AN ASSESSMENT OF THE MANAGEMENT OF CLINICAL ALARMS IN THE NURSING CARE OF CRITICALLY ILL PATIENTS AT THE CRITICAL CARE UNIT, KENYATTA NATIONAL HOSPITAL

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Declaration

I declare that this thesis is the result of my original work and that it has not been submitted either wholly or in part in any other institution for an academic award.

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Supervisor's Approval

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Dedication

I dedicate this work to my loving husband Sino Alaly for being my number one supporter and cheering me on even when it seemed like I was almost giving up. I also dedicate this work to my sisters and brothers; Chacha, Gati, Rioba, Pauline, Godwill, Maurice, my parents Mr. John Meng'anyi, Mrs. Alphonsina Bhoke, my mother in-law Mrs. Catherine Alaly, and my brother in-law Victor for believing in me.

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TABLE OF CONTENTS

Declaration ii

Supervisor's Approval iii

Dedication iv

Acknowledgements v

TABLE OF CONTENTS vi

LIST OF TABLES xi

LIST OF FIGURES xiv

Abbreviations/ Acronyms xv

Operational Definitions xvii

Abstract xix

Chapter One: Introduction 1

1.1. Background Information 1

1.2. Statement of the Problem 5

1.3. Justification 6

1.4. Expected Benefits of the Study 7

1.5. Research Questions 7

1.6. Research Objectives 7

1.6.1. Broad Objective 7

1.6.2. Specific Objectives 7

Chapter Two: Literature Review 8

2.0. Introduction 8

2.1. Clinical alarm devices used in critical care units 10

2.1.1. Physiologic monitors 10

2.1.2. Pulse oximeter 10

2.1.3. Ventilator 10

2.1.4 Infusion pump 11

2.1.5. Alarm designs 11

2.2. Alarm generation 11

2.3. Standards and recommendations 12

2.4. Goals of clinical alarms 13

2.5. Classification of clinical alarms 13

2.5.1. False alarms 13

2.5.2. Non-actionable alarms 14

2.5.3. Actionable alarms 15

2.6. Problems related to alarms/ Causes of alarm triggers 15

2.6.1. Artifacts 15

2.7. Patients and alarms 17

2.8. Nurses knowledge 18

2.9. Nursing intervention 18

2.10. Expected practice and Nursing actions 19

2.11. Theoretical Framework 21

2.12. Conceptual Framework 23

Chapter Three: Study Design and Methodology 25

3.1. Study design 25

3.2. Study area 25

3.3. Study population 26

3.3.1. Inclusion criteria 26

3.3.2. Exclusion criteria 26

3.4. Sample size 27

3.5. Sampling technique 28

3.6. Research instruments 28

3.7. Data collection methods 29

3.8. Variables 29

3.9. Pretesting of the questionnaire 29

3.10. Data management and analysis 30

3.11. Ethical consideration 30

3.12. Limitations of the study 31

3.13. Recommendations 31

3.14. Dissemination of the results 31

Chapter Four: Results 32

4.0. Introduction 32

4.1. Distribution of socio-demographic characteristics among study participants 32

4.1.3. Professional qualifications among respondents 33

4.1.4. Years worked as a nurse 34

4.1.5. Critical Care Nursing Training 34

4.1.6. Number of years worked in CCU 35

4.1.7. Alarm management training 35

4.2. Alarms in the CCU 35

4.4. Nurses intervention/ actions in the management of clinical alarms 44

4.5. Nurses intervention in management of clinical alarms in relation to patients' outcome .. 45

4.6. Association of Socio Demographic Characteristics of respondents and Knowledge of Clinical Alarms 46

4.7. Association of Socio demographic characteristics of nurses and Nurses' Interventions/Actions in the Management of clinical alarms 53

4.8. Association of Socio demographic characteristics of Nurses and Nurses' Interventions in the Management of Clinical Alarms in Relation to Patients' Outcome 62

Chapter Five: Discussion 65

5.0. Introduction 65

5.1. Socio demographic characteristics 65

5.2. Common reasons as to why alarms are set off in the CCU, KNH 65

5.3. Knowledge of nurses on the different clinical alarms in management of clinical alarms in the CCU 67

5.4. Various interventions employed by nurses in management of clinical alarms in the CCU .. 68

5.5. Patients' outcomes in relation to the nurses' intervention to the clinical alarms at the time the alarms beep 71

5.6. Conclusion and Recommendations 72

References 74

Work plan 78

Budget 79

Appendix I: Consent Form for the Nurses 80

Appendix II: Questionnaire 83

Appendix V: Letter to KNH/UoN Ethics and Research Committee 88

Appendix VI: Letter of Approval from KNH/UON Ethics and Research Committee 89

LIST OF TABLES

Table 1: Types of alarms on clinical devices 12

Table 2: Most common artifacts that trigger false alarms and their sources 15

Table 3: How to avoid most common artifacts/ sources that trigger false alarms 16

Table 4: Parameters that nurses commonly set alarm limits for 39

Table 5: Number that fill alarm checklists and how often 39

Table 6: Reasons as to why the respondents do not fill alarm checklists 40

Table 7: Common causes of alarms to beep in the unit 42

Table 8: Frequency and percentage of the nurses' knowledge on clinical alarms 43

Table 9: Frequency and percentages of nurses' responses to alarms 44

Table 10: Nurses interventions in relation to patient outcome 45

Table 11: Association of socio demographic characteristics and alarm sound can be relied on to determine alarm urgency in terms of patients change in condition 46

Table 12: Association of socio demographic characteristics and the question: when an alarm is reliable each time it signals, this is known as alarm specificity 47

Table 13: Association of socio demographic characteristics and high priority alarm indicates an urgent situation 48

Table 14 Association of socio demographic characteristics and medium priority alarm indicates a dangerous situation and a quick response from the medical staff is needed 49

Table 15: Association of socio-demographic characteristics and the question: "A low priority alarm indicates an alert situation and the attention of the medical staff is needed 50

Table 16: Association of socio demographic characteristics and skin preparation is not important in reducing false alarms 51

Table 17: Association of socio demographic characteristics and the question: wiping electrodes with a rough washcloth prevents spurious signals 52
Table 18: Association of socio demographic characteristics and the nurses' action: I ensure proper skin preparation of patients before placing electrodes 53
Table 19: Association of socio demographic characteristics and the nurses' action: I change the patient's electrodes daily 54
Table 20: Association of socio demographic characteristics and the action: I assess the cause of the alarm beep when it alarms 55
Table 21: Association of socio demographic characteristics and the action: I disable the alarms every time they beep 56
Table 22: Association of Social demographic factors and the action: I pause the alarms every time they beep 57
Table 23: Association of socio demographic characteristics and the action: I reset the alarm limits every time alarms beep 58
Table 24: Association of socio demographic characteristics and the nurses' action: I ignore alarms every time they beep 59
Table 25: Association of socio demographic characteristics and the nurses' responses to the action: I check and assess the patient's condition every time the alarm beeps 60
Table 26: Association of socio demographic characteristics and the nurses' responses to the action: I reset alarm settings of the machine each time I admit a patient 61
Table 27: Association of socio demographic characteristics and the nurses' response: My response to an alarm improves the patients' condition 62

Table 28: Association of socio demographic characteristics and the nurses' response: My response to an alarm does not improve the patients' condition 63
Table 29: Association of socio demographic factors and the nurses' response: Often when I respond to an alarm the patient needs further attention by the anesthetist 64

LIST OF FIGURES

Figure 1: Percentage of Marital Status among respondents..... 32

Figure 2: Distribution of Professional qualifications among study participants 33

Figure 3: Years worked as a nurse..... 34

Figure 4: CCU Trained 34

Figure 5: Number of years worked in CCU..... 35

Figure 6: Types of Alarms in the unit..... 36

Figure 7: Alarms that Nurses are more likely to respond to..... 38

Figure 8: Parameters that commonly set off alarms in the unit..... 41

Abbreviations/ Acronyms

AACN- American Association of Critical Care Nurses

A- Afternoon Shift

AARC- American Association for Respiratory Care

bpm- beats per minute

BScN- Bachelor of Science in Nursing

C.I- Confidence Interval

CCU- Critical Care Unit

CO_2- Carbon dioxide

CPD- Continuous Professional Development

CCN- Critical Care Nursing

CT- Computed Tomography

DAN- Diploma in Advanced Nursing

dB- Decibels

ECG- Electrocardiogram

ECRI- Emergency Care Research Institute

ECS- European Committee for Standardization

EMG- Electromyogram

EN- European Normalization standard

ERC- Ethics and Research Committee

$EtCO_2$ - End Tidal Carbon dioxide

FDA- Food and Drug Administration

$FiCO_2$ – Fraction of inspired carbon dioxide

FiO_2 – Fraction of inspired of Oxygen

IFAS- Institute of Food and Agricultural Sciences

KNH- Kenyatta National Hospital

KRCHN- Kenya Registered Community Health Nurse

M- Morning Shift

MRI- Magnetic Resonance Imaging

MScN- Masters of Science in Nursing

NICU- Neonatal Intensive Care Unit

ORN- Operating Room Nurse

Paw- Airway Pressure

PHD- Doctor of Philosophy

PICU- Pediatric Intensive Care Unit

SPO_2- Saturation of Oxyhemoglobin

SPSS- Statistical Package for Social Sciences

ST- Sinus Tachycardia

UoN- University of Nairobi

USA- United States of America

VE- Minute Ventilation

VT- Expiratory Tidal Volume

WHO- World Health Organization

N- Night shift

Operational Definitions

Alarm Sensitivity - Ability of an alarm to react to small changes in the patients' physiological status and faults in the machine, which could be technical or clinical. This ability allows the alarm to detect changes even when they are not necessarily due to a change in the patient's physiological condition. The alarm therefore beeps even when there are other non physiological interferences with the particular alarm fitted device.

Alarm set off- this refers to the beeping or the noise produced by an alarm when there is a change in the preset physiological parameter, like for example oxygen saturation, the alarm beeps when it is on the high end or low end.

Alarm Specificity- How accurate an alarm is in detecting physiological changes in a patient. The alarm in this situation is therefore able to give the true physiological status or condition of the patient.

Clinical Alarm- It is an audible or visual sound from a device that when heard by the nurse or any other medical staff, indicates that there is something wrong with the patient or the patient's condition has changed.

Critical Care Unit – A specialized section of the hospital that admits the critically ill patients under the care of medical and nursing staff and contains equipment and monitoring devices necessary to provide intensive care. In this study it excludes the burns unit and the renal unit.

Critically ill patient- Any patient admitted in the unit who requires immediate organ support for example ventilation support, requires intubation and could either be sedated, unconscious or semi-comatose.

Management of clinical alarms – In the context of this study it refers to the interventions or responses undertaken by nurses according to the institution's policies, international standards and manufacturer's instructions when the alarm beeps. Beeping of the alarm indicates a change in the patient's physiological status or a fault in the machine. These responses can be; setting of the initial alarm limits when admitting a patient, disabling the alarm, silencing the alarm or resetting the alarm limits. Alarm limits are set according to upper and lower physiological limits in order to detect changes in patients' conditions. It is of utmost importance that the policies, standards and manufacturer's instructions are followed because failure to can yield detrimental effects on the patient like, death of the patients or worsening of the patients' condition or they can yield positive effects like improving the patient's condition.

Nursing intervention - The nurses' actions or responses in the event that an alarm beeps or the nurses' actions in the initial setting of alarm limits. That is if the nurse disables the alarm, silences the alarm or resets the alarm limits when the alarm sets off or the particular alarm limits that the nurse sets when the nurse admits a new patient into the critical care unit.

Nursing knowledge- The training and understanding the nurse has on alarm management in terms of the alarm limits and the relationship between alarm limits and different types of patients' conditions.

Patient outcome- What happens to the patient after the nurses' have undertaken certain actions in response to alarm set off, it can be a positive outcome in that the patient's physiological status is stabilized or it can be a negative outcome where the patient either changes condition for the worse or dies.

Abstract

Alarms play a crucial role alerting people on emergency situations. Clinical alarms in the hospital in the same sense are very crucial in determining the patient's condition. This is more so in the critical care units where patients are unconscious and cannot speak out. The purpose of this study was to assess the practices of nurses in management of clinical alarms in the care of critically ill patients at the Critical Care Unit, Kenyatta National Hospital. The study was a descriptive cross sectional study conducted in the month of June 2014 where 87 nurses were recruited as study participants. A structured self administered questionnaire was used to collect data. Out of 87 respondents 48(55.2%) reported that "Always" the common causes of alarms to beep in the unit are changes in patient condition, 16(18.4%) due to mechanical errors, 22(25.3%) poor setting of alarm limits and 16 (18.4%) artifacts. The study participants scored an average 69% on the questions posed to them on knowledge of clinical alarms and 17(20%) nurses thought pulse oximetry on its own was the leading cause of alarm beep. There was a statistically significant association between the question on knowledge: "Wiping electrodes with a rough washcloth prevents spurious signals and helps to remove part of the stratum corneum allowing electrical signals to travel" with years worked in CCU (p=0.049), between questions on nurses' interventions: "I change the patient's electrodes daily" with gender (p=0.028), "I assess the cause of the alarm beep when it alarms" with the age in years (p=0.028) and "I reset alarm settings of the machines each time I admit a patient" with whether trained in Critical Care Nursing or not (p=0.036). The study revealed that there is a deficit in knowledge on the management of clinical alarms and effective assessment and training on management of clinical alarms is necessary. Protocols and policies on alarm management are also not available and need to be developed.

Chapter One: Introduction

1.1.Background Information

Technological advances in the health sector have increased over the past 25 years bringing about advances in more sophisticated and complicated monitoring equipment with built-in audible alarms. Alarms are intended to alert the members of the medical team regarding a deviation from a predetermined "normal status" and are considered to be a key tool in improving the safety of patients by communicating information that requires a response or awareness by the operator (Cvach et al., 2009)

An alarm is an automatic warning that results from a measurement, or any other acquisition of descriptors of a state, and indicates a relevant deviation from a normal state. Loeb (1993) in a study titled, "A measure of intraoperative attention to monitor displays" surveyed the reaction of anesthesiologists to relevant changes in monitoring parameters, and showed that anesthesiologists needed a mean- time of 61 seconds to recognize a change in the parameters; 16% of the changes were unrecognized for over 5 minutes (Schmid et al., 2013).

In a study carried out by Milligan, Allan, and Cuthil (2012) titled, "Name that Tune: Alarms in Critical Care- how good are we at recognizing them?", aimed at evaluating whether the staff working in intensive care could identify audible alarms, nurses were better at identifying the alarms than doctors. The median score for nursing staff was 19 out of 23 (83%) and 10 out of 23 (43%) for medical staff (Milligan et al., 2012). Studies are scarce when it comes to management of alarms by nurses in the nursing care of patients. Most of the studies are based on the audibility of alarms and anesthesiologists' management of alarms.

The alarm design should adequately represent the underlying situation. The various goals of device alarms are: to detect the life threatening situations, detect imminent danger, diagnose (diagnostic alarms, they indicate a pathophysiological condition e.g. shock), detection of life threatening device malfunction e.g. disconnection from the patient, occlusion of the connection to the patient, disconnection from power, gas etc and detection of imminent device malfunctions (Schmid et al., 2013).

In the Critical Care Unit (CCU) setting, a large number of medical devices are attached to patients, generating numerous alarm signals every day. Alarms in the CCU play an important role in warning of situations that could be potentially life threatening to the patient (Solsona et al., 2001).

Several studies have demonstrated that alarms are not clinically relevant and tend to lower the attentiveness of the medical staff and in turn lower patient safety. Alarm sounds are not only associated with patient delirium which increases patient mortality but also with medical staff memory and judgment disturbances, decreased sensitivity and exhaustion. Many attempts have been made to reduce the number of clinically meaningless alarms by using statistical methods and artificial intelligence systems (Inokuchi et al., 2013).

Specificity is a measure of normality when disease is not present. When an alarm remains silent and disease is not present, that is a true negative alarm. When an alarm remains silent and disease is present, that is a false negative alarm (Burgess et al., 2009). Current studies aim at looking at ways to improve the specificity of the alarm devices as opposed to the sensitivity. A high number of false alarms in alarming devices have a high sensitivity as opposed to specificity. The patients found in the CCU are critically ill hence a missed emergency can easily cause harm

to the patient. The alarm specificity here is very important. If the alarms are more sensitive as opposed to being more specific they might create a culture of false alarms in the nurses hence they will be ignored. The ignoring of an alarm by a nurse thinking it is false can lead to detrimental effects to the patient.

The role of the nurse in CCU is to observe the information that is provided by the different device systems and to decide whether the readings they get from the devices exceed or are lower than certain limits so that they can intervene. They also perform certain routine tasks to determine the biophysical parameters of the patients every few hours. Nurses therefore respond to alarms and initiate actions. They may therefore end up relying on the alarms entirely if the alarms are dependable or they may ignore the cues from the alarms if most of the alarms that are set off are false alarms.

Alarms in critical care units are generated from any number of devices that is, infusion pumps, respiratory monitoring equipment, feeding pumps, bed or chair alarms, wound vacuum devices, sequential compression devices, cardiac monitors, ventilators and patient call systems. However there is no standardization of these alarm sounds among manufacturers hence the caregivers must be able to distinguish the sounds and react based on the perceived importance of the sound. The irony of the situation is that the sounds which are meant to protect patients have led to increased unit noise, alarm fatigue and a false sense of security regarding patient safety (Cvach et al., 2009).

Nurses are at risk of becoming desensitized to the alarms that are meant to protect patients when the frequency of alarms is high. The probability of responding to an alarm is lower if the false alarm rate is high and alarms in use today do not convey the intended sense of urgency. Urgency

in this sense means the condition of the patient whether it has changed for the worse or whether any prompt management of the patient's condition is required at the time of the alarm set off. Nurses in the critical care units stated that the primary problem with alarms is that they are continuously alarming and that the largest contributor to the number of false alarms in the critical care units is the pulse oximetry alarm (Graham and Cvach, 2010).

Although alarms are an important indispensable and life saving feature, they can be a nuisance and can compromise quality and safety of care by frequent false positive alarms. Nurses should therefore be familiar of the alarm modes and should check and reset the alarm settings at regular intervals or after a change in clinical status of the patient.

1.2. Statement of the Problem

In the modern CCU environment heavy reliance is placed on technology to carry out a range of functions concerned with both monitoring patients' physiological status and delivering treatments in the form of drugs and various types of respiratory support. The CCU nurse is the practitioner with the closest contact with patients and therefore the greatest level of interaction with the technological equipment associated with the patients' care (Browne and Cook, 2011).The clinical devices that monitor the condition of patients in the CCU produce different types of alarms to alert the clinical staff. These devices generate enough false alarms to cause a reduction in responding known as the "cry wolf effect" which stems from a folk tale of a boy herding his father's cows and being attacked by a wolf. In situations where the nurses have to multitask, have a nurse to patient ratio of more than 1:1 as stipulated by the WHO national guidelines, there may be problems in management of alarms. From the researcher's observation at the time of rotation in the CCU, KNH the nurse to patient ratio is a bracket of two nurses to three patients or a bracket of two nurses to four patients. The nurses also multitask, especially the nurses in the night shift who sometimes end up taking the patients for CT scans and they are the same nurses who are required to take care of other patients. The researcher also observed that the alarms in the CCU at KNH have a tendency to alarm not only because of changes in the physiological status of patients but also due to technical problems in the machine devices. Therefore the false alarm effect can be generated as a result of technical problems in the machine and the nurses being overworked, leading to poor management of clinical alarms. Scarcity of research in Kenya on alarm management is also an issue hence there is a need to assess the management of clinical alarms during the nursing care of critically ill patients at KNH, CCU so as to have evidence based basis of managing the clinical alarms.

1.3.Justification

Patient alarms are one of the most essential means by which the clinical staff is alerted to potential dangers facing patients. Alarms have saved incalculable numbers of patients by alerting the clinical staff prior to a catastrophic event. Although alarms are essential, problems still remain concerning the ideal alarm design and the physiologic parameter to monitor. Alarms can neither be set too rigid (due to increasing false alarms) nor too lax (alarm fails to alert the clinical staff in time. The clinical status of the patient determines the essential monitoring parameters. The alarm limits are therefore set only in the parameters that are likely to become abnormal if the patient's condition deteriorates (Cvach et al., 2009).

Mechanical ventilation systems have alarms connected to the spirometer to detect changes in the expired volume (airway pressure alarms) and other alarms to detect failure in the oxygen or air supply systems. Monitors have alarm signals for heart rate, arterial blood pressure, and cardiac arrhythmia. Pulse oximeter probes also have alarm systems which warn when a maximum or minimum value is reached. To ensure that such systems function adequately the minimum and maximum thresholds must be properly set (Solsona et al., 2001).

A number of factors affect the way in which humans make use of technology. When alarms are viewed as false positive or nuisance alarms they may cause a delay in reaction time or reduce the probability of nurses responding. The aim of this research was to assess the practices of nurses in management of clinical alarms in the care of critically ill patients at the Critical Care Unit (CCU), Kenyatta National Hospital as currently there is no such study in Kenya therefore this study will be of a valuable nature to the nursing profession, in alarm management policy formulation and will provoke more research on alarm management not only in the CCU but in the theatres and accident and emergency unit.

1.4. Expected Benefits of the Study

This research will act as a baseline for any future research on alarm management undertaken by the institution or any other institution in the country as research in this area is scarce, it will also enable the management of KNH to understand the importance of training the staff on alarm management and the importance of having protocols on alarm management.

1.5.Research Questions

1. What are the common reasons as to why alarms are set off in the CCU, KNH?
2. What is the nurses' knowledge on the different types of alarms in the CCU, KNH?
3. What are the nursing interventions applied in the management of clinical alarms and the patient outcomes related to these interventions?
4. What are the patients' outcomes in relation to the nurses' intervention in at the time alarms beep?

1.6.Research Objectives

1.6.1. Broad Objective

To assess the management of clinical alarms in the nursing care of critically ill patients at the Critical Care Unit, Kenyatta National Hospital.

1.6.2. Specific Objectives

1. To establish the common reasons as to why alarms are set off in the CCU, KNH.
2. To determine the knowledge of nurses on the different clinical alarms in the CCU
3. To determine the various interventions employed by nurses in management of clinical alarms in the CCU.
4. To determine the patients' outcomes in relation to the nurses interventions to the clinical alarms at the time the alarms beep.

Chapter Two: Literature Review

2.0.Introduction

The word ‘alarm’ historically originates from the Latin word ‘ad arma’ or the French word ‘l’arme’ which can be translated into ‘ to your weapons’, that is the gadget or the action one uses to alert others of an impending enemy. Hence the word indicates a call for immediate action, for attack or for defense (Schmid et al., 2013).

Alarms have existed ever since humans have lived in groups. Some of the first documented alarms are watchmen on towers in the Middle Ages who warned of fires or enemies by ringing bells. In complex fields of work like aviation, mining, anesthesiology and intensive care medicine especially in regard to monitoring of vital functions, alarms are ubiquitous and have been the subject of medical, technical and psychological research for decades. Monitoring of vital functions and functions of life-support devices is essential for critically ill patients, although real evidence based data are scarce. However, modern patient monitors (including alarms) must be constructed in accordance to approved and current international standards(Schmid et al., 2013).

Alarms are inherent in the work of critical care and are intended to alert clinicians to deviations from a predetermined “normal” status. “Normal status” in this sense is the pre-determined alarm limits that depict the physiological levels that are taken to mean that a patient is in good clinical condition. Alarms are important and sometimes life saving and can compromise patient safety if ignored.

A 2006 American College of Clinical Engineering survey of more than 1300 health care professionals showed that a large percentage of respondents believed that what are commonly

called “nuisance alarms” occur frequently (81%), disrupt patient care (77%) and can reduce trust in alarms, causing clinicians to disable them (78%). In other studies researchers stated that a high percentage (86% - 99.4%) of false positive alarms produced by physiological monitors, resulted in a less than 1% of change of management of the patient (Graham and Cvach, 2010).

According to a recent article in the Washington Post, over a three and a half year period ending June 2012, the Joint Commission had reports of 98 alarm related incidents including 80 deaths in more than 60% of the cases, alarms were either inappropriately turned off or were not audible in all areas that the studies were carried (http://scienceofcaring.ucsf.educ/acute-and-transitional-care-battling-alarm-fatigue).

In a study on, “Attitude of resident doctors towards intensive care units’ alarm settings”, which involved 80 resident doctors, it was found that out of the 80 respondent resident doctors, 55% residents believed that alarms occurred due to patient disturbance, 15% believed that alarms were due to technical problems with the monitors or sensors, and 30% thought it was truly related to the patients’ clinical status. In this study, 82% of residents set the alarms by themselves, 10% believed that alarms should be adjusted by nurses, 4% believed the technical staff should take the responsibility of setting alarm limits and 4% believed that alarm levels should be pre-adjusted by the manufacturer (Garg et al., 2010).

Various studies have concluded that over 90% of alarm sounds may not be clinically important. In a study by Chambrin et al.(1999) titled: “Multicentric study of monitoring alarms in the adult intensive care unit”, 72% of all alarms resulted in no medical action. The study reported a positive and negative predictive value for alarms to be 27% and 99% respectively. In a survey by Siebeg et al., (2008) regarding, “User’s opinions on intensive care unit alarms”, it was mentioned

that 52.2% of the nurses considered themselves the ones that control alarm limits (Garg et al., 2010).

Studies by Tsien (1997) and Siebig et al (2010), show that the sensitivity of the current alarms is close to 100%. However their specificity which is important for medical staff could not be determined. Thus nurses, researchers and medical companies need to establish an evidence-based practice model and find a mutually acceptable solution to this matter.

2.1.Clinical alarm devices used in critical care units

2.1.1. Physiologic monitors

These are comprehensive patient monitoring systems that can be configured to continuously measure and display a number of parameters via electrodes and sensors that are connected to the patient. They may include the electrical activity of the heart via an ECG, respiration rate (breathing) blood pressure, body temperature, cardiac output and amount of oxygen and carbon dioxide in the blood, apnea, and intracranial pressure. Each patient bed in CCU has a physiologic monitor that measures some of these body activities.

2.1.2. Pulse oximeter

This monitors the arterial hemoglobin oxygen saturation (oxygen level) of the patient's blood with a sensor which can be clipped on the finger, toe or earlobe.

2.1.3. Ventilator

Assists with or controls pulmonary ventilation in patients who cannot breathe on their own. They regulate the volume, pressure and flow of patient respiration.

2.1.4 Infusion pump

This is a device that delivers fluids intravenously or epidurally through a catheter. Infusion pumps employ automatic, programmable pumping mechanisms to deliver continuous anesthesia, drugs, and blood infusions to the patient.

2.1.5. Alarm designs

Alarms are displayed in two ways or as a combination of both. Acoustic alarms give a warning sound and visual alarms involve a flashing or coloring of the related parameter in an eye catching manner. Some clinical devices have both the acoustic and visual alarm systems.

2.2. Alarm generation

Monitoring devices provide for the setting of an alarm on most physiological data. This therefore creates a great number of potential false alarms. Thus, it is possible to count more than 40 alarm sources, taking into account ventilation data, electrocardiogram, arterial pressure and pulse oximetry for a patient undergoing mechanical ventilation. There are also alarms generated by the infusion pump, the nutrition pump, the automatic syringe and the dialysis etc. The present technique used to generate an audible alarm signal is based on setting a threshold. For every parameter, the trigger of the alarm is set off immediately if the value set reaches the limit or in some cases when the value has been beyond the set limit for a given time. On the same monitoring system, when the values of several parameters are beyond the limit, an audible signal is triggered on the first parameter that reached the alarm threshold; alternatively there can be a hierarchy of alarms.

2.3. Standards and recommendations

The European Committee for Standardization (ECS) has established a classification of the alarms in three categories (1) High priority; this indicates an urgent situation. One that can lead immediately to a vital problem, it requires an immediate response from the medical staff (2) Medium priority; this indicates a dangerous situation, a quick response from the medical staff is needed, and (3) Low priority**;** this indicates an alert situation, the attention of the medical staff is needed.

Table 1: Types of alarms on clinical devices

Type of alarm	Alarm category	Note	Standard
Electric or pneumatic failure	High priority		EN 794-1
FiO_2 high or low	At least medium priority	Is applicable as soon as O_2 concentration is different from that of ambient air	EN 794-1
Paw high	High priority		EN 794-1
VE low* or VT low*	At least medium priority		EN 794-1
Apnoea	At least medium priority		EN 794-1
Disconnection	At least medium priority	Could be detected for example from a low Paw, a low ET_{CO2} and a low tidal volume	EN 794-1
Continuous pressure	High priority	Is relative to a continuous pressure kept over a given limit during more than 15± 1.5 seconds	EN 794-1
$EtCO_2$ High Low	 Medium priority Medium priority		EN 864 EN 864
$FiCO_2$ high	Medium priority		EN 864
SpO_2 High Low Sensor failure	 No priority indicated No priority indicated Low or medium priority	For neonatology	 EN 865 EN 865 EN 865

Legend: According to these standards, except for the ventilators used in neonatology, the measurement of expiratory tidal volume (VT) or minute ventilation (VE) must be provided. $ETCO_2$, end tidal CO_2; $FiCO_2$, concentration of carbon dioxide during inspiration; FiO_2, concentration of oxygen during inspiration; Paw, airway pressure ; Spo2, saturation of oxyhemoglobin determined by pulse oximetry. EN , the number of standard according to the European Committee for Standardization (Chambrin, 2001).

2.4. Goals of clinical alarms

Device alarms may have levels or categories of alarms which may or may not follow a hierarchical order. An example of the hierarchical order can be seen in a physiologic monitor: detection of a life threatening situation (crisis alarm), detection of life device malfunction (system failure), detection of imminent danger (warning alarm), detection of potential device malfunction (system warning), and detection of unsafe situation (advisor alarm). The severity of the alarm can be determined by the type of sound emitted, for instance, a crisis alarm is distinctly different from an advisory alarm. The caregiver uses the sound of the alarm to determine how to respond. There are also alarms in therapeutic devices that may not have hierarchical order so the alarm sounds the same regardless of the situation that triggers the alarm. The caregiver is expected to hear the alarm, register the meaning of the alarm, and act. Patient safety relies upon alarms being easily distinguished and clinicians reacting in a timely manner (Chambrin, 2001).

2.5. Classification of clinical alarms

Alarms can be classified into technically correct or technically false and clinically relevant or clinically irrelevant alarms. They are classified as technically correct if they are based upon a technically correct measurement. Technically false alarms are not based on a technically correct measurement, for example interference with pulse oximetry caused by ambient light. Because not all technically correct alarms are clinically relevant, they can be further differentiated into clinically relevant or not clinically relevant, for example inadequate thresholds (Schmid et al., 2013).

2.5.1. False alarms

These are alarms without clinical or therapeutic consequence. They are generated due to bad or missing data. False alarms are often caused by a patient's motion or poor sensor placement,

intermittent cables, and limitations in the device alarm detection algorithm. Manufacturers have advanced the design of sensors and detection algorithms, but if the medical devices are not properly applied or maintained, false alarms will persist.

Lawless (1994) suggested that 94% of all alarms in a Pediatric Intensive Care Unit (PICU) were clinically irrelevant. Tsien and Fackler (1997) in their observation of clinical alarms in a PICU also found that 92% of alarms were false alarms. In both these studies, all alarms were recorded by the nursing staff. The nurses also assessed the relevance and validity of the clinical alarms. In a study by Siebig et al. (2010), the conclusion was that results by Tsien, Fackler and Lawless were not only limited to the PICU, as from the study they conducted themselves, only 17% of the alarms were relevant, with 44% of the alarms being technically false. Chambrin et al. (1999) conducted a multicenter study including all medical ICU patients and the medical staff recorded all alarms which were assessed according to clinical relevance and the reaction of the medical staff. In this study, 26% of the alarms were the result of technical problems and 24% were caused by staff manipulation (Schmid et al., 2013).

2.5.2. Non-actionable alarms

These are true alarms that do not require a clinical intervention or are the result of intentional actions. They distract clinicians' attention needlessly and therefore are a nuisance. They are short duration alarms which correct themselves in most of the cases. Examples are short duration low oxygen saturation or heart rate alarms. These cases occur frequently with the alarming vital sign returning to a normal range within a few seconds. Logging these cases may be important for patient care plans, and repeated patterns may be a precursor to an emerging alarm condition, but what is to be noted is that audible annunciation of an alarm does not necessarily require an immediate response each and every time it occurs. Intentional activities by trained clinicians at

the bedside can generate non-actionable alarms. For example suctioning an intubated patient can trigger a ventilator alarm that does not require changing or modifying settings, yet the occurrence of the audio alarm adds to environment stimulation for all clinicians within the vicinity of the device. Non- actionable alarms are the highest contributor to nuisance alarms.

2.5.3. Actionable alarms

These require timely intervention to avoid an adverse event. Defining actionable alarms requires identifying the most important attributes of the alarm that have a high probability of causing harm. Time to response must also be considered. A common trait of actionable physiologic alarms is persistence. Most high or low sustained vital signs are examples of actionable alarms.

2.6. Problems related to alarms/ Causes of alarm triggers

2.6.1. Artifacts

These are interfering signals that originate from sources other than the physiological parameters being monitored. They may stem from monitoring equipment issues or undesired signals. They may distort or completely misinterpret the true underlying electrophysiological signal that is being sought. Many false alarms are caused by artifacts. The main sources of artifacts are of physiological and non-physiological origin. Most of these artifacts directly influence the measured signals leading to incorrect measurements and hence this triggers the alarm.

Table 2: Most common artifacts that trigger false alarms and their sources

Signal	Artifact source	Parameter
Ventilation alarms		
1. Pulse oximetry	Movement Injection of contrast dye Interruption of blood flow by non-invasive blood pressure Ambient light	Oxygen saturation Pulse frequency
2. Capnography	Occlusion of CO_2- line (by kinking or built up fluid) Ventilator circuit leakage Atmospheric pressure variations	End- tidal CO_2 Inspired CO_2 Respiratory

	Suctioning Dead space in measurement circuit	rate
Hemodynamic alarms 1. ECG	Electrosurgical interference Power line interference Movement artifacts (patient movement, positioning) Electrode instability or electrode distortion EMG/ neuromonitoring interference Incorrect connection or lead contact Pacing/ defibrillation Abnormally tall T-waves mistaken as QRS-complex MRI interference	Heart rate ST-values Arrhythmia detection
2. Non-invasive blood pressure	Movement Inadequate size or cuff position Compression of cuff by external forces (clinical staff or equipment pressing against the cuff) Kinked cuff tubing and leaking of cuff bladder	Systolic, diastolic blood pressure Mean arterial pressure
Other alarms Temperature	Dislocated sensor	Temperature

Legend: ECG; electrocardiogram, EMG; electromyogram, MRI; magnetic resonance imaging; CO_2; carbon dioxide (Schmid et al., 2013).

Table 3: How to avoid most common artifacts/ sources that trigger false alarms

Artifact sources	How to avoid the artifact
Pulse oximetry- Movement	Reduce patient movement as much as possible
Injection of contrast dye	Consider observing patient's clinical status till saturations normalize
Interruption of blood flow by non-invasive blood pressure	Place the blood pressure cuff on the limb without the pulse oximetry probe
Ambient light	Cover the limb with the pulse oximetry probe to avoid exposure of the probe to ambient light and ensure dim lighting when not taking care of patient
Capnography-Occlusion of CO_2- line (by kinking or built up fluid)	Check and ensure there is no kinking or build up of fluid in the capnograph tube.
Ventilator circuit leakage	Check and ensure there is no leakage in the ventilator circuit
Dead space in measurement circuit	Do not connect a catheter mount to the endotracheal tube together with a capnograph connection.
ECG	See, Expected practice and Nursing actions2.10

Non-invasive blood pressure- Movement	Reduce patient movement as much as possible by mobilizing the limb with side pillows
Inadequate size or cuff position	Ensure right cuff size and the right placement of the cuff
Compression of cuff by external forces (clinical staff or equipment pressing against the cuff)	Ensure the limb that has the cuff is not compressed by any equipment
Kinked cuff tubing and leaking of cuff bladder	Ensure the cuff is not leaking and the tubing is not kinked at all times.

Legend: Modified from:
(www.accn.org/.../Patient%20Alarm%20Management%20Handouts.Patient Alarm Management Handouts)

2.7. Patients and alarms

Sound levels below 40dB are recommended by the WHO guidelines for community noise for undisturbed night sleep of patients. In the CCU sound levels are frequently above this level hence depriving patients of sleep. Sleep deprivation leads to an impairment of the immune response and increased sympathetic nervous system activity. Catecholamine secretion by the sympathetic nervous system increases heart rate, metabolism and oxygen consumption. In patients with a preexisting heart disease and also patients who are sick but don't have a preexisting heart disease, frequent arousal from sleep may lead to cardiac arrhythmias (Schmid et al., 2013).

Over 30% of patients treated in CCUs become confused or develop delirium. These patients have longer hospital stays and higher mortality and morbidity. Risk factors for the development of CCU- related delirium are sedation use and invasive procedures, but there is also a link to environmental factors, including noise-induced sleep disturbance (Darbyshire and Young, 2013).

2.8. Nurses knowledge

The need of various monitoring parameters varies among patients because of their clinical status. The priority in alarm management therefore is first to recognize and locate the source of the alarm and then to attribute a significance to this alarm. For an experienced user, locating the alarm is facilitated by the different sounds produced by the equipment. What is bothersome is the repetition and loudness of the alarms. The proper setting of alarm limits is essential. The default alarm limits cannot be applicable for all patients because of the different parameters and action required if the monitoring parameters change by a certain limit (Garg et al., 2010).

Alarms produce noise louder than 80dB that can lead to sleep deprivation and continuous stress for both patients and staff. Such constant demand may result in nurses delaying their intervention, trying to recognize life-threatening alarms by sound only. A study demonstrated that experienced nurses are able to recognize only 38% of vital alarms. This practice could therefore have severe consequences when the patient's condition is deteriorating (Chambrin, 2001).

2.9. Nursing intervention

Perceived alarm urgency contributes to the nurse's alarm response but nurses use additional strategies to determine response including the criticality of the patient, signal duration, rarity of alarming device and workload. A caregiver's "probability match" is the alarm response based on the perceived true alarm rate. If an alarm system is perceived to be 90% reliable, the response rate will be about 90%, if the alarm system is perceived to be 10% reliable, the response rate will be about 10%. Nurses respond to alarms for different reasons, not just the fact that the alarm sounds. Nurses adjust the order of their activities by evaluating alarm urgency in relation to the patients' condition and have a greater tendency to react to alarms of longer duration and

considered rare, that is alarms that beep for long and alarms that occur rarely as opposed to all the time. As workload complexity increases, alarm response and task 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. Adjusting alarms to patient's actual needs ensures that alarms are valid and provides an early warning to potential critical situations. Documenting alarm parameters in the medical record was found to be an effective intervention for improving alarm adjustment compliance (Cvach, 2012).

2.10. Expected practice and Nursing actions

According to the American Association of Critical-Care Nurses (AACN) practice alerts, alarm fatigue develops when a person is exposed to an excessive number of alarms of which most could be false alarms. This may result in sensory overload, which may cause the person to become desensitized to the alarms. Consequently, the response to alarms may be delayed or alarms may be missed altogether. Patient deaths have been attributed to alarm fatigue. AACN therefore have suggested several strategies to improve patient safety in the event of reducing the number of false alarms.

These practices entail proper skin preparation for ECG electrodes by: washing the isolated electrode area with soap and water to decrease skin impedance and signal noise thereby enhancing conductivity, wiping the electrode with a rough washcloth or gauze and or using sandpaper on the electrode to roughen a small area of the skin prevents spurious signals which are recorded when there is poor electrode contact and it also helps to remove part of the stratum corneum to allow the electrical signals to travel. Alcohol should not be used for skin preparation as it can dry out the skin. Excessive hair at the electrode site should also be clipped.

The nurse is also supposed to ensure the ECG electrodes are changed daily, and customize alarm parameters and levels on ECG monitors. Customization of the electrodes entails the nurse ensuring that the alarms are customized; to meet the individual patients and within one hour of assuming care of a patient and as the patient's condition changes.

The nurse should also customize delay and threshold settings on oxygen saturation via pulse oximetry (SPO_2) monitors. The nurse can do this by collaborating with an inter-professional team, including biomedical engineering to determine the best delay and threshold settings and also by using disposable adhesive pulse oximetry sensors, and replacing the sensors when they no longer adhere properly to the patient's skin.

The institutions should provide initial and ongoing education about devices with alarms. The education should be on monitoring systems and alarms as well as operational effectiveness to new nurses and all other health care staff on a periodic basis. The organization should budget for ongoing education when purchasing monitoring systems.

Evidence suggests that daily changing of electrodes decreases the number of false alarms. In a quality improvement study in the USA, the average percentage of alarms per bed decreased by 46% by changing ECG electrodes daily.

Changing alarm default settings and customizing alarms according to patient need, including parameters and levels, have decreased the number of false alarms in some institutions. A 43% reduction in critical care alarms was observed in a CCU setting in USA, when default alarm parameters were changed and registered nurses were educated about the change. Similarly in a medical-surgical unit with telemetry monitoring, changing the high heart rate alarm from 120 beats per minute (bpm) to 130 bpm resulted in a 50% decrease in the number of alarms.

The combination of both customized alarm delay and threshold settings optimizes the SPO_2 monitor to its highest potential, producing an alarm when action is required. Pulse oximeters typically measure oxygen saturation best in patients who have adequate peripheral perfusion and are not moving. The newest technologies in both disposable, adhesive pulse oximetry sensors and next generation monitoring improve accuracy in states of low perfusion and increased motion. The accuracy here is in terms of the alarms being more specific hence are more clinically relevant (Graham and Cvach, 2010)

2.11. Theoretical Framework

In this study the classical conditioning theory will be used as a theoretical framework and Calista Roy's adaptation model will be used to conceptualize the different variables.

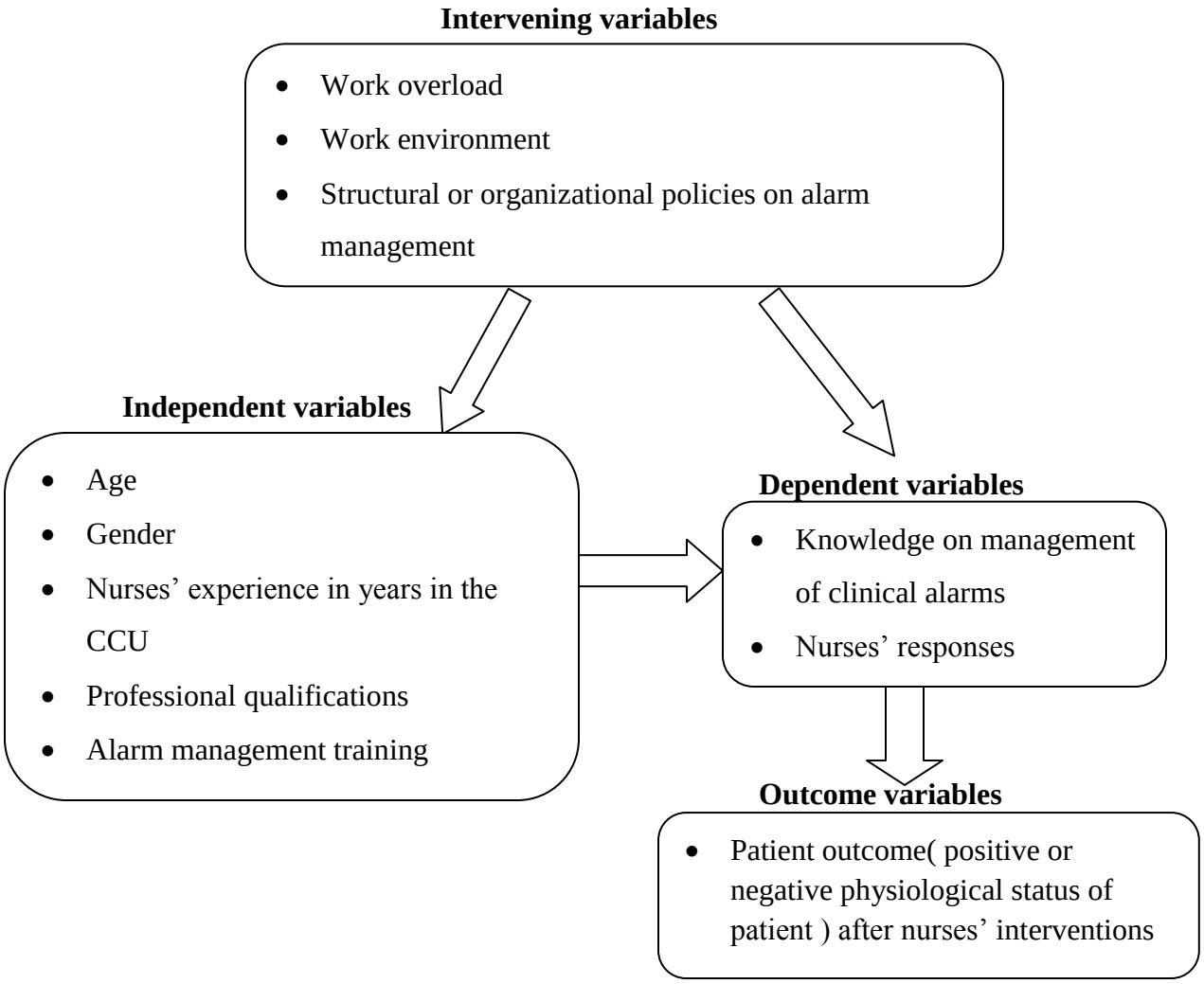
The Classical Conditionig Theory By Ivan Pavlov/ Pavlovian or Respondent Conditionig (1849-1936)

According to Pavlov an unconditioned stimulus elicits an unconditioned reflex which is a reflex that occurs naturally. When the unconditioned stimulus is paired with a neutral stimulus with time the neutral stimulus ends up eliciting an unconditioned response from the study subject or the person. The dog in Pavlov's theory elicited an unconditioned response which was salivation. The unconditioned response occurred naturally without the dog learning. When the unconditioned stimulus (food) was paired with a neutral stimulus (the ringing of the bell), with time the ringing of the bell elicited salivation (unconditioned response) from the dog (Westen 1995, p.).

In the critical care unit setup, the changing of the patients' condition elicits a response from the nurse. The nurse responds by intervening in the best possible way to improve the patients'

condition or to save the patients' life. If a patient is dyspnoeic for example, the nurse increases the patient's oxygen flow, props up the patient and calls for the anesthetist to come and intervene. Changing of the patient's condition is therefore an unconditioned stimulus and the nurse's response is unconditioned response. The nurse's response occurs naturally, that is, the nurse is expected to respond to the change in patients' wellbeing naturally without any coercion. On the other hand if the device the patient is attached to, whether a cardiac monitor, physiologic monitor or a mechanical ventilator has an alarm which alarms when the patient's condition changes, the nurse learns to associate the change in the patient's condition with the alarm being set off. The alarm is therefore a neutral stimulus. Initially the nurse might just be used to checking the patient's condition by observation and monitoring the vital signs but once the nurse learns that the alarm in the device can be able to show the true condition of the patient then the nurse is conditioned to respond to the alarm when it sets off. The alarm then finally becomes a conditioned stimulus when the nurse likens it to change in the patients' condition. Like any other stimulus, if the stimulus ceases to be reliable, the person tends to get desensitized to the stimulus that is the stimulus becomes extinct. In this context, if the alarm ceases to be reliable then the nurses will cease to be conditioned to it. If the alarms are most of the time false alarms, then the conditioned stimulus which is the alarm becomes an unreliable stimulus hence the nurse becomes desensitized to it and may not take the alarms very seriously.

2.12. Conceptual Framework



Calista Roy's Adaptation Model will be used as the conceptual framework. Her concepts of focal stimuli, regulator subsytem, cognator subsystem and contextual stimulus will be applied. The alarms in the critical care unit will represent the focal stimuli, the regulator subsystem is the nurse's ability to differentiate the different types of alarms and interpret their meanings as well as the actions taken by the nurses when the alarms are set off. The cognator subsystem will be represented by the nurses' judgment when they are responding to the alarms in terms of the decisions they make during intervening on the patients' condition. Finally the contextual stimulus will be represented by the intervening variables. According to Calista Roy the focal

stimuli is the internal or external stimulus immediately affecting the system, the regulator subsystem is an automatic response to stimulus (neural, chemical and endocrine), the contextual stimulus is the other stimuli present in the situation while the cognator subsystem responds through four cognitive-emotive channels (perceptual and information processing, learning, judgment and emotion). On the concept of the cognator subsystem this, study will concentrate on the cognitive-emotive channel of judgment.

The independent variables in this study will be represented by the cognator subsystem as they represent the variables in the nurses that allow them to respond to alarms in the CCU, thus their judgment. The dependent variables on the other hand are represented by the regulator subsystem as they are the inherent reactions that the nurses elicit when the clinical alarms in the CCU are set off.

Chapter Three: Study Design and Methodology

3.1.Study design

This was a descriptive cross-sectional quantitative study that was conducted over a one month period during the month of June, 2014, where the nurses in the Critical Care Unit, Kenyatta National Hospital were recruited as study participants. This design was selected as it helps to best describe the different types of clinical alarms in the critical care unit, the clinical alarms that mostly set off in the unit, the knowledge of nurses on the clinical alarms in the unit, the nurses' management of the clinical alarms and the association between the nurses' social demographic factors and the knowledge and management of the clinical alarms.

3.2.Study area

The study was carried out at Kenyatta National Hospital (KNH) Critical Care Unit. Kenyatta National hospital is the largest referral hospital in Kenya and the second largest in Africa and it covers 45.7 hectares. Within KNH complex are College of Health Sciences, University of Nairobi, Kenya Medical Training College, Kenya Medical Research Institute and National Laboratory Services (Ministry Of Health). Kenyatta National Hospital has a bed capacity of 1,800 with 50 wards, 22 out-patient clinics, and 24 theatres (16 specialized). On average in a day KNH hosts between 2,500 and 3,000 patients in the wards and 89,000 in-patients and 600,000 out-patients annually respectively with a total staff of 6,213. The hospital receives the highest number of critically ill patients in the country.

The Critical Care Unit (CCU) at KNH is located on the first floor in the old hospital wing bordering renal unit to the south, and burns unit to the immediate north. It is a 24 hour service unit, with a 21 bed capacity and 112 qualified nurses. The nurses work in three shifts which are

morning hours, afternoon hours and night duty. The unit serves critically ill patients with all conditions. It admits patients who need specialized care such as mechanical ventilation, ionotropic support, patients with traumatic brain injuries and pre and postoperative patients with neurological and other conditions (KNH website and CCU statistics).

3.3. Study population

The study population was all qualified nurses in the unit who consented to participate in the study.

3.3.1. Inclusion criteria

- All new nurses who were working in the unit at the time of the study and by the time of the study had worked for six months and above and who consented to participate in the study,
- All qualified nurses who had been permanently deployed to the unit at the time of data collection and consented to participate in the study and
- All qualified nurses who were in the unit at the time of the study and were not permanently deployed to the unit and consented to participate in the study.

3.3.2. Exclusion criteria

- All staff in the CCU who were not nurses- the doctors, biomedical staff and the support staff
- Student nurses who were on clinical rotation in the unit,
- Nurses who declined to participate in the study and nurses who were absent at the time of data collection.

3.4. Sample size

The sample size was determined using the Cochran's formula (IFAS, 2009) as follows:

$$n = \frac{z^2 pq}{d^2}$$

Where,

n= the desired sample size if the target population is more than 10,000

z=the standard normal deviation at the required Confidence Interval (C.I.).In this study it will be 95% with a 5% margin of error.

p= the proportion in the target population estimated to have characteristics being measured. If there is no estimate available for the proportion in the target population assumed to have the characteristics of interest, 50% should be used (Fisher et al. Mugenda & Mugenda 2003)

q= 1-p

d= the level of statistical significance set <0.05

For this study, the proportion of the target population was not known hence 50% was used i.e. p=0.5, z=1.96, and a level of statistical significance of 0.05 was desired. The sample size was then calculated as follows:

$$n = \frac{(1.96)^2\,(0.5)(0.5)}{(0.05)^2}$$

$$n = 384$$

Since the target population was less than 10,000, the required sample size is smaller. A final sample estimate (n_f) was calculated using the Fisher et al, formula (Mugenda & Mugenda 2003):

$$n_f = \frac{n}{1 + (n-1)/N}$$

Where:

n_f = the desired sample size (when the population is less than 10,000)

n= the desired sample size (when the population is more than 10,000)

N= the estimate of the population size.

The target population (estimate of the population size) was 112 nurses. The above can therefore be substituted as follows:

$$n_f = \frac{384}{1 + (384 - 1)/112}$$

n_f= 86. 87 hence 87 nurses

Therefore the sample size was 87 nurses.

3.5. Sampling technique

The sampling method that was used was convenience sampling technique. This technique was used because the nurses in the critical care unit work in different shifts of, morning shift from 7.30 a.m. to 12.30 p.m.(M shift), afternoon shift from 12.30 p.m. to 5.30 p.m. (A shift) and night shift 5.30 p.m. to 7.30 a.m.(N shift). Getting all the nurses at once would have been challenging hence the convenience non-probability sampling was more appropriate for this study population.

3.6. Research instruments

A structured questionnaire was used to collect data on the socio demographic data, nurses' knowledge on alarm management and various interventions undertaken by the nurses in the management of clinical alarms in relation to the outcome of patients during the nursing when the alarms are set off. Some of the questions on knowledge of alarms were borrowed from an online CPD by the American Association for Respiratory Care (AACR) program on continuing education.

3.7. Data collection methods

A structured self administered questionnaire was used to collect data. The respondents were issued with the questionnaire by the researcher and incase of any queries the researcher responded to them at hand. To avoid loss of questionnaires the researcher was around as the respondents filled the questionnaire and collected all the questionnaires at the end of each working shift. The questionnaires were coded to keep track on the number.

3.8.Variables

Independent variables in the study were the age of the respondents, gender, professional qualifications of the respondents, knowledge on alarm management and experience of the respondents which was measured by the number of years the respondents have worked in the unit.

The dependent variables were the nurses' intervention when the alarms were set off, that is the nurses' responses or the actions the nurses took when the clinical alarms were set off.

The intervening variables were the workload, work environment, structural or organizational policies.

3.9.Pretesting of the questionnaire

The questionnaire was pretested at the Acute Room, Accident and Emergency Unit on 10 nurses. The figure of 10 is as suggested in the book titled, "Nursing Research Principles and methods (Polit & Beck 2003).

This was an ideal unit to pretest the tool as the alarm limit settings in the clinical device systems in the acute room are the same as the settings in the critical care unit. The nurses in the acute room deal with critically ill patients just like the critical unit as the patients are mostly on transit

into the critical care unit or theatre. The researcher was therefore able to review and amend questions that were not clearly understood by participants. The results of the pretest were not included in the final analysis of the data.

3.10. Data management and analysis

Data captured in questionnaires was double entered into a computer database designed using MS- Excel application. Regular file back-up was done to avoid any loss or tampering. Data cleaning and validation was performed in order to achieve a clean dataset that was exported into a Statistical Package format (SPSS version 20.0) to be analyzed.

The quantitative data was analyzed using Statistical Package of Social Sciences (SPPS) version 20. Descriptive analysis was done for the demographic variables using frequency and proportions. The association between independent and dependent variables was determined using Chi square ($p \leq 0.05$) and Cramer's V. The results were presented in form of tables, pie charts and graphs

3.11. Ethical consideration

Clearance was sought and obtained from the Ethics and Research Committee Kenyatta National hospital/University of Nairobi. Permission to carry out the research was sought from the Kenyatta National Hospital Research and programs department, the Administration Director of Anesthesia and the manager Critical Care Unit. An informed consent form was developed so that only those who consented to participate in the study signed and were given the questionnaire. No names were included in the questionnaires and information gathered was for research purposes only. There were no risks involved in the study. Ethical principles of autonomy, justice, beneficence and confidentiality were applied. The principles of autonomy were applied to let

participants make an informed consent on whether to participate. This included disclosing the nature of the study to participants, the risks, benefits, opportunity to ask questions and to state that the participant would not be penalized in case they withdraw from the study. The principle of beneficence was used to minimize any risks to the participants by explaining to the participants that no risks would be involved when they participate in the study. On the principle of justice, there was equitable selection of participants and there was no coercion of the participants. The participants were also assured of confidentiality and anonymity in the use of the study results as the questionnaires did not have names hence there would be no victimization of the respondents.

3.12. Limitations of the study

This study cannot be generalized on the other medical and non-medical personnel as the study participants were nurses only. The study is also not representative of the nurses from other CCUs in the country but rather of only nurses working at the CCU, KNH.

3.13. Recommendations

Further studies are needed on the other medical personnel who are involved in the management of clinical alarms in the care of critically ill patients in the critical care unit. The concept of alarm fatigue also needs to be explored. This will go a long way in improving patient care.

3.14. Dissemination of the results

The research findings from the study were compiled, written and presented to the relevant stakeholders for examination purposes, publication and abstract presentation for scientific use. The results were also presented to the management of Kenyatta National Hospital to aid in development of policies in alarm management.

Chapter Four: Results

4.0. Introduction

This chapter presents the findings of the study. The study participants involved in this study were qualified nurses working at the Critical Care Unit of KNH. The results are presented in tables, pie charts and bar graphs.

4.1. Distribution of socio-demographic characteristics among study participants

The frequency and percentage distribution of socio-demographic characteristics among the qualified nurses who participated in this study are presented in the following sub-topics.

4.1.1. Distribution of respondents by age in years and gender

Among the 87 respondents; 44(50.6%) were between 36-44 years, 27(31%) were between 25-35 years and 16(18.4%) were between 45-55 years. Majority of the respondents were females 62(71.3%) whereas males were only 25(27.6%).

4.1.2. Marital status of study participants

Out of the total 87 nurses who participated in the study majority were married 65(77%) followed by being single 16(19%), (Figure 1 below).

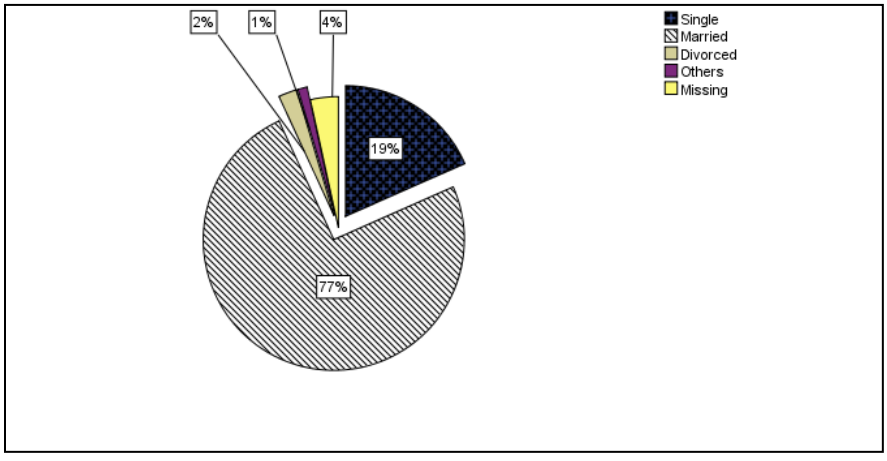


Figure 1: Percentage of Marital Status among respondents

4.1.3. Professional qualifications among respondents

With respect to level of professional education most 78(89.7%) of the nurses had attained Kenya Registered Community Health Nursing, 7(8%) Bachelor of Science in Nursing degree, 1(1.1%) Master degree of Science in Nursing degree and 1(1.1%) Kenya Registered Nursing (Figure 2 below).

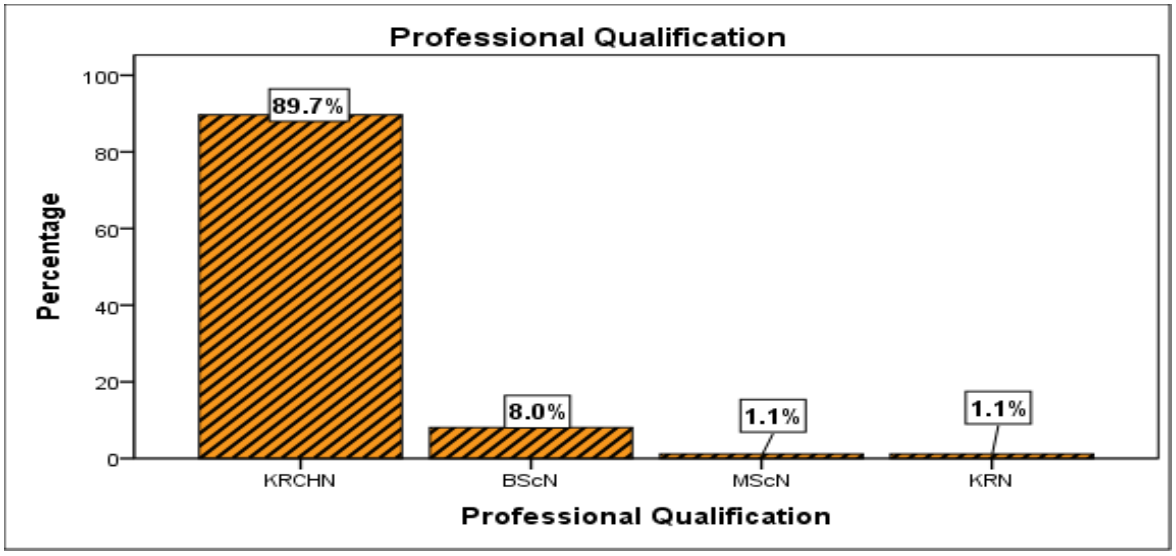


Figure 2: Distribution of Professional qualifications among study participants

4.1.4. Years worked as a nurse

Majority 63(72%) of the nurses had worked as nurses for more than 10 years whilst 3(3%) had worked less than two years (see Figure 3).

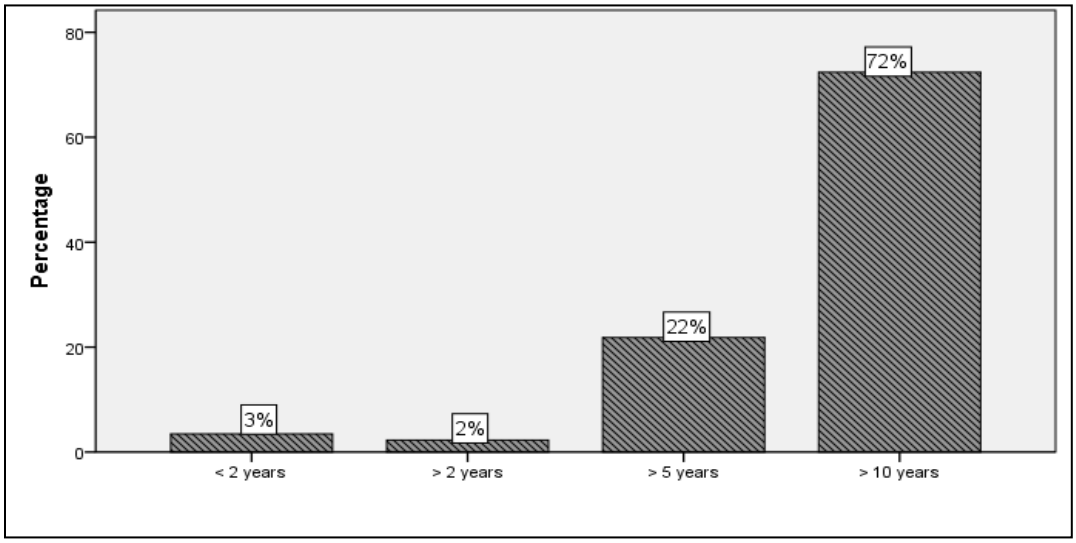


Figure 3: Years worked as a nurse

4.1.5. Critical Care Nursing Training (n=87)

A large proportion of the nurses 77(88.5%) in the critical care unit had received training in Critical Care Nursing while the remaining 10(11.5%) had not been trained, (Figure 4).

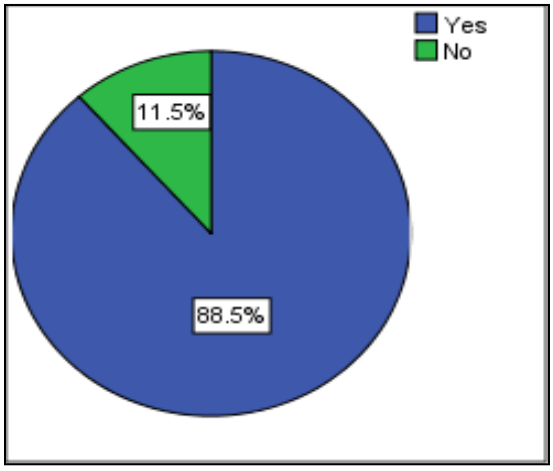


Figure 4: CCU Trained

4.1.6. Number of years worked in CCU (n=87)

In this study 33(38%) of the participants had worked in CCU for 5 years and above whilst 26(30%) had worked for 10 years and above, 15(17%) for less than two years and 13(15%) for 2-5 years, with a mean of 2.8 years, (see Figure 5 below).

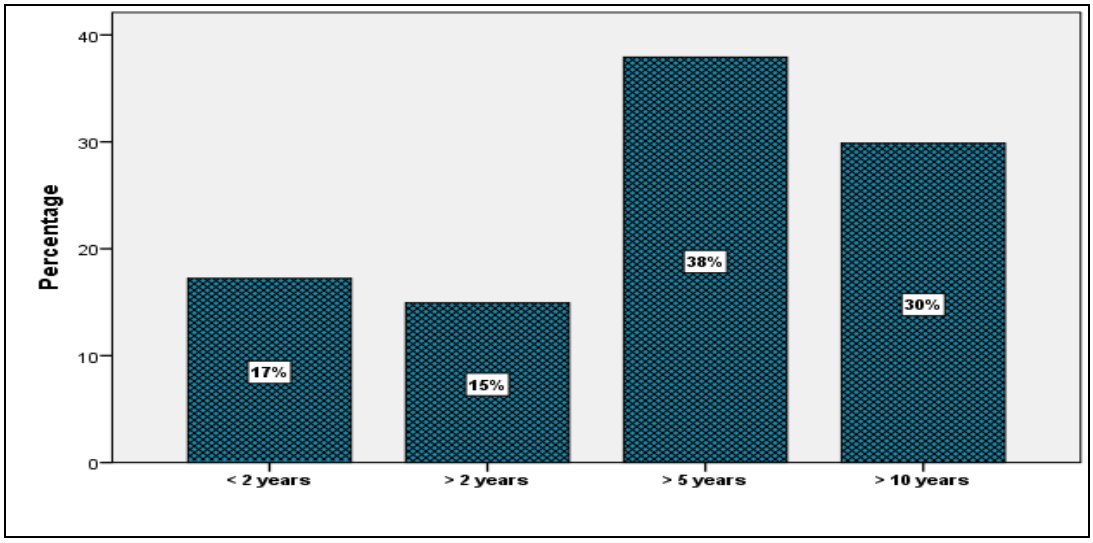


Figure 5: Number of years worked in CCU

4.1.7. Alarm management training

Of the respondents, 70(81.4%) reported that they had never undertaken training on alarm management and 16(18.6%) reported to have undertaken training in alarm management.

4.2. Alarms in the CCU (n=87)

4.2.1. Types of clinical alarms in the unit

Majority of the participants 71(81.6%) reported the alarms in the unit are both audio and visual alarms whilst 14(16.1%) and 2(2.3%) indicated that there were only audio alarms and visual alarms respectively, see Figure 6 below.

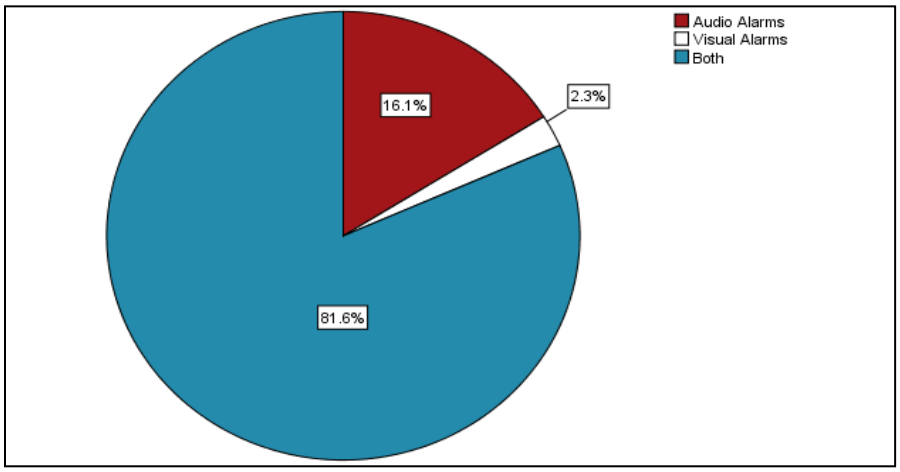


Figure 6: Types of Alarms in the unit

4.2.2. Audibility of clinical alarms in the unit (n=87)

Of the respondents, 83(95.4%) reported "Yes" the clinical alarms in the unit were audible enough while a few 4(4.6%) reported "No", they were not.

4.2.3. Nurses' ability to distinguish the different alarm sounds in the unit and determine the device sounding the alarm (n=87)

More than three quarters of the respondents 82(94.3%) reported "Yes" they were able to distinguish the different alarm sounds in the unit in relation to the device that is sounding the alarm while only 5(5.7%) reported "No" they were not able.

4.2.4. Reported level of reliability of the clinical alarms in the unit in determining the urgency of the patient's condition (n=87)

Majority of the nurses 77(88.5%) in the critical care unit reported that the clinical alarms in the unit are reliable in determining the urgency of the patient's condition and a few 10(11.5%) reported that the alarms are not reliable.

4.2.5. Reasons given as to why the clinical alarms are considered reliable or not in determining the patients' condition (n=87)

A total of 53 nurses answered this question and out of these 28(52.3%) reported that they considered the alarms to be reliable because alarms are classified according to color and sound hence one is able to detect the change in the patients' condition by looking at the color and listening to the sound of the alarms. The other 6 (11.3%) nurses who reported that the alarms are reliable indicated that the classification of alarms according to low, intermediate and high priority alarms enabled them to be able to assess the urgency of the patients' condition and 11 (20.8%) nurses reported that the alarms are reliable as they alert one when the patient is not hemodynamically stable.

One (1.9%) nurse reported that the alarms are reliable as power failure alarms or oxygen failure alarms are so distinct and one (1.9%) other nurse reported that alarms are reliable as the tone and frequency of the ring determines the urgency of the patients' condition.

Five nurses (9.4%) reported that the alarms are not reliable as follows:

- Alarm sound is the same, you can't distinguish any emergency,
- Because the alarms do not mention where the problem is and the magnitude,
- The alarms alarm even when there is no change in the patients' condition,
- Most of the time a number of the alarms are out of order, and

- Some alarms are default, you must check the patient physically, and sometimes alarms cheat.

4.2.6. Alarms that the nurses in the unit are more likely to respond to (n=87)

As presented in Figure 7 below, majority of the nurses 68(78.2%) in the critical care unit reported that they were more likely to respond to alarms of short duration, frequently occurring alarms, and rare alarms. A few 9(10.3%) reported that they were more likely to respond to rare alarms, 6(6.9%) alarms of short duration, 3(3.4%) frequently occurring alarms and1(1.1%) alarms of short duration and rare alarms.

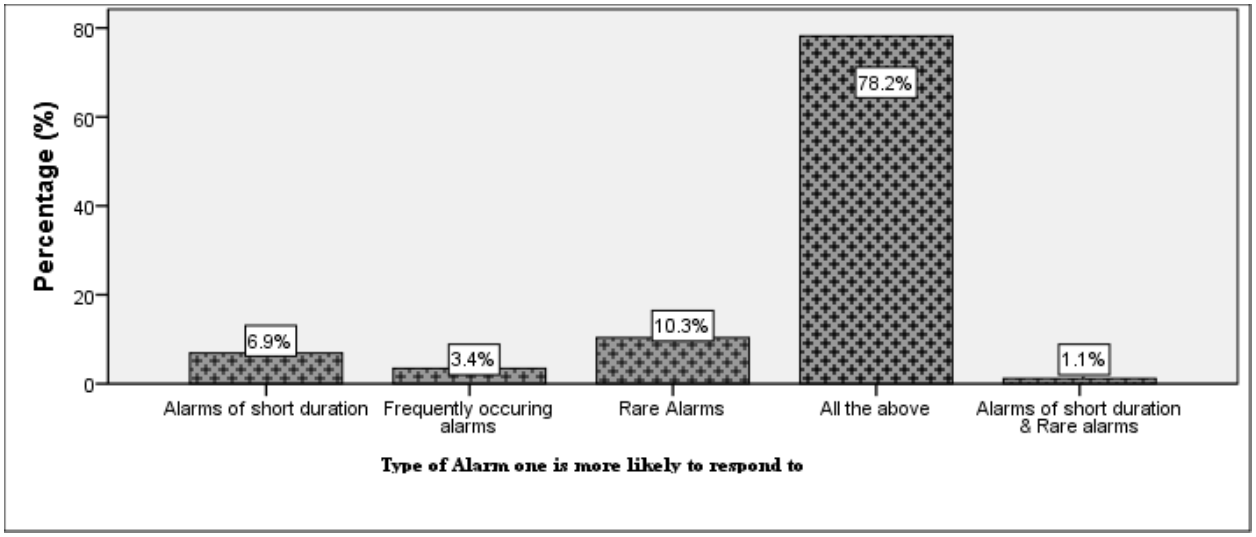


Figure 7: Alarms that Nurses are more likely to respond to

4.2.7. Parameters that Nurses commonly set alarm limits for in the unit (n=87)

According to most of the nurses in the unit, they commonly set alarm limits for the following parameters as illustrated in Table 4 below.

Table 4: Parameters that nurses commonly set alarm limits for

Variable	YES n (%)	NO n (%)
Pulse oximetry	83 (95.4%)	4 (4.6%)
Capnography	66 (75.9%)	21 (24.1%)
ECG	85 (97.7%)	2 (2.3%)
Non-invasive Blood pressure	82 (94.3 %)	5 (5.7%)
Respiratory rate	86 (98.9%)	1 (1.1%)
Saturation	87 (100%)	0

4.2.8. Number of respondents that fill alarm checklists and the frequency of filling alarm checklists

Most 71(81.6%) of the respondents did not fill alarm checklists while only 16(18.4%) reported filling alarm checklists (Table 5)

Table 5: Number that fill alarm checklists and how often

Variable	Frequency	Percentage (%)
How many fill in alarm checklists		
Yes	16	18.4%
No	71	81.6%
If they fill in alarm checklists, how often		
Daily	6	6.9%
At the start of the shift	6	6.9%
Occasionally	4	4.6%
During admission	-	-

4.2.9. Reasons given by the respondents as to why they do not fill alarm checklists

A total of 55 (100%) nurses answered this question and they reported that they don't fill alarm checklists because of the following reasons: no alarm checklists have been provided in the unit and there are no protocols stating that they have to fill alarm checklists. (Table 6)

Table 6: Reasons as to why the respondents do not fill alarm checklists

Reason	**Frequency**	**Percentage (%)**
1. No alarm checklists have been provided in the unit and there are no protocols stating that they have to fill alarm checklists Reasons: • The issue had not been highlighted in the unit • The checklists are out of stock • Monitors record the events of the alarms	3	5.5%
2. Other reasons as to why they do not fill alarm checklists • They do not have the nursing materials or paperwork • The amount of work in CCU is too much • The alarm trends are indicated in the monitor if need be for retrieving • Has not been considered or thought of in CCU • It is not the norm or practice • They occasionally fill when there is change in patients' condition • Heavy workload and staff shortage • No provision in the nursing charts • Not provided but I take necessary action • Nurses have not been taught the importance of maintaining alarm checklists • Shortage of monitors or mechanical ventilators and • There is no facilitation for alarm checklist filling.	52	94.5%

4.2.10. Parameters that commonly Set off alarms in the unit according to Nurses (n=87)

Out of the respondents 21(24%) reported that pulse oximetry, ECG and respiratory rate were the highest causes of alarms beeping in the unit and 17(20 %) pulse oximetry, capnography, ECG, Non-invasive blood pressure and respiratory rate (shown as all the above in figure 9). Pulse oximetry was thought to be the leading cause of alarm beep on its own by 17(20%) of the nurses.

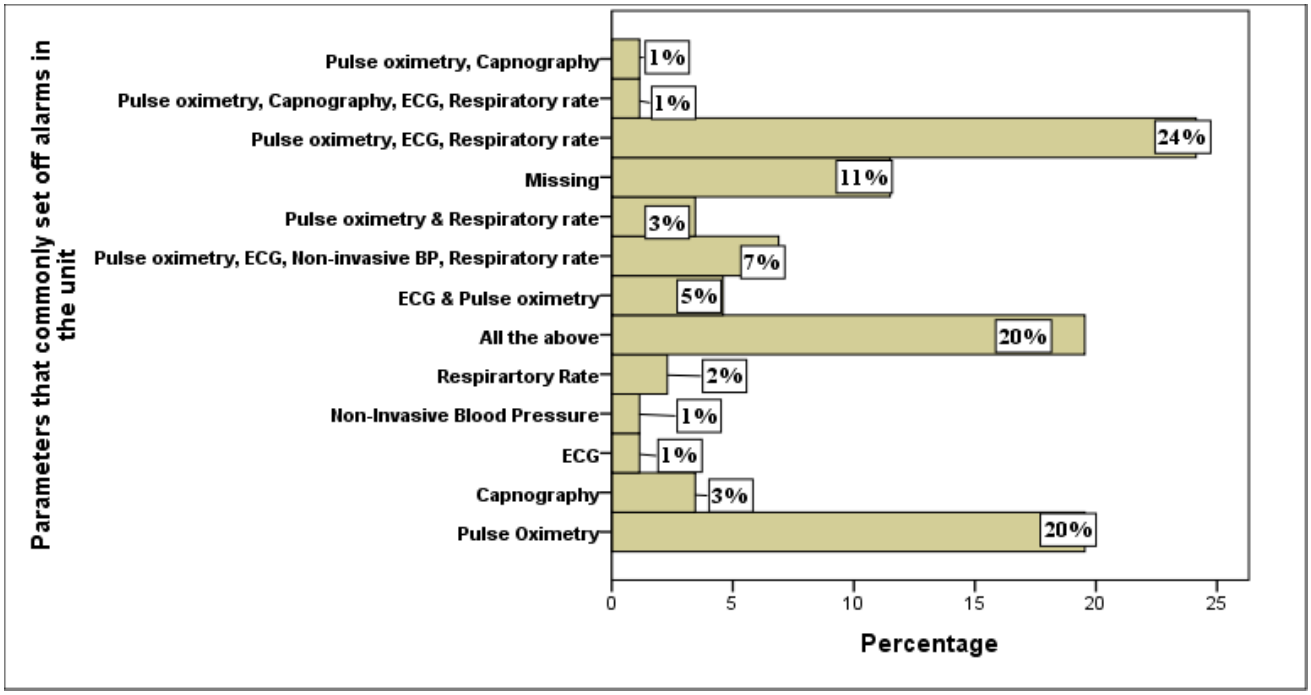


Figure 8: Parameters that commonly set off alarms in the unit

4.2.11. Common causes of alarm set off/beep in the unit according to Nurses

A large proportion of the respondents 54(62.1%) reported that mechanical errors were, 'Sometimes' the cause of alarm beep whilst 48(55.2%) indicated that change in patient condition is "Always" the cause of alarm beep, 37(42.5%) and 48(55.2%) of them reported that "Sometimes" poor setting of the alarm limits and "Sometimes" artifacts respectively, are the causes of the alarm beep displayed in Table 7 below

Table 7: Common causes of alarms to beep in the unit

Variable	Never n (%)	Sometimes n (%)	Often n (%)	Always n (%)
Mechanical errors	5(5.7%)	54 (62.1%)	12 (13.8%)	16 (18.4%)
Change in the patient's condition	1 (1.1%)	6 (6.9%)	32 (36.8%)	48 (55.2%)
Poor setting of the alarm limits	4 (4.6%)	37 (42.5%)	24 (27.6%)	22 (25.3%)
Artifacts	8 (9.2%)	48 (55.2%)	15 (17.2%)	16 (18.4%)

4.3. Nurses knowledge on clinical alarms

Table 8 below illustrates the percentage of how the nurses in the critical care unit scored in a series of questions on knowledge of alarms. There were a total of 7 questions of which the correct scores totaled 14 points. The sample of nurses tested was 87 (87×14) hence a total of 1218 points (100%). From the figures in table 9 below, the 87 nurses managed to score a total of 420 points (420 × 2= 840) hence 69% , that is 40／1218×100%). Therefore in this test the nurses in the unit scored an average of 69% in general.

Table 8: Frequency and percentage of the nurses' knowledge on clinical alarms

Nurses knowledge				
Variable	**True n (%)**	**False n (%)**	**Not sure n (%)**	**Correct Response n (%)**
Alarm sound can be relied on to determine alarm urgency in terms of patients change in condition	77 (88.5%)	8 (9.2%)	2 (2.3%)	True
When an alarm is reliable each time it signals, this is known as alarm specificity.	65 (74.7%)	12(13.8%)	10(11.5%)	True
High priority alarm indicates an urgent situation	82 (94.3%)	4 (4.6%)	1 (1.1%)	True
Medium priority alarm indicates a dangerous situation and a quick response from the medical staff is needed	47 (54%)	36(41.4%)	4 (4.6%)	True
A low priority alarm indicates an alert situation and the attention of the medical staff is needed	68 (78.2%)	14(16.1%)	5 (5.7%)	True
Skin preparation is not important in reducing false alarms	21(24.1%)	52(59.8%)	14 (16.1%)	False
Wiping the electrode with a rough washcloth or gauze and or using sandpaper on the electrode to roughen a small area of the skin prevents spurious signals and it also helps to remove part of the stratum corneum to allow the electrical signals to travel	29 (33.3%)	34(39.1%)	24 (27.6%)	True
Total Score	**420×2=840/1218×100= 69%**			

4.4. Nurses intervention/ actions in the management of clinical alarms

An average of 27.6 % of the nurses responded, "Never", to the nursing interventions in Table 9 below while 27.2% responded, "Sometimes", 18.8% "Often" and 38.8% responded "Always".

Table 9: Frequency and percentages of nurses' responses to alarms

Nurse's response to alarm				
Variable	**Never n (%)**	**Sometimes n (%)**	**Often n (%)**	**Always n (%)**
I ensure proper skin preparation of patients before placing electrodes	2 (2.3%)	27 (31%)	21(24.1%)	37(42.5%)
I change the patients' electrodes daily	5 (5.7%)	32 (36.8%)	27 (31%)	23(26.4%)
I assess the cause of the alarm beep when it alarms.	-	6 (6.9%)	14(16.1%)	67 (77%)
I disable the alarms every time they beep	42(48.3%)	27 (31%)	11(12.6%)	7 (8%)
I pause the alarms every time they beep	21 (23%)	45 (51.7%)	17(19.5%)	4 (4.6%)
I reset the alarm limits every time alarms beep	20 (23%)	48 (55.2%)	10(11.5%)	9 (10.3%)
I ignore alarms every time they beep	78(89.7%)	9 (10.3%)	-	-
I check and assess the patient's condition every time the alarm beeps	-	8 (9.2%)	18(20.7%)	61(70.1%)
I reset alarm settings of the machines each time I admit a new patient	1 (1.1%)	11 (12.6%)	13(14.9%)	62(71.3%)
Average Scores (%)	**27.6%**	**27.2%**	**18.8%**	**38.8%**

4.5. Nurses intervention in management of clinical alarms in relation to patients' outcome

An average of 14(16.1%) of the nurses responded, "Almost always" to the nursing interventions in relation to patient outcome in Table 10 below while 11(12.2%) responded, "Frequently", 29(32.9%) "Sometimes", 16(18%) "Occasionally", and 18(20.7%) "Hardly ever".

Of the respondents 35(40.2%) reported that their response to alarms "Always" improves the patient condition while 41(47.1%) reported that it "Hardly ever" improves the patient's condition and 45(51.7%) reported that often when they responded to an alarm the patient "Sometimes" required further attention by the anesthetist as shown in Table 10 below.

Table 10: Nurses interventions in relation to patient outcome

Variable	Almost always n (%)	Frequently n (%)	Sometimes n (%)	Occasionally n (%)	Hardly ever n (%)
My response to an alarm improves the patient's condition	35 (40.2%)	23 (26.4%)	22 (25.3%)	6 (6.9%)	1 (1.1%)
My response to an alarm does not improve the patient's condition	5 (5.7%)	3 (3.4%)	19 (21.8%)	19 (21.8%)	41 (47.1%)
Often when I respond to the alarm the patient needs further attention by the anesthetist	2 (2.3%)	6 (6.9%)	45 (51.7%)	22 (25.3%)	12 (13.8%)
Average Scores (%)	**14(16.1%)**	**11(12.2%)**	**29(32.9%)**	**16(18%)**	**18(20.7%)**

4.6. Association of Socio Demographic Characteristics of respondents and Knowledge of Clinical Alarms

4.6.1. Association of socio demographic characteristics and responses to "alarm sound can be relied on to determine alarm urgency in terms of patients change in condition"

There was no statistically significant association between the variables.

Table 11: Association of socio demographic characteristics and alarm sound can be relied on to determine alarm urgency in terms of patients change in condition

Socio demographic variables	True n (%)	False n (%)	Not Sure n (%)	Correct response	Chi	df	p value	Cramer's V
Age in years					2.315	4	0.678	0.678
25-35	25 (92.6%)	2 (7.4%)	0 (0.0%)	True				
36-44	38 (86.4%)	4 (9.1%)	2(4.5%)					
45-55	14 (87.5%)	2(12.5%)	0 (0.0%)					
Gender					2.059	2	0.357	0.357
Male	24 (96%)	1 (4.0%)	0 (0.0%)					
Female	53 (85.5%)	7 (11.3%)	2 (3.2%)					
Professional qualification					1.304	6	0.971	0.971
KRCHN	68 (87.2%)	8 (10.3%)	2 (2.6%)					
BScN	7 (100%)	0 (0.0%)	0 (0.0%)					
MScN	1 (100%)	0 (0.0%)	0 (0.0%)					
KRN								
Years worked as a Nurse					5.376	6	0.497	0.497
Below 2 years	2 (66.7%)	1 (33.3%)	0 (0.0%)					
Above2 years	2 (100%)	0 (0.0%)	0 (0.0%)					
Above 5 years	19 (100%)	0 (0.0%)	0 (0.0%)					
Above 10 years	54 (85.7%)	7 (11.1%)	2 (3.2%)					
Years worked in CCU					8.891	6	0.180	0.180
Below 2 years	14 (93.3%)	1 (6.7%)	0 (0.0%)					
Above2 years	11 (84.6%)	1 (7.7%)	1 (7.7%)					
Above 5 years	26 (78.8%)	6 (18.2%)	1 (3%)					
Above 10 years	26 (100%)	0 (0.0%)	0 (0.0%)					
CCN Trained					4.787	2	0.091	0.091
Yes	70 (90.9%)	6 (7.8%)	1 (1.3%)					
No	7 (70%)	2 (20%)	1 (10%)					
Alarm management trained					2.456	2	0.293	0.293
Yes	13 (81.2%)	3 (18.8%)	0 (0.0%)					
No	63 (90%)	5 (7.1%)	2 (2.9%)					

4.6.2. Association of Socio demographic characteristics and responses to the question:

"When an alarm is reliable each time it signals, this is known as alarm specificity"

There was no statistically significant association between the variables.

Table 12: Association of socio demographic characteristics and the question: when an alarm is reliable each time it signals, this is known as alarm specificity

Socio demographic variables	True n (%)	False n (%)	Not Sure n (%)	Correct response	Chi	df	p value	Cramer's V
Age in years					1.097	4	0.895	0.895
25-35	21 (77.8%)	3 (11.1%)	3 (11.1%)	True				
36-44	31 (70.5%)	7 (15.9%)	6 (13.6%)					
45-55	13 (81.2%)	2 (12.5%)	1 (6.2%)					
Gender					1.199	2	0.549	0.549
Male	17 (68%)	5 (20%)	3 (11.3%)					
Female	48 (77.4%)	7 (11.3%)	7 (11.3%)					
Professional qualification					10.579	6	0.102	0.102
KRCHN	57 (73.1%)	12 (15.4%)	9 (11.5%)					
BScN	7 (100%)	0 (0.0%)	0 (0.0%)					
MScN	0 (0.0%)	0 (0.0%)	1 (100%)					
KRN	1 (100%)	0 (0.0%)	0 (0.0%)					
Years worked as a Nurse					5.436	6	0.489	0.489
Below 2 years	3 (100%)	0 (0.0%)	0 (0.0%)					
Above2 years	1 (50%)	1 (50%)	0 (0.0%)					
Above 5 years	14 (73.7%)	4 (21.1%)	1 (5.3%)					
Above 10 years	47 (74.6%)	7 (11.1%)	9 (14.3%)					
Years worked in CCU					6.682	6	0.351	0.351
Below 2 years	13 (86.7%)	0 (0.0%)	2 (13.3%)					
Above2 years	7 (53.8%)	3 (23.1%)	3 (23.1%)					
Above 5 years	24 (72.7%)	6 (18.2%)	3 (9.1%)					
Above 10 years	21 (80.8%)	3 (11.5%)	2 (7.7%)					
CCN Trained					0.863	2	0.650	0.650
Yes	58 (75.3%)	11 (14.3%)	8 (10.4%)					
No	7 (70%)	1 (10%)	2 (20%)					
Alarm management trained					2.293	2	0.318	0.318
Yes	11 (68.8%)	4 (25%)	1 (6.2%)					
No	53 (75.7%)	8 (11.4%)	9 (12.9%)					

4.6.3. Association of Socio demographic characteristics and the responses to the question: "High priority alarm indicates an urgent situation

There was no statistically significant association between the variables.

Table 13: Association of socio demographic characteristics and high priority alarm indicates an urgent situation

Socio demographic variables	True n (%)	False n (%)	Not Sure n (%)	Correct response	Chi	df	p value	Cramer's V
Age in years					5.184	4	0.269	0.269
25-35	27 (100%)	0 (0.0%)	0 (0.0%)	True				
36-44	31 (70.5%)	7 (15.9%)	6 (13.6%)					
45-55	16 (100%)	0 (0.0%)	0 (0.0%)					
Gender					3.509	2	0.173	0.173
Male	22 (88%)	2 (8%)	1 (4%)					
Female	60 (96.8%)	2 (3.2%)	0 (0.0%)					
Professional qualification					1.796	6	0.937	0.937
KRCHN	74 (94.9%)	3 (3.8%)	1 (1.3%)					
BScN	6 (85.6%)	1 (14.3%)	0 (0.0%)					
MScN	1 (100%)	0 (0.0%)	0 (0.0%)					
KRN	1 (100%)	0 (0.0%)	0 (0.0%)					
Years worked as a Nurse					3.901	6	0.690	0.690
Below 2 years	3 (100%)	0 (0.0%)	0 (0.0%)					
Above2 years	2 (100%)	0 (0.0%)	0 (0.0%)					
Above 5 years	17 (89.5%)	1 (5.3%)	1 (5.3%)					
Above 10 years	60 (59.4%)	3 (4.8%)	0 (0.0%)					
Years worked in CCU					10.465	6	0.106	0.106
Below 2 years	13 (86.7%)	2 (2.3%)	0 (0.0%)					
Above2 years	11 (84.6%)	2 (2.3%)	0 (0.0%)					
Above 5 years	32 (97%)	0 (0.0%)	1 (3%)					
Above 10 years	26 (100%)	0 (0.0%)	0 (0.0%)					
CCN Trained					0.689	2	0.709	0.709
Yes	72 (93.5%)	4 (5.2%)	1 (1.3%)					
No	10 (100%)	0 (0.0%)	0 (0.0%)					
Alarm management trained					1.213	2	0.545	0.545
Yes	16 (100%)	0 (0.0%)	0 (0.0%)					
No	65 (92.9%)	4 (5.7%)	1 (1.4%)					

4.6.4. Association of Socio demographic characteristics and the responses to the question: "Medium priority alarm indicates a dangerous situation and a quick response from the medical staff is needed"

There was no statistically significant association between the variables.

Table 14 Association of socio demographic characteristics and medium priority alarm indicates a dangerous situation and a quick response from the medical staff is needed

Socio demographic variables	True n (%)	False n (%)	Not Sure n (%)	Correct response	Chi	df	p value	Cramer's V
Age in years					4.249	4	0.373	0.373
25-35	13 (48.1%)	13 (48.1%)	1 (3.7%)	True				
36-44	27 (61.4%)	16 (36.4%)	1 (2.3%)					
45-55	7 (43.8%)	7 (43.8%)	2 (12.5%)					
Gender					3.116	2	0.211	0.211
Male	10 (40%)	13 (52%)	2 (8%)					
Female	37 (59.7%)	23 (37.1%)	2 (3.2%)					
Professional qualification					2.656	6	0.851	0.851
KRCHN	42 (48.3%)	32 (41%)	4 (5.1%)					
BScN	4 (57.1%)	3 (42.9%)	0 (0.0%)					
MScN	0 (0.0%)	1 (100%)	0 (0.0%)					
KRN	1 (100%)	0 (0.0%)	0 (0.0%)					
Years worked as a Nurse					4.051	6	0.670	0.670
Below 2 years	2 (66.7%)	1 (33.3%)	0 (0.0%)					
Above2 years	2 (100%)	0 (0.0%)	0 (0.0%)					
Above 5 years	9 (47.4%)	10 (52.6%)	0 (0.0%)					
Above 10 years	34 (54%)	25 (39.7%)	4 (6.3%)					
Years worked in CCU					4.771	6	0.574	0.574
Below 2 years	9 (60%)	6 (40%)	0 (0.0%)					
Above2 years	8 (61.5%)	5 (38.5%)	0 (0.0%)					
Above 5 years	18 (54.5%)	14 (42.4%)	1 (3%)					
Above 10 years	12 (46.2%)	11 (42.3%0	3 (11.5%)					
CCN Trained					0.756	2	0.685	0.685
Yes	42 (54.5%)	32 (41.6%)	3 (3.9%)					
No	5 (5%)	4 (40%)	1 (10%)					
Alarm management trained					2.299	2	0.317	0.317
Yes	11 (68.8%)	5 (31.2%)	0 (0.0%)					
No	35 (50%)	31 (44.3%)	4 (5.7%)					

4.6.5. Association of Socio demographic characteristics and the responses to the question: "A low priority alarm indicates an alert situation and the attention of the medical staff is needed"

There was no statistically significant association between the variables.

Table 15: Association of socio-demographic characteristics and the question: "A low priority alarm indicates an alert situation and the attention of the medical staff is needed

Socio demographic variables	True n (%)	False n (%)	Not Sure n (%)	Correct response	Chi	df	p value	Cramer's V
Age in years					2.815	4	0.589	0.589
25-35	19 (70.4%)	5 (18.5%)	3 (11.1%)	True				
36-44	36 (81.8%)	7 (15.9%)	1 (2.3%)					
45-55	13 (81.2%)	2 (12.5%)	1 (6.2%)					
Gender					4.650	2	0.098	0.098
Male	16 (64%)	6 (24%)	3 (12%)					
Female	52 (83.9%)	8 (12.9%)	2 (3.2%)					
Professional qualification					1.763	6	0.940	0.940
KRCHN	61 (78.2%)	12 (15.4%)	5 (6.4%)					
BScN	5 (71.4%)	2 (28.6%)	0 (0.0%)					
MScN	1 (100%)	0 (0.0%)	0 (0.0%)					
KRN								
Years worked as a Nurse					6.359	6	0.384	0.384
Below 2 years	3 (100%)	0 (0.0%)	0 (0.0%)					
Above2 years	2 (100%)	0 (0.0%)	0 (0.0%)					
Above 5 years	12 (63.2%)	4 (21.1%)	3 (15.8%)					
Above 10 years	51 (81%)	10 (15.9%)	2 (3.2%)					
Years worked in CCU					3.139	6	0.791	0.791
Below 2 years	11 (73.3%)	3 (20%)	1 (6.7%)					
Above2 years	9 (69.2%)	2 (15.4%)	2 (15.4%)					
Above 5 years	27 (81.8%)	5 (15.2%)	1 (3%)					
Above 10 years	21 (80.8%)	4 (15.4%)	1 (3.8%0					
CCN Trained					1.113	2	0.573	0.573
Yes	59 (76.6%)	13 (16.9%)	5 (6.5%)					
No	9 (90%)	1 (10%)	0 (0.0%)					
Alarm management trained					1.548	2	0.461	0.461
Yes	14 (87.5%)	2 (12.5%)	0 (0.0%)					
No	53 (75.7%)	12 (17.1%)	5 (7.1%)					

4.6.6. Association of Socio demographic characteristics and the responses to the question: "Skin preparation is not important in reducing false alarms"

There was no statistically significant association between the variables.

Table 16: Association of socio demographic characteristics and skin preparation is not important in reducing false alarms

Socio demographic variables	True n (%)	False n (%)	Not Sure n (%)	Correct response	Chi	df	p value	Cramer's V
Age in years					8.292	4	0.081	0.081
25-35	8 (29.6%))	18 (66.7%)	1 (3.7%)	False				
36-44	7 (15.9%))	28 (63.6%)	9 (20.5%)					
45-55	6 (37.5%)	6 (37.5%)	4 (25%)					
Gender					1.749	2	0.417	0.417
Male	7 (28%)	16 (64%)	2 (8%)					
Female	14 (22.6%)	36 (58.1%)	12 (19.4%)					
Professional qualification					3.930	6	0.686	0.686
KRCHN	20 (25.6%)	44 (56.4%)	14 (17.9%)					
BScN	1 (14.3%)	6 (85.7%)	0 (0.0%)					
MScN	0 (0.0%)	1 (100%)	0 (0.0%)					
KRN	0 (0.0%)	1 (100%)	0 (0.0%)					
Years worked as a Nurse					8.638	6	0.195	0.195
Below 2 years	0 (0.0%)	3 (100%)	0 (0.0%)					
Above2 years	0 (0.0%)	2 (100%)	0 (0.0%)					
Above 5 years	3 (15.8%)	15 (78.9%)	1 (5.3%)					
Above 10 years	21 (24.1%)	52 (59.8%)	14 (16.1%)					
Years worked in CCU					12.550	6	0.051	0.051
Below 2 years	3 (20%)	12 (80%)	0 (0.0%)					
Above2 years	2 (15.4%)	9 (69.2%)	2 (15.4%)					
Above 5 years	5 (15.2%)	19 (57.6%)	9 (27.3%)					
Above 10 years	11 (42.3%)	12 (46.2%)	3 (11.5%)					
CCN Trained					1.619	2	0.445	0.445
Yes	19 (24.7%)	47 (61%)	11 (14.3%)					
No	2 (20%)	5 (50%)	3 (30%)					
Alarm management trained					1.837	2	0.399	0.399
Yes	6 (37.5%)	8 (50%)	2 (12.5%)					
No	15 (21.4%)	43 (61.4%)	12 (17.1%)					

4.6.7. Association of Socio demographic characteristics and the responses to the question: "Wiping electrodes with a rough washcloth or gauze and or using sandpaper on the electrode prevents spurious signals and helps to remove part of the stratum corneum allowing electrical signals to travel"

The study showed that there was a statistically significant association between the response of the question and the years the nurses worked in CCU (p=0.049) but there was no statistical significance between the other socio demographic variables and response to the question.

Table 17: Association of socio demographic characteristics and the question: wiping electrodes with a rough washcloth prevents spurious signals

Socio demographic variables	True n (%)	False n (%)	Not Sure n (%)	Correct response	Chi	df	p value	Cramer's V
Age in years					1.449	4	0.836	0.836
25-35	8 (29.6%)	10 (37%)	9 (33.3%)	True				
36-44	15 (34.1%)	19 (43.2%)	10 (22.7%)					
45-55	6 (37.5%)	5 (31.2%)	5 (31.2%)					
Gender					3.838	2	0.147	0.147
Male	5 (20%)	10 (40%)	10 (40%)					
Female	24 (38.7%)	24 (38.7%)	14 (22.6%)					
Professional qualification					7.064	6	0.315	0.315
KRCHN	26 (33.3%)	29 (37.2%)	23 (29.5%)					
BScN	3 (42.9%)	4 (57.1%)	0 (0.0%)					
MScN	0 (0.0%)	0 (0.0%)	1 (100%)					
KRN	0 (0.0%)	0 (0.0%)	1 (100%)					
Years worked as a Nurse					5.160	6	0.523	0.523
Below 2 years	2 (66.7%)	1 (33.3%)	0 (0.0%)					
Above2 years	0 (0.0%)	2 (100%)	0 (0.0%)					
Above 5 years	6 (31.6%)	7 (36.8%)	6 (31.6%)					
Above 10 years	21 (33.3%)	24 (38.1%)	18 (28.6%)					
Years worked in CCU					**12.654**	**6**	**0.049**	**0.049**
Below 2 years	6 (40%)	8 (53.3%)	1 (6.7%)					
Above2 years	1 (7.7%)	6 (46.2%)	6 (46.2%)					
Above 5 years	16 (48.5%)	9 (27.3%)	8 (24.2%)					
Above 10 years	6 (23.1%)	11 (42.3%)	9 (34.6%)					
CCU Trained					1.416	2	0.493	0.493
Yes	24 (31.2%)	31 (40.3%)	22 (28.6%)					
No	5 (50%)	3 (30%)	2 (20%)					
Alarm management trained					2.407	2	0.300	0.300
Yes	7 (43.8%)	7 (43.8%)	2 (12.5%)					
No	22 (31.4%)	26 (37.1%)	22 (31.4%)					

4.7. Association of Socio demographic characteristics of nurses and Nurses' Interventions/Actions in the Management of clinical alarms

4.7.1. Association of Socio demographic characteristics and the responses of nurses to the action: "I ensure proper skin preparation of patients before placing electrodes".

There was no statistically significant association between the variables.

Table 18: Association of socio demographic characteristics and the nurses' action: I ensure proper skin preparation of patients before placing electrodes

Socio demographic variables	Never	Sometimes	Often	Always	Chi	df	P Value	Cramer's V
Age in years					11.369	6	0.078	0.078
25-35	0 (0.0%)	11 (40.7%)	7 (25.9%)	9 (33.3%)				
36-44	0 (0.0%)	12 (27.3%)	10 (22.7%)	22 (50%)				
45-55	2 (12.5%)	4 (25%)	4 (25%)	6 (37.5%)				
Gender					3.621	3	0.305	0.305
Male	0 (0.0%)	11 (44%)	6 (24%)	8 (32%)				
Female	2 (3.2%)	16 (25.8%)	15 (24.2%)	29 (46.8%)				
Professional qualification					7.423	9	0.593	0.593
KRCHN	2 (2.6%)	25 (32.1%)	17 (21.8%)	34 (43.6%)				
BScN	0 (0.0%)	1 (14.3%)	3 (42.9%)	3 (42.9%)				
MScN	0 (0.0%)	1 (100%)	0 (0.00%)	0 (0.00%)				
KRN	0 (0.00%)	0 (0.00%)	1 (100%)	0 (0.00%)				
Years worked as a Nurse					6.070	9	0.733	0.733
Below 2 years	0 (0.0%)	2 (66.7%)	0 (0.0%)	1 (33.3%)				
Above2 years	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100%)				
Above 5 years	0 (0.0%)	7 (36.8%)	4 (21.1%)	8 (42.1%)				
Above 10 years	2 (3.2%)	18 (28.6%)	17 (27%)	26 (41.3%)				
Years worked in CCU					8.822	9	0.454	0.454
Below 2 years	1 (6.7%)	6 (40%)	1 (6.7%)	7 (46.7%)				
Above2 years	0 (0.0%)	2 (15.4%)	5 (38.5%)	6 (46.2%)				
Above 5 years	0 (0.0%)	13 (39.4%)	8 (24.2%)	12 (36.4%)				
Above 10 years	1 (3.8%)	6 (23.1%)	7 (26.9%)	12 (46.2%)				
CCU Trained					1.898	3	0.594	0.594
Yes	2 (2.6%)	25 (32.5%)	17 (22.1%)	33 (42.9%)				
No	0 (0.0%)	2 (20%)	4 (40%)	4 (40%)				
Alarm management trained					3.857	3	0.277	0.277
Yes	0 (0.0%)	4 (25%)	2 (12.5%)	10(62.5%)				
No	2 (2.9%)	23 (32.9%)	19 (27.1%)	26 (37.1%)				

4.7.2. Association of Socio demographic characteristics and the action of the nurses: "I change the patient's electrodes daily"

The study showed that there was a statistically significant association between the response of the question and gender (p=0.028) but there was no statistical significance between the other socio demographic variables and response to the question.

Table 19: Association of socio demographic characteristics and the nurses' action: I change the patient's electrodes daily

Socio demographic variables	Never	Sometimes	Often	Always	Chi	Df	P Value	Cramer's V
Age in years					4.344	6	0.630	0.630
25-35	1 (3.7%)	11 (40.7%)	9 (33.3%)	6 (22.2%)				
36-44	2 (4.5%)	18 (40.9%)	13 (29.5%)	11 (25%)				
45-55	2(12.5%)	3 (18.8%)	5 (31.2%)	6 (37.5%)				
Gender					9.099	3	0.028	0.028
Male	2 (8%)	12 (48%)	10 (40%)	1 (4.0%)				
Female	3 (4.8%)	20 (32.3%)	17 (27.4%)	22(35.5%)				
Professional qualification					7.907	9	0.544	0.544
KRCHN	5 (6.4%)	25 (32.1%)	26 (33.3%)	22(28.2%)				
BScN	0 (0.0%)	5 (71.4%)	1 (14.3%)	1 (14.3%)				
MScN	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)				
KRN	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)				
Years worked as a Nurse					8.410	9	0.493	0.493
Below 2 years	0 (0.0%)	2 (66.7%)	1 (33.3%)	0 (0.0%)				
Above2 years	0 (0.0%)	0 (0.0%)	2 (100%)	0 (0.0%)				
Above 5 years	0 (0.0%)	7 (36.8%)	7 (36.8%)	5 (26.3%)				
Above 10 years	5 (7.9%)	23 (36.5%)	17 (27%)	18(28.6%)				
Years worked in CCU					6.499	9	0.689	0.689
Below 2 years	1 (6.7%)	8 (53.3%)	3 (20%)	3 (20%)				
Above2 years	0 (0.0%)	6 (46.2%)	5 (38.5%)	2 (15.4%)				
Above 5 years	2 (6.1%)	8 (24.2%)	12 (36.4%)	11(33.3%)				
Above 10 years	2 (7.7%)	10 (38.5%)	7 (26.9%)	7 (26.9%)				
CCU Trained					2.277	3	0.517	0.517
Yes	5 (6.5%)	29 (37.7%)	22 (28.6%)	21(27.3%)				
No	0 (0.0%)	3 (30%)	5 (50%)	2 (20%)				
Alarm management trained					5.133	3	0.162	0.162
Yes	0 (0.0%)	3 (18.8%)	6 (37.5%)	7 (43.8%)				
No	5 (7.1%)	28 (40%)	21 (30%)	16(22.9%)				

4.7.3. Association of Socio demographic characteristics and the nurses' action: "I assess the cause of the alarm beep when it alarms"

The study showed that there was a statistically significant association between the response to the question and the age in years of the nurses (p=0.006) but there was no statistically significant association between the other socio demographic variables and response to the question.

Table 20: Association of socio demographic characteristics and the action: I assess the cause of the alarm beep when it alarms

Socio demographic variables	Never	Sometimes	Often	Always	Chi	df	P Value	Cramer's V
Age in years					14.415	4	0.006	0.006
25-35		2 (7.4%)	7 (25.9%)	18 (66.7%)				
36-44		0 (0.0%)	6 (13.6%)	38 (86.4%)				
45-55		4 (25%)	1 (6.2%)	11 (66.8%)				
Gender					3.888	2	0.143	0.143
Male		1 (4%)	7 (28%)	17 (68%)				
Female		5 (8.1%)	7 (11.3%)	50 (47.7%)				
Professional qualification					6.979	6	0.323	0.323
KRCHN		6 (7.7%)	11 (14.1%)	61 (78.2%)				
BScN		0 (0.0%)	2 (28.6%)	5 (71.4%)				
MScN		0 (0.0%)	1 (100%)	0 (0.0%)				
KRN		0 (0.0%)	0 (0.0%)	1 (100%)				
Years worked as a Nurse					6.965	6	0.324	0.324
Below 2 years		1 (33.3%)	0 (0.0%)	2 (66.7%)				
Above2 years		0 (0.0%)	0 (0.0%)	2 (100%)				
Above 5 years		0 (0.0%)	5 (26.3%)	14 (73.7%)				
Above 10 years		5 (7.9%)	9 (14.3%)	49 (77.8%)				
Years worked in CCU					2.082	6	0.912	0.912
Below 2 years		2 (13.3%)	2 (13.3%)	11 (73.3%)				
Above2 years		1 (7.7%)	2 (15.4%)	10 (76.9%)				
Above 5 years		1 (3%)	5 (15.2%)	27 (25.4%)				
Above 10 years		2 (7.7%)	5 (19.2%)	19 (73.1%)				
CCU Trained					2.223	2	0.329	0.329
Yes		5 (6.5%)	14 (18.2%)	58 (75.3%)				
No		1 (10%)	0 (0.0%)	9 (90%)				
Alarm management trained					5.957	2	0.051	0.051
Yes		0 (0.0%)	0 (0.0%)	16 (100%)				
No		6 (8.6%)	14 (20%)	50 (71.4%)				

4.7.4. Association of Socio demographic characteristics and the nurses' action: "I disable the alarms every time they beep"

There was no statistically significant association between the variables.

Table 21: Association of socio demographic characteristics and the action: I disable the alarms every time they beep

Socio demographic variables	Never	Sometimes	Often	Always	Chi	df	P Value	Cramer's V
Age in years					3.198	6	0.784	0.784
25-35	14 (51.9%)	7 (25.9%)	5 (18.5%)	1 (3.7%)				
36-44	22 (50%)	14 (31.8%)	4 (9.1%)	4 (9.1%)				
45-55	6 (37.5%)	6 (37.5%)	2 (12.5%)	2 (12.5%)				
Gender					2.996	3	0.392	0.392
Male	10 (40%)	11 (44%)	2 (8%)	2 (8%)				
Female	32 (51.6%)	16 (25.8%)	9 (14.5%)	5 (8.1%)				
Professional qualification					8.411	9	0.493	0.493
KRCHN	39 (50%)	22 (28.2%)	10 (12.8%)	7 (9%)				
BScN	0 (0.0%)	1 (14.3%)	5 (71.4%)	1 (14.3%)				
MScN	1 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)				
KRN	1 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)				
Years worked as a Nurse					6.494	9	0.690	0.690
Below 2 years	2 (66.7%)	0 (0.0%)	1 (33.3%)	0 (0.0%)				
Above2 years	1 (50%)	0 (0.0%)	1 (50%0	0 (0.0%)				
Above 5 years	9 (47.4%)	6 (31.6%)	3 (15.8%)	1 (5.3%)				
Above 10 years	30 (47.6%)	21 (33.3%)	6 (9.5%)	6 (9.5%)				
Years worked in CCU					9.098	9	0.428	0.428
Below 2 years	4 (26.7%)	6 (40%)	4 (26.7%)	1 (6.7%)				
Above2 years	6 (46.2%)	5 (38.5%)	2 (15.4%)	0 (0.0%)				
Above 5 years	16 (48.5%)	9 (27.3%)	4 (12.1%)	4 (12.1%)				
Above 10 years	16 (61.5%)	7 (26.9%)	1 (3.8%)	2 (7.7%)				
CCN Trained					0.701	3	0.873	0.873
Yes	38 (49.4%)	24 (31.2%)	9 (11.7%)	6 (7.8%)				
No	4 (40%)	3 (30%)	2 (20%)	1 (10%)				
Alarm management trained					3.024	3	0.388	0.388
Yes	10 (62.5%)	3 (18.8%)	1 (6.2%)	2 (12.5%)				
No	31 (44.3%)	24 (34.3%)	10 (14.3%)	5 (7.1%)				

4.7.5. Association of socio demographic characteristics and the action: "I pause the alarms every time they beep"

There was no statistically significant association between the variables.

Table 22: Association of Social demographic factors and the action: I pause the alarms every time they beep

Socio demographic variables	Never	Sometimes	Often	Always	Chi	Df	P Value	Cramer's V
Age in years					6.579	6	0.362	0.362
25-35	8 (29.6%)	15 (55.6%)	4 (14.8%)	0 (0.0%)				
36-44	11 (25%)	23 (52.3%)	7 (15.9%)	3 (6.8%)				
45-55	2 (12.5%)	7 (43.8%)	6 (37.5%)	1 (6.2%)				
Gender					3.871	3	0.276	0.276
Male	4 (16%)	12 (48%)	8 (32%)	1 (4%)				
Female	17(27.4%)	33 (53.2%)	9 (14.5%)	3 (4.8%)				
Professional qualification					8.045	9	0.530	0.530
KRCHN	20(25.6%)	38 (48.7%)	16 (20.5%)	4 (5.1%)				
BScN	0 (0.0%)	6 (85.7%)	1 (14.3%)	0 (0.0%)				
MScN	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)				
KRN	1 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)				
Years worked as a Nurse					8.528	9	0.482	0.482
Below 2 years	1 (33.3%)	1 (33.3%)	1 (33.3%)	0 (0.0%)				
Above2 years	0 (0.0%)	2 (100%)	0 (0.0%)	0 (0.0%)				
Above 5 years	3 (15.8%)	9 (47.4%)	7 (36.8%)	0 (0.0%)				
Above 10 years	17 (27%)	33 (52.4%)	9 (14.3%)	4 (6.3%)				
Years worked in CCU					11.988	9	0.214	0.214
< 2 years	3 (20%)	6 (40%0	4 (26.7%)	2 (13.3%)				
> 2 years	0 (0.00%)	10 (76.9%)	3 (23.1%)	0 (0.0%)				
>5 years	11(33.3%)	15 (45.5%)	5 (15.2%)	2 (6.1%)				
> 10 years	7 (26.9%)	14 (53.8%)	5 (19.2%)	0 (0.0%)				
CCU Trained					0.0805	3	0.848	0.848
Yes	19(24.7%)	40 (51.9%)	15 (19.5%)	3 (3.9%)				
No	2 (20%)	5 (50%)	2 (20%)	1 (10%)				
Alarm management trained					0.682	3	0.877	0.877
Yes	4 (25%)	7 (43.8%)	4 (25%)	1 (16%)				
No	16(22.9%)	38 (54.3%)	13 (18.6%)	3 (4.3%)				

4.7.6. Association of Socio demographic characteristics and the nurses' action: "I reset the alarm limits every time alarms beep"

There was no statistically significant association between the variables.

Table 23: Association of socio demographic characteristics and the action: I reset the alarm limits every time alarms beep

Socio demographic variables	Never	Sometimes	Often	Always	Chi	Df	P Value	Cramer's V
Age in years					1.386	6	0.967	0.967
25-35	5 (18.5%)	14 (51.9%)	4 (14.8%)	4 (14.8%)				
36-44	11 (25%)	24 (54.5%)	5 (11.4%)	4 (9.1%)				
45-55	4 (25%)	9 (56.2%)	2 (12.5%)	1 (6.2%)				
Gender					6.445	3	0.092	0.092
Male	10 (40%)	11 (44%)	3 (12%)	1 (4%)				
Female	10 (16.1%)	36 (58.1%)	8 (12.9%)	8 (12.9%)				
Professional qualification					11.183	9	0.263	0.263
KRCHN	19 (24.4%)	40 (51.3%)	10 (12.8%)	9 (11.5%)				
BScN	1 (14.3%	6 (85.7%)	0 (0.0%)	0 (0.0%)				
MScN	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)				
KRN	0 (0.0%)	0 (0.0%)	1 (100%0	0 (0.0%)				
Years worked as a Nurse					4.277	9	0.892	0.892
Below 2 years	1 (33.3%)	2 (66.7%)	0 (0.0%)	0 (0.0%)				
Above2 years	0 (0.0%)	2 (100%)	0 (0.0%)	0 (0.0%)				
Above 5 years	5 (26.3%)	11 (57.9%)	1 (5.3%)	2 (10.5%)				
Above 10 years	14 (22.2%)	32 (50.8%)	10 (15.9%)	7 (11.1%)				
Years worked in CCU					6.088	9	0.731	0.731
Below 2 years	6 (40%)	8 (53.3%)	0 (0.0%)	1 (6.7%)				
Above2 years	3 (23.1%)	7 (53.8%)	1 (7.7%)	2 (15.4%)				
Above 5 years	6 (18.2%)	18 (54.5%)	6 (18.2%)	3 (9.1%)				
Above 10 years	5 (19.2%)	14 (53.8%)	4 (15.4%)	3 (11.5%)				
CCN Trained					0.182	3	0.980	0.980
Yes	18 (23.4%)	41 (53.2%)	10 (13%)	8 (10.4%)				
No	2 (20%)	6 (60%)	1 (10%)	1 (10%)				
Alarm management trained					2.019	3	0.569	0.569
Yes	3 (18.8%)	11 (68.8%)	1 (6.2%)	1 (6.2%)				
No	17 (24.3%)	35 (50%)	10 (14.3%)	8 (11.4%)				

4.7.7. Association of Socio demographic characteristics and the action: "I ignore alarms every time they beep"

There was no statistically significant association between the variables.

Table 24: Association of socio demographic characteristics and the nurses' action: I ignore alarms every time they beep

Socio demographic variables	Never	Sometimes	Often	Always	Chi	df	P Value	Cramer's V
Age in years					3.731	4	0.444	0.444
25-35	24(88.9%)	2 (7.4%)		1 (3.7%)				
36-44	40(90.9%)	4 (9.1%)		0 (0.0%)				
45-55	13(81.2%)	3 (18.8%)		0 (0.0%)				
Gender					1.568	2	0.457	0.457
Male	21 (84%)	4 (16%)		0 (0.0%)				
Female	56(90.3%)	5 (8.1%)		1 (1.6%)				
Professional qualification					0.464	6	0.998	0.998
KRCHN	69(88.5%)	8 (10.3%)		1 (89.7%)				
BScN	6 (85.7%)	1 (14.3%)		0 (0.00%)				
MScN	1 (100%)			0 (0.0%)				
KRN	1 (100%)	0 (0.0%)		0 (0.0%)				
Years worked as a Nurse					12.207	6	0.058	0.058
Below 2 years	3 (100%)	0 (0.0%)		0 (0.0%)				
Above2 years	2 (100%)	0 (0.0%)		0 (0.0%)				
Above 5 years	13(64.8%)	6 (31.6%)		0 (0.0%)				
Above 10 years	59(93.7%)	3 (4.8%)		1 (1.6%)				
Years worked in CCU					11.116	6	0.085	0.085
Below 2 years	15 (100%)	0 (0.0%)		0 (0.0%)				
Above2 years	9 (69.2%)	4 (30.8%)		0 (0.0%)				
Above 5 years	29(87.9%)	4 (12.1%)		0 (0.0%)				
Above 10 years	24(92.3%)	1 (3.8%0		1 (3.8%)				
CCN Trained					0.134	2	0.935	0.935
Yes	68(88.3%)	8 (10.4%)		1 (1.3%)				
No	9 (90%)	1 (10%)		0 (0.0%)				
Alarm management trained					0.308	2	0.857	0.857
Yes	14(87.5%)	2 (12.5%)		0 (0.0%)				
No	62(88.6%)	7 (10%)		1 (1.4%)				

4.7.8. Association of Socio demographic characteristics and the responses of the nurses to the nurses' action: "I check and assess the patient's condition every time the alarm beeps"

There was no statistically significant association between the variables.

Table 25: Association of socio demographic characteristics and the nurses' responses to the action: I check and assess the patient's condition every time the alarm beeps

Socio demographic variables	Never	Sometimes	Often	Always	Chi	df	P Value	Cramer's V
Age in years					3.902	4	0.419	0.419
25-35		3 (11.1%)	7 (25.9%)	17 (63%)				
36-44		2 (4.5%)	8 (18.2%)	34 (77.3%)				
45-55		3 (18.8%)	3 (18.8%)	10 (62.5%)				
Gender					5.516	2	0.063	0.063
Male		1 (4%)	9 (36%)	15 (60%)				
Female		7 (11.3%)	9 (14.5%)	46 (74.2%)				
Professional qualification					5.390	6	0.495	0.495
KRCHN		8 (10.3%)	16 (20.5%)	54 (69.2%)				
BScN		0 (0.0%)	1 (14.3%)	6 (85.7%)				
MScN		0 (0.0%)	1 (100%)	0 (0.0%)				
KRN		0 (0.0%)	0 (0.0%)	1 (100%)				
Years worked as a Nurse					11.287	6	0.080	0.080
Below 2 years		0 (0.0%)	2 (66.7%)	1 (33.3%)				
Above2 years		1 (50%)	1 (50%)	0 (0.0%)				
Above 5 years		1 (5.3%)	5 (26.3%)	13 (68.4%)				
Above 10 years		6 (9.5%)	10 (15.9%)	47 (74.6%)				
Years worked in CCU					8.889	6	0.180	0.180
Below 2 years		1 (6.7%0	2 (13.3%)	12 (80%)				
Above2 years		1 (7.7%)	6 (46.2%)	6 (46.2%)				
Above 5 years		5 (15.2%)	6 (18.2%)	22 (66.7%)				
Above 10 years		1 (3.8%)	4 (15.4%)	21 (80.8%)				
CCN Trained					0.646	2	0.724	0.724
Yes		7 (9.1%)	15 (19.5%)	55 (71.4%)				
No								
Alarm management trained					2.080	2	0.354	0.354
Yes		3 (18.8%)	3 (18.8%)	10 (62.5%)				
No		5 (7.1%)	15 (21.4%)	50 (71.4%)				

4.7.9. Association of Socio demographic characteristics and the nurses' responses to the action: "I reset alarm settings of the machines each time I admit a patient"

The study showed that there was a statistically significant association between the responses to the question and if CCN trained (p=0.036) but there was no statistical significance between the other socio demographic variables and response to the question.

Table 26: Association of socio demographic characteristics and the nurses' responses to the action: I reset alarm settings of the machine each time I admit a patient

Socio demographic variables	Never	Sometimes	Often	Always	Chi	df	P Value	Cramer's V
Age in years					5.563	6	0.474	0.474
25-35	0 (0.0%)	1 (3.7%0	5 (18.5%)	21 (77.8%)				
36-44	1 (2.3%)	8 (18.2%)	7 (15.9%)	28 (63.6%)				
45-55	0 (0.0%)	2 (12.5%)	1 (6.2%)	13 (81.2%)				
Gender					5.264	3	0.153	0.153
Male	0 (0.0%)	2 (8%)	7 (28%)	16 (64%)				
Female	1 (1.6%)	9 (14.5%)	6 (9.7%)	46 (74.2%)				
Professional qualification					7.542	9	0.581	0.581
KRCHN	1 (1.3%)	10 (12.8%)	10 (12.8%)	57 (73.1%)				
BScN	0 (0.0%)	1 (14.3%)	2 (28.6%)	4 (57.1%)				
MScN	0 (0.0%)	0 (0.0%)	1 (100%)	0 (0.0%)				
KRN	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)				
Years worked as a Nurse					4.772	9	0.854	0.854
Below 2 years	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (100%)				
Above2 years	0 (0.0%)	1 (50%)	0 (0.0%)	1 (50%)				
Above 5 years	0 (0.0%)	2 (10.5%)	4 (21.1%)	13 (68.4%)				
Above 10 years	1 (1.6%)	8 (12.7%)	9 (14.3%)	45 (71.4%)				
Years worked in CCU					7.146	9	0.622	0.622
Below 2 years	1 (6.7%)	1 (6.7%)	2 (13.3%)	11 (73.3%)				
Above2 years	0 (0.0%)	3 (23.1%)	2 (15.4%)	8 (61.5%)				
Above 5 years	0 (0.0%)	4 (12.1%)	6 (18.2%)	23 (69.7%)				
Above 10 years	0 (0.0%)	3 (11.5%)	3 (11.5%)	20 (76.9%)				
CCN Trained					8.569	3	0.036	0.036
Yes	0 (0.0%)	9 (11.7%)	12 (15.6%)	56 (72.7%)				
No	1 (10%)	2 (20%)	1 (10%)	6 (60%)				
Alarm management trained					0.415	3	0.937	0.937
Yes	0 (0.0%)	2 (12.5%)	3 (18.8%)	11 (68.8%)				
No	1 (1.4%)	9 (12.9%)	10 (14.3%)	50 (71.4%)				

4.8. Association of Socio demographic characteristics of Nurses and Nurses' Interventions in the Management of Clinical Alarms in Relation to Patients' Outcome

4.8.1. Association of Socio demographic characteristics and the nurses' response: "My response to an alarm improves the patients' condition"

There was no statistically significant association between the variables.

Table 27: Association of socio demographic characteristics and the nurses' response: My response to an alarm improves the patients' condition

Socio demographic variables	Almost always	Frequently	Sometimes	Occasionally	Hardly ever	Chi	df	P Value	Cramer's V
Age in years						4.166	8	0.842	0.842
25-35	11 (40.7%)	6 (22.2%)	9 (33.3%)	1 (3.7%)	0 (0.0%)				
36-44	1 (2.3%)	4 (9.1%)	9 (20.5%)	11 (25%)	19 (43.2%)				
45-55	0 (0.0%)	1 (6.2%)	4 (25%)	6 (37.5%)	5 (31.2%)				
Gender						2.456	4	0.652	0.652
Male	8 (32%)	8 (32%)	8 (32%)	1(4%)	0 (0.0%)				
Female	27 (43.5%)	15 (24.2%)	14 (22.6%)	5 (8.1%)	1 (1.6%)				
Professional qualification						6.003	12	0.916	0.916
KRCHN	30 (38.5%)	21 (26.9%)	20 (25.6%)	6 (7.7%)	1 (1.3%)				
BScN	4 (57.1%)	2 (28.6%)	1 (14.3%)	0 (0.0%)	0 (0.0%)				
MScN	0 (0.0%)	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)				
KRN	1 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)				
Years worked as a Nurse						10.638	12	0.560	0.560
Below 2 years	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	2(66.7%)				
Above2 years	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100%)	0 (0.0%)				
Above 5 years	0 (0.0%)	0 (0.0%)	4 (21.1%)	5 (26.3%)	10 (52.6%)				
Above 10 years	1 (1.6%)	6 (9.5%)	17 (27%)	16 (25.4%)	23 (36.5%)				
Years worked in CCU						9.126	12	0.692	0.692
Below 2 years	8 (53.3%)	3 (20%)	4 (26.7%)	0 (0.0%)	0 (0.0%)				
Above2 years	4 (30.8%)	5 (38.5%)	4 (30.8%)	0 (0.0%)	0 (0.0%)				
Above 5 years	10 (30.3%)	10 (30.3%)	8 (24.2%)	4 (12.1%)	1 (3%)				
Above 10 years	13 (50%)	5 (19.2%)	6 (23.1%)	2 (7.7%)	0 (0.0%)				
CCN Trained						0.467	4	0.977	0.977
Yes	31 (40.3%)	20 (26%	20 (26%)	5 (6.5%)	1 (1.3%)				
No	4 (40.0%)	3 (30%)	2 (20%)	1 (10%)	0 (0.0%)				
Alarm management trained						0.942	4	0.918	0.918
Yes	8 (50%)	4 (25%)	3 (18.8%)	1 (6.3%0	0 (0.0%)				
No	27 (38.6%)	19 (27.1%)	18 (25.7%)	5 (7.1%)	1 (1.4%)				

4.8.2. Association of Socio demographic characteristics and the nurses' response: "My response to an alarm does not improve the patients' condition"

There was no statistically significant association between the variables.

Table 28: Association of socio demographic characteristics and the nurses' response: My response to an alarm does not improve the patients' condition

Socio demographic variables	Almost always	Frequently	Sometimes	Occasionally	Hardly ever	Chi	df	P Value	Cramer's V
Age in years						7.475	8	0.486	0.486
25-35	12 (44.4%)	6 (22.2%)	6 (22.2%)	0 (0.0)	3 (11.1%)				
36-44	21 (47.7%)	10 (22.7%)	10 (22.7%)	1 (2.3%)	2 (4.5%)				
45-55	7 (43.8%)	3 (18.8%)	4 (25%)	2 (12.5%)	0 (0.0%)				
Gender						2.906	4	0.574	0.574
Male	12 (48%)	7 (28%)	4 (16%)	0 (0.0%)	2 (8%)				
Female	28 (45.2%)	12 (19.4%)	16 (25.8%)	3 (4.8%)	3 (4.8%)				
Professional qualification						9.609	12	0.650	0.650
KRCHN	37 (47.4%)	15 (19.2%)	18 (23.1%)	3 (3.8%)	5 (6.4%)				
BScN	3 (42.9%)	3 (42.9%)	1 (14.3%)	0 (0.0%)	0 (0.0%)				
MScN	0 (0.0%)	1(100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)				
KRN	0 (0.0%)	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)				
Years worked as a Nurse						9.083	12	0.696	0.696
Below 2 years	2 (66.7%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	0 (0.0%)				
Above2 years	1 (50%)	0 (0.0%)	1 (50%)	0 (0.0%)	0 (0.0%)				
Above 5 years	12 (63.2%)	2 (10.5%)	5 (26.3%)	0 (0.0%)	0 (0.0%)				
Above 10 years	25 (39.7%)	17 (27%)	13 (20.6%)	3 (4.8%)	5 (7.9%)				
Years worked in CCU						13.111	12	0.361	0.361
Below 2 years	8 (53.3%)	2 (13.3%)	3 (20%)	1 (6.7%)	1 (6.7%)				
Above2 years	9 (69.2%)	2 (15.4%)	0 (0.0%)	1 (7.7%)	1 (7.7%)				
Above 5 years	14 (42.4%)	7 (21.2%)	8 (24.2%)	1 (3%)	3 (9.1%)				
Above 10 years	9 (34.6%)	8 (30.8%)	9 (34.6%)	0 (0.0%)	0 (0.0%)				
CCN Trained						3.800	4	0.434	0.434
Yes	34 (44.2%)	18 (23.4%)	19 (24.7%)	2 (2.6%)	4 (5.2%)				
No	6 (60%)	1 (10%)	1 (10%)	1 (10%)	1 (10%)				
Alarm management trained						0.918	4	0.922	0.922
Yes	8 (50%)	4 (25%)	3 (18.8%)	0 (0.0%)	1 (6.3%)				
No	32 (45.7%)	15 (21.4%)	16 (22.9%)	3 (4.3%)	4 (5.7%)				

4.8.3. Association of Socio demographic characteristics and the nurses' response: "Often when I respond to an alarm the patient needs further attention by the anesthetist"

There was no statistically significant association between the variables.

Table 29: Association of socio demographic factors and the nurses' response: Often when I respond to an alarm the patient needs further attention by the anesthetist

Socio demographic variables	Almost always	Frequently	Sometimes	Occasionally	Hardly ever	Chi	df	P Value	Cramer's V
Age in years						3.309	8	0.914	0.914
25-35	1 (3.7%)	2 (7.4%)	13 (48.1%)	7 (25.9%)	4 (14.8%)				
36-44	1 (2.3%)	2 (4.5%)	22 (50%)	12 (27.3%)	7 (15.9%)				
45-55	0 (0.0%)	2 (12.5%)	10 (62.5%)	3 (18.8%)	1 (6.2%)				
Gender						1.016	4	0.907	0.907
Male	1 (4%)	1 (4%)	13 (52%)	6 (24%)	4 (16%)				
Female	1 (1.6%)	5 (8.1%)	32 (51.6%)	16 (25.8%)	8 (12.9%)				
Professional qualification						9.335	12	0.674	0.674
KRCHN	1 (1.3%)	6 (7.7%)	38 (48.7%)	21 (26.9%)	12 (15.4%)				
BScN	1 (14.3%)	0 (0.0%)	5 (71.4%)	1 (14.3%)	0 (0.0%)				
MScN	0 (0.0%)	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)				
KRN	0 (0.0%)	0 (0.0%)	1 (100%)	0 (0.0%)	0 (0.0%)				
Years worked as a Nurse						8.431	12	0.751	0.751
Below 2 years	0 (0.0%)	0 (0.0%)	3 (100%)	0 (0.0%)	0 (0.0%)				
Above2 years	0 (0.0%)	0 (0.0%)	2 (100%)	0 (0.0%)	0 (0.0%)				
Above 5 years	2 (10.5%)	6 (31.6%)	11 (57.9%)	0 (0.0%)	0 (0.0%)				
Above 10 years	10(15.9%)	16 (25.4%)	29 (46%)	6 (9.5%)	2 (3.2%)				
Years worked in CCU						17.188	12	0.143	0.143
Below 2 years	1 (6.7%)	0 (0.0%)	13 (86.7%)	1 (6.7%)	0 (0.0%)				
Above2 years	0 (0.0%)	1 (7.7%)	7 (53.8%)	5 (38.5%)	0 (0.0%)				
Above 5 years	0 (0.0%)	3 (9.1%)	14 (42.4%)	9 (27.3%)	7 (21.2%)				
Above 10 years	1 (3.8%)	2 (7.7%)	11 (42.3%)	7 (26.9%)	5 (19.2%)				
CCN Trained						3.322	4	0.505	0.505
Yes	2 (2.6%0	4 (5.2%	40 (51.9%)	20 (26%)	11(14.3%)				
No	0 (0.0%)	2 (20%)	5 (50%)	2 (20%)	1 (10%)				
Alarm management trained						1.654	4	0.799	0.799
Yes	0 (0.0%)	1 (6.3%)	9 (56.3%)	5 (31.3%)	1 (6.3%)				
No	2 (2.9%)	5 (7.1%)	35 (50%)	17 (24.3%)	11 (15.7%)				

Chapter Five: Discussion

5.0. Introduction

The purpose of this study was to assess the practices of nurses in the management of clinical alarms during the nursing care of critically ill patients. A total of eighty seven nurses (87) from the critical care unit participated in the study and responded to questions related to the types of alarms in the unit, the audibility of the alarms in the unit, the reliability of the alarms, knowledge on alarms and nurses' responses to the alarms as well as the relationship between the nurses' responses and the patient's outcome.

5.1. Socio demographic characteristics

Of the eighty seven (87) nurses who participated in the study 62(71.3%) were females and males were 25(28.7%). These results show that nursing is still a female dominated profession as it was several years ago although many males are now joining the profession. In sub Saharan Africa only 10% of the nurses are males. In Kenya female nurses comprise 77% of the nursing workforce and males 23%.

Of the 87 nurses, 77(88.5%) had undergone training in critical care nursing. Thus we can conclude that the nurses in the unit are highly qualified academically in relation to matters concerning critical care nursing. Thirty eight percent 33(38%) of the nurses had worked in the unit for more than five years, 26(30%) for more than ten years, 15(17%) for less than two years and 13(15%) for more than two years.

5.2. Common reasons as to why alarms are set off in the CCU, KNH

The respondents reported that the common parameters that set off alarms in the unit are the pulse oximetry or saturation 17(20%), pulse oximetry, respiratory rate, ECG 21(24%), and non

invasive blood pressure, pulse oximetry, capnography, ECG 17(20%) respectively. The nurses (3%) reported that Capnography is also a cause but it is not very commonly set as most of the monitors in the unit do not have the mode for Capnography as they give priority to pediatric patients. The conclusion therefore was that the leading cause of alarm set off was pulse oximetry/saturation. These findings are in line with a study carried out by Inokuchi et al., (2013) in which they concluded that the types of devices that alarm the most frequently were direct measurements of arterial pressure (33.5%), oxygen saturation (24.2%) and ECG (5.3%).

On average a total of 5.2% of the nurses in the unit reported that mechanical errors, change in patient's condition, poor setting of the alarm limits and artifacts "Never" cause alarms to beep in the unit while, an average of forty two percent (42%) of the nurses reported that mechanical errors, change in the patient's condition, poor setting of the alarm limits and artifacts "Sometimes" caused alarms to beep in the unit. An average of twenty four percent (24%) of the nurses on the other hand reported that "Often" mechanical errors, change in the patient's condition, poor setting of the alarm limits and artifacts were the common causes of alarms beeping in the unit and the rest twenty nine point three (29.3%) percent reported that "Always" the cause of the alarms beeping was mechanical errors, change in the patient's condition, poor setting of the alarm limits and artifacts. These findings are therefore consistent with most studies on alarm devices. Mechanical errors and artifacts can bring about desensitization of nurses to alarms as the alarms will be viewed as false alarms. As a result the nurses are also inclined to disable or pause alarms and this can be detrimental to the patient. To minimize chances of getting false alarms, the biomedical staff should be keen to ensure that the machines are in good working order to reduce instances of false alarms, nurses should ensure proper placement of ECG electrodes and skin preparation before placement of electrodes and they should also be

keen when setting alarm limits so that they are not set far from the physiological limits of each individual patient.

These results are comparable to a multicenter study by Chambrin et al., (1999) involving all medical CCU patients and the medical staff. The conclusion of the study was, 26% of alarms were as a result of technical problems and 24% were caused by staff manipulation.

5.3. Knowledge of nurses on the different clinical alarms in management of clinical alarms in the CCU

In response to seven questions borrowed from an online CPD by the American Association for Respiratory Care (AACR) program on continuing education posed to the respondents, on average the respondents scored sixty nine percent (69%).

In a national online survey carried out by Korniewicz, Tobey and Yadin (2008) in the US on "Effectiveness of Clinical Alarms", many of the responses to the alarms indicated that alarm settings are not overly complex and that lack of training on alarms compared with other alarm management issues, is not an important concern. The Emergency Care Research Institute (ECRI) though has reported that from its experience, problems with alarms often stem from alarms being improperly configured or inadvertently defeated by staff and that both the design of the device's alarm system and the health worker's level of proficiency contribute to the problems with alarms. The researchers therefore concluded that effective and ongoing training is still of vital importance and that although many alarm systems seem straight forward on the surface, the intricacies are often not well understood by staff (Korniewicz et al., 2008)

In determining the association of the different questions on knowledge posed to the nurses and the social demographic factors one of the questions, "Wiping electrodes with a rough washcloth

or gauze and or using sandpaper on the electrode prevents spurious signals and helps to remove part of the stratum corneum allowing electrical signals to travel", showed a statistically significant association (p=0.049) to the socio demographic factor: "years worked in the critical care unit". The nurses who had worked in CCU for more than five years scored the highest (48.5%) whilst the ones who had worked in CCU for more than ten years scored the least (23.1%).

This association can perhaps be explained by the fact that this particular action of wiping electrodes with a rough washcloth or gauze or using sandpaper on the electrodes prevents spurious signals and helps to remove part of the stratum corneum allowing electrical signals to travel in management of alarms, is a recent practice as seen in studies by, Drew, Funk., (2006)" Practice standards for ECG monitoring in hospital settings: executive summary and guide for implementation" and Cvach et al (2012), "Daily electrode change and effect on cardiac monitor alarms: an evidence-based practice approach" , in the sense that the nurses who have not worked in the unit for long have not come across the practice yet in terms of experience. The nurses who have worked for more than ten years in the unit might not be conversant with the practice because of the perceived attitude of health workers that lack of training on alarm management is not that important as reported by Korniewicz, Tobey and Yadin (2008).

5.4. Various interventions employed by nurses in management of clinical alarms in the CCU

The respondents in the study were noted to respond to carrying out most of the interventions/actions asked in the questionnaire without any association with the socio demographic factors with an exception of three actions/interventions which showed an association with some socio demographic factors was noted as follows:

"I assess the cause of the alarm beep when it alarms" (Association with Age in years, p=0.06). This statistical significance showed that 38(86.4%) of the age group between 36-44 years were more likely to always assess the cause of the alarm beep compared to the other age groups of whom 66.7% (18) of age group 25-35 years and 66.8% (11) 45-55 years responded always.

"I reset alarm settings of the machines each time I admit a patient" (Association with if trained in critical care nursing p=0.036). This association indicated that the proportion of nurses who were trained in critical care nursing and responded: "Always" to I reset alarm settings of the machines each time I admit a patient were 56(72.7%), 12(15.6%) responded "Often", 9(11.7%) "Sometimes" and 0% responded "Never". The ones who were not trained in critical care nursing on the other hand responded as follows: "Always" 6(60%), "Often" 1(10%), "Sometimes" 2(20%) and "Never" 1(10%).

The third action/intervention which had a statistical significant association (p= 0.028) with gender was "I change the patient's electrodes daily", where 8% (2) of the males answered "Never", 48% (12) "Sometimes", 40% (10) "Often" and 4% (1) "Always". The females responded as follows: 4.8% (3) "Never", 32.3% (20) "Sometimes", 27.4% (17) "Often" and 35.5% (22) "Always".

Some of the studies that have been carried out on the responses or actions of nurses to clinical alarms are as follows:

Bitan et al. (2004) observed that nurses in a NICU setting have a wealth of information about patients and are engaged in a number of tasks that are critical for the patients and are not necessarily cued by alarms hence even though nurses consider information from alarms; alarms do not cause them to take immediate action. The overall likelihood of a nurse responding to an

alarm was very low and for more than 90% of alarms, the nurse did not attend to the patient during the minute following the alarm.

High false alarm rates have remained an important yet unresolved concern in the Intensive Care Unit over the past two decades. High false alarm rates lead to desensitization of the medical staff to the warnings of the alarms and this is associated with slow response times and detrimental decreases in the quality of care for the patient (Aboukhalil et al., 2008).

Health care personnel have been shown in previous studies to use alarms in a variety of ways depending on the particular process on which they are working. Sometimes when they appear not to have noticed the alarms, they may have in fact made use of the information and respond much later, perhaps after a minute or so (Edworthy, 2013).

Currently there are no studies showing a statistical significant association of nurses' actions/responses to clinical alarms and any socio demographic variables. The results of this study therefore cannot be compared to any other studies nor be used to make concrete conclusions. In future observational comparison studies should be undertaken geared towards these particular variables to prove whether there are any associations.

Nurses respond to alarms for different reasons, not just the fact that the alarm sounds. Nurses adjust the order of their activities by evaluating alarm urgency in relation to the patients' condition and have a greater tendency to react to alarms of longer duration and considered rare, that is alarms that beep for long and alarms that occur rarely as opposed to all the time. As workload complexity increases, alarm response and task 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. Adjusting alarms to patient's actual needs

ensures that alarms are valid and provides an early warning to potential critical situations. Documenting alarm parameters in the medical record was found to be an effective intervention for improving alarm adjustment compliance (Cvach, 2012). However the results of these study imply that the respondents in this study usually respond to alarms of all durations, that is whether of short duration, frequently occurring or rare alarms.

Most of the respondents in this study reported that they do no fill alarm checklists and no alarm checklists are available in the unit. Cvach (2012) reported that documenting alarm parameters in the medical record was found to be an effective intervention for improving alarm adjustment compliance. This can therefore be noted as a noncompliance by the respondents in the study and one of the major reasons the respondents gave for not filling alarm checklists was non availability of alarm checklists and alarm protocols in the unit.

5.5. Patients' outcomes in relation to the nurses' intervention to the clinical alarms at the time the alarms beep

In this study the nurses were asked to report on whether their responses to alarms each time they beep improves the patients' condition, doesn't improve the patients' condition or often when they respond to the alarm the patient requires further attention from the anesthetist. Seventy eight point eight percent (78.8%) of the nurses reported that their response "Sometimes" improves the patients' 74.4% reported that their response to the alarm hardly ever improves the patients' condition. This can be compared with a study by Tsien and Fackler (1997) conducted in a pediatric CCU where the findings showed that 86% of the alarms were false alarms and only 8% were genuine clinical alarms.

Most of the time alarms result from measurement and movement artifacts and the vast majority of all threshold alarms in the intensive care unit do not have real clinical impact on the care of the critically ill patients (Imhoff, 2009).

5.6. Conclusion and Recommendations

The results of this study show that nurses need more training on alarm management and that alarm checklists are not filled in the unit hence a need for development of alarm protocols and policies in the institution. The results also conclude that mechanical errors, poor setting of alarm limits and artifacts contribute to set off of the alarms in the unit. Pulse oximetry has also been noted as the leading cause of alarms set off in the unit.

Poor management of clinical alarms can be very detrimental to the outcome of the patient. Nurses and all health care workers need to be knowledgeable and be on their toes on issues concerning alarm management hence the following recommendations:

- The management of the hospital should develop protocols and policies on alarm management which will address the issue of completion of alarm checklist to be completed at the beginning and end of each shift.
- Nurses working at the CCU should be trained on the proper use of clinical alarms, use of new equipment and knowledge of appropriate responses to alarms.
- The biomedical staff should be sensitized on the issue of mechanical errors since it is one of the reasons as to why alarms beep in the unit so that they are keen on ensuring that all the alarm devices are not faulty hence setting off false alarms.
- The management of the hospital should recruit enough nurses at the CCU as one of the reasons for not filling alarm checklists was that there is too much workload for the nurses

and shortage of staff. There should be monthly discussions on the adverse events associated with clinical alarms

- Research should be undertaken in the areas of alarm fatigue, false alarms and nuisance alarms among nurses at CCU as well as other medical team members such as doctors, biomedical staff and the auxiliary staff. Longitudinal or prospective study designs can be used to capture the true picture on clinical alarms.

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Work plan

	Oct 2013	Nov 2013	Dec 2013	Jan 2014	Feb 2014	Mar 2014	April 2014	May 2014	June 2014	July 2014	Aug 2014	Sep 2014
Proposal development												
Ethical clearance												
Pretesting of tool												
Data collection												
Data processing and analysis												
Report writing and thesis defense												

Budget

Component	**Activity Description**	**Item**	**Unit of Measurement**	**Unit Cost (Kshs)**	**Total Cost (Khs)**
Literature review	Personal literature search, transport and use of modem	Browse for literature in journals, dissertations, books,	16 weeks	@1000	16,000
	Stationary	A ream of A4 papers	1	@500	500
		Proposal typing	3 drafts	@500	1,500
		Proposal printing	3 drafts	@400	1,200
		Photocopy charges	6 drafts	@350	2,100
Approvals	KNH/UON Ethics		1	@ 2000	2,000
Sub total					**23,300**
Research Phase	Pretesting	Printing and photocopying	10 copies	@50	500
	Questionnaires & consent form	Photocopying	72 copies	@50	3,600
	Data collection	Research assistants	2-4 weeks	@500	28,000
	Data processing and analysis				20,000
Sub total					**52,100**
Report Writing phase	Draft report	Typing & printing Photocopying	170 pages 5 copies	@30 @600	5,100 3,000
	Final report	Correction & printing	170 pages	@10	1,700
		Photocopying	5 copies	@600	3,000
		Binding	5 copies	@1000	5,000
Dissemination Budget	Dissemination Report	Typing & Printing	10 pages	@30	3000
		Photocopying	50 copies	@5	150
		Contingencies		10% of total	9635
Sub total					**30,585**
Grand Total					**105,985**

Appendix I: Consent Form for the Nurses

TITLE: AN ASSESSMENT OF THE MANAGEMENT OF CLINICAL ALARMS IN THE NURSING CARE OF CRITICALLY ILL PATIENTS AT THE CRITICAL CARE UNIT, KENYATTA NATIONAL HOSPITAL

Researcher's statement

Hello, my name is Lucy Wankuru Meng'anyi, a second year postgraduate student at the University Of Nairobi, College of Health Sciences, pursuing a Masters Degree in Critical Care Nursing.

I am carrying out a study on "**An Assessment of the Management of Clinical Alarms in the Nursing Care Of Critically Ill Patients at the Critical Care Unit, Kenyatta National Hospital"** as part of my course requirement. The study will be assessing the nurses' knowledge on clinical alarms, how the nurses respond to alarms and the interventions they employ in management of patients when the alarms set off.

The purpose of this consent form is to provide you with information you need to help you decide whether to be in the study or not. Please read the form carefully. You may ask questions about the purpose of the research, what I will ask you to do, the possible risks and benefits, your rights as a volunteer and anything else about the research or this form that is not clear. When I have answered all your questions, you can decide if you want to participate in the study or not. You may refuse to participate and you are free to withdraw from this study at any time without penalty or loss of benefits to which you are otherwise entitled to.

Your participation in the study is on voluntary basis and will not result in any physical or psychological harm. There will be no penalty if you decide to withdraw from the study. In case

you decide to participate in the study, you will be required to fill a questionnaire which will take about 15 minutes which you will be guided through. You are free to ask any questions about the study at any time. There is no monetary benefits for you as an individual participant but the information collected will help in the improvement of nursing care of patients in the critical care unit and all the other units in the hospital that utilize clinical patient monitoring devices that have alarms. The information will also aid the management of the institution to better understand issues concerning alarm management and empower the staff on evidence based practice in management of the clinical alarm systems.

You will not be required to write any of your personal particulars on the questionnaire and the information you provide will be kept confidential and anonymous. The questionnaires will be kept under lock and key and only the researcher and the supervisors will access them. Your participation will be highly appreciated.

Information dissemination plan

The results of this study will be presented to the management of the Critical Care Unit, KNH, the management of Kenyatta National Hospital, the Kenyatta National Hospital Research Department to aid in development of policies in alarm management which will help in the improvement of patient care and the relevant stakeholders for examination purposes, publication and abstract presentation for scientific use. The means of disseminating the results will be group briefings which will be held at the critical care unit with collaboration from the institution (KNH). Moreover, the participants' particulars will not be included or identified as the results will be in form of raw data.

Please contact the following people if you have questions or concerns about the content of this study; Researcher: **Lucy Wankuru** of the **University of Nairobi**- **telephone number: 0721419297** or email at robi@uonbi.ac.ke, as well as the Chairperson, KNH/UoN-ERC, Professor A.N. Guantai; **2726300 Ext: 44102**, Fax: **0725272**; Email: uonknh_erc@uonbi.ac.ke.

Participant's Statement

I have read the foregoing information, and I have had the opportunity to ask questions about it and any questions I have asked have been answered clearly and to my satisfaction. I do therefore agree voluntarily to participate in this study and understand that I have the right to withdraw from the study at any time without in any way attracting any penalties.

Signature of participant: _____ Date: _____

Name of the researcher: Lucy Wankuru Meng'anyi

Signature of researcher _____ Date: _____

Appendix II: Questionnaire

AN ASSESSMENT OF MANAGEMENT OF CLINICAL ALARMS IN THE NURSING CARE OF CRITICALLY ILL PATIENTS AT THE CRITICAL CARE UNIT, KENYATTA NATIONAL HOSPITAL

Questionnaire number: _____

Instructions

Please answer all the following questions in the space provided or tick in boxes provided at the end of each choice.

Section A. Demographic Data

1. Age in complete years_____
2. Gender
    a) Male []
    b) Female []
3. Marital status
    a) Single []
    b) Married []
    c) Divorced []
    d) Others (please specify)_____
4. Professional qualification
    a) KRCHN []
    b) BSCN []
    c) Masters of science in nursing []
    d) PHD []
5. How long have you worked as a nurse?
    a) Less than 2 years []
    b) > 2 years []
    c) > 5 years []
    d) >10 years []
6. How long have you worked at the critical care unit?
    a) < less than 2 years []
    b) > 2 years []
    c) > 5 years []
    d) > 10 years []

7. Have you trained as a critical care nurse?
    a) Yes []
    b) No []
8. If yes in 7 above, please indicate the year you completed your critical care training.

Year _____

9. Have you had any training on alarm management since you first qualified as a critical care nurse?
    a) Yes []
    b) No []
10. If yes in 9 above, please indicate when you went for training
    Year trained _____
11. If yes in 10 above, please indicate the length of time covered in the training in terms of hours.

No of hours covered _____

SECTION B: General Questions about Alarms

12. Which types of alarms exist in the unit?
    a) Audio alarms- alarms that produce sound when patients parameters change []
    b) Visual alarms- different colors []
    c) Both? []
13. Are the clinical alarms in the unit sufficiently audible?
    a) Yes []
    b) No []
14. Are you able to distinguish the different alarm sounds in the unit and determine the device that is sounding the alarm with ease?
    a) Yes []
    b) No []
15. Can the clinical alarms in the unit be relied on to determine the urgency of the patient's condition?
    a) Yes []
    b) No []
16. If you answered Yes or No in question 15, please elaborate

    _____

    _____

    _____

17. Which alarm are you more likely to respond to?
    a) Alarms of short duration []
    b) Frequently occuring alarms []
    c) Rare alarms []
    d) All of the above []

18. Do you set alarm limits for the following parameters in the unit?

For question number 17 please indicate (√) whether Yes or No in the table provided below.

		YES	**NO**
a)	Pulse oximetry		
b)	Capnography		
c)	ECG		
d)	Non- invasive blood pressure		
e)	Respiratory rate		
f)	Saturation		

19. Do you fill in an alarm checklist for each patient?
    a) Yes []
    b) No []
20. If Yes for question 19, how often?
    a) Daily []
    b) At the start of my shift []
    c) Occassionaly []
    d) During admission []
21. If No to question 19, please state why

    _____

    _____

    _____

22. Which of the following parameters commonly sets off alarms in the unit?
    a) Pulse oximetry []
    b) Capnography []
    c) ECG []
    d) Non- invasive blood pressure []
    e) Respiratory rate []
    f) Saturation []
    g) All the above []

23. What causes alarms to beep in the CCU on a scale of 1-4?

For this question, Use Never, Sometimes, Often, Always to respond to this question. where Never =1, Sometimes=2, Often =3, Always=4

		Never	**Sometimes**	**Often**	**Always**
a)	Mechanical errors.				
b)	Change in the patient's condition.				
c)	Poor setting of the alarm limits				
d)	Artifacts.				

Section C: 24. Nurses' Knowledge on Clinical Alarms

For this section please tick whether True, False or Not sure in the spaces provided. (True=2, False=1, Not Sure= 0)

	Question statement	**True**	**False**	**Not sure**
1.	Alarm sound can be relied on to determine alarm urgency in terms of patients change in condition.			
2.	When an alarm is realiable each time it signals, this is known as alarm specificity.			
3.	High priority alarm indicates an urgent situation			
4.	Medium priority alarm indicates a dangerous situation and a quick response from the medical staff is needed			
5.	A low priority alarm indicates an alert situation and the attention of the medical staff is needed			
6.	Skin preparation is not important in reducing false alarms			
7.	Wiping the electrode with a rough washcloth or gauze and or using sandpaper on the electrode to roughen a small area of the skin prevents spurious signals and it also helps to remove part of the stratum corneum to allow the electrical signals to travel			

Section D: 25. Nurses' Interventions /Actions in the Management of Clinical Alarms

For this part of the section please indicate (√) in the spaces provided whether Never, Sometimes, Often, Always the table below (Never =1, Sometimes=2, Often =3, Always=4)

		Never	Sometimes	Often	Always
1.	I ensure proper skin preparation of patients before placing electrodes				
2.	I change the patients' electrodes daily				
3.	I assess the cause of the alam beep when it alarms.				
4.	I disable the alarms every time they beep				
5.	I pause the alarms every time they beep				
6.	I reset the alarm limits every time alarms beep				
7.	I ignore alarms every time they beep				
8.	I check and assess the patient's condition every time the alarm beeps				
9.	I reset alarm settings of the machines each time I admit a new patient				

Section E: 26. Nurses' Intervention in managemnt of clinical alarms in Relation to Patients' Outcome

Part I: For this part please indicate (√) in the space provided whether Hardly ever, Ocassionally, Sometimes, Frequently, Almost always the table below (Hardly ever =1, Ocassionaly= 2, Sometimes=3, Frequently =4, Almost always=5)

		Almost always	Frequently	Sometimes	Occasionally	Hardly ever
1	My response to an alarm improves the patient's condition					
2	My response to an alarm does not improve the patient's condition.					
3	Often when I respond to the alarm the patient needs further attention by the anesthetist.					

Appendix V: Letter to KNH/UoN Ethics and Research Committee

Lucy Wankuru Meng'anyi,

University of Nairobi,

College of Health Sciences,

School of Nursing Sciences,

Mobile No: 0721419297

7th February 2014

To,

The Chairperson,

KNH/UON Ethics and Research Committee,

P.O.BOX. 20723/00202,

Nairobi.

Dear Sir/Madam

RE: REQUEST FOR RESEARCH AUTHORISATION

I am a second year postgraduate student pursuing a Masters in Critical Care Nursing at the university. Conducting a research is part of the requirements for the award of the degree and it is on this note that I apply for authorization to conduct research. I will be conducting the research at the Critical Care Unit, Kenyatta National Hospital. My research topic is "An Assessment of the Management of clinical alarms in the nursing care of critically ill patients at the Critical Care Unit, Kenyatta National Hospital.

Your consideration will be highly appreciated.

Thanks in advance.

Yours faithfully,

Lucy .W. Meng'anyi

Reg No: H56/80942/2012

Appendix VI: Letter of Approval from KNH/UON Ethics and Research Committee

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
(254-020) 2726300 Ext 44355

KNH/UON-ERC
Email: uonknh_erc@uonbi.ac.ke
Website: www.uonbi.ac.ke

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/138 Link:www.uonbi.ac.ke/activities/KNHUoN 15th May 2014

Lucy Wankuru Meng'anyi
School of Nursing Sciences
College of Health Sciences
University of Nairobi

Dear Lucy

RESEARCH PROPOSAL: AN ASSESSMENT OF THE MANAGEMENTOF CLINICAL ALARMS IN THE NURSING CARE OF CRITICALLY ILL PATIENTS AT THE CRITICAL CARE UNIT, KENYATTA NATIONAL HOSPITAL (P71/2/2014)

This is to inform you that the KNH/UoN-Ethics & Research Committee (KNH/UoN-ERC) has reviewed and **approved** your above proposal. The approval periods are 15th May 2014 to 14th May 2015.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH/UoN ERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH/UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH/UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH/UoN-Ethics & Research Committee for each batch of shipment.
g) Submission of an *executive summary* report within 90 days upon completion of the study This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

For more details consult the KNH/UoN ERC website **www.uonbi.ac.ke/activities/KNHUoN.**

Protect to Discover

Yours sincerely

PROF. M. L. CHINDIA
SECRETARY, KNH/UON-ERC

c.c. The Principal, College of Health Sciences, UoN
The Deputy Director CS, KNH
The Chairperson, KNH/UoN-ERC
The Assistant Director, Health Information, KNH
The Director, School of Nursing Sciences, UoN
Supervisors: Mrs. Lilian Omondi, Mrs. Margaret Muiva