The effect of alarm fatigue nursing management protocol on critical care nurses' experience.

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Abstract

Background: Intensive care units are construction for additional services and tools such as patient call systems, monitors, suction pumps, and mechanical ventilators. These tools are prepared with an alarm system in their sets. Excessive number of alarms cause alarm fatigue among critical care nurses, which can result in alarms desensitization and impaired recognition of worsening patient conditions. Critical care nurses are accountable for constant checking and maintenance of alarm nursing management protocol associated with critically ill patients. Recent studies reported that the most of nurses did not recognize how to check alarm fatigue.

Aim: To appraise the effect of alarm fatigue nursing management protocol on critical care nurses' Experience.

Method: A quasi-experimental design was utilized during the current study and it was conducted on 60 nurses who had more than two years of working experience in the ICUs and are elaborate in providing direct care in the ICUs in the Emergency Hospital at Mansoura University.

Results: Revealed that significant improvement ($p<0.001$) of perception scores among studied nurses of all perception items about alarm fatigue post protocol implementation compared with their pretest score. Also, There were statistically significant variances between nurses' perception and practices in relation to alarm fatigue nursing management indicating good perception and satisfactory practice 95% following protocol implementation, compared with poor perception and unsatisfactory practice 100% pre- protocol implementation.

Conclusion: Alarm fatigue nursing management protocol could be applied in our ICU settings. Continuous education and training for critical care nurses on monitoring systems and alarm setting in critical care units, decreasing response time to false alarms, assisting in progress patient's outcomes and avert alarm fatigue.

Recommendation: More research should be undertaken on alarm fatigue management where all the nurses, doctors and biomedical personnel should be included.

Keywords: Alarm fatigue, Alarm management, Clinical alarm, Critical care nurses' experience, Intensive care unit.

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Introduction

Alarm fatigue is crucial issue to patient safety; for that reason, scientific alarms are sited at ICU patient bedsides to supply best possible clinical intervention to patients. Within critical care units, the patient is enveloped by a multitude of apparatus for monitoring, diagnostics, and therapy [1]. All devices have alarm capabilities and produce optic and acoustic alarms to attentive the staff to modify either in the patient's status or in a fault of the equipment. Likewise, Clinical alarms are planned to prop up immediate patient estimation by warning critical care nurses to a major clinical episode. Conversely, the massiveness of these alarms lessens their value [2].

Alarm correspond a non-usual condition that is screened, for instance respiratory rate, blood pressure, pulse oximeter impression, and cardiac rhythm. Usually auditory, visual warning coupled with the alarm [3]. The particular apparatus has a sill purpose put, and when that threshold is crossed, whichever over or under the objective, an alarm is aroused [4]. Hospital safety organizations have scheduled alarm fatigue the sensory load and desensitization that nurses experience when exposed to an extreme amount of alarms as one of the headmost ten technology risks in acute care settings [5,6].

Nearby 566 records of patient dooms related to screening apparatus alarms during 2005–2008 obtained through the FDA Administration. In additional definite pattern, the FDA 2010 received more than 2500 adverse incident determination connected with mechanical ventilator utilize, wherein one third of the episodes indicated an alarm fatigue linked topic [7,8]. This information is recommended to be an underestimation of an overlooked patient safety issue. In view of that, numerous organizations based in the USA for instance the Critical- Care Nurses American Association have been focusing their pains to improve alarm safety in healthcare [9-11].

Critical care nurse (CCNs) change their actions by respecting alarm urgency in link to the patients' condition, have a greater tendency to reply to alarms of longer duration, and considered rare. As workload complexity, alarm response and duty performance deteriorates. Thus, signal duration is an important influence to the nurses ' response but workload, patient condition and task complexity may lead to other reaction

strategies. Conforming alarms to patient's actual needs ensures that alarms are valid and provides an early warning to prospective dangerous [12-14].

As said by the American Association (AACN, 2012) practice notification, alarm fatigue develops when CCN is showing too many alarms of which most could be fake alarms. This may result in sensational burden. ICU Patient dies have been attributed to alarm fatigue [15]. The approaches suggested by AACN are: expansion evasion parameter settings, skin preparation for electrocardiogram electrodes by; washing the electrode area with soap and water to decrease skin impedance and signal noise thereby enhancing conductivity, wiping the electrode with gauze to roughen a small area of the skin to prevent spurious signals which are recorded when there is poor electrode contact and to allow the electrical signals to travel.

Other fundamental steps are the utilize of pulse oximetry device and changing the sensors when they no longer hold properly to the patient's skin, electrodes change daily, Appropriate oxygen saturation settings through pulse oximetry. Alcohol should not apply for skin preparation as it can dry out the skin. Unnecessary hair at the electrode site should also be clipped. In USA, the usual proportion of false alarms for each patient lowered 46% with shifting electrocardiogram electrodes once a day [16].

As well, the AACN advocates that hospitals should develop policies and procedures to comply with ICU medical devices alarm. Accompanying alarm fatigue management training to CCNs and other technicians covers further regulation parameters. ICU patient monitoring, estimation, with proper intervention CCNs are responsible for the continuous conservation of alarm fatigue nursing management protocol associated with critically ill patients. So, alarm fatigue nursing management protocol for critically ill patients is established in ICU. Hence, this study will accomplish to layout and apply alarm fatigue nursing management protocol for CCNs to manage alarm fatigue and definitely regard critically ill patient safety care [17-19].

Significance of the study

Alarm fatigue is an emerging problem leading to serious patient safety issues that has shown to impact patient mortality. In addition, it arises when clinicians become desensitized to the huge number of alarms going off around them. Many health care professionals are affected by this phenomenon [20]. Therefore, pertinent to find a resolution to this problem. There is lack of distinction between a genuine alarm and a false alarm. This makes it difficult for CCNs to make different between a false alarm along with a true emergency. The Joint Commission TJC emphasizes alarm indicators per day can arrive at numerous hundred relying on the unit throughout the hospital. So, it force create interest for further researches into this field, which including their perception and practice regarding alarm fatigue [21,22].

Purpose

The purpose of this study was to appraise the effect of alarm fatigue nursing management protocol on critical care nurses' experience.

Research Hypotheses

Two research hypotheses were formulated for this study:

H1. The mean post perception scores of CCNs who were exposed to the designed alarm fatigue nursing management protocol were higher than their pre perception mean scores.

H2. The mean post practice scores of CCNs who were exposed to the designed alarm fatigue nursing management protocol were higher than their pre practice mean scores.

Method

Study design and setting

A quasi-experimental design (pre/posttest design) was used in this study. Participants' recruitment and data collection occurred at the Intensive Care Units (ICUs) of Emergency Hospital at Mansoura University. All ICUs make available services for traumatized patients transferred from emergency room, operating room, and hospital wards. The nurse patient ratio in these units is 1:2 in all shifts.

Subjects

The study involved a convenience sample (60) nurses who had more than two years of working experience in the ICUs and provided that direct care for patients in the above ICUs, and agreeable to share happily and gave consent were enrolled in the study.

Sample size: Calculating sample size for studying "The Effect a designed alarm fatigue nursing management protocol on the CCNs' experience ", through DSS research.com sample size calculator software, at 5% ∞ error (95.0% significance) and 20.0% β error (management 80.0% power of the study), assuming the percentage of CCNs agreed that clinical alarm disrupts patients care was 91.0% and expected to decrease 20.0% after applying the protocol to be (72.8%) [23]. The calculated sample size is 54 nurses and we can add 10.0% for better data quality so the studied sample will be 60 nurses.

Data collection instruments

The researchers based on reviewing the relevant literature used two tools.

Tool I " Critical care nurses ' alarm fatigue perception Questionnaire".

Tool II "Critical care nurses' alarm fatigue practice checklist".

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

This tool includes two parts. Part I covering socio-demographic characteristics of CCNs such as age, job title, educational level, and years of experience in the ICUs. Part II was developed by the researcher to assess nurses' perception about alarm fatigue management before and after carrying out the protocol. This tool was adapting from, and covering twenty-three items of CCNs' perception regarding alarm fatigue nursing management [24]. AskingParticipants to attribute their level of harmony with the declarations on a three-point Likert scale ranged from always, sometimes and never. In which 3 symbolizes always and 1 symbolizes never. While some items had reversed score in which 3 symbolizes never and 1 symbolizes always.

Scoring system: The scores gained per stride was summed up to acquire the total maximum (69) pro CCNs' perception. The overall score of CCNs' perception was deliberated and categorized like this: 75% and more were reflected satisfactory, less than 75% were considered unsatisfactory

Tool II: "Critical Care Nurses' Alarm Fatigue Practice Checklists"

This tool was developed by the researcher when studying related literature to assess CCNs' practices regarding alarm fatigue nursing management in the medical field [25-30]. This tool casing six special items as following: accurate ECG electrodes skin preparation, adjust settings on oxygen saturation using pulse oximetry, customize alarm parameters on cardiac monitors, infusion pump troubleshooting alarm, ventilator troubleshooting alarms, and ASSET mnemonic [31].

Scoring system: Every practical point scored on the base of "Done correct", "Done incorrect", and "Not done". Done correct attained (2 point). However, done incorrect achieved (1 point) and not done attain (Zero). The nurses' practices scores obtain for every step was aggregated to gain the whole score of (84). Total scoring was organized into two classes as follow: scores like to or above 75% were deliberated agreeable practice level, while scores under 75% were reflected unsatisfactory practice level.

Validity and reliability of the tool

The tool content validity was appreciated by seven experts from Critical Care and Emergency Nursing, and Medicine fields. Necessary modifications were done accordingly. The reliability of the tools (I and II) were tested using Cronbach's alpha test and found to be (0.92 and 0.94) respectively which pointed high reliability tool.

Pilot study

A pilot study was done to test the clarity, feasibility, and applicability of the data collection tool. It involved 6 nurses (10% of the total sample) who were excluded from the study sample.

Ethical considerations

An ethical approval was obtained from the Ethics Committee of Faculty of Nursing (No. 108/2018). Informed consent was achieved from the nurses prior the starting of the study when given them with full data about the study containing the aim, benefits, threats, process and time of the study. They were also informed that they had the right to terminate at any stage without penalty.

Data collection

In addition, confidentiality of participants' personal data was well maintained.

Preparation

An approved consent to conduct the study was attained from the administrative authorities of Mansoura University Hospital. The researcher designed alarm fatigue protocol founded on the nurses' educational requirements by different policies. Additionally, recent nursing textbooks and the related literature to evaluate core components of alarm fatigue nursing intervention. The protocol was experienced for validity by 5 connoisseurs in the academic field from the Faculties of Nursing, and Medicine.

Implementation phase

Pre protocol assessment phase: An explanation about the goal and nature of the study were discussed with the head nurse and nurse's staff in the ICUs. The researcher tried to build trust relationship and keep relaxing atmosphere for nurses in order to gain their cooperation and interest. During this phase, the investigator assessed nurses ' perception concerning alarm fatigue management and assembles socio-demographic data, via tool I. The researcher explained alarm fatigue perception questionnaire, read some questions, and clarified the ambiguity. Every interview continued for 30-35 minutes, after that the researcher composed the sheets and checkered unanswered questions. The investigator to evaluate nurses' practical level performed forthright surveillance; the investigator perceived all during day shifts by tool II, the investigator was filling out the observational checklists and was recognized nurses' practices linked to alarm fatigue nursing management.

Protocol implementation phase: Alarm fatigue nursing management protocol was provided thru six weeks, every week involved two sessions, and each session takes around forty to sixty minutes. The session time was between morning and afternoon shift or through morning shift after giving the routine care to the critically ill patients. Thorough objective of this protocol was to expand and cultivate skills and knowledge learned during these sessions, to provide safety patients' care. Theoretical sessions focused on alarm fatigue meaning, false alarm meaning, purpose of clinical alarms, alarm fatigue causes (false and true alarm), alarm types, alarm fatigue nursing management actions, and alarm reports. Theoretical sessions explained using simple, brief and clear words; at the end of each session, the researcher summarized the bulk of

information with nurse's staff and emphasized the most important points. Before starting each session, the researcher evaluated nurses information related to the topics discussed in the previous session to ensure that they remembered the instruction given and to reinforce their perception.

Practical session delivered throughout 10 training sessions. Each practical session lasted for forty minutes during the shift work in small groups (for each 5 nurses) debating with them in working area to assist the meeting. Practical session focused on the following items: form alarm system safety as a hospital priority, recognize the greatest imperative alarm signals to manage, form policies and procedures for managing alarm fatigue, providing good skin preparation, location of ECG electrodes, using proper oxygen saturation probes and placement, checking alarm settings at the beginning of each shift, customizing alarm parameter settings for individual patients in accordance with unit or hospital policy. Enough time was given for discussions, clarifications and any questions regarding the practical skills. Every session integrated displaying easy training videos for practical skills linked to alarm fatigue nursing management using audiovisual aids. Pre-post perception questionnaire and pre-post observation checklist was done after application of the alarm fatigue nursing management protocol. The data collection documented through 6 months started from 1 October 2018 to the end of March 2019.

Protocol evaluation phase:

Pretest evaluation: Pretest evaluation was conducted for all participants prior to implementing the protocol. It included alarm fatigue perception assessment questionnaire and observational checklists filling (1st evaluation).

Post protocol implementation test evaluation: Posttest evaluation was accompanied after implementation of the alarm fatigue protocol (theoretical and practical part) on the representative sample using the same tools (2nd evaluation).

Statistical analysis

Collected data were coded, computed and statistically analyzed using SPSS (statistical package of social sciences), version 22. Data were presented as frequency and percentages (qualitative variables) and mean ± SD (quantitative continuous variables). Chi square (χ^2) was used for comparison of categorical variables. Paired t test was used for comparison of continuous quantitative variables before and after intervention. The difference was considered significant at $p \leq 0.05$.

Results

Table 1 shows that, the majority of the study group subjects (56.7%, 61.7%) had Bachelor degree and were in the age group of 20-30 years old respectively.

Table 1. *Participants' demographic data and baseline characteristics.*

Variable	**(n=60)**	**%**
	N (%)	
Age (years)		
20 -30 years	37	61.7
31 – 40 years	23	38.3
Employment years		
2 – 10 years	37	61.7
11 – 20 years	23	38.3
Education		
BSc nurses	34	56.7
Technical nurses' Institute	26	43.3
Familiarity with the term "Alarm Fatigue"		
No	16	26.7
Yes	44	73.3

Table 2 shows the comparing response of the studied nurses to the items of perception about alarm fatigue before and after intervention. It is found that, there is a significant* ($p \leq 0.001$) improvement of their response after intervention to all items of the perception assessment tool.

Table 2. *Comparing perception of the studied nurses before and after intervention.*

No	**Items**	**Time**	**Always 3**		**Sometimes 2**		**Never 1**		**Significance test**
			No	%	No	%	No	%	
1	I give awareness to the changes of alarm source after hearing the alarm.	Pre	8	13.3	12	20	40	66.7	χ^2=45.39
		Post	41	68.3	12	20	7	11.7	P<0.001
2	I am certain that the alarms are right.	Pre	16	26.7	25	41.7	19	31.7	χ^2=37.07
.		Post	47	78.3	5	8.3	8	13.3	P<0.001
3	I go to the patient's bed at once after I listen to alarms.	Pre	7	11.7	15	25	38	63.3	χ^2=51.26
		Post	45	75	8	13.3	7	11.7	P<0.001

4*	Throughout my shift I limit the number of alarms.	Pre	27	45	18	30	15	25	χ^2=30.65
		Post	11	18.3	4	6.7	45	75	P<0.001
5*	Alarms delay my focus on specialized duties.	Pre	28	46.7	14	23.3	18	30	χ^2=25.02
		Post	8	13.3	7	11.7	45	75	P<0.001
6*	I get anxious when I listen to an alarm.	Pre	30	50	13	21.7	17	28.3	χ^2=15.47
		Post	13	21.7	9	15	38	63.3	P<0.001
7	I have a correct qualified response toward alarms.	Pre	12	20	14	23.3	34	56.7	χ^2=32.29
		Post	42	70	9	15	9	15	P<0.001
8	I attempt to differentiate the informing alarms (yellow) and warning alarms	Pre	4	6.7	12	20	44	73.3	χ^2=59.42
		Post	44	75	6	10	9	15	P<0.001
9*	I stop as I hear the alarm maybe it is settled by itself.	Pre	47	78.3	13	21.7	0	0	χ^2=74.36
		Post	7	11.7	9	15	44	73.3	P<0.001
10*	I give more concentration to the alarms in the night time.	Pre	21	35	10	16.7	29	48.3	χ^2=1.07
		Post	16	26.7	10	16.7	34	56.7	P 0.585
11*	In the morning shift the crowd hinders my direct response to alarms.	Pre	34	56.7	13	21.7	13	21.7	χ^2=26.26
		Post	10	16.7	11	18.3	39	65	P<0.001
12	At the beginning of each shift I give further concentration to the alarms.	Pre	6	10	11	18.3	43	71.7	χ^2=27.14
		Post	31	51.7	11	18.3	18	30	P<0.001
13	I have an immediate response to the ventilator alarms.	Pre	9	15	18	30	33	55	χ^2=30.15
		Post	37	61.7	13	21.7	10	16.7	P<0.001
14	I have a direct reaction to the infusion pump alarms.	Pre	10	16.7	10	16.7	40	66.7	χ^2=41.93
		Post	43	71.7	9	15	8	13.3	P<0.001
15	I have an immediate response to cardiac monitoring alarms.	Pre	12	20	7	11.7	41	68.3	χ^2=36.45
		Post	40	66.7	11	18.3	9	15	P<0.001
16*	In the way of time my feeling to alarms decreases.	Pre	38	63.3	7	11.7	15	25	χ^2=29.43
		Post	9	15	17	28.3	34	56.7	P<0.001
17*	I am indifferent to the alarms.	Pre	34	56.7	12	20	14	23.3	χ^2=18.20
		Post	14	23.3	10	16.7	36	60	P<0.001
18	During a CPR in a patient I turn out to be unresponsive to the alarms of other patients.	Pre	28	46.7	18	30	14	23.3	χ^2=5.36
		Post	38	63.3	8	13.3	14	23.3	P 0.069
19*	By repetition of alarms I become unconcerned to them.	Pre	44	73.3	7	11.7	9	15	χ^2=53.85
		Post	5	8.3	14	23.3	41	68.3	P<0.001
20*	Variety and harmony of alarms confuse me in making decisions.	Pre	35	58.3	11	18.3	14	23.3	χ^2=23.25
		Post	12	20	9	15	39	65	P<0.001

21*	I do not give concentration to the alarm when I do not sense well.	Pre	38	63.3	11	18.3	11	18.3	χ^2=33.84
		Post	10	16.7	9	15	41	68.3	P<0.001
22*	I inactivate the alarms in the night time.	Pre	36	60	14	23.3	10	16.7	χ^2=48.72
		Post	7	11.7	5	8.3	48	80	P<0.001
23*	I become confused with successive sounds of alarms.	Pre	36	60	9	15	15	25	χ^2=28.32
		Post	9	15	10	16.7	41	68.3	P<0.001

Table 3. *Average score of perception of the studied nurses about alarm fatigue before and after intervention.*

perception score	Before Intervention	After intervention	Significance test
Min–Max	29.0–50.0	43.0–65.0	Paired t=17.339
Mean ± SD	37.63 ± 4.66	57.33 ± 5.66	P<0.001

Table 3 shows that the average mean score of perception of the studied nurses about alarm fatigue facing problems is significantly (p<0.001) increased from 37.63 ± 4.66 before intervention to become 57.33 ± 5.66 after intervention.

Table 4 as regard perception level; all studied nurses had unsatisfactory (<75.0% of total score) before intervention, while 83.3% of them had satisfactory level of knowledge (≥75.0%) after intervention. The difference is statistically significant (p<0.001).

Table 4. *Level of perception of the studied nurses about alarm fatigue before and after intervention.*

	Before Intervention		After intervention		Significance test
perception Level	No	%	No	%	
Unsatisfactory (<75.0%)	60	100	10	16.7	χ^2=85.71
Satisfactory (≥ 75.0%)	0	0	50	83.3	P<0.001

Tables 5a and 5b demonstrates comparing practice of the studied nurses before and after intervention and it shows that nurses' performance improved regarding proper skin preparation for ECG electrodes, customize alarm parameters, customize delay and threshold settings on oxygen saturation, ventilator troubleshooting alarms, infusion pump troubleshooting alarm, and using ASSET mnemonic to help prevent alarm fatigue post protocol application compared to pre protocol. There was highly statistical significant difference in relation to nurses' practice with p value<0.001.

Table 5a. *Comparing practice of the studied nurses before and after intervention.*

No.	Provide proper skin preparation for ECG electrodes	Time	Done correctly		Done Incorrectly		Not Done		Significance test
			No	%	No	%	No	%	
1	shaving hair	Pre	0	0	0	0	60	100	^{2}=45.39
		Post	40	66.7	12	20	8	13.3	P<0.001
2	Wash the isolated electrode area with soap and water	Pre	0	0	8	13.3	52	86.7	^{2}=37.07
		Post	34	56.7	16	26.7	10	16.7	P<0.001
3	Wipe the electrode area with a rough wash cloth or gauze	Pre	0	0	0	0	60	100	^{2}=51.26
		Post	31	51.7	17	28.3	12	20	P<0.001
4	Do not use alcohol for skin preparation; it can dry out the skin.	Pre	50	83.3	6	10	4	6.7	^{2}=30.65
		Post	60	100	0	0	45	0	P<0.001
5	Change ECG electrodes daily or more often if needed	Pre	0	0	0	0	60	100	^{2}=25.02
		Post	38	63.3	16	26.7	6	10	P<0.001

6	Change batteries every day during the start of the 7pm-7am shift	Pre	26	43.3	13	21.7	21	8	^{2}=15.47
		Post	33	55	19	31.7	35	13.3	P<0.001
	Customize alarm parameters and levels on ECG monitors								
1	Ensure staff competency on monitor functionality	Pre	20	33.3	24	40	16	26.7	χ^2=11.18
		Post	38	63.3	15	25	7	11.7	P 0.004
2	Modify the alarms to meet the requirements of individual patients condition and age	Pre	13	21.7	23	38.3	24	40	χ^2=17.53
		Post	35	58.3	15	25	10	16.7	P<0.001
3	Modify alarms according to unit or hospital rule	Pre	30	50	21	35	9	15	χ^2=3.39
		Post	37	61.7	12	20	11	18.3	P 0.184
4	Set modified alarms within 1 hour of assuming care of a patient and as the patient's condition changes	Pre	18	30	12	20	30	50	χ^2=12.07
		Post	35	58.3	12	20	13	21.7	P 0.002
5	Know and adjust heart rate alarm parameters or limits including high and low limits	Pre	14	23.3	9	15	37	61.7	χ^2=74.59
		Post	60	100	0	0	0	0	P<0.001
6	Reassess alarm settings every eight hours and alarms should be adjusted accordingly	Pre	0	0	0	0	60	100	χ^2=108.57
		Post	49	81.7	8	13.3	3	5	P<0.001
7	Ensure there is a proper telemetry monitoring order every shift.	Pre	14	23.3	12	20	34	56.7	χ^2=41.93
		Post	49	81.7	5	8.3	6	10	P<0.001
8	Only a Registered Nurse who is staff on the unit can silence the alarm based on real time assessment of the patient.	Pre	0	0	0	0	60	100	χ^2=94.93
		Post	46	76.7	7	11.7	7	11.7	P<0.001
9	Reduce the generally number of alarm signals allied to a patient's HR and SPO^2 levels by locale the signals specific to that patient's baseline.	Pre	0	0	0	0	60	100	χ^2=108.57
		Post	53	88.3	4	6.7	3	5	P<0.001
10	Examine individual alarm signals for correct settings, and accurate operation	Pre	10	16.7	14	23.3	36	40	χ^2=71.42
		Post	55	91.7	5	8.3	0	0	P<0.001
	Customize delay and threshold settings on oxygen saturation via pulse oximetry (SpO^2) Monitors								
1	Use disposable, adhesive pulse oximetry sensors	Pre	0	0	0	0	60	100	-
		Post	0	0	0	0	60	100	-
2	replace the sensors when they no longer adhere properly to the patient's skin	Pre	15	25	33	55	12	20	χ^2=58.41
		Post	56	93.3	4	6.7	0	0	P<0.001
3	Do not use Spo^2 finger clip sensor on the ear.	Pre	0	0	0	0	60	100	χ^2=120.00
		Post	60	100	0	0	0	0	P< 0.001
4	Place Spo^2 probe on warm extremities	Pre	25	41.7	21	35	14	23.3	χ^2=49.41
		Post	60	100	0	0	0	0	P<0.001

Table 5b. *Comparing practice of the studied nurses before and after intervention.*

No.	**Ventilator troubleshooting alarms**	**Time**	**Done correctly**		**Done Incorrectly**		**Not Done**		**Significance test**
			No	%	No	%	No	%	

1	Adjust alarm setting to appropriate value	Pre	24	40	23	38.3	13	21.7	χ^2=39.17
		Post	56	93	4	6.7	0	0	P<0.001
2	Auscultate chest and confirm correct tube placement.	Pre	26	43	12	20	22	36.7	χ^2=36.96
		Post	56	93	4	6.7	0	0	P<0.001
3	Check cuff pressure, reinflate cuff if leaking	Pre	22	37	2	3.3	36	60	χ^2=51.71
		Post	56	93	4	6.7	0	0	P<0.001
4	Reconnect patient to circuit if disconnected. Check circuit for leak	Pre	20	33	15	25	25	41.7	χ^2=44.48
		Post	54	90	6	10	0	0	P<0.001
5	Review patient's analgesia/sedation requirements	Pre	19	32	9	15	32	53.3	χ^2=40.83
		Post	53	88	3	5	4	6.7	P<0.001
6	Care for pain, reposition carefully and reassure your patient	Pre	11	18	12	20	37	61.7	χ^2=56.46
		Post	52	87	3	5	5	8.3	P<0.001
7	If patient wake and is equipped to start weaning, decrease ventilator rate	Pre	19	32	32	53.3	9	15	χ^2=49.03
		Post	56	93	4	6.7	0	0	P<0.001
8	Suction patient if required	Pre	32	53	17	28.3	11	18.3	χ^2=36521
		Post	60	100	0	0	0	0	P<0.001
9	Evaluation of ventilator settings and graphics	Pre	13	22	29	48.3	18	30	χ^2=52.56
		Post	55	92	3	5	2	3.3	P<0.001
	Infusion pump troubleshooting alarm								
1	Check battery or power supply	Pre	23	38	23	38.3	14	23.3	χ^2=53.49
		Post	60	100	0	0	0	0	P<0.001
2	Verify the settings on the infusion pump prior to starting the medication or fluid	Pre	24	40	21	35	15	25	χ^2=33.04
		Post	54	90	3	5	3	5	P<0.001
3	Use the "5 rights" for safe medication administration: the right patient, the right drug, the right dose, the right route, and the right time	Pre	21	35	39	65	0	0	χ^2=47.08
		Post	57	95	3	5	0	0	P<0.001
4	Check your device for reconfiguration	Pre	18	30	19	31.7	23	38.3	χ^2=37.93
		Post	51	85	6	10	3	5	P<0.001
5	Warming the medication to room temperature	Pre	30	50	15	25	15	25	χ^2=27.35
		Post	55	95	5	8.3	0	0	P<0.001
6	Avoid "burping" IV bags. Some bags need air in them to displace the fluid	Pre	19	32	13	21.7	28	46.7	χ^2=43.19
		Post	54	90	3	5	3	5	P<0.001
7	Slowly prime the IV set. Priming slowly helps minimize air bubble formation	Pre	8	13	24	46.7	24	40	χ^2=75.09
		Post	55	95	5	8.3	0	0	P<0.001
8	If your pump beeps, stop all lines, check your settings and restart	Pre	14	23	13	21.7	33	55	χ^2=60.72
		Post	56	93	2	3.3	2	3.3	P<0.001

	Using the following ASSET mnemonic to help prevent alarm fatigue and provide quality patient outcomes								
1	Alarm sensitivity	Pre	0	0	0	0	60	100	χ^2=98.18
		Post	47	78	7	11.7	6	10	P<0.001
2	Sounding notification	Pre	13	22	12	20	35	58.3	χ^2=54.83
		Post	52	87	6	10	2	3.3	P<0.001
3	Significant need to monitor	Pre	18	30	17	28.3	25	41.7	χ^2=34.87
		Post	49	82	8	13.3	3	5	P<0.001
4	Evaluate situation	Pre	22	37	11	18.3	27	45	χ^2=38.43
		Post	53	88	6	10	1	1.7	P<0.001
5	Timely response/technology training	Pre	17	28	21	35	22	36.7	χ^2=49.62
		Post	54	90	6	10	0	0	P<0.001

Table 6 explores the total mean practice scores of the study nurses all through the study period before and after protocol implementation. It demonstrated that the average scores of all items of practices are significantly (p<0.001) raised after intervention.

Table 6. *Total means practice scores of the study group subjects all through the study period before and after protocol implementation.*

Total mean practice scores of the study group subjects	**Pre protocol**	**Post protocol**	**Significance test**
	Mean ± SD	Mean ± SD	
Provide proper skin preparation for ECG electrodes	2.98 ± 1.05	9.20 ± 2.28	t=21.070,p<0.001
Customize alarm parameters and levels on ECG monitors	5.88 ± 2.74	16.62 ± 3.56	t=18.752,p<0.001
Customize delay and threshold settings on oxygen saturation via pulse Oximetry (SpO2) Monitors	4.23 ± 1.08	5.93 ± 0.25	t=11.409,p<0.001
Ventilator troubleshooting alarms	8.72 ± 3.95	17.13 ± 1.72	t=15.614,p<0.001
Infusion pump troubleshooting alarm	8.08 ± 3.43	15.18 ± 1.70	t=13.471,p<0.001
Using the following ASSET mnemonic to help prevent alarm fatigue and offer quality patient outcomes	3.35 ± 2.80	9.05 ± 1.85	t=14.075,p<0.001
Total Score	**33.25 ± 8.69**	**73.12 ± 6.24**	**t=28.856,P<0.001**

Table 7 and Figure 1 show the practice levels among the study subjects all through the study period. It is found that, all of the study subjects (100%) were having unsatisfactory level (<75.0% of total score) of practices before implementation of the protocol while (95%) were having satisfactory level (≥ 75.0% of total score) of practices immediately post of the protocol implementation.

Table 7. *Practice score levels among the study subjects all through the study period.*

Practice score levels among the study subjects	**Before**		**After**		**Significance test**
	No	%	No	%	
Unsatisfactory (<75.0%)	60	100	3	5.0	χ^2=104.80
Satisfactory (≥ 75.0%)	0	0	57	95.0	P<0.001

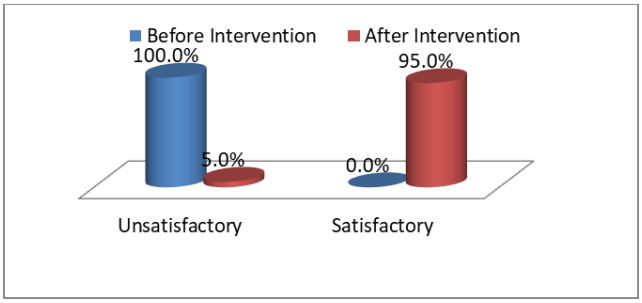

Figure 1. *Level of alarm fatigue among the study subjects all through the study period.*

Table 8 shows that the average total score of score levels among the study subjects is lower in younger studied nurses than older ones, but the difference is not significant (p>0.05). In addition, there is no significant difference in relation to education or familiarity with the term "Alarm Fatigue".

Table 8. *Relationship between average total score of alarm fatigue management observational checklist in the studied nurse before and after intervention and their characteristics.*

Characteristics	Average score before	Average score after
Age (years)		
20-30 years	31.86 ± 6.97	72.59 ± 5.96
31–40 years	35.48 ± 10.71	73.95 ± 6.71
Significance test	t=1.586,P0.118	t=0.820,P0.415
Employment years		
2–10 years	31.86 ± 6.97	72.59 ± 5.96
11–20 years	35.48 ± 10.71	73.95 ± 6.71
Significance test	t=1.586,P0.118	t=0.820,P0.415
Education		
BSc nurses	33.26 ± 7.59	72.85 ± 5.05
Technical nurses' Institute	33.23 ± 10.12	73.46 ± 7.60
Significance test	t=0.015,P0.988	t=0.372,P0.711
Familiarity with the term "Alarm Fatigue"		
No	33.69 ± 10.81	73.19 ± 7.91
Yes	33.09 ± 7.93	73.09 ± 5.61
Significance test	t=0.233,P0.816	t=0.053,P0.958

Discussion

Intensive care units are construction for additional services and tools such as patient call systems, monitors, suction pumps, and mechanical ventilators. These tools are prepared with an alarm system in their sets. Excessive number of alarms cause alarm fatigue among critical care nurses, which can result in alarms desensitization and impaired recognition of worsening patient conditions [32-34].

Clinical alarms is one of the utmost imperative methods that inform the critical care nurses for prompt or possible threats fronting critically ill patients. Alarm setting and management in the ICU are among the key responsibilities of the CCNs. Current researches stated that the most of nurses did not recognize how to avoid alarm fatigue [27,23,35]. Consequently, this study was started to determine the effect of alarm fatigue nursing management protocol on CCNs' experience.

Based on the results of the study, it showed that more than half of CCNs had age fluctuated from (20-30) and duration of their experiences in ICUs were (2-10) years. This results are harmonized with who reported that more than one-third of nurses' aged between 20 to 30 years and had (2-10) years of experience in the ICUs [27].

In this study, there were highly statistical significant improvement of perception and practice among studied nurses following protocol implementation as compared to pre-protocol implementation.

Concerning perception score among studied nurses before and after protocol implementation, the current study revealed a

great significant enhancement (P<0.001) of perception scores amongst studied nurses of all knowledge items of alarm fatigue post protocol implementation compared with their pretest score. This finding was consistent with that concluded that post test score towards alarm fatigue is improving among nurses following protocol implementation [34,36]. Similarly, showed that there were a statistically significant variances between nurses' perception post protocol implementation compared with poor perception pre protocol implementation, [27,23,13,37].

Concerning the practice items reported by the studied nurses before and after training. It was found that the practices score domains of (proper skin preparation for ECG electrodes, customize alarm parameters, customize delay and threshold settings on oxygen saturation, ventilator troubleshooting alarms, and infusion pump troubleshooting alarm) were deficient among studied nurses before protocol implementation and they become highly significantly improved (p<0.001) after protocol implementation. This finding in harmony with, they stated that the training protocol helps to increase the practice level of nurses and highly statistical significant improved (p<0.001) post protocol training [27,38].

As regard dissemination of studied nurses in relative to mean scores of practice before and after protocol implementation. The present study found that improved total mean practices score post protocol implementation than pre protocol application. This finding was agreed with they reported that nurse's practice was improved after protocol implementation [36,34,23].

Additionally, the present study revealed that completely studied nurses practice levels were unsatisfactory pre protocol implementation and the majority of nurses had satisfactory level after protocol implementation. The unsatisfactory level may be related to decrease level of nurses' knowledge and skills. This finding in harmony with who stated that additional training would improve nurses' knowledge and skills to better understand monitor's alarm parameters [27,23].

Finally, continuous education and training for CCNs on monitoring systems and alarm setting in critical care units, decreasing response time to false alarms, helping in enhance patient's outcomes and avoid alarm fatigue. Therefore, the present study aimed to determine the effect of alarm fatigue nursing management protocol on CCNs' experience to reduce alarm fatigue [39-42].

Conclusion

Rapidly advancing technology holds great promise for improving alarm fatigue management and patient care. Centered on the findings of our study, we accomplish that alarm fatigue nursing management protocol could be applied in our ICU settings. There were a statistically significant variances between nurses' perception and practices in relation to alarm fatigue nursing management indicating good perception and satisfactory practice following protocol implementation, compared with poor perception and unsatisfactory practice pre-protocol implementation. The alarm management field must remain to interchange in the trend of reducing alarm fatigue, which will increase patient safety and improvement both nursing and patient satisfaction. Future large-scale studies are needed to evaluate the effectiveness of alarm fatigue nursing management protocol on functional outcomes of patients in ICU. Finally, more research should be undertaken on alarm fatigue management where all the nurses, doctors and biomedical personnel should be included.

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