaches have showed potential for minimizing alarm fatigue. For example, personalized alarm settings, effective cooperation, and technological solutions classified as "smart care" have improved alarm management capacities in ICUs **(Movahedi, , Sadooghiasl, Ahmadi, & Vaismoradi, 2023)**. As well, the American Association of Critical Care Nurse, recommends that hospitals adopt policies and processes to comply with ICU medical device alarms.

Alarm fatigue management training for CCNs and other technicians includes additional regulation parameters. CCNs are responsible for monitoring and estimating ICU patients and implementing appropriate interventions to prevent alarm fatigue and manage critically sick patients effectively. So, there was a great need for assessing CCNs' knowledge and perceptions regarding alarm fatigue **(Sliman, Abd El-Aziz & Mansour, 2020).**

2.1 Aim of the Study

The aim of this study is to assess critical care nurses' knowledge and perceptions regarding alarm fatigue.

2.2 Research Questions

This study is being conducted to answer the following questions:

Q1: What is the critical care nurses' knowledge level regarding alarm fatigue?

Q2: What are the critical care nurses' perceptions regarding alarm fatigue?

1. Method

In this study a descriptive exploratory research design was used to assess the critical care nurses' knowledge and perceptions regarding alarms fatigue.

3.2 Setting

This study was conducted in Medical ICUs of Medical Specialized Hospital - Mansoura University. It includes seven units; these units provide services for critically ill patients with hepatic, cardiovascular and endocrinal disorders. These units were well equipped with advanced technology required for critically ill patients such as mechanical ventilators, bedside monitors, infusion pumps, ECG machines, suction machines and portable ultrasound. The nurse-to-patient ratio was nearly1:2 in the morning shift and 1:3 in the other shifts.

3.3 Study Sample

A convenience sample of (70) CCNs with more than one year of working experience in selected CCUs who were involved in patients' direct care with different levels of education was involved in the current study. Nurses who agreed to participate in the study and gave their approval were accepted.

3.4 Data Collection Tools

In this study, based on reviewing the relevant literatures, two tools were utilized to collect the data for the existing study:

Tool I: Nurses' Alarm Fatigue Questionnaire

This tool consisted of two parts using alarm fatigue questionnaire.

Part I: Demographic ***Characteristics of Critical Care Nurses***

This part was developed by the researcher to assess CCNs demographic characteristics data such as: age, gender, educational background, job title, type of unit, total clinical experience, clinical experience at the current unit, and weekly working hours.

Part II: Critical Care *Nurses'* ***knowledge regarding alarm fatigue Questionnaire***

This part was adapted from **Ahmed, Sayed, and Gamal, (2023), Torabizadeh, Yousefinya, Zand, Rakhshan, & Fararooei, (2017) , Mekonne, (2020)** and **Elbilgahy, Wady, and Badawy, (2023).** It aims to assess the level of nurses' knowledge regarding alarm fatigue, which was covered (20) items.

Scoring System

the scoring system of this part of the questionnaire was as follows: A total of 20 items were deliberated like this: "Correct "(1), and "Incorrect" (0). Nurses' knowledge was assessed and classified as follows: Knowledge levels of 80% or more was interpreted as "good," knowledge levels of 70–80% was rated "average," and knowledge levels of less than 70% was considered "poor." **(Elbilgahy, Wady, & Badawy, 2023).**

Tool II: "Critical Care Nurses' Alarm Fatigue Perception Questionnaire"

This tool was adapted from **Alkubati, et al., (2024); Ahmad & Younes, (2023); Sliman, Abd El-Aziz, & Mansour, (2020) & Ashrafi., Najafi Mehri & Nehrir, (2017).** It aimed to assess nurses' perception regarding alarm fatigue. This tool covered 30 items of CCNs' perceptions regarding alarm fatigue. Participants were asked to rate how in agreement they were with the declarations on a three-point Likert scale that ranged from never sometimes and always. where 1 symbolized never and 3 symbolized always. However, the scores for several items were reversed with 3 symbolized never and 1 symbolized always.

Scoring System

The scores were gained per stride and summed up to acquire the total maximum (90) points of CCNs' perceptions. The CCNs' perception score as a whole was discussed and divided into the following categories: 75% and more were considered to be satisfactory, while less than 75% were considered unsatisfactory **(Sliman, et al., (2020)**

Ethical Consideration

An ethical approval was obtained from the Research Ethics Committee of the Faculty of Nursing- Mansoura University with Re.No 462. An official permission to conduct the current study was obtained from Mansoura University Medical Specialized Hospital administrative authorities after introducing and providing a complete explanation about the aim and nature of the study, as well as critical care nurses informed consent to accept the assessment.

The questionnaire was with accompanying letter, explaining the purpose of the study and elaborated on how the data collection was utilized. The participants' identities were kept in a private way, and the responses to the questionnaires were interpreted as informed consent for participation in the study. To prevent divulging the hospital's name or the identities of the personnel, each questionnaire had a code number, and the replies made by the hospital and nurses were kept in confidence.

Data Collection Process

This study was conducted in two phases: preparation and implementation phase.

1. **Preparation phase**

An ethical approval was obtained from the Research Ethics Committee, Faculty of Nursing, Mansoura University. Permission to conduct the current study was obtained from the responsible authorities of the study setting after the explaining the aim and nature of the study. The tool of the data collection was assessed for its content validity by experts who are specialized in the field of the study. Preparation of the tools that were done after reviewing the previous relative literatures.

2. **Implementation phase**

At the beginning the researcher was building trust relationships and kept a relaxing atmosphere for nurses in order to gain their cooperation and interest. An explanation of the aim and nature of the study to CCNs who agreed to participate in the

study then inform consent was obtained by the researcher. The researcher followed the recommended personal protective measures during data collection process as well as privacy and safety were absolutely assured. The researcher attended the previously mentioned setting two days per week (Saturday and Wednesday) from 12 Pm to 7 Pm. Critical care nurses' demographic characteristics were collected by using part I of Tool I. Critical care nurses' knowledge regarding alarm fatigue using were assessed by using Part II of Tool I. The researcher explained the alarm fatigue knowledge questionnaire, read some questions, and clarified it for them. Assessment of CCNs' alarm fatigue perception questionnaire were done by using Tool II. A self- observational questionnaire using Tool I and II was done by the researcher during the period of the study.

Statistical Analysis

All statistical analyses were performed using SPSS for windows version 20.0 (**SPSS, Chicago, IL**). Continuous data were normally distributed and were expressed in mean ± standard deviation (**SD**). Categorical data were expressed in number and percentage. Chi-square test (or fisher's exact test when applicable) was used for comparison of variables with categorical data. Correlation co-efficient test was used to test for correlations between two variables with continuous data. The reliability (internal consistency) test for the questionnaires used in the study was calculate. Statistical significance was set at $p<0.05$.

Validity of the Tool:

The study Tools was translated into Arabic by Document Translation Services, Mansoura University. The content validity of the tools was reviewed by a panel of five experts in the Critical Care & Emergency Nursing specialty of the Faculty of Nursing, Mansoura University, before using it to ensure that the questions were consistently conveyed and carried the anticipated meaning that they were prepared for, and modifications were done as simplifying the meaning, rearranging the sequence, and integrating some questions.

Reliability of the Tool

The tool's reliability was tested through Cronbach's alpha value of the Critical Care Nurses' knowledge regarding alarm fatigue Questionnaire is 0.896, and of the Critical Care Nurses' Alarm Fatigue Perception Questionnaire is 0.901 respectively.

Results

Table1 shows that 91.7% of the studied participants were in age group of 18<30 years old, and 60% of them were female. For educational background, 55% of CCNs had technical institute degree. In addition, 66.7% of studied nurses had <5 years of ICU experience. Concerning weekly working hours 66.7% of CCNs worked more than 42hours/week.

Table 2 shows that 70.0%of the studied participants defined alarm fatigue, and 75.0% of them answered the cause of alarm fatigue correctly. Regarding the statement of, ''most healthcare workers being exposed to alarm fatigue'' 98.3%, of CCNs answered correctly. All the studied participants gave the correct answer of 100.0% to the most alarm device that leads to alarm fatigue. Concerning the symptoms of alarm fatigue 85.0% of the studied participants had correct answer. For the consequences of alarm fatigue 73.3% of CCNs replied correctly.

Concerning the time that the nurse turned off the alarm to prevent him or her from getting alarm fatigue, 91.7% of CCNs gave the correct answer. Also, 91.7% of them identified the meaning of false alarm. Regarding to the prevention of alarm fatigue only 8.3% of the studied participant had the correct answer. Finally, in the current study, it was found that 25.0% of the CCNs have poor knowledge level regarding alarm fatigue, 26.7% of them have average knowledge level, while 48.3% of them have a good knowledge, with (mean ± SD: 15.4 ± 2.9).

Table 3 shows that 58.3% of the CCNs always have a proper professional response toward alarms. Also, 58.3% of the studied participants replied that they never hurry when they hear the alarm; as it may be an auditory error. In addition, 65.0% of nurses sometimes alarms delay their focus on specialized duties. On other hand, 58.3% of CCNs said that sometimes in the morning shift the crowd hinders their direct response to alarms.

Furthermore, 85.0% of CCNs always have an immediate response to the ventilator alarms, and 71.7% of them gave awareness to the changes in alarm source after they heard it. Also, 68.3% of nurses sometimes become confused with excessive sounds of alarms. Furthermore, 36.7% of nurses sometimes pay more attention to the alarms in certain shifts. Thus, 50.0% of CCNs, always react differently to the low and high-volume alarms of the ventilator. Finally, 61.7% of the respondents had satisfactory perception regarding alarm fatigue, while 38.3% of them had unsatisfactory perception,

the mean score of the overall perceptions was 71.4 ± 5.0.

Table 4 summarizes the association between general characteristics of nurses and their knowledge levels regarding alarm fatigue. It revealed that, there was a significant association between educational level and level knowledge of alarm fatigue. Nurses with a bachelor's degree showed notably better knowledge compared to those with a technical institute degree ($p < 0.001$). Nurses with less than 5 years of ICU experience had poor knowledge of alarm fatigue, whereas those with 10–15 years of experience demonstrated better knowledge ($p = 0.004$). Similar patterns were observed with working experience at the current unit. Nurses with less than 5 years of experience had poor knowledge compared to those with longer tenure ($p = 0.036$). while, factors like age, gender, job title, working place, and weekly working hours do not play a significant role in determining the knowledge levels of nurses regarding alarm fatigue.

Table 5 clarifies the analysis of the association between various characteristics of nurses and their perception of alarm fatigue yielded the following, a significant association was found with nurses holding a bachelor's degree exhibiting more satisfactory perceptions of alarm fatigue compared to those with a technical institute degree ($p = 0.004$). Nurses with less than 5 years of ICU experience have unsatisfactory perceptions of alarm fatigue, while those with 5–10 years showed more satisfactory perceptions ($p = 0.006$). A strong association was noted, with all nurses having less than 5 years of experience at their current unit reporting unsatisfactory perceptions, while those with more experience had more satisfactory perceptions ($p < 0.001$).

Figure 1 illustrates the correlation between critical care nurses' knowledge level of alarm fatigue and their perceptions. It reveals a positive relationship ($p<0.002$*): as knowledge increases, perceptions of alarm fatigue tend to improve. This suggests that higher levels of knowledge are linked to more satisfactory perceptions.

Table 1. Number and distribution of the General Characteristics of the Nurses

Characteristics	n	%
Age (Years)		
- 18 < 30	55	91.7
- 30 < 40	5	8.3
Gender		
- Male	24	40.0
- Female	36	60.0
Educational background		
- Technical institute degree	33	55.0
- Bachelor degree	27	45.0
Job title		
- Registered nurse	27	45.0
- Technical nurse	33	55.0
Working place		
- Intermediate cardiac care unit	14	23.3
- Intermediate hepatic care unit	17	28.3
- Intermediate diabetes care unit	15	25.0
- Critical medicine and intensive care unit	14	23.3
ICU Experience years		
< 5	40	66.7
5 < 10	16	26.7
10 < 15	4	6.7
Working experience at the current unit (Years)		
< 5	43	71.7
5 < 10	14	23.3
10 < 15	3	5.0
Weekly working hours		
< 35 per week (4 – 5/day)	3	5.0
35 – 42 per week (5 – 6 /day)	17	28.3
> 42 per week (>6 /day)	40	66.7

Data are expressed as numbers (No), frequency (%)

Table 2. Number and distribution of the Critical Care Nurses' knowledge regarding alarm fatigue

Statements	Correct		Incorrect	
	n	%	n	%
What is Alarm Fatigue?	42	70.0	18	30.0
What is the cause of alarm fatigue?	45	75.0	15	25.0
Which of the following health care worker is the most exposed to alarm fatigue?	59	98.3	1	1.7
Which of the following critical care nurse is easily developed alarm fatigue?	49	81.7	11	18.3
Which of the following alarm device leads to alarm fatigue in the ICU?	60	100.0	0	0.0
Which of the following are the symptoms of alarm fatigue?	51	85.0	9	15.0
What are the consequences of alarm fatigue?	44	73.3	16	26.7
Which of the following factors are contributed to alarm fatigue?	29	48.3	31	51.7
Which of the following issues inhibits effective management of clinical alarms?	45	75.0	15	25.0
Which of the following strategies reduced alarm fatigue?	45	75.0	15	25.0
How does alarm fatigue affect the patient's safety?	44	73.3	16	26.7
Why is it important to handle alarm fatigue in all ICU?	57	95.0	3	5.0
On what basis are alarm devices set in the ICU?	51	85.0	9	15.0
When do you pay less attention to the patient's alarm devices?	49	81.7	11	18.3
When does the nurse turn off the alarm devices to prevent him or her from getting alarm fatigue?	55	91.7	5	8.3
What do you do when the alarm goes off repeatedly or multiple times?	43	71.7	17	28.3
What does the word false alarm mean?	55	91.7	5	8.3
What is the ASSET mnemonic used for in the ICU?	45	75.0	15	25.0
Which of the following is the way of managing alarm fatigue?	49	81.7	11	18.3
How do you prevent alarm fatigue in the ICUs?	5	8.3	55	91.7
Critical Care Nurses' knowledge level	n		%	
Poor knowledge	15		25.0	
Average knowledge	16		26.7	
Good knowledge	29		48.3	
Mean ±SD	15.4 ±2.9			

Data were expressed as numbers (n), frequency (%), Intensive Care Unit (ICU) & Standard Deviation (SD).

Table 3. Number and distribution of the Critical Care Nurses' Alarm Fatigue Perception level

Statements	Never		Sometimes		Always	
	n	%	n	%	n	%
I have a proper professional toward alarms	0	0.0	25	41.7	35	58.3
I do not hurry with hearing the alarm; as it may be an auditory error	35	58.3	21	35.0	4	6.7
I pay more attention to the alarms in night shift	43	71.7	11	18.3	6	10.0
Alarms delay my focus on specialized duties	13	21.7	39	65.0	8	13.3
I go to the patient's bed at once I listen to alarms	2	3.3	9	15.0	49	81.7
I get anxious when I listen to an alarm	8	13.3	35	58.3	17	28.3
In the morning shift the crowd hinders my direct response to alarms	8	13.3	35	58.3	17	28.3
I have an immediate to the ventilator alarms	1	1.7	8	13.3	51	85.0
I give awareness to the changes in alarm source after I hear the alarm	1	1.7	16	26.7	43	71.7
I become confused with excessive sounds of alarms	12	20.0	41	68.3	7	11.7
I stop as I hear the alarm maybe it is settled by itself	32	53.3	26	43.3	2	3.3
I have a direct reaction to the infusion pump alarms	1	1.7	12	20.0	47	78.3
I have an immediate response to cardiac monitoring alarms	2	3.3	7	11.7	51	85.0
During CPR on a patient, I turn out to be unresponsive to the alarms of another patient	16	26.7	37	61.7	7	11.7
Variety and harmony of alarms confused me in making decisions	36	60.0	14	23.3	10	16.7
Alarm sounds make me nervous	33	55.0	16	26.7	11	18.3
I pay more attention to the alarms in certain shifts	22	36.7	22	36.7	16	26.7
Generally, I hear a certain amount of noise in the ward	6	10.0	37	61.7	17	28.3
I react differently to the low and high-volume alarms of the ventilator	4	6.7	26	43.3	30	50.0
I do not give concentration to the alarm when I do not sense well	38	63.3	15	25.0	7	11.7
I take action only for the continuous red alarms	26	43.3	22	36.7	12	20.0
Sometimes I really do not hear the alarm	27	45.0	27	45.0	6	10.0
The sound of some alarms is annoying, I turn them off	40	66.7	16	26.7	4	6.7
I am certain that the alarms are true	5	8.3	34	56.7	21	35.0
In the way of time my feeling to alarms decreases	23	38.3	32	53.3	5	8.3
I am indifferent to the alarm	39	65.0	14	23.3	7	11.7
By repetition of alarms, I become unconcerned to them	43	71.7	14	23.3	3	5.0
At the beginning of each shift, I give further concentration to the alarms	2	3.3	22	36.7	36	60.0
Throughout my shift, I limit the number of alarms	30	50.0	26	43.3	4	6.7
I attempt to differentiate the informing alarm (yellow) and the warning alarms	1	1.7	22	36.7	37	61.7
Critical Care Nurses' Alarm Fatigue Perception level	n		%			
Unsatisfactory perception	23		38.3			
Satisfactory perception	37		61.7			
Mean ±SD	71.4 ±5.0					

Data were expressed as numbers (n), frequency (%) &, Standard Deviation (SD)

Table 4. Association between general characteristics of the nurses and knowledge level regarding alarm fatigue

Characteristics	Poor knowledge (n=15)		Average knowledge (n=16)		Good knowledge (n=29)		Chi – Square / Fisher's exact test	
	n	%	n	%	n	%	X^2	P
Age (Years)								
18 < 30	14	93.3	13	81.3	28	96.6		
30 < 40	1	6.7	3	18.8	1	3.4	3.233	0.199
Gender								
Male	5	33.3	4	25.0	15	51.7		
Female	10	66.7	12	75.0	14	48.3	3.439	0.179
Educational background								
Technical institute degree	15	100.0	9	56.3	9	31.0		
Bachelor degree	0	0.0	7	43.8	20	69.0	19.013	<0.001**
Job title								
Registered nurse	4	26.7	9	56.3	13	44.8		

Technical nurse	11	73.3	7	43.8	16	55.2	2.810	0.245
Working place								
Intermediate cardiac care unit	3	20.0	4	25.0	7	24.1		
Intermediate hepatic care unit	8	53.3	5	31.3	4	13.8		
Intermediate diabetes care unit	1	6.7	4	25.0	10	34.5		
Critical medicine and intensive care unit	3	20.0	3	18.8	8	27.6	9.119	0.167
ICU Experience years								
< 5	15	100.0	12	75.0	13	44.8		
5 < 10	0	0.0	4	25.0	12	41.4		
10 < 15	0	0.0	0	0.0	4	13.8	15.388	0.004*
Working experience at the current unit (Years)								
< 5	15	100.0	11	68.8	17	58.6		
5 < 10	0	0.0	5	31.3	9	31.0		
10 < 15	0	0.0	0	0.0	3	10.3	10.262	0.036*
Weekly working hours								
< 35 per week (4 – 5/day)	2	13.3	0	0.0	1	3.4		
35 – 42 per week (5 – 6 /day)	3	20.0	5	31.3	9	31.0		
> 42 per week (>6 /day)	10	66.7	11	68.8	19	65.5	3.530	0.473

Data were expressed as numbers (n), frequency (%), Intensive Care Unit (ICU), P by Chi – Square / Fisher's exact test (X^2), significant if P value ≤ 0.05

Table 5. Association between General Characteristics of the Nurses and Alarm Fatigue Perception Questionnaire Level

Characteristics	Unsatisfactory perception (n=23)		Satisfactory perception (n=37)		Chi – Square / Fisher's exact test	
	n	%	N	%	X^2	P
Age (Years)						
18 < 30	22	95.7	33	89.2		
30 < 40	1	4.3	4	10.8	0.776	0.379
Gender						
Male	8	34.8	16	43.2		
Female	15	65.2	21	56.8	0.423	0.515
Educational background						
Technical institute degree	18	78.3	15	40.5		
Bachelor degree	5	21.7	22	59.5	8.154	0.004*
Job title						
Registered nurse	10	43.5	17	45.9		
Technical nurse	13	56.5	20	54.1	0.035	0.852
Working place						
Intermediate cardiac care unit	4	17.4	10	27.0		
Intermediate hepatic care unit	9	39.1	8	21.6		
Intermediate diabetes care unit	7	30.4	8	21.6		
Critical medicine and intensive care unit	3	13.0	11	29.7	4.232	0.237
ICU Experience years						
< 5	21	91.3	19	51.4		
5 < 10	2	8.7	14	37.8		
10 < 15	0	0.0	4	10.8	10.400	0.006*
Working experience at the current unit (Years)						
< 5	23	100.0	20	54.1		
5 < 10	0	0.0	14	37.8		
10 < 15	0	0.0	3	8.1	14.745	<0.001**
Weekly working hours						
< 35 per week (4 – 5/day)	1	4.3	2	5.4		
35 – 42 per week (5 – 6 /day)	5	21.7	12	32.4		
> 42 per week (>6 /day)	17	73.9	23	62.2	0.898	0.638

Data were expressed as numbers (n), frequency (%), Intensive Care Unit (ICU), P by Chi – Square / Fisher's exact test (X2), significant if P value ≤ 0.05

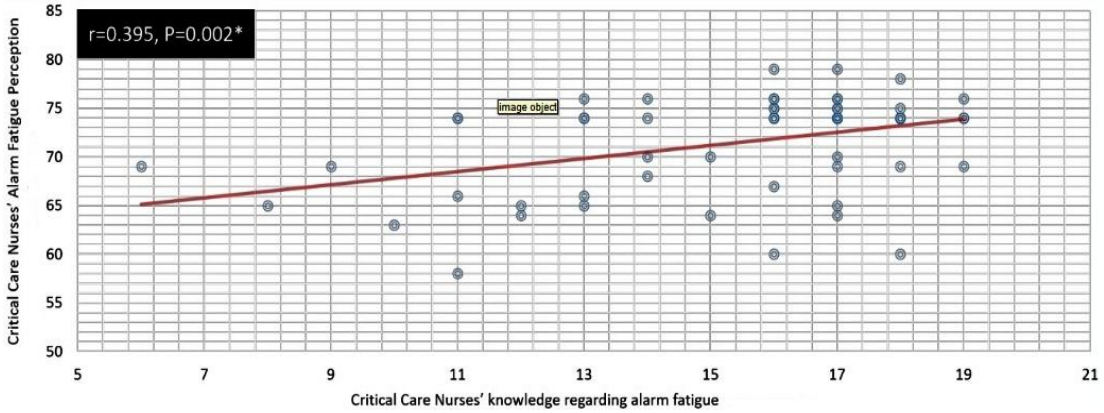

Figure 1. Correlation Between Critical Care Nurses' knowledge Level Regarding Alarm Fatigue and Critical Care Nurses' Alarm Fatigue Perceptions level

Discussion

Intensive care units (ICUs) have been exposed to continuous loud noise exposure. The high sound intensity in ICUs is caused by numerous sources. Moreover, this sound intensity is heightened by alerts that indicate alterations in the physiological parameters of patients or malfunctions in machines. Patient safety, worker productivity, and employee health will all suffer as a result of this circumstance **(Ceylan&Karac,2023)**. Furthermore, alarm fatigue and noise are serious issues that cause a lot of emotional occurrences **(Chai X et al. 2023)**. As a result, this study aimed to assess CCNs' knowledge and perceptions regarding alarm fatigue. Regarding the general characteristics of the studied nurses, the current study showed that the majority of studied nurses were in the age group of 18 < 30years, followed by more than half of them were female.

In addition, more than half of the studied participants had less than 5 years of experience in ICU. Also, more than half of them worked more than 42 hours/week. These results were in agreement with **Elbilgahy, Wady, & Badawy (2023)** study which entitled "Effect of Implementing an Educational Intervention about Managing Alarm Fatigue on Improving Clinical Practices of Pediatric Critical Care Nurses" who reported that, the majority of nurses, (75.7%) were female, more than two fifth of them (44.3%) were in the age group of 18- 29, (66.7%) of them had less than 5 years of ICU experience, and worked more than 42 hours per week (>6hrs/day).

For the educational background, it was found that more than half of CCNs had technical institute degree. This result was in line with the study conducted by **Aysha, & Ahmed, (2019)** which entitle "The effect of implementing clinical alarm nursing intervention program on nurses' knowledge, practice and patient outcomes at intensive care unit", and showed that more than half of nurses (57.5%) had technical institute degree.

The current study demonstrated the percentage distribution of the investigated nurses for their knowledge of alarm fatigue. This study provided a comprehensive overview of CCNs' knowledge regarding alarm fatigue. Nearly three-quarters of nurses demonstrated a good understanding of what alarm fatigue is. This result was in line with **Casey et al. (2018)** in their study which entitled "Critical care nurses' knowledge of alarm fatigue and practices towards alarms", who stated that the majority of nurses 87.9% (n =146) were familiar with the term alarm fatigue.

Three -quarters of CCNs identified the cause of alarm fatigue correctly. This result finding was indifferent with the study carried out by **Mekonnen, (2020)** which entitled "assessment of knowledge of alarm fatigue, practice towards alarms and associated factors among nurses working in adult intensive care units of federal governmental hospitals in Addis Ababa, Ethiopia" and showed that (65.4%) of nurses said that they don't know what cause alarm fatigue. This difference may be due to different study sittings and /or different level of education. The majority of CCNs recognized that nurses are highly exposed to alarm fatigue. This result was supported by **Casey, (2018)** who reported that (90%) of the intensive care nurses were frequently exposed to false alarms.

Furthermore, all CCNs gave the full answer correctly which is the highest score to the device that led to alarm fatigue in the ICU. It means that nurses have a good knowledge related to the alarm devices (ventilator). This result was supported by the study of **Rudraraju &Fatima, (2024)**, which entitled "Alarm Configuration in Intensive Care Units of a Corporate Hospital" and reported that

monitor, ventilator, syringe pump and dialysis machine are leading to alarm fatigue.

Also, the current study found that the majority of the CCNs could identify alarm fatigue symptoms as (headache, fatigue and anxiety). This result supported in a cross-sectional study which entitled, ''Nurses alarm fatigue influencing factors and its relationship with burnout in the CCUs'' by **Nyarok et al., (2024)**, and stated that (79,4) of nurses experienced headache, while (77,20%) of them had anxiety and headache. Alarm fatigue is a domain of mental health that is very crucial to health-related quality of life of the healthcare providers.

As for the consequences of alarm fatigue, nearly three-quarters of the studied participants answered it correctly, this finding was in line with a study by **Seok, Cho, Kim & Suh, (2021)** which entitled "Degree of Alarm Fatigue and Mental Workload of Hospital Nurses in Intensive Care Units" and reported that, the number of nurses who directly or indirectly experienced an alarm related event error accounted for (82.2%) of the total participants. Furthermore, in the current study the majority of CCNs replied that they did not turn off the alarm devices to prevent them getting alarm fatigue. This report was in line with **Ceylan& Karakoç, (2023)** which entitled, "Evaluation of alarm fatigue in nurses working in intensive care units", and reported that (63.3%) of studied participants answered with the same statement.

Moreover, the current findings found that the majority of nurses defined the word false alarm correctly. This result was in agreement with a study by **Rudraraju & Fatima, (2024)** who reported that (60.7%) of nurses can differentiate between false and nuisance alarms. While (25%) of nurses thought that they were the same. This disagreement may be due to differences of the level of education.

As for prevention and effective management, one of the most striking findings is that only 8.3% of nurses know how to prevent alarm fatigue in ICUs (which is the lowest score). This highlights a significant gap in knowledge and suggests that while nurses may understand how to manage alarm fatigue once it occurs, there is a lack of emphasis on preventive measures, which could be achieved through continuous training. Similar findings showed in a study by **Mekonnen, (2020)**, who reported that, (66.0%) of nurses did not know how to prevent alarm fatigue. Also, **Casey et al., (2018)**, reported that, (52.1%) of nurses had the similar findings.

Regarding the overall knowledge levels among critical care nurses, it was found that (25%), of nurses has poor knowledge, (26.7) of them has average knowledge, and (48.3%) of them has a good knowledge. The mean knowledge score was 15.4 ± 2.9, suggesting a moderate level of knowledge across the board. While nearly half of the nurses have a good understanding, there is still a significant portion with poor or average knowledge, indicating a need for ongoing education and support. These findings were in agreement with **Mekonnen, (2020),** who reported that (66%) had a good knowledge, while (34%) had a poor knowledge of alarm fatigue.

According to the findings, nurses need to be put in place with thorough educational interventions, offering tools for lifelong learning, and addressing concerns with personnel and workload. The findings revealed a significant insight into the perceptions of alarm fatigue among CCNs. Based on the results of the study, it showed that, more than half of CCNs reported a satisfactory perceptions of alarm fatigue, while one third of them reported unsatisfactory perceptions of alarm fatigue in ICU. Also, the present study findings revealed that more than half of CCNs always have a proper professional response toward alarms. Which indicate that the recognition in their critical role in patient care is good. This result was in agreement with, **Sliman, Abd ElAziz & Mansour, (2020)**, who did a quasi-experimental study, which entitled (The effect of alarm fatigue nursing management protocol on critical care nurses' experience), and found that (56.7%) of study group have the same statement before intervention.

The present study found that more than half of studied nurses replied that they never hurry when they hear the alarm; as it may be an auditory error. This result was nearly to the study by **Alkubati, et al., (2024)** which entitled "Levels and Factors of Nurses' Alarm Fatigue in Critical Care Settings in Saudi Arabia", who reported that, nurses usually they do not hurry with hearing the alarm. Alarm sounds mainly affect and delay nurse on their duties that has been assigned for. Therefore, the present study revealed that more than two third of the studied nurses said that, sometimes alarms delay their focus on specialized duties, this result was in agreement with, **Lewandowska, et al. (2023)** who reported that (35.5%) of nurses said that, sometimes alarm sounds prevent them from focusing on their professional duties.

Moreover, the present study found that more than half of CCNs sometimes, in the morning shift, the crowd hinders them to give direct response to alarms, this result was parallel with the study conducted by **Lewandowska et al. (2023)** who found that (40%) of study participants said that sometimes, in some shifts, the heavy workload in the ward prevents their quick response to alarms. The current study found that, more than three-quarters of nurses always have an immediate response to the ventilator alarms, this result was similar with **Sliman, Abd ElAziz & Mansour (2020)** who reported that (61.7%) of the study group replied with always to the same statement post -intervention.

Nearly three-quarters of CCNs replied that always they give awareness to the changes in the alarm source after they heard it. The similar findings were found in post- intervention in a study by **Sliman, Abd ElAziz & Mansour, (2020)** who reported that (68.3%) of the study group replied with (always) to the same statement. In addition, more than two third of the studied nurses said that sometimes, they become confused with excessive sounds of alarms, this result finding was supported by **Ali & Alharbi, (2024)** in their study which entitled "Alarm Fatigue among Nurses Working in Neonatal and Pediatric Intensive Care Units" who reported that the percentage of false alerts that are not actionable has a substantial effect on fatigue levels; fatigue increases as the number of false alarms increases from 30% to 70%.

Furthermore, the results of the current study showed that more than one third of the studied nurses said that they never pay more attention to the alarms in certain shifts. These findings were in different with **Lewandowska, et al., (2023)** who found that (37.2%) of nurses said that they usually pay more attention to the alarms in certain shifts. The same differences have been seen in a study by **Alkubati, et al., (2023)** who reported that, nearly (33.0%) of nurses responded with (usually) to the same statement. these differences may be due to work overload in certain shifts.

The baseline sound level in ICU rises to 90–110 dB when alarms are introduced. Because of this, the nurses who work in ICU are subjected to loud noises all the time. This circumstance has a detrimental impact on the hospitalized ICU patients in addition to the staff. Patients may have delirium and disturbed sleep as a result of this noise. Therefore, controlling the volume and alarm is essential. The present study revealed that a half of CCNs always react differently to the low and high-volume alarms of the ventilator, this result was indifferent of the study by **Ali & Alharbi, (2024)** who reported that (35,6%) of the participants said that rarely they react differently to the low and high-volume alarms of the ventilator. These differences may be due to the policy of the study setting and skills level.

Regarding the association between various demographic and professional characteristics of nurses and their knowledge levels of alarm fatigue. A highly statistically significant association was found between educational background and knowledge level ($p<0.001$), as well as years of experience, but there was no statistically significant association with the nurses' age or gender. These findings were in agreement with **Elbilgahy, Wady, & Badawy, (2023)** who reported that, there was no statistically significant association with nurses' age or gender, but there was a highly statistically significant association with the nurses' overall level of knowledge, years of experience.

The findings of this study reveal several significant associations between the general characteristics of nurses and their perception of alarm fatigue. Nurses with a bachelor's degree were more likely to have a satisfactory perception of alarm fatigue compared to those with a technical institute degree ($p=0.004$). This suggests that higher educational attainment may equip nurses with better skills or knowledge to manage alarm fatigue effectively. Secondly, ICU experience also showed a significant association with CCNs' perception of alarm fatigue. Nurses with less than 5 years of ICU experience predominantly had an unsatisfactory perception of alarm fatigue, whereas those with more experience tended to have a satisfactory perception ($p=0.006$). This indicates that experience in the ICU environment may play a crucial role in developing strategies to cope with alarm fatigue. Additionally, the work experience at the current unit was significantly associated with alarm fatigue perception.

Nurses with less than 5 years of experience at their current unit were more likely to have an unsatisfactory perception ($p<0.001$). The current finding highlights the importance of familiarity and adaptation to the specific working environment in mitigating alarm fatigue. Similar study finding was found in a study which entitled "Evaluation of alarm fatigue among intensive care unit nurses during the COVID-19 pandemic: An exploratory study" by **Ajri-Khameslou et al., (2023)** who did an exploratory study and highlighted that work experience ($B = -0.238$, $p<0.001$) was a significant predictor of alarm fatigue. Nurses with less time in their current unit were more

likely to experience unsatisfactory perceptions of alarm fatigue.

These results underscore the importance of targeted interventions focusing on educational and experiential factors to improve nurses' perception and knowledge about alarm fatigue. The result was supported in a study carried out by **Sliman, Abd ElAziz & Mansour, (2020)** who were conducted a quasi-experimental study saying that there was a great significant enhancement ($P<0.001$) of perception scores amongst studied nurses of all knowledge items of alarm fatigue.

Finally, the current study found that there was a significant positive correlation ($p<0.002$), between critical care nurses' knowledge regarding alarm fatigue and their perceptions of alarm fatigue which is a crucial area of investigation, especially in light of the increasing reliance on alarm systems in intensive care settings. this finding was indifferent with a study by **Elbilgahy, Wady, & Badawy, (2023)** who discovered that years of experience and educational level significantly correlated with total knowledge and practice scores. these differences may be due to the differences in the study setting and /or the nature of the study.

Conclusion

Nearly half of CCNs demonstrated a good knowledge of alarm fatigue, gaps exist, especially in understanding contributing factors. Higher education levels, such as bachelor's degrees, correlate with improved knowledge, emphasizing the need for enhanced nursing education.

Although perceptions of alarm fatigue are generally satisfactory, many nurses experience anxiety and confusion when responding to alarms. These points need for tailored training programs that address both educational and practical strategies to improve nurses' Knowledge and perception, ultimately enhancing patient safety and care quality.

Recommendations

- Develop comprehensive training programs on alarm fatigue and conduct periodic evaluations to address ongoing challenges.
- Host workshops or seminars on best practices and new technologies for alarm systems should be used. Finally, more research should be undertaken on alarm fatigue where all the critical care nurses and doctors should be included.

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Conflict of Interests

There isn't any possible conflict of interest regarding the study, writing, and/or publication of this article.

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