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Alarm Configuration in Intensive Care Units of a Corporate Hospital

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Abstract

In intensive care units (ICUs), inappropriate alarm configuration practices pose significant challenges to patient safety and healthcare providers. The current practices lack standardized guidelines, resulting in excessive alarms and alarm fatigue, where healthcare providers become desensitized and may miss critical events. The absence of standardized protocols and ineffective alarm prioritization exacerbate the problem. The present study aims to understand the various alarm configuration practices in the Intensive Care Unit and to proactively evaluate the limitations of clinical alarm systems management. It focused on identifying reasons for the occurrence of nuisance and false alarms, factoring in the proportion of these unnecessary alarms, and chalking out measures to reduce these false and nuisance alarms.

After months of ICU observation, Alarm desensitization, and Alarm fatigue came out to be eminent issues in the functioning of an Intensive Care Unit. The clamor of alarms has been demonstrated to hinder patient recovery, lengthen stays, have a poor impact on patient satisfaction, and cause patient anxiety, sleep difficulties, delirium, elevated blood pressure and heart rates, and immune system deterioration. Therefore, fewer alerts and a simpler alarm configuration procedure can aid in better patient outcomes. The response to all alarms is imperative but false and nuisance alarms make it challenging for the nurses to differentiate and respond to genuine alarms. The study focused on identifying reasons for the occurrence of nuisance and false alarms, factoring in the proportion of these unnecessary alarms, and chalking out measures to reduce these false and nuisance alarms. This included a checklist to monitor the alarms in ICUs on a daily basis for various equipment including cardiac monitors, ventilators, dialysis machines, syringe pumps, and infusion pumps. These were monitored for around 5 hours a day and the analysis revealed most of the equipment especially cardiac monitors giving out false and nuisance alarms. A pre-assessment questionnaire was made to assess the knowledge and perception regarding clinical alarms for nurses. The analysis revealed that 40% of nurses could not differentiate between false and nuisance alarms.

INTRODUCTION

As one of the most essential technical components of the intensive care unit (ICU), continuous monitoring of patient's vital parameters has significantly improved patient safety by alerting staff through an alarm. When a parameter deviates from the normal range, hospitals routinely use clinical alarms to alert healthcare givers regarding the deterioration of the patient's condition. The process of clinical alarm identification and the interventions followed are crucial for the patient's clinical outcomes. Any organization that aims to achieve patient safety must have a robust clinical alarm management system in place. Given the advent of technology in healthcare, the number, and kinds of alarms we now

use have increased. Hence the risks that come with them have increased as well. The Joint Commission has also developed a proposed National Patient Safety Goal for 2013 that addresses clinical alarm systems.

Alarms are widespread in an intensive care unit (ICU), where the patients are being treated for critical ailments. They serve to alert medical staff to any device malfunctions as well as changes in vital factors. Monitors, respirators, injection pumps, and a variety of other devices can all provide sound signals. However, it turns out that these signals are always incorrect or clinically inconsequential, making up 85–99% of all alerts. While they are in theory meant to keep a patient safe, their onslaught may be too much for nurses. Alarm fatigue is a particular risk for nursing personnel, who spend most of their time with patients and monitor their condition round-the-clock. When a nurse is on duty, there are often 150 to 400 alarms created for each patient to which they respond. It is proved that a nurse working in an ICU spends 35% of the time responding to alarms.

Due to the increased frequency of alarms, alarm fatigue and desensitization are growing concerns among healthcare personnel. This not only jeopardizes patient safety but also poses a risk of patient death, particularly in intensive care units.

STATEMENT OF PROBLEM

In intensive care units (ICUs), inappropriate alarm configuration practices pose significant challenges to patient safety and healthcare providers. The current practices lack standardized guidelines, resulting in excessive alarms and alarm fatigue, where healthcare providers become desensitized and may miss critical events. Insufficient alarm customization options based on patient needs and inadequate consideration of the clinical workflow further contribute to compromised patient care. Additionally, the absence of standardized protocols and ineffective alarm prioritization exacerbate the problem. Addressing these issues through standardized guidelines, improved customization, consideration of workflow, and effective prioritization is crucial to ensure appropriate alarm configuration practices in ICUs, promoting patient safety and timely interventions.

NEED FOR THE STUDY

Advances in technology have facilitated the implementation of improved alarm management systems in the healthcare sector. There is a need to identify challenges encountered by the intensive care unit (ICU), with clinical alarm management systems to ensure the utilization of these technological resources for patient safety. The study aims to understand the various alarm configuration practices in the Intensive Care Unit and to proactively evaluate the limitations of clinical alarm systems management. The study also aims to perform a pre-assessment of the knowledge and perception of nurses about clinical alarms to develop a training module to correct the existing configuration practices for alarms.

OBJECTIVES

1. To understand the responsiveness and alarm handling in the ICUs.
2. To identify the issues causing alarm fatigue in ICUs.
3. To assess the knowledge and pereption of nurses on clinical alarms.
4. To ensure the recommended change in vital threshold is mentioned in the medical reports.

SCOPE

The study involved assessing the timeliness and effectiveness of healthcare providers' response to alarms in ICUs. The ICUs taken up for the study were.

1. ICUs selected for pre-assessment include: Surgical ICU, Medical ICU-1, Medical ICU-2, Medical ICU- extension, Advanced Critical Care Unit, Cardiac ICU and Transplant ICU
2. ICUs selected for Audit include- Surgical ICU, Medical ICU 1 and ACCU

METHODOLOGY

The data for the present study was taken both from Primary & Secondary sources.The Primary data was collected by Direct Observation, Checklist and a structured Questionnaire The Secondary data was gathered from Journals and Websites, and from Hospital Policy documents. The Analytical tool used was Measure of Central Tendency (Mean).

REVIEW OF LITERATURE

Poncette AS, Wunderlich MM, Spies C, Heeren P, Vorderwülbecke G, Salgado E, Kastrup M, Feufel MA, Balzer F. Patient Monitoring Alarms in an Intensive Care Unit: Observational Study With Do-It-Yourself Instructions. J Med Internet Res. 2021 May 28;23(5):e26494. doi: 10.2196/26494. PMID: 34047701; PMCID: PMC8196351./

This study talks about how one of the most essential technical components of the intensive care unit (ICU), continuous monitoring of patient's vital parameters has significantly improved patient safety by alerting staff through an alarm when a parameter deviates from the normal range. However, the vast number of alarms regularly overwhelms staff and may induce alarm fatigue, a condition recently exacerbated by COVID-19 and potentially endangering patients. This study focused on providing a complete and repeatable analysis of the alarm data of an ICU's patient monitoring system. We aimed to develop do-it-yourself (DIY) instructions for technically-versed ICU staff to analyze their monitoring data themselves, which is an essential element for developing efficient and effective alarm optimization strategies.

Schmid, F., Goepfert, M.S. & Reuter, D.A. Patient monitoring alarms in the ICU and in the operating room. *Crit Care* 17, 216 (2013). https://doi.org/10.1186/cc12525

This study shows that medical progress has led to obvious improvements in ICU and perioperative monitoring over recent decades. With the increase in 'monitorable' parameters, rates of alarms have also increased. However technical progress has rarely affected the rates of false alarms. In addition to noise-related increases in burn-out rates, false alarms lead to desensitization of medical staff to alarms with the risk of critical situations potentially being ignored despite correct alarming. Patients are also directly affected by alarm-related sleep disorders with subsequent development of delirium and increased sympathetic nervous system activity and catecholamine secretion. In recent years, many promising approaches using statistical methods and artificial intelligence have been developed for the reduction of false alarms without obvious changes in false alarm rates in our clinical reality.

TY - JOUR AU - Schmid, Felix AU - Goepfert, Matthias AU - Reuter, Daniel PY - 2013/03/19 SP - 216 SN - 978-3-642-35108-2 T1 - Patient Monitoring Alarms in the ICU and in the Operating Room VL - 17 DO - 10.1186/cc12525 JO - Critical care (London, England) ER -

This study talks about historically, the word 'alarm' originates from the Latin, 'ad arma', or the French, 'à l'arme', which can be translated into 'to your weapons'. Hence, the word indicates a call for

immediate action, for the attack, or for defense. Alarms have existed ever since humans have lived in groups. Some of the first documented alarms were watchmen on towers in the Middle Ages, who warned of fires or enemies by ringing bells. Warning fires provided a visual alert to enemy attacks, visible across long ranges and enabling an early reaction of armed forces. Today, comparable systems are available that send warning SMSs (Short Message Service) of nearing tsunamis to mobile phones [1].

Sinno, ZC., Shay, D., Kruppa, J. *et al.* The influence of patient characteristics on the alarm rate in intensive care units: a retrospective cohort study. *Sci Rep* 12, 21801 (2022). https://doi.org/10.1038/s41598-022-26261-4

Intensive care units (ICU) are often overflooded with alarms from monitoring devices which constitutes a hazard to both staff and patients. To date, the suggested solutions to excessive monitoring alarms have remained on a research level. We aimed to identify patient characteristics that affect the ICU alarm rate with the goal of proposing a straightforward solution that can easily be implemented in ICUs. Alarm logs from eight adult ICUs of a tertiary care university hospital in Berlin, Germany were retrospectively collected between September 2019 and March 2021. Adult patients admitted to the ICU with at least 24 hours of continuous alarm logs were included in the study. The sum of alarms per patient per day was calculated.

Fatma Dursun Ergezen, Emine Kol, Nurses' responses to monitor alarms in an intensive care unit: An observational study, Intensive and Critical Care Nursing, Volume 59, 2020, 102845, ISSN 0964-3397, https://doi.org/10.1016/j.iccn.2020.102845. (https://www.sciencedirect.com/science/article/pii/S0964339720300483)

This article shows that the present study aimed to determine the types of monitor alarms and nurses' responses to them in an adult intensive care unit. This was an observational descriptive research study conducted in the adult intensive care unit of a university hospital in the Mediterranean region of Turkey. The nonparticipant observation method was used. Data were collected by two observers using a semi-structured observation form developed according to the literature.

Schmid F, Goepfert MS, Kuhnt D, Eichhorn V, Diedrichs S, Reichenspurner H, Goetz AE, Reuter DA. The wolf is crying in the operating room: patient monitor and anesthesia workstation alarming patterns during cardiac surgery. *Anesth Analg.* 1, 2011, Vol. 112.

This article shows alarms exist as a risk mitigation strategy and are a crucial aspect of all critical care or life-sustaining machinery. Risk analyses highlight potentially hazardous situations for which alarms should be used to warn clinicians of impending dangers. Issues arise, however, when the number of alarms in hospitals impart high cognitive loads on clinicians and strain their working capacity. A study of perioperative alarms in surgical settings (1) identified 8,975 alerts and alarms occurring across 124 hours of monitoring yet only 6,386 were classified as serious and life-threatening. Furthermore, only 70% were deemed valid, with the remaining 30% caused by artifacts, and of these valid alarms only 39% were classified as clinically relevant! One consequence of false alarms is the intentional ignoring, or hesitation to respond by clinicians to avoid 'Crying Wolf' and annoyance may encourage users to ignore signals or even take risks by changing alarm thresholds to inappropriate levels. Reaction times also increase when there is low alarm validity; (2).

Ruskin KJ, Hueske-Kraus D. Alarm fatigue: impacts on patient safety. Curr Opin Anaesthesiol. 2015 Dec;28(6):685-90 Wilken M, Hüske-Kraus D, Klausen A, et al. Alarm fatigue: causes and effects. Stud Health Technol Inform. 2017;243:107-111. ECRI Top 10 Technology Risks 2017-

18.Keith J. Ruskina and Dirk Hueske-Kraus, Alarm fatigue: impacts on patient safety, Volume 28, Number 6, December 2015
www.aami-bit.org/doi/full/10.2345/0899-8205-46.4.268¬
This article proves that non-actionable alarm signals are often caused by motion artifacts, manipulation of the patient or patient movement, inappropriate alarm limits, or faulty technology, and can divert time and attention away from patients.4 Our solution can be configured to alert caregivers when vital signs reach your chosen thresholds, and to remain silent when events are non-actionable. With a Care Event that brings alarms and information to caregivers on the go-to reporting and analysis tools, and consulting and clinical education services to fine-tune your approach, you can gain control over clinical alarms in critical care environments.
Ruppel H, Bonafide CP. Sounds good: the bright future of clinical alarm management initiatives. BMJ Qual Saf. 2020 Sep;29(9):701-703. doi: 10.1136/bmjqs-2019-010561. Epub 2020 Feb 21. PMID: 32086299; PMCID: PMC7442598.
This study shows that adverse patient events from alarm fatigue, particularly related to excessive physiologic monitor alarms, have received widespread attention over the last decade, including from the news media. In the United States, hospitals redoubled alarm safety efforts following the 2013 Joint Commission Sentinel Event Alert and subsequent National Patient Safety Goals on alarm safety. We are now beginning to understand how to reduce the excessive nonactionable alarms (including invalid alarms as well as those that are valid but not actionable or informative), better manage alarm notifications, and ultimately improve patient safety. Alarm data are readily available and measuring alarm response time during patient care is possible. Yet we have few high-quality reports describing clear improvement to clinical alarm burden, and most published interventions are of limited scope, duration, or both. To demonstrate value in alarm quality improvement (QI) efforts moving forward, we need more rigorous evidence for interventions and more meaningful outcome measures.
Siobhán Casey, Gloria Avalos, Maura Dowling, Critical care nurses' knowledge of alarm fatigue and practices towards alarms: A multicentre study, Intensive and Critical Care Nursing,Volume 48,2018,Pages 36-41, ISSN 0964-3397,
This article shows that medical devices rely on auditory alarms to notify doctors when either the patient or the equipment deviates from a preset normal status. According to the American College of Clinical Engineering Healthcare Technology Foundation [ACCE HTF], 2007 this ensures protection from injury. Medical device auditory warning sounds, however, have increased exponentially because of advancements in healthcare technology (Borowski et al., 2011). Alarm fatigue has only recently been studied by researchers (Alsaad et al. 2017, Bonafide et al. 2014, Cho et al. 2016, Deb and Claudio, 2015, Funk et al. 2016, Funk et al. 2014, Gazarian et al. 2015, Honan et al. 2015, Joshi et al. 2017, Ruppel et al. 2018, Varpio et al. 2012). North America is where most of this research originates. This may be somewhat explained using various nurse-patient ratios and single occupancy rooms in the US as opposed to other countries, which makes the problem more obvious.
Lewandowska K, Weisbrot M, Cieloszyk A, Mędrzycka-Dąbrowska W, Krupa S, Ozga D. Impact of Alarm Fatigue on the Work of Nurses in an Intensive Care Environment-A Systematic Review. Int J Environ Res Public Health. 2020 Nov 13;17(22):8409. doi: 10.3390/ijerph17228409. PMID: 33202907; PMCID: PMC7697990.
This study proves that alarms are commonplace in intensive therapy settings where the patients being treated are in severe condition. Nurses are particularly vulnerable to the so-called alarm fatigue since

they spend the most of their time with patients and are constantly checking their health. The goal of this study is to analyze the literature on how nursing staff perceive clinical alarms and how that perception affects their job in an intensive care unit (ICU). Methods: The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) procedure was used for conducting a systematic review of the literature. Electronic databases like PubMed, OVID, EBSCO, ProQuest Nursery, and Cochrane Library had their contents searched. Along with "intensive care unit," "nurse," "alarm fatigue," and "workload," other search terms were also used.

Lewandowska, Katarzyna, Wioletta Mędrzycka-Dąbrowska, Lucyna Tomaszek, and Magdalena Wujtewicz. 2023. "Determining Factors of Alarm Fatigue among Nurses in Intensive Care Units—A Polish Pilot Study" *Journal of Clinical Medicine* 12, no. 9: 3120. https://doi.org/10.3390/jcm12093120

This study talks about the fact that alarm fatigue has only recently been studied by researchers (Alsaad et al. 2017, Bonafide et al. 2014, Cho et al. 2016, Deb and Claudio, 2015, Funk et al. 2016, Funk et al. 2014, Gazarian et al. 2015, Honan et al. 2015, Joshi et al. 2017, Ruppel et al. 2018, Varpio et al. 2012). North America is where most of this research originates. This may be somewhat explained using various nurse-patient ratios and single occupancy rooms in the US as opposed to other countries, which makes the problem more obvious. Even when no intervention is required, the sheer act of identifying, evaluating, and confirming an alarm greatly adds to overall workplace overwork. Only 5-13% of alarms in the monitoring systems result in a clinical response or intervention. In clinical practice, a significant proportion of false alarms remain a challenge that is challenging to resolve.

DATA ANALYSIS AND PRESENTATION

Knowledge of Nurses

1. Question: Monitor settings to be set for each patient by:

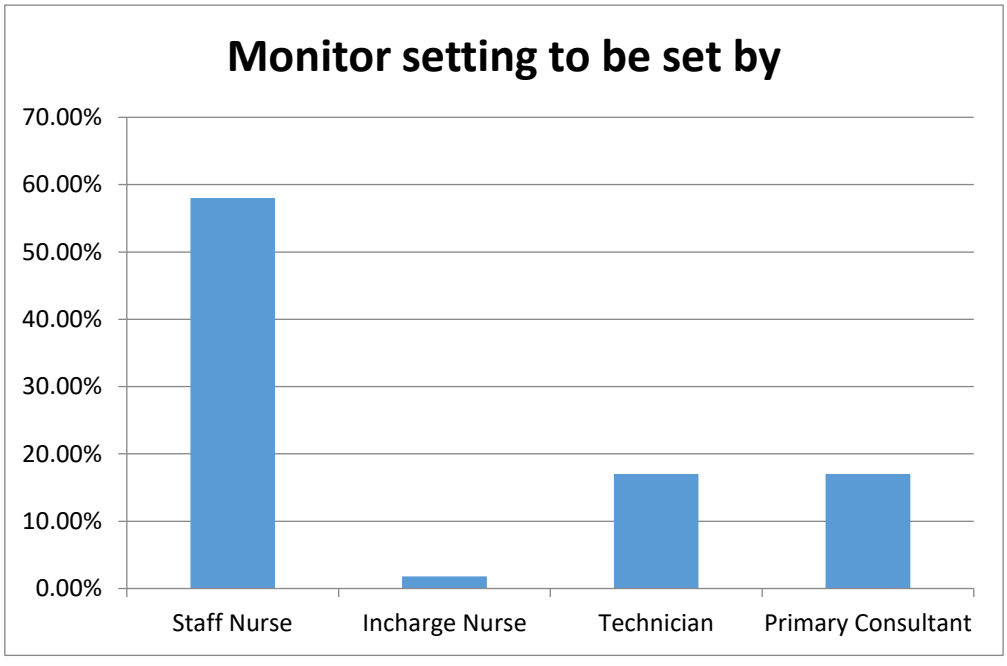

fig 1.2

Only 17% gave the right answer (Primary consultant)

2. Question: Is the Customization of patient monitor settings mandatory?

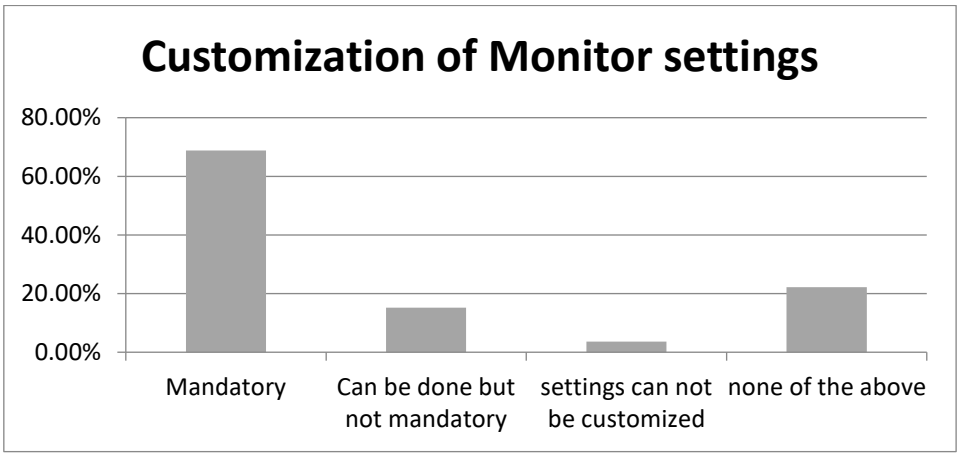

fig 1.3

69.4% gave the right answer (Mandatory customization).
3.6% think settings cannot be customized.

3. Question: Ventilator gives alarms for which of the following settings:

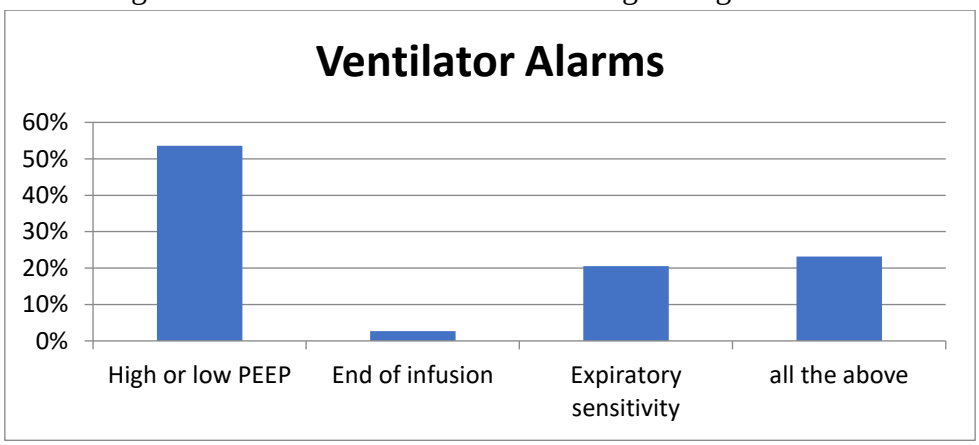

fig 1.4

Only 53% gave the correct answer (High or low PEEP)

4. Question: Alarms occur in syringe pumps due to:

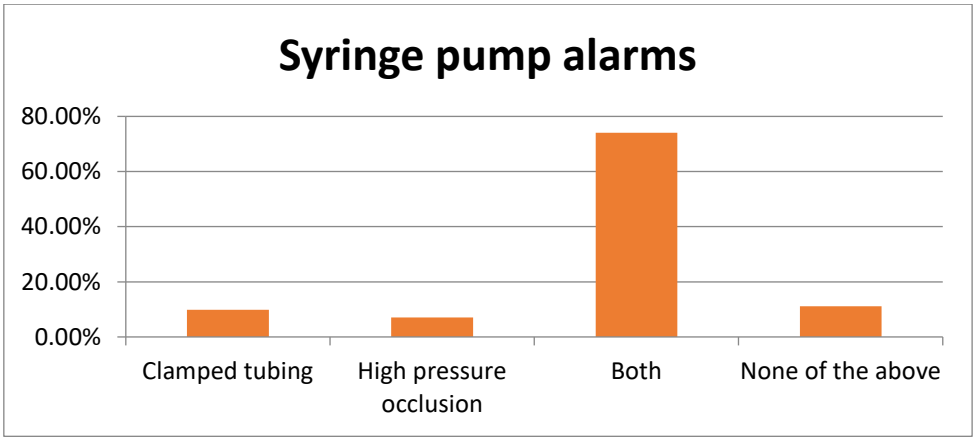

fig 1.5

72.2% gave the correct answer (Both).
8.9% think it is not due to either.

5. Question: Standard threshold (high and low) for heart rate in patient monitors is:

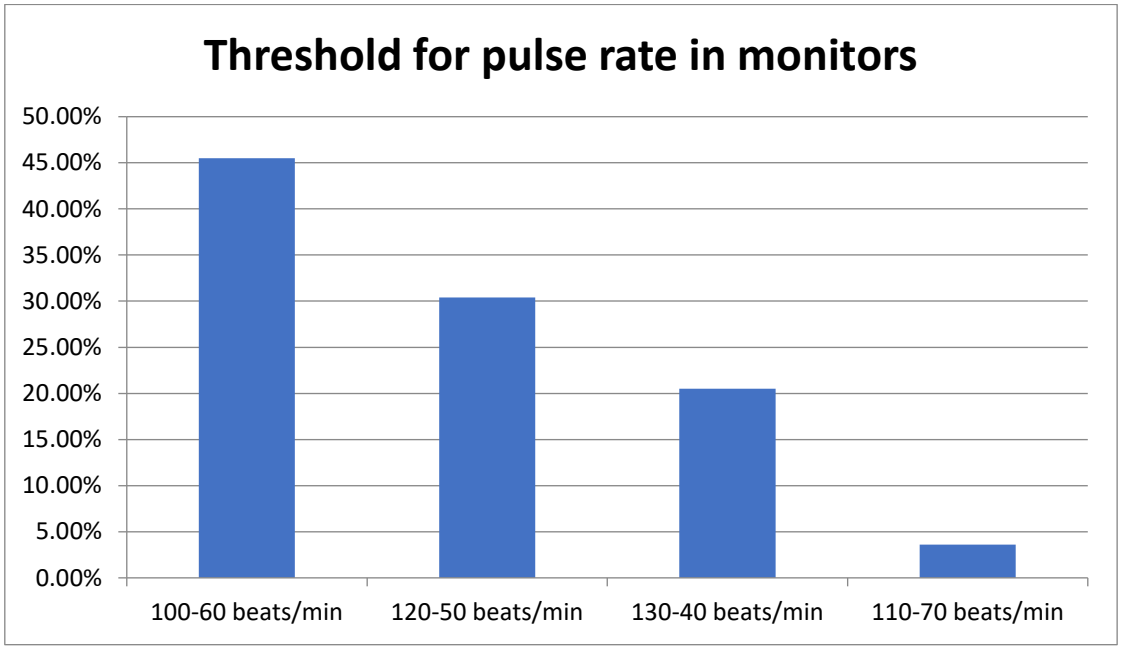

fig 1.6

Only 30.3% gave the correct answer (120-50 beats/min)

6. Question: In case of simultaneous alarms, which alarm should be responded to first?

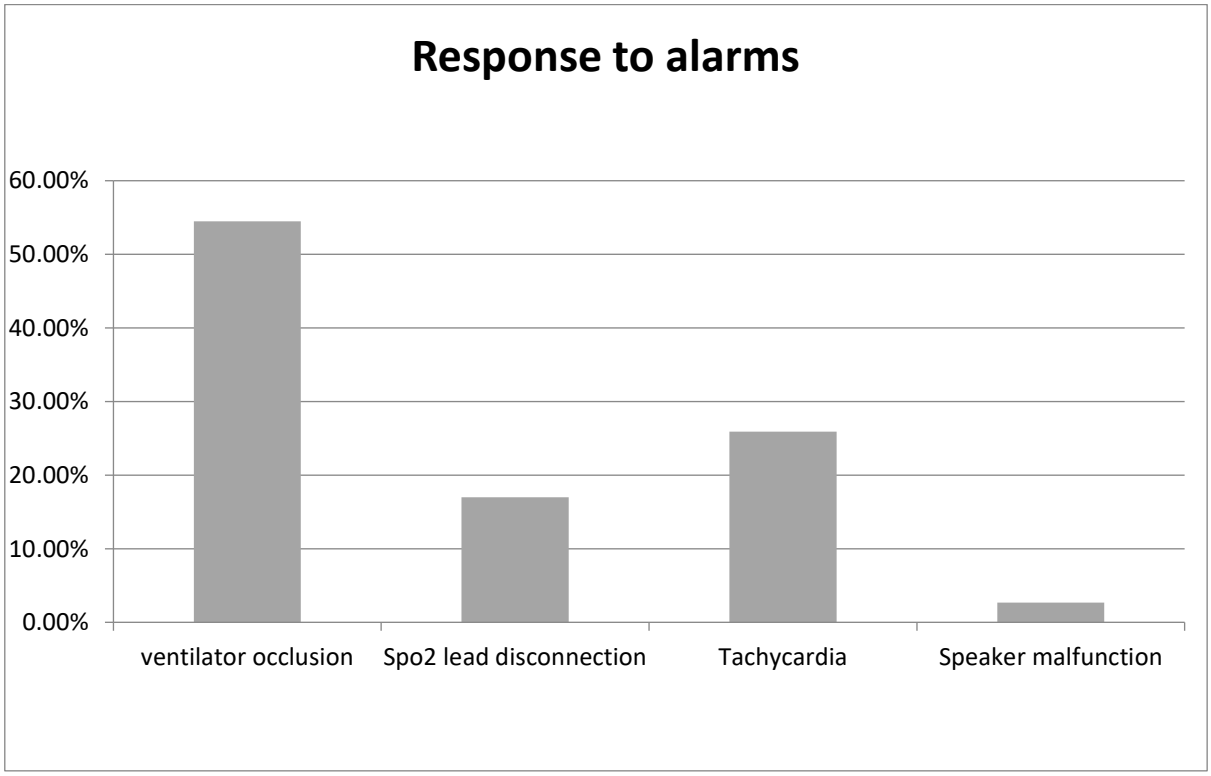

fig 1.7

Only 54% gave the correct answer (Ventilator occlusion)

7. Question: The customization of cardiac monitor settings is based on?

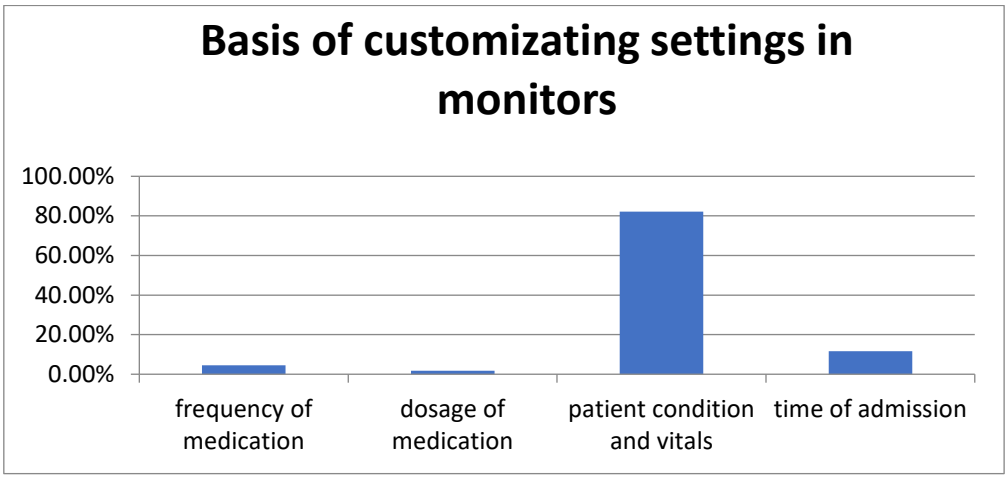

Fig 1.8

82.1% gave the correct answer (patient condition and vitals)

Perception of Nurses

8. Question: Have you started tuning out to clinical alarms due to their increased frequency?

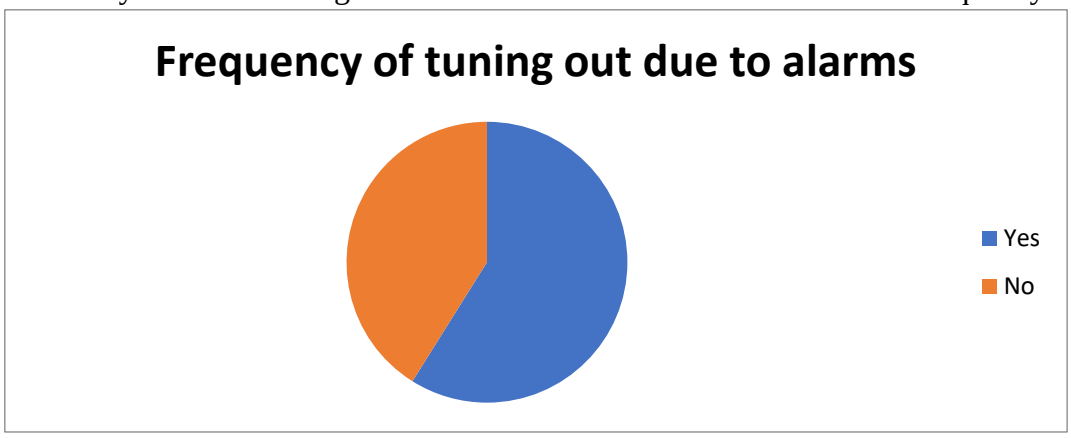

fig 1.9

58.9% of Nurses have accepted that the increased frequency of alarms causes them to tune out.

9. Question: Does having to respond to constant alarms in the ICU make you anxious?

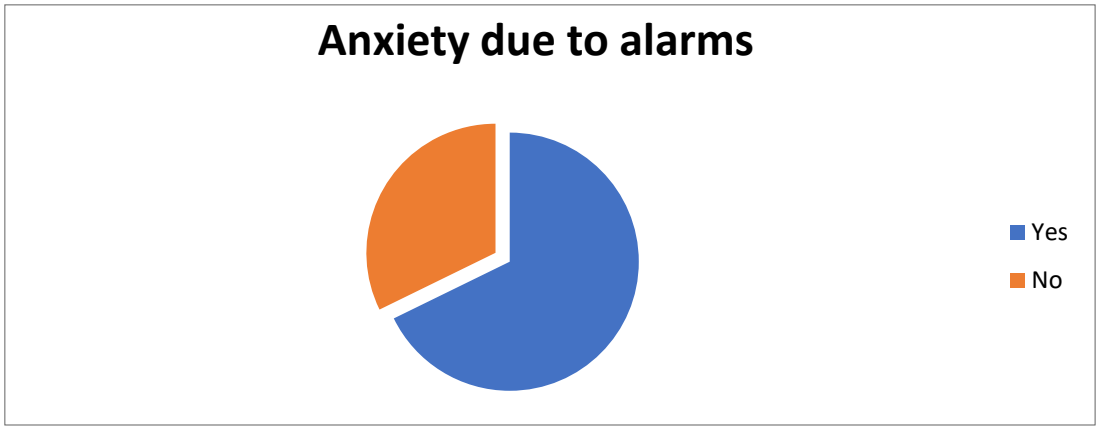

fig 1.10

64.4% of Nurses have accepted that having to respond to multiple alarms makes them anxious.

10. Question: Can you differentiate between false and nuisance alarms

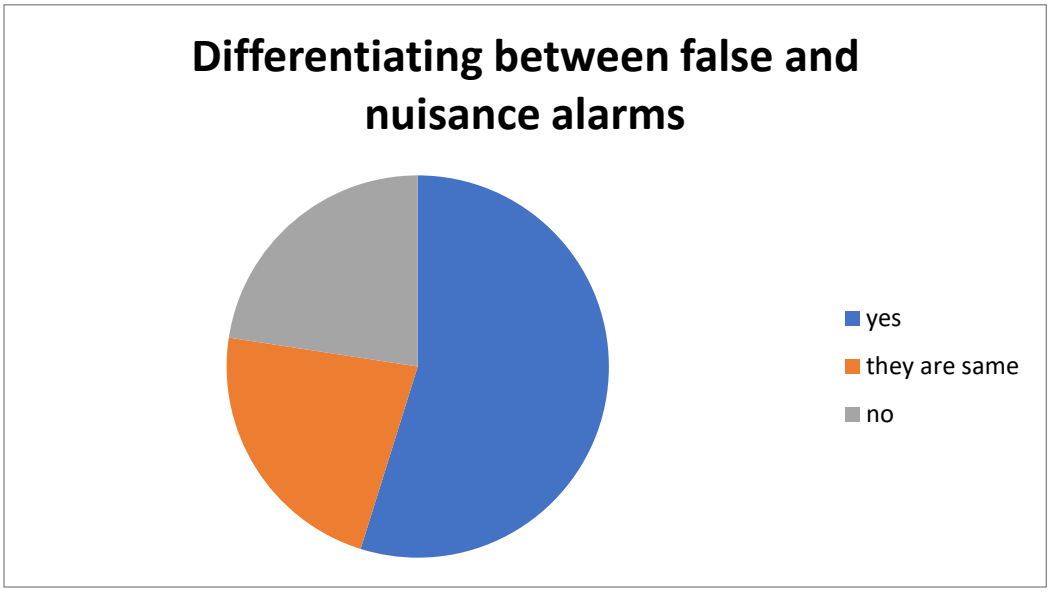

Fig 2

60.7% of nurses can differentiate between them.

25% of nurses think false and nuisance alarms are the same.

DATA ANALYSIS OF PATIENT ALARMS IN THE ICUs

1. Data Analysis of Patient Alarms in the Surgical ICU

- The total number of alarms observed in a period of 5 days between 1-5 pm was 122.
- Out of these 74.5% of alarms were from the patient's bedside monitors.
- 19.7% were nuisance alarms that weren't silenced.
- 44% of the alarms were false alarms that were not responded to.
- And only 1.09% of the total patient bedside monitor alarms were silenced.
- Out of total alarms observed only 9% were from the ventilators which showed a 100% rate of immediate response.
- 5 instances were observed where the nurses were present but did not silence the alarm

1. FALSE ALARMS- LEADS WERE DISCONNECTED DUE TO MOVEMENT OF THE PATIENT AND NOT PLACED BACK.
2. NUISANCE ALARMS- SINCE MONITOR SETTINGS WERE NOT CUSTOMIZED ACCORDING TO PATIENTS, EVEN A SLIGHT VARIATION FROM THE NORMAL THRESHOLD WHICH WAS EXPECTED IN THE RESPECTIVE PATIENT'S CASE LED ALARMS WHICH WERE NOT SILENCED.
3. SILENCED ALARMS- OUT OF THE TOTAL ALARMS ONLY 1.09% WERE SILENCED.

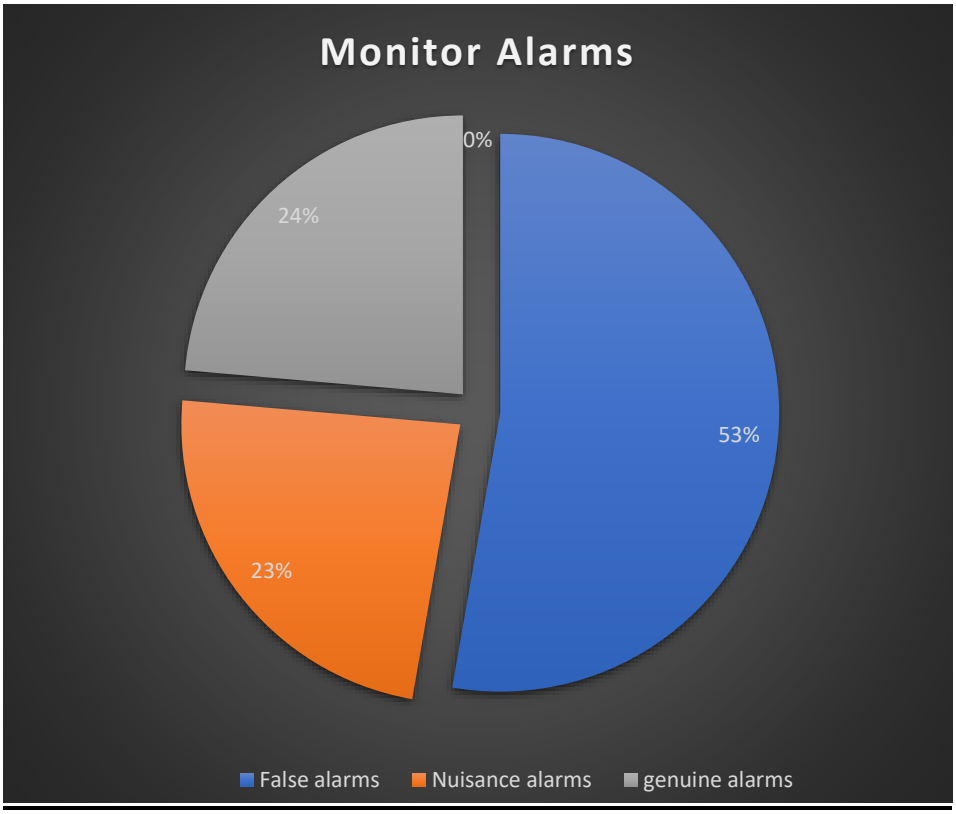

Fig 2.1

Table 1

EQUIPMENT	MONITOR	VENTILATOR	SYRINGE PUMP	DIALYSIS MACHINE
TOTAL NO. OF ALARMS OBSERVED (122)	91	11	12	8
IN PERCENTAGE	74.5%	9%	9.83%	6.55%
FALSE ALARMS OBSERVED	44%	54.5% (WITH RESPECT TO TOTAL VENTILATOR ALARMS)	0	0
RESPONSE RATE OBSERVED	1.09% (SILENCED)	90%	33.33%	25%
COMPLIANCE WITH STAFF SETTING THRESHOLD (AS PER	0% compliance rate (not set according to patient.)	100% (SET BY DOCTOR)	100% (SET BY MANUFACTURER)	0 (SET BY TECHNICIAN)

POLICY)				
COMPLIANCE WITH STAFF CHANGING THRESHOLD (AS PER POLICY)	0% (NOT CHANGED BY NURSE DURING OBSERVATION)	100% (CHANGED BY DOCTOR)	100% (CHANGED BY NURSE)	100% (CHANGED BY TECHNICIAN)

2. Data Analysis of Patient Alarms in the Medical ICU-1

- The total number of alarms observed in the Medical ICU-1 from 3RD-7TH JULY 2023, from 1-5 PM was 73 alarms.
- Out of these alarms, the patient's bedside monitor occupied 84.9% of the total alarms and the ventilator alarms were 6.45%.
- The monitor alarms were 62 out of which 54.8% were nuisance alarms and 40.3% were false alarms.
- Only 14.5% of these alarms were silenced.

1. FALSE ALARMS- LEADS WERE DISCONNECTED DUE TO THE MOVEMENT OF THE PATIENT AND NOT PLACED BACK.
2. NUISANCE ALARMS- SINCE MONITOR SETTINGS WERE NOT CUSTOMIZED ACCORDING TO PATIENTS, EVEN A SLIGHT VARIATION FROM THE NORMAL THRESHOLD WHICH WAS EXPECTED IN THE RESPECTIVE PATIENT'S CASE LED ALARMS WHICH WERE NOT SILENCED.
3. SILENCED ALARMS- OUT OF THE TOTAL ALARMS ONLY 14.5% WERE SILENCED

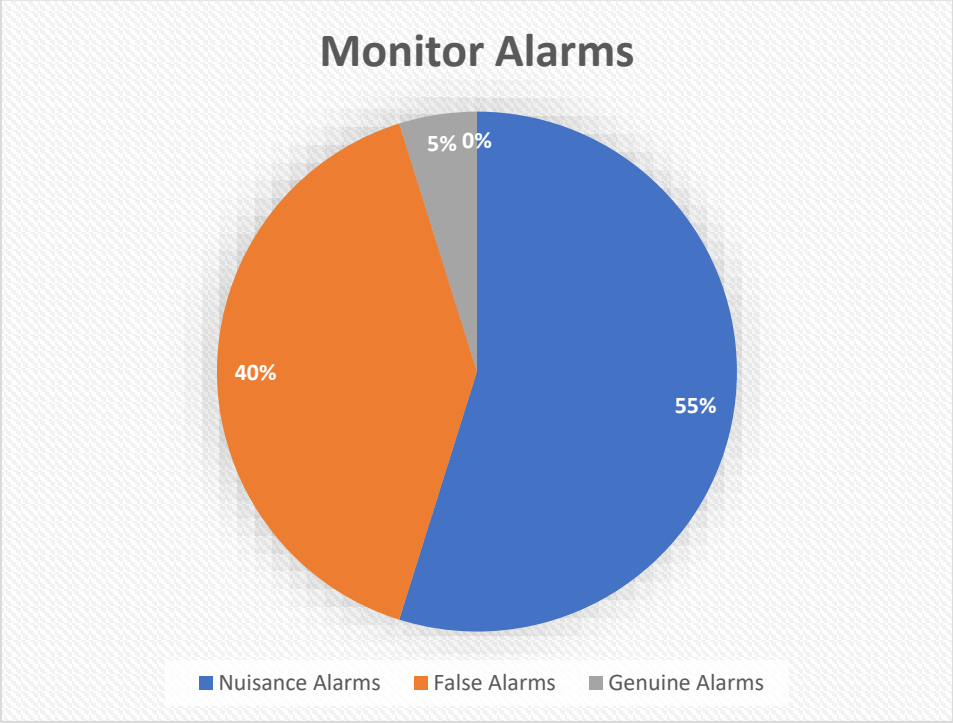

Fig 2.2

Table 2

EQUIPMENT	MONITOR	VENTILATOR	INFUSION PUMP	SYRINGE PUMP
TOTAL NO. OF ALARMS OBSERVED (73)	62	8	3	2
IN PERCENTAGE	84.9%	6.45%	4.1%	2.73%
FALSE ALARMS OBSERVED	40.3%	0	0	0
RESPONSE RATE OBSERVED	14.5% (SILENCED)	100%	33.33%	0
COMPLIANCE WITH STAFF SETTING THRESHOLD (AS PER POLICY)	100% (SET BY THE MANUFACTURER)	100% (SET BY DOCTOR)	100% (SET BY THE MANUFACTURER)	100% (SET BY THE MANUFACTURER)
COMPLIANCE WITH STAFF CHANGING THRESHOLD (AS PER POLICY)	NOT CHANGED DURING OBSERVATION	100% (CHANGED BY DOCTOR)	100% (CHANGED BY THE NURSE)	100% CHANGED BY THE NURSE)

3. Data Analysis of Patient Alarms in ACCU

- The total number of alarms observed in the ACCU in a period of 4 days between 1-5 PM was 159.
- 144 out of these alarms were from the bedside and transport monitors.
- Out of the alarms observed only 8.17% of alarms were from the ventilator out of which 84.6% showed an immediate response rate.
- Out of the bedside and transport monitor alarms observed only 17.36% were silenced.
- The observed bedside patient monitor alarms comprise of 20.83% nuisance alarms and 20.13% false alarms.

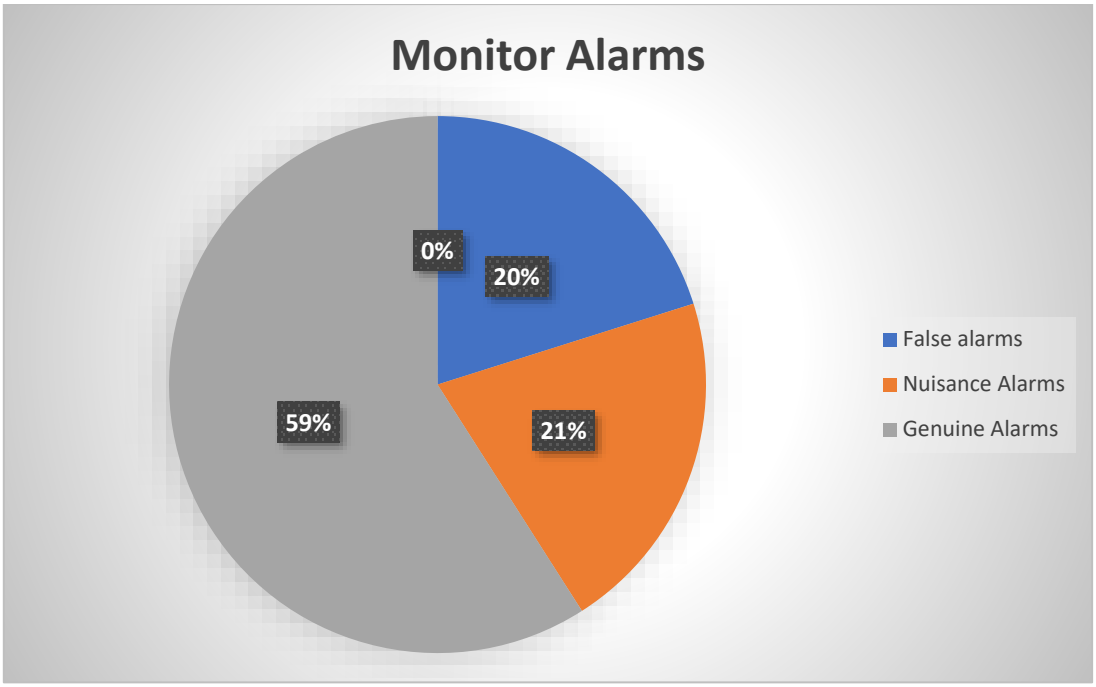

Fig 2.3

1. FALSE ALARMS- LEADS WERE DISCONNECTED DUE TO THE MOVEMENT OF THE PATIENT AND NOT PLACED BACK.
2. NUISANCE ALARMS- SINCE MONITOR SETTINGS WERE NOT CUSTOMIZED ACCORDING TO PATIENTS, EVEN A SLIGHT VARIATION FROM THE NORMAL THRESHOLD WAS EXPECTED IN THE RESPECTIVE PATIENT'S CASE LED ALARMS WHICH WERE NOT SILENCED.
3. SILENCED ALARMS- OUT OF THE TOTAL ALARMS ONLY 17.36% WERE SILENCED.

Table 3

EQUIPMENT	MONITOR	TRANSPORT MONITOR	VENTILATOR	SYRINGE PUMP
TOTAL NO. OF ALARMS OBSERVED (159)	77	67	13	2
IN PERCENTAGE	45.3%	42.1%	8.17%	1.25%
FALSE ALARMS OBSERVED	20.83%	13.88%	0	0
RESPONSE RATE OBSERVED	16.88%	16.41%	84.6% (IMMEDIATE RESPONSE)	0
COMPLIANCE WITH STAFF SETTING THRESHOLD (AS	0 (NOT SET BY INTENSIVIST ACCORDING TO EACH	0 (NOT SET BY INTENSIVIST ACCORDING TO EACH	100% (SET BY DOCTOR)	100 % (SET BY MANUFACTURER)

PER POLICY)	PATIENT)	PATIENT)		
COMPLIANCE WITH STAFF CHANGING SETTINGS (AS PER POLICY)	0% (NURSE DOES NOT CUSTOMIZE FOR EVERY PATIENT)	0% (NURSE DOES NOT CUSTOMIZE FOR EVERY PATIENT)	100% (CHANGED BY DOCTOR)	100% (CHANGED BY NURSE)

4. CONSOLIDATED DATA ANALYSIS OF SICU, MICU-1 & ACCU

- THE TOTAL NUMBER OF ALARMS OBSERVED IN THE THREE ICUs IN A PERIOD OF 14 DAYS BETWEEN 1-5 PM WAS 354 ALARMS.
- OUT OF THE ALARMS OBSERVED, 297 ALARMS WERE FROM BEDISDE AND TRANSPORT MONITORS.
- ONLY 7.9% OF THE ALARMS STUDIED WERE FROM THE VENTILATOR WHICH SHOWED AN 81.8% IMMEDIATE RESPONSE RATE.
- 4.23% OF OBSERVED ALARMS WERE FROM SYRINGE PUMPS AND INFUSION PUMPS AND ONLY 0.84% WERE FROM THE DIALYSIS MACHINE.

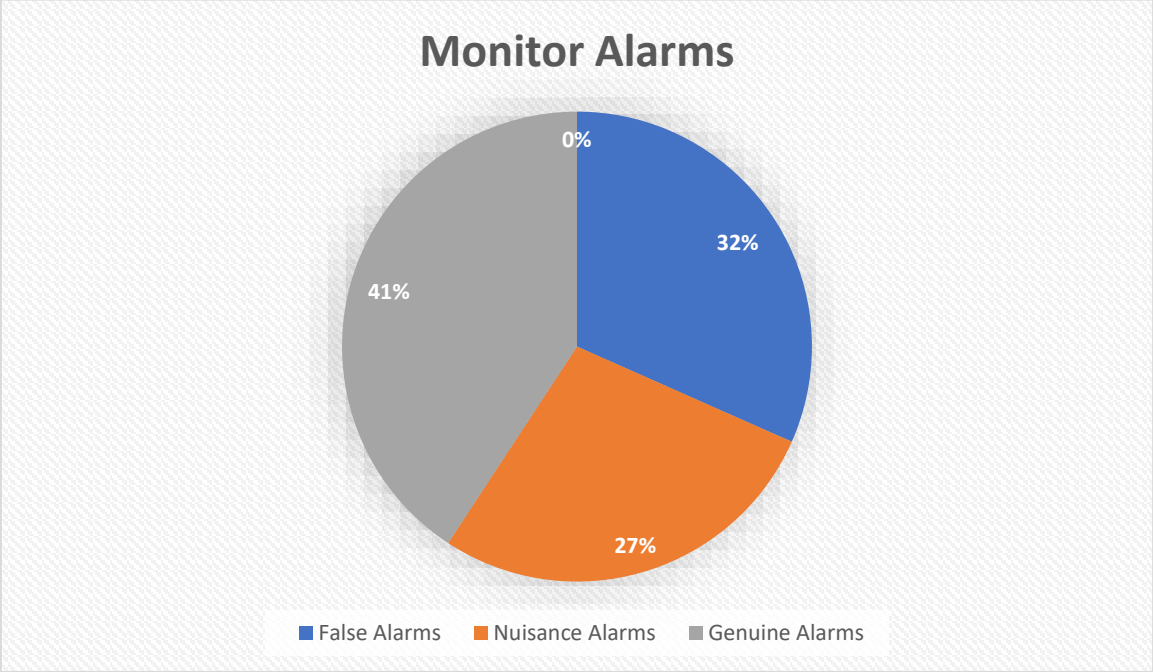

Fig 2.4

1. FALSE ALARMS- LEADS WERE DISCONNECTED DUE TO THE MOVEMENT OF THE PATIENT AND NOT PLACED BACK.
2. NUISANCE ALARMS- SINCE MONITOR SETTINGS WERE NOT CUSTOMIZED ACCORDING TO PATIENTS, EVEN A SLIGHT VARIATION FROM THE NORMAL THRESHOLD WAS EXPECTED IN THE RESPECTIVE PATIENT'S CASE LED ALARMS WHICH WERE NOT SILENCED.
3. SILENCED ALARMS- OUT OF THE TOTAL ALARMS ONLY 17.36% WERE SILENCED.

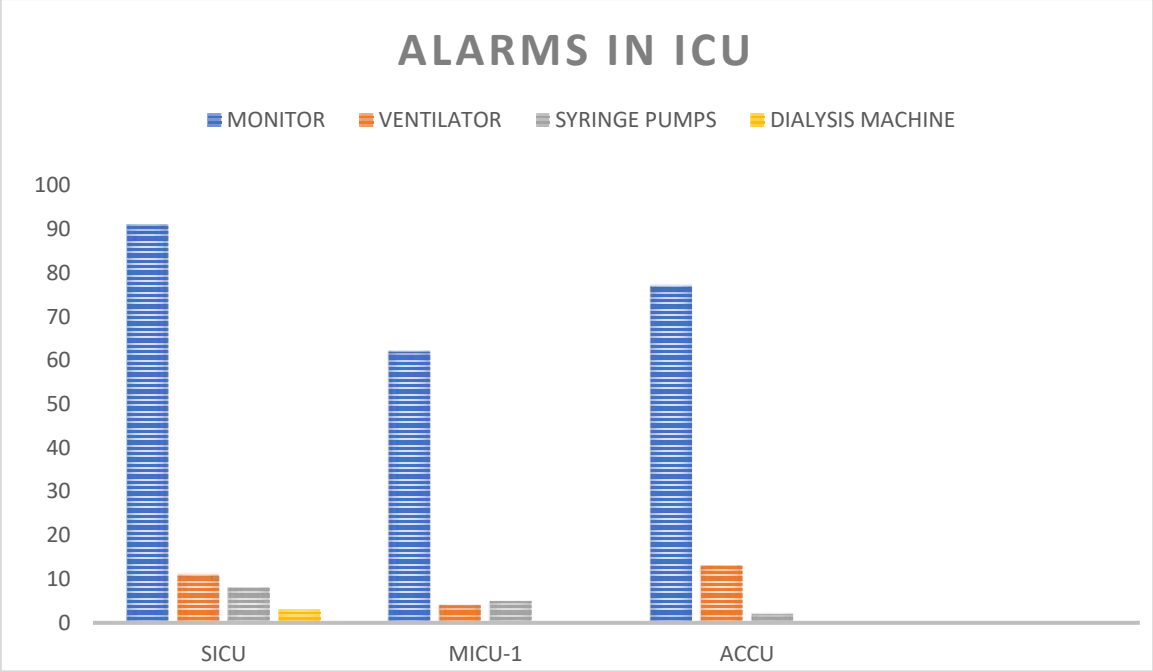

Fig 2.5

Table 4

EQUIPMENT	MONITOR	TRANSPORT MONITOR	VENTILATOR	SYRINGE AND INFUSION PUMPS	DIALYSIS MACHINE
TOTAL ALARMS OBSERVED (354)	230	67	28	15	3
IN PERCENTAGE	64.97%	18.9%	7.9%	4.23%	0.84%
FALSE ALARMS OBSERVED	31.64%	30.9%	25% (WITH RESPECT TO TOTAL VENTILATOR ALARMS OBSERVED)	0	0
RESPONSE RATE OBSERVED	14.14% (SILENCED)	16.41	81.81% (IMMEDIATE REPONSE)	33.33%	25%
COMPLIAN	0% COMPLIANCE	0%	100 % (SET	100% (SET BY	0% (IT IS

CE WITH STAFF SETTING THRESHOLD (AS PER POLICY)	(INTENSIVIST DOES NOT SET FOR EACH PATIENT)	COMPLIANCE (INTENSIVIST DOES NOT SET FOR EACH PATIENT)	BY DOCTOR)	MANUFACTURER)	SET BY THE TECHNICIAN ON DOCTOR'S ORDERS)
COMPLIANCE WITH STAFF CHANGING THRESHOLD (AS PER POLICY)	0% (NURSE DOES NOT CHANGE/CUSTOMIZE FOR EACH PATIENT)	0% (NURSE DOES NOT CUSTOMIZE FOR EACH PATIENT)	100% (CHANGED BY DOCTOR)	100% (CHANGED BY NURSE)	100% (CHANGED BY TECHNICIAN)

OBSERVATIONS AND INFERENCES.

Observations of Clinical Alarms in Surgical ICU

- The Central Monitor does not show the vitals of all patient beds. (Cabling error)
- Copy of the clinical alarms policy present in the ICU
- Threshold changes for patient monitors are not recorded.
- The monitors in the Surgical ICU are set to non-latching (can be changed).
- The respiratory rate threshold given in the policy chart is 6-40 cycles/min, but it is 8-30 cycles/min in the operating manual.
- The technician was setting up the dialysis machine on the doctor's written orders as opposed to the policy which states that the doctor is supposed to set the thresholds.
- Out of all the equipment observed 100% of the monitor settings were set to standard thresholds. None of the settings were customized according to patients.
- 0% compliance rate with changing settings according to the policy
- 0% compliance rate with setting customized thresholds for each patient

Observations of Clinical Alarms in Medical ICU-1

- The Central Monitor does not show the vitals of all patient beds. (Cabling error)
- Copy of the clinical alarms policy present in the ICU
- Threshold changes for patient monitors are not recorded.
- The monitors in the MEDICAL ICU are set to latching (can be changed).
- The respiratory rate threshold given in the policy chart is 6-40 cycles/min, but it is 8-30 cycles/min in the operating manual.
- The technician was setting up the dialysis machine on the doctor's written orders as opposed to the policy which states that the doctor is supposed to set the thresholds.
- Out of all the equipment observed 100% of the monitor settings were set to standard thresholds. None of the settings were customized according to the patients.

- 2 instances were observed where the concerned nurse was not aware of why the alarms were beeping despite the vitals being stable.
- 6 instances were observed when the nurse was present and yet did not silence the alarms.
- 0% compliance rate with changing settings according to the policy
- 0% compliance rate with setting customized thresholds for each patient

Observations of Clinical Alarms in ACCU

- Copy of the clinical alarms policy present in the ICU
- Threshold changes for patient monitors are not recorded.
- The monitors in the ACCU are set to non-latching (can be changed).
- The respiratory rate threshold given in the policy chart is 6-40 cycles/min, but it is 8-30 cycles/min in the operating manual.
- The technician was setting up the dialysis machine on the doctor's written orders as opposed to the policy which states that the doctor is supposed to set the thresholds.
- Out of all the equipment observed 100% of the monitor settings were set to standard thresholds. None of the settings were customized according to patients.
- Monitor for bed no 4 showed a battery malfunction warning for 4 days.
- Speaker malfunction observed in the monitor for bed no. 9 for 4 days.
- 16 instances were observed where nurses were present and did not silence the alarms.
- 0% compliance rate with changing settings according to the policy
- 0% compliance rate with setting customized thresholds for each patient

Consolidated Observations of ICUs

- The total number of alarms observed in the three ICUs in a period of 14 DAYS between 1-5 PM was 354 alarms.
- Out of the alarms observed, 297 alarms were from both bedside and transport monitors.
- Only 7.9% of the alarms studied were from the ventilator which showed an 81.8% immediate response rate.
- 4.23% of observed alarms were from syringe pumps and infusion pumps and only 0.84% was from the dialysis machine.

Findings on Knowledge and Perception of Nurses on Clinical Alarms

- A total of 112 responses were recorded from ICU nurses from 8 different ICUs.
- These include Surgical ICU, Medical ICU-1, Medical ICU-2, Medical ICU extension, Transplant ICU, Cardiac ICU, PICU and ACCU
- Only 17% of the nurses are aware that the cardiac monitor settings are to be set by the primary consultant.
- 69.4% of nurses are aware that customization of monitor settings is mandatory.
- 3.6% of nurses think the settings of a cardiac monitor cannot be customized.
- Only 53 % of nurses were able to answer ventilator alarm categories correctly.
- 72.2% of nurses knew the alarm occurrence criteria for syringe pumps.
- Only 30.3% are aware of the standard threshold for heart rate to be set in cardiac monitors.

- Only 54% of nurses responded to the question regarding the prioritization of alarms in different equipment correctly.
- 82.1% of the nurses are aware of the basis for setting the threshold for each patient which is the patient's medical condition and vitals.
- 58.9% have agreed to the fact that the increased of alarms causes them to tune out thereby increasing alarm desensitization.
- 64.4% of nurses have accepted having to respond to multiple alarms makes them anxious thereby proving their alarm fatigue.
- 60.7% can differentiate between false and nuisance alarms.
- 25% of nurses think they are the same kind of alarms.

Summary and Conclusion

After months of ICU observation, Alarm desensitization, and Alarm fatigue came out to be eminent issues in the functioning of an Intensive Care Unit. The clamour of alarms has been demonstrated to hinder patient recovery, lengthen stays, have a poor impact on patient satisfaction, and cause patient anxiety, sleep difficulties, delirium, elevated blood pressure and heart rates, and immune system deterioration. Therefore, fewer alerts and a simpler alarm configuration procedure can aid in better patient outcomes. The response to all alarms is imperative but false and nuisance alarms make it challenging for the nurses to differentiate and respond to genuine alarms. The study focused on identifying reasons for the occurrence of nuisance and false alarms, factoring in the proportion of these unnecessary alarms, and chalking out measures to reduce these false and nuisance alarms. This included a checklist to monitor the alarms in ICUs on a daily basis for various equipment including cardiac monitors, ventilators, dialysis machines, syringe pumps, and infusion pumps. These were monitored for around 5 hours a day and the analysis revealed most of the equipment especially cardiac monitors giving out false and nuisance alarms. A pre-assessment questionnaire was made to assess the knowledge and perception regarding clinical alarms for nurses. The analysis revealed that 40% of nurses could not differentiate between false and nuisance alarms. A training module and video were made to educate the nurses regarding the different types of alarms from various equipment along with the appropriate responses to them.

To reinforce the importance of documentation of settings, forms for cardiac monitors and ventilators were made to record the setting and changing of settings according to the policy of the hospital. The authority to set and change these settings is imperative to enforce accountability; the customization of these settings will lead to the minimization of nuisance alarms thereby, reducing half the unnecessary noise in these ICUs. The Policy on Clinical Alarms was altered to fit the current needs of the ICUs. This included focusing on threshold limits of patient vitals, assigning the responsibility of customization to particular staff members, appropriate settings for alarm audibility, maintenance and testing of alarm systems, education and response during alarm failure and alarm-related incidents.

The education of nursing staff plays a crucial role in implementing these appropriate alarm configuration practices since it teaches them to identify and differentiate between different kinds of alarms and deal with them. Reduction in these unnecessary alarms will also reduce unnecessary pressure and anxiety of nurses facing innumerable alarms, leading to them responding appropriately to all alarms, improving the quality of care, and enhancing patient safety.

Patient safety can be directly impacted by high rates of false and non-actionable alarms that affect staff care performance. Thus, fewer false alarms can aid staff in effectively handling alarms that are of clinical significance.

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