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Determining Critical Care Nurses' Alarm Fatigue: Developing Alarm Management Guideline

Ghada Moh. S. Elhessewi[1], Yaldez K. Zein Eldin[2]
[1]*Lecturer, Nursing Administration Department, Faculty of Nursing, Damanhour University*
[2] *Assistant Professor, Nursing Administration Department, Faculty of Nursing, DamanhourUniversity*
Corresponding author: Yaldez K. Zein Eldin,

Abstract:*Alarm fatigue occurs when care providers become overwhelmed or overloaded by excessive numbers of alarms leading to sensory overburden in such a way that important critical alarms are ignored or missed.*
Aim*: The present study aims to determine if critical care nurses are suffering from alarm fatigue or not and to develop alarm management guideline.*
Setting: *the study was conducted in all Critical Care Units in 4 hospitals located in El Behira Governorate, namely; Damanhour General Chest hospital, Abu-Hummus General Hospital, Kafr el Dawar General hospital and Damanhour National Medical Institute…*
Subjects: *The study subjects included all nurses (n= 150) working in critical care units of the previously mentioned hospitals and accepted to participate in the study.*
Tools: *the researchers developed a self-administered questionnaire which was designed to assess the nurses' alarm fatigue and how they manage different types of alarms and if there are any alarm management guidelines in their hospitals.*
Results: *alarm fatigue dimension received the highest mean percent score (66.92%) while the lowest mean percent score (33.47%) was given for the alarm management guideline. As for the alarm fatigue dimension, Damanhour national medical institute's nurses received the highest mean score (69.90±10.56) and the lowest (61.67 ± 11.18) was for Abu Hummus General hospital. (p=0.002). Also, nurses' years of experience differed in Alarm fatigue dimension significantly (p= 0.006) where nurses with less than 1 year of experience scored the highest mean percent (75.44 ± 8.44) while the lowest mean percent (55.56 ± 6.36) was for nurses having 10 or more years of experience.*
Recommendations:*the current study recommends to develop alarm management guidelines to help nurses deal with the recurrent nuisance alarms and to increase nurses' awareness to the presence of alarm fatigue while dealing with it with the minimum losses.*

Keywords: *Alarm fatigue, nuisance alarms, clinical alarms management, patient safety.*

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I. Introduction

Safety issues in health care organizations are linked strongly to many aspects, one of them is "alarm fatigue"[(1)]. The ECRI Institute has published a report about the "Top Ten Health Technology Hazards"which is based on wide research in health technology safety,alarm hazards have been identified for every year at or near the top of the list[(2)]. Furthermore, The Joint Commission considered alarm fatigue as one of the causative factors of alarm- related sentinel events[(3)].Alarm fatigue occurs when care providers become overwhelmed or overloaded by excessive numbers of alarms leading to sensory overburden in such a way that important critical alarms are ignored or missed[(4)]. Although the criticality of alarm fatigue and its related undesired consequences, some research found that 72-99% of alarms were false alarms and have been judged clinically insignificant[(5-7)]. Furthermore, it was reported by Wallis(2010) that Between 85% and 99% of alarm signals are false alarms that do not actually require clinical intervention, resulting in widespread alarm desensitization and immunity[(8)]. Consequently, as a result of such desensitization and immunity, alarms limits are either adjusted outside the safe limits or have delayed response or even muted or shut down. All these practices can affect patient safety, possibly leading to life-threatening patient events[(9-10)].Since January 2005, alarm fatigue in hospitals has been linked to over 200 patient deaths[(11)]. For instance, in 2010, 2011, and 2012 a series of major articles on problems with clinical alarms has been published by the Boston Globe[(11-15)]. The first article in the series discussed a patient death at a Massachusetts hospital which was directly linked to alarms signaling a critical event went unnoticed by 10 nurses[(12)].Another study conducted by the ACCE Healthcare Technology Foundation (2011) found that one in five hospitals was able to recognize an avoidable adverse event related to patient alarms[(16)].

Many contributing factors had been found to be related to alarm fatigue, first as stated by the Joint Commission in 2013 is the absence or inadequate alarm systems, second the improper alarm settings, third the inaudible alarms, and alarm signals inappropriately turned off[3]. Experts in the Association for the Advancement of Medical Instrumentation (2011) believe that in many cases such patient deaths and sentinel events are often under-reported or even undetected to be the major cause of nurses' alarm fatigue[10]. Much work has been accomplishedsearching for ways to reduce 'false positive' alarms and hopefully diminishdesensitizationand alarm immunity without compromising patient safety[17-19]. These ways could be summarized to some points. First, the individualization of alarm thresholds to be clinically appropriate for individual patient as a mean to reduce the occurrence of nuisance alarms leading to alarm fatigue[3,20-21]. Second, train the health care providers on proper use of alarm systems, as well as, develop protocol for alarm settings[22]. Another measure that was stated by Cvach (2012) is the importance of frequent staff development program in order to increase nurses 'awareness of alarm fatigue, and consequently include alarm response into their main daily activities[9]. In a trial of the Joint Commission to reduce the alarm fatigue's negative consequences that threaten patient safety, it issued a Sentinel Event Advisory alert in 2013, with additional alarm-related National Patient Safety Goals becoming effective in January 2014. Many phases will be used to achieve Joint commission goals, the first one will necessitate hospitals to establish alarms as an organization priority as well as to identify the most important alarms to manage based on their own internal situations. Phase II in 2016 will expect the development and implementation of specific device alarm safety management's policies and procedures, in addition to, the necessity of educating those working in the organizationabout alarm system management[23].In Egypt, there are no studies conducted searching for the possibility of occurrence of alarm fatigue for critical care nurses based on extensive web search and up to the knowledge of the researchers. Hence, the current study is conducted aiming to determine if nurses working in critical care units are suffering from alarm fatigue and to develop an alarm fatigue management guideline to be handed to the studied hospitals' managers so they can use it to help reduce alarm fatigue and consequently avoid its negative effects.

II. Methodologies

2.1 Aim of the study

The present study aims to determine if critical care nurses are suffering from alarm fatigue or not and to develop alarm management guidelines.

2.2 The study questions:

1. Do nurses suffer Alarm fatigue?
2. How do nurses manage continuous beeping alarms?
3. Is there any guideline that help nurses manage alarm?

III. Materials & Methods:

3.1Materials

3.2 Research design: An exploratory research design was used to conduct the study.

3.3Setting:

The study was conducted in all Critical Care Units in 4 hospitals located in El Behira Governorate, namely; Damanhour General Chest hospital, Abu-Hummus General Hospital, Kafr el Dawar General hospital and Damanhour National Medical Institute. The stated hospitals were selected based on the agreement of hospital administrator to conduct the study as well as they are the four large hospitals providing services for El Behira Governorate's patients.

3.4Subjects

The study subjects included all nurses (n= 150) working in critical care units of the previously mentioned hospitals and accepted to participate in the study.

3.5Study instrument

After a thorough review of literature[24-25], the researchers developed a self-administered questionnaire which was designed to assess the nurses' alarm fatigue and how they manage different types of alarms and if there are any alarm management guidelines in their hospitals.

The instrument is composed from two parts:

1. The first part consisted of socio-demographic data namely; years of experience, the hospital name and their job title
2. The second part consisted of three dimensions, namely; A) Alarm fatigue (12 statements). B) Alarm management (4 general statements) then three sub-dimensions according to the type of Alarms (Cardiac monitor alarm 4 statements, Ventilator alarms 4 statements and finally Bed exit alarm 1 statement). C)

Alarm management guidelines (5 statements). The 30 statements were on 3 points likert scale ranging from 1= disagree to 3 = agree.

3.6 Methods:

The study was conducted as follows:

1. An official permission was obtained from the director of all studied hospitals and from the nursing director also.
2. The study instrument was designed by the researchers after extensive review of related literatureand its content validity was tested by five experts in the field of the study. Accordingly, the necessary modifications were done.
3. Reliability of the tool was done using Cronbach's Alpha where it was (0.89) for the entire tool.
4. A pilot study was carried out on 10% of the subjects (n =15) nurses working in critical care units and were not included in the study subjects. It was used to ensure the clarity of the questionnaire, identify the obstacles and the problems that may be encountered in data collection and estimate the time needed to fill the questionnaire.
5. After data was analyzed, the researchers started to develop the alarm management guidelines as a result of data interpretation.
6. Outlines of the developed alarm management guidelines:
   6.1. Definition of alarm fatigue.
   6.2. consequences of alarm fatigue on patient safety.
   6.3. Alarm fatigue management process/ steps.
7. Distribution of the alarm management guidelines at the studied hospital in order to be a reference for hospital managers and critical care nurses to reduce occurrence alarm fatigue and therefore lessen the harmful consequences.

3.7Ethical considerations:

1. An informed consent was obtained from all staff after explanation of the aims of the study.
2. Confidentiality, anonymity and privacy were assured by not asking about their names on the questionnaire.
3. Participation was on voluntary basis.
4. Participants were given the right to withdraw from the study at any time without any drawbacks.

3.8 Statistical Analysis:

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0**.** Qualitative data were described using number and percent.Quantitative data were described using mean, standard deviation. Significance of the obtained results was judged at the 5% level.
The tests used were :

1 Student t-test

For normally quantitative variables, to compare between two studied groups

2 -F-test (ANOVA)

For normally quantitative variables, to compare between more than two groups

IV. Results

Table (1): Distribution of the study participants according to their demographic characteristics (n=150)

Demographic Characteristics	No.	%
Job title		
Technical nurses	64	42.7
Professional nurses	86	57.3
Hospital		
Abu Hummus General Hospital	30	20.0
Chest General Hospital	27	18.0
Damanhour National Medical Institute	49	32.7
Kafr el Dawar General Hospital	44	29.3
Experience		
> 1 year	19	12.7
<1 - >5 years	68	45.3
<5 - >10 years	60	40.0
<10 years	3	2.0

As shown in table (1) regarding the demographic characteristics of nurses working in different hospitals, (57.3%) were professional nurses. Regarding their work place, the highest percentage (32.7%) was for nurses working in Damanhour National Medical Institute, while the lowest (18%) was for those working in

Chest general hospital. As for nurses' experience, (45.3%) were experienced from 1 to ≥ 5 years while only (2%) were experienced more than 10 years.

Table (2): Mean and Mean percent scores of the three sub-dimensions and the total of alarm fatigue management scale (n=150)

	Total score	**Mean % score**
Alarm fatigue	16.06 ± 2.99	66.92 ± 12.45
Alarm management	16.83 ± 3.80	64.74 ± 14.60
Alarm management guidelines	3.35 ± 2.86	33.47 ± 28.59
Overall	**36.24 ± 5.57**	**60.40 ± 9.28**

Table (2) shows the mean and mean percent scores as rated by nurses regarding the three sub-dimensions of the alarm fatigue scale. It could be seen from the table that alarm fatigue dimension received the highest mean percent score (66.92%) while the lowest mean percent score (33.47%) was given for the alarm management guidelines.

Table (3): Mean and Mean percent scores of the three sub-dimensions and the total of alarm fatigue management scale in relation to participants' demographic characteristics (n=150)

Mean % score	**N**	**A-Alarm Fatigue**	**B-Alarm management**	**C-Alarm management guidelines**	**Overall**
Job title					
Technical nurses	**64**	66.08 ± 12.53	65.75 ± 9.56	34.69 ± 25.01	60.70 ± 7.35
Professional nurses	**86**	67.54 ± 12.43	64.0 ± 17.45	32.56 ± 31.10	60.17 ± 10.53
t (p)		0.708(0.480)	0.784(0.435)	0.464(0.643)	0.362(0.718)
Hospital					
Abu Hummus General Hospital	**30**	61.67 ± 11.18	65.38 ± 7.49	44.0 ± 23.43	60.33 ± 6.67
Chest General Hospital	**27**	62.50 ± 14.43	63.53 ± 17.25	35.56 ± 32.50	58.46 ± 12.55
Damanhour National Medical Institute	**49**	69.90±10.56	67.35±15.35	30.41±28.43	62.21±8.54
Kafr el Dawar General Hospital	**44**	69.89±12.32	62.15±15.56	28.41±28.36	59.62±9.21
F(p)		5.064* (0.002*)	1.065(0.366)	2.097(0.103)	1.124(0.342)
Experience					
> 1 year	**19**	75.44 ± 8.44	56.48 ± 11.54	13.68 ± 24.32	56.93 ± 7.03
<1 - >5 years	**86**	65.81 ± 13.32	65.33 ± 18.49	35.59 ± 30.39	60.56 ± 11.86
<5 - >10 years	**60**	66.04 ± 11.60	66.60 ± 9.08	37.17 ± 26.24	61.47 ± 6.04
<10 years	**3**	55.56 ± 6.36	66.67 ± 4.44	36.67 ± 5.77	57.22 ± 3.47
F(p)		4.353*(0.006*)	2.480(0.063)	3.694*(0.013*)	1.285(0.282)

t, p: t and p values for Student t-test F,p: F and p values for ANOVA test *: Statistically significant at p ≤ 0.05

As shown in table (3) as regard to alarm fatigue dimension, there is a significant difference between nurses according to their place of work, where Damanhour national medical institute's nurses received the highest mean score (69.90±10.56) and the lowest (61.67 ± 11.18) was for Abu Hummus General hospital. (p=0.002). Also, nurses' years of experience differed in Alarm fatigue dimension significantly (p= 0.006) where nurses with less than 1 year of experience scored the highest mean percent (75.44 ± 8.44) while the lowest mean percent (55.56 ± 6.36) was for nurses having 10 or more years of experience.

Table (4): Distribution of the studied cases according to managing alarm fatigue strategies scale (n=150)

Alarm Fatigue	**Total score**	**Mean % score**
Alarm sounds and/or visual displays should differentiate the priority of alarm.	1.71±0.45	85.67±22.69
Alarm sounds and/or visual displays should be distinct based on the parameter (e.g. heart rate) or source (device type).	1.69±0.48	84.33±23.98
Continuous alarms occur frequently	1.79±0.50	89.67±24.78
Continuous alarms disrupt patient care	1.17±0.77	58.67±38.31
Continuous alarms reduce trust in alarms and cause care givers to inappropriately turn alarms off at times other than setup or procedural events	1.08±0.71	54.0±35.48
Properly setting alarm parameters and alerts is overly complex in existing devices.	1.35±0.67	67.33±33.27
Newer monitoring systems (e.g., less than three years old) have solved most of the previous problems we	1.26±0.75	63.0±37.29

experienced with clinical alarms.		
The alarms used on my floor/area of the hospital are adequate to alert staff of potential or actual changes in a patient's condition.	1.43±0.56	71.33±27.99
Environmental background noise has interfered with alarm recognition	1.20±0.77	60.0±38.43
There have been frequent instances where alarms could not be heard and were missed.	1.32±0.76	66.0±38.13
The medical devices used on my unit/floor all have distinct outputs (i.e., sounds, repetition rates, visual displays, etc.) that allow users to identify the source of the alarm.	0.89±0.81	44.67±40.61
When a number of devices are used with a patient, it can be confusing to determine which device is in an alarm condition	1.17±0.66	58.33±32.98

Table (4) shows the mean percent scores for each items of the Alarm Fatigue dimension, it could be seen From the table that the highest percent scores (89.67%) goes for the items that describes the noise of alarms which occurs frequently while the lowest mean percent scores (44.67%) is for the criteria for the medical devices used that allow the users to identify the source of the alarm.

V. Discussion

Alarm fatigue is a significant problem that leads to many sentinental events[(26)]. The current study was conducted aiming to detect if nurses suffer from alarm fatigue and to develop guidelines that help them to manage the alarms promptly to avoid further alarm fatigue. The present research found that alarm fatigue received the highest mean percent score among nurses in comparison with other dimensions. This could be attributed to that in Egypt, there are no hospitals that guide nurses how to deal with persistent alarms, also there is no study done to show how alarm fatigue can affect patient's safety. On the same line, many research agreed that nurses are complaining alarm fatigue and this has unpleasant consequences on patient safety[(1,27-29)]. Furthermore, the current study found that the alarm management guidelines received the lowest percent scores, as the guidelines are not present in any of the studied hospitals. This could be justified that the governmental hospitals are very old, with little resources and funds, they are not seeking accreditation or any improvement, even they can hardly manage hospitalized patients and their requirements. Also, the absence of management support that is essential in developing alarm management systems or programs. All these are factors that lead to absence of alarm management guidelines. Therefore, they are not interested in alarm fatigue of nurses or the training for nurses about how to manage alarms, which in turn lead to the absence of alarms management guidelines. The contrast was found by Evans et al (2011) who stated that hospitals have to train nurses on alarm fatigue and different ways of its management [(20)]. Also, many researchers and organizations developed alarm management strategies to reduce alarm fatigue among nurses and help them manage the fatigue. Regarding nurses suffering from alarm fatigue in different hospitals, the current study showed that nurses working in Damanhour national medical institute received the highest mean score as compared to other hospitals with a significant difference between hospitals. This result is not surprising, as Damanhour National Medical Institute is considered the largest hospital that serves El Beheira Governorate and has a large intensive care unit and huge number of staff. In relation to nurses' years of experience, the present findings showed that nurses with less than 1 year of experience scored the highest mean percent with a significant difference between participants' groups. This is a weird result, as it is known that when individuals get more experienced they complain fatigue either physically or mentally, but in the current study, this finding could find a justification as the little experienced nurses are fresh graduate who do not have experience with long shifts and noisy environments and alarms that do not stop. On the other hand, the more experienced nurses get used to the beeps of the alarm without fatigue or a little sense of alarm fatigue. This finding is consistent with Baird (2015) and Edworthy (2013) who found that there is a strong relationship between nurses' years of experiences and their feeling of alarm fatigue and alarm desensitization[(25,30)]As for the alarm fatigue dimension, the present research findings showed that the highest percent score go for the occurrence of the frequent noisy alarms while the lowest mean percent score is for the criteria of the medical devices used that allow the users to identify the source of the alarm. This is an expected finding, as the nuisance alarms that mainly lead nurses to turn it off without taking care of the cause of the alarm is probably the main reason for alarm fatigue. This finding is parallel with those of the Joint Commission (2011, 2013) which stated that nurses have many problems in responding to alarms and they have to develop different strategies to avoid noisy alarms to avoid therefore the alarm fatigue [(3,21)]. In addition to Funk et al (2009) who found that nurses are complaining of frequent noisy alarms and they are in need for sufficient knowledge and skills to deal effectively with alarms and its fatigue[(31)].

VI. Conclusion And Recommendations

The study was conducted to determine if nurses working in ICUs are suffering from alarm fatigue and to develop guidelines to help them deal with alarm fatigue. The results showed that alarm fatigue received the highest mean percent score among nurses in comparison with other dimensions. Additionally, it was concluded that nurses working in Damanhour national medical institute received the highest mean score as compared to other hospitals with a significant difference between hospitals. Also, the highest mean percent score among alarm fatigue dimension items was for the occurrence of the frequent noisy alarms.

According to the concluded findings, the current study recommends the following:

1. Establish alarm management guidelines to help nurses deal with the recurrent nuisance alarms.
2. Increase nurses' awareness to the presence of alarm fatigue.
3. Train nurses on how to differentiate between false alarms and alarms that need rapid response to save patient's life.
4. Include nurses in the orientation phase while starting using new machines and adjust their alarms settings.

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