



### IMPROVING SAFETY CULTURE BY ESTABLISHING ALARM FATIGUE PERFORMANCE IN THE ADULT INTENSIVE CARE UNIT, DAMMAM HOSPITAL

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#### ABSTRACT

Alarm fatigue is becoming a more significant global public health issue that compromises patient safety. Alarm fatigue is especially common among critical care nurses, who are the frontline healthcare providers that provide patients with the most direct care and round-the-clock patient monitoring. An excessive number of alerts, together with erroneous and ineffective alerts, can cause alarm fatigue and negatively impact the psychological well-being of nurses and patients during their recovery process. To find a way to lower the number of false alarms and assess the effectiveness of the measures put in place, a quantitative, descriptive cross-sectional approach was employed. In the adult Intensive Care Unit (ICU) at National Guard Health Affairs (NGHA) Dammam, this pilot project was carried out from June 2019 to November 2020. In order to identify true alarms and false alarms, the Central Monitor Nurse Daily Checklist was utilized as a data collection tool in conjunction with education training and departmental policies and procedures. There are about 820 alerts per patient each day, including 104 telemetry and 716 bedside alarms. Three months into the project, the project's top alarm measurement was 1503 alarms per patient per day. The project has shown a constant trend in alarm declinations after this peak, largely as a result of project improvement activities. The lowest recorded alarm count in November 2020 was 226 alerts, a 72% decrease from the initial 820 alarms. Nonetheless, the declining trend over the previous three months showed a 22%, 42%, and 48% drop in the overall number of alarms. This study found that alarm fatigue, which is influenced by a number of variables, including safety culture practices, was more common among critical care nurses working in the Intensive Care Unit at NGHA Dammam. Overall, during the first two months of its deployment, this study effectively met its aim and had a considerable impact on the reduction of "false alarms". The results of this study, taken together with improved psychological health for nurses and the provision of a therapeutic environment for patients, offer crucial direction for future intervention programs aimed at reducing alarm fatigue among critical care nurses. Future studies should concentrate on the traits of adherence and management, as well as the obstacles that prevent ICU staff from continuing to implement interventions and false alarm reduction strategies.

**Keywords:** *Improving Safety Culture, Alarm Fatigue Performance, Adult Intensive Care Unit*

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### Introduction

When medical professionals are overexposed to alerts from their devices, it can lead to alarm desensitization, alarm fatigue, and missing or delayed alarm responses. Alarm fatigue has gained recognition as a significant patient safety concern as the number of alerts utilized in healthcare increases (Agency for Healthcare Research and Quality, 2019). Even though alarm fatigue is a well-established issue, alarm-related incidents are frequently underreported, and there is currently no study looking at strategies to deal with the problem.

Raising the bar for healthcare in general requires fostering a culture of safety. Key elements of safety culture generally include acknowledging the high-risk nature of an organization's operations, creating a blame-free environment where people can report errors without fear of consequences, encouraging cross-disciplinary teamwork to find solutions to patient safety issues, and allocating organizational resources to address safety concerns. There are several strategies to combat alert fatigue through improving safety culture, and these interventions are often implemented as part of system- or unit-wide initiatives (Bach et al., 2018).

These components include, for example: leadership establishing priorities for the use of alarm technology; leadership ensuring that clear procedures for safe alarm management and response are in place; and at all staff levels, procedures are established for exchanging information about alarm-related incidents, prevention techniques, and instruction, as stated by Kendall et al. (2020). System-wide interventions are needed to address alarm fatigue through enhancing safety culture. These include having leadership make sure that safe alarm management procedures are well-defined and that protocols are in place for exchanging information on alarm-related occurrences and preventative measures (Spiva et al., 2020).

Moderate evidence for lower alert volume and noise levels when safety culture features are implemented is provided by the studies included in this summary. Two studies demonstrated a perceived reduction in alarm tiredness (Nyarko et al., 2023; Liu et al., 2023). Surveys evaluating nurses' perceptions of alarm fatigue and behavioral changes towards alert management yielded inconsistent results. To investigate the impact of safety culture components on alarm fatigue process and result metrics, more excellent studies are required.

To comprehend the demands and circumstances that exist today and lead to alarm fatigue, it is crucial to perform a baseline alarm risk assessment. Evaluation of computer systems and medical equipment, data analysis from clinical event reporting systems, assessment of patient satisfaction, and examination of the physical surroundings are all possible components of conducting an alert risk assessment (Lehet et al., 2023). The effect of doing alarm risk assessments on lowering alarm fatigue has not received much attention in the literature as of yet. The reviews in this review focus on alarm risk assessment as part of broader system-wide initiatives or quality improvement (QI) projects; yet, they offer rather solid evidence in favor of using Critical Care teams to perform these evaluations.



### Literature Review

In order to keep an eye on their patients' ailments, nurses and doctors employ a range of tools and technology in the increasingly computerized field of healthcare. The majority of medical equipment has built-in visual or audio alarms that are meant to notify the doctor when a patient's condition deviates from a specified normal range. To help nurses and doctors decide how to respond, many device alarms have varied sounds, pitches, or both depending on the severity (i.e., advisory, warning, or crisis alarm). Mechanical or electrical issues, such as devices in need of new batteries, can also result in non-clinical system status or alarms (Healthcare Technology Foundation, 2016). Alarm fatigue can result from an excessive frequency of alarms combined with a high frequency of false alarms, which poses a risk to patient and healthcare worker safety. Despite this, device alarms can be a valuable tool in clinical decision-making.

Hospitals are prioritizing improving alarm management as alarm fatigue is becoming more widely acknowledged as a serious safety concern. The Manufacturer and User Facility Device Experience (MAUDE) reporting system of the U.S. Food and Drug Administration (FDA) received 566 reports of patient deaths associated with monitoring device alarms between 2005 and 2008 (Joint Commissions on Accreditation of Healthcare Organizations, 2011). Due to the high rate of false alerts and excessive number of alarms, alarm fatigue had a significant role in these incidents (Welch, 2019). In one study conducted at a prominent academic medical centre, nearly 59,000 alarms were recorded in a 12-day period (Bach et al., 2018); in another study, 16,953 alarms were recorded in an 18-day period on a single medical unit (Lee et al., 2021). According to studies, the proportion of false alarms might vary from 72% to 98%.

Several national organizations have prioritized tackling alarm fatigue and produced alarm management standards in an effort to raise awareness of this issue. The ECRI Institute has regularly recognized alarm dangers as a significant concern ever since launching its yearly list of the top 10 health technology hazards in 2011. 2011 saw a summit between the FDA and the Association for the Advancement of Medical Instruments (AAMI). The American College of Clinical Engineers, the Joint Commission, and the ECRI Institute collaborated to address alarm safety concerns, and they released a study containing problems, recommendations, and top priorities (Phillips et al., 2020). An important contributing factor to patient mortality was found to be alarm fatigue in a Sentinel Event Alert on medical device alarm safety published by The Joint Commission (2013). The 2014 National Patient Safety Goals on Alarm Management were published later that year by the Joint Commission, and they were to be implemented in two stages. Hospitals must make managing alarms a top priority for the entire organization starting in 2014 and determine which alerts are most critical to handle based on internal policies.

The monitored unit's typical procedure is to rely on a physiological monitor to "watch" the patient round-the-clock and notify the nurse of any major rhythm issues. Nurses and doctors are supposed to be informed via alarms of any changes from a predefined "normal" status. Alarm fatigue, on the other hand, could happen if nurses and doctors are overloaded with monitor alarms to the point where they disable, silence, or disregard them. In light of this, Graham & Cvach's (2010) assessed the kind and frequency of monitor alerts on a medical progressive care unit as part of a modest test of modifications to enhance alarm management.



The monitoring software was changed to enhance the audibility of crucial alarms, and nurses were instructed to customize the alarm parameter limits and levels for each patient. According to Graham & Cvach's (2010) research, there has been a 43% decrease in critical monitor alerts compared to baseline data. The implementation of an interdisciplinary monitoring policy, rigorous assessment and adjustment of monitor alarm parameter limits and levels, and monitor alarm default adjustments can all be credited with alert reduction as mentioned by Phillips et al., (2020).

Intensive Care Units (ICUs) are frequently excessively noisy, surpassing 70–80 dBA, which might have detrimental impacts on staff, as confirmed by Armbruster et al., (2023). But the World Health Organization's corresponding recommendation a sound pressure level that is on average less than 35 dBA does. In light of this, Armbruster et al., (2023) carried out an intervention pertaining to noise. Staff members on the three intensive care units reported high levels of noise exposure, and staff members were trained to increase awareness that changing one's behavior could have a positive impact on the noise environment. These findings came from a monocentric prospective longitudinal study that was carried out on 179 healthcare professionals and other professional groups between October 2021 and August 2022 using an online questionnaire.

### Problem Statement

Welch (2019) states that '*alarm fatigue*' happens when medical professionals, particularly nurses, grow insensitive to safety alerts as a result of frequent alerts. This might result in missed alerts or delayed reactions. The frequent occurrence of false or ineffective alarms exacerbates alarm desensitization. Non-actionable alarms happen when the alarm system operates as intended but indicates an event that is not clinically significant and/or does not require further intervention (Winters et al., 2018). False alarms are alarms that occur in the absence of an intended legitimate event (Lehet et al., 2023). In addition to being bothersome, this large rate of nuisance alerts makes it so that employees begin to question the alarm's dependability and, as a result, reduce, disregard, or deactivate it (Kim et al., 2023). This has a negative impact on patient safety since doctors miss or disregard numerous significant and actionable clinical signals in addition to annoying ones.

This statement is also supported by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) (2002) cited in The Joint Commissions (2013), where approximately 23 reports of death or injury were related to mechanical ventilation. Nineteen of those events resulted in death, and 4 resulted in coma; 65% are related to alarms. Issues include delayed or no response to alarms; the alarm is turned off or set incorrectly; no alarm for certain types of ventilator cuts; or alarms cannot be heard in all areas of patient care. This review prompted JCAHO to include alarm safety in the National Patient Safety Goals for 2003. There are basically two types of alarms, i) True alarms i.e. true alarms that require immediate attention and intervention and ii) False alarms also called '*nuisance alarms*', causing panic and bringing unnecessary resources to unnecessary places.

Following this issue, NGHHA Dammam has 6 beds to accommodate critical patients for further management. Most of the cases admitted to the NGHHA ICU include cases related to chronic heart and respiratory diseases as well as emergency cases such as bleeding and other critical cases. These critically ill patients mostly require the assistance of ventilators in their care management. In the Intensive Care Unit (ICU), NGHHA Dammam, '*bedside alarms*' are used to call attention to



patients, to inform changes in patient physiology, or to warn of failures in medical devices; however, up to 68% of those alarms are false and cause desensitization to alarm fatigue among staff and also cause discomfort to ventilated patients. Therefore, beginning in 2019, National Guard Dammam Hospital was expected to establish policies for managing alarms and educate staff about alarm management.

This small study was conducted on 16.6.2019 to 22.6.2019 which is a 1-week survey at the ICU, NGHHA Dammam by identifying true and false alarms using visual and auditory inspection and manual counting. Data were collected by the primary nurse during the admission period of each patient over a period of one week. Six patients with beside alarm provided were involved. Data were extracted from the central monitor and entered into MS Excel. Specific forms were developed for the principal investigator to capture data. Figure 1 shows the result of total number of alarms for each bed. All the beds can hear alarms from the other patients with decibels measured; at the bed side was 73.6dB and from other beds was 65.4dB. Approximately 495 alarms (mean), or 68% of false alarms, are based on the observation total of 820 alarms/day/bed, bedside alarms of 716/day/be, and telemetry of 104 alarms/bed/day.

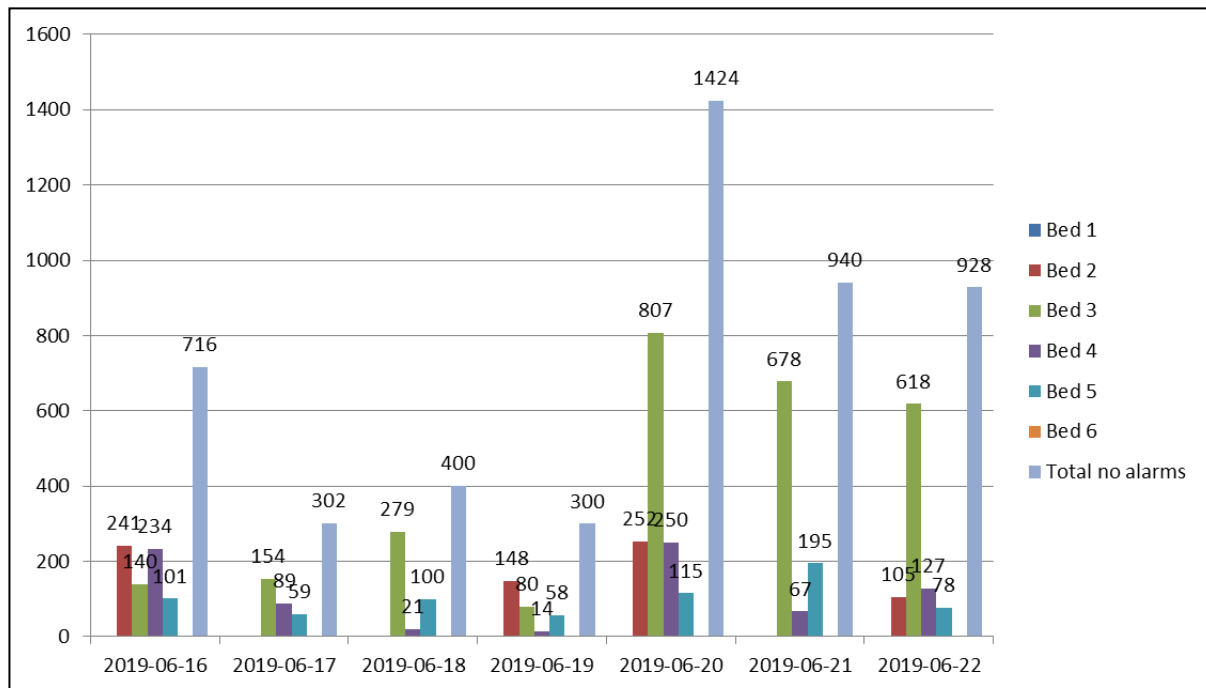
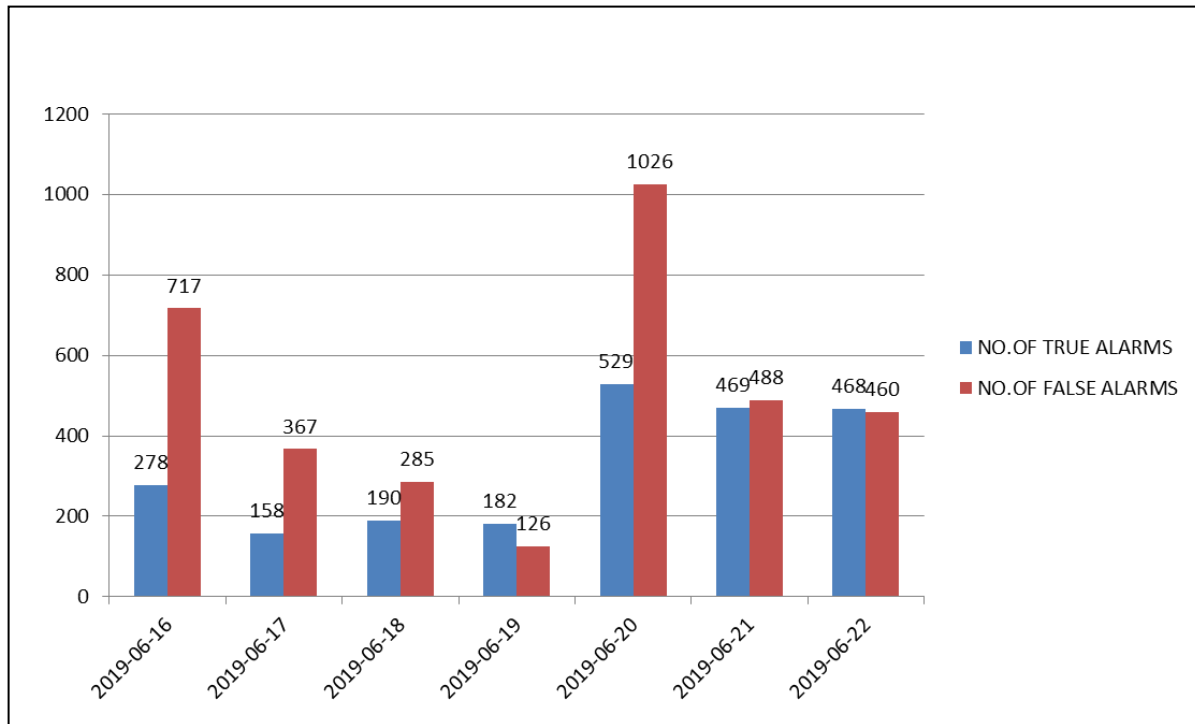


Figure 1. Statistic on total number of alarm/bed/day for 1 week duration



**Figure 2.** Pre intervention statistic on total number of 'true alarm' and 'false alarm'

While Figure 2 shows the difference between 'true alarm' and 'false alarm' identified within the 1-week period. In relation to that, an intervention was carried out to minimize the number of false alarms as to improve patient's comfort and nurse's desensitization to alarms. The finding clearly shows that health workers including nurses and physicians as well as patients are highly exposed to fatigue alarms which can have a negative impact on health and well-being.

Staff training and Departmental Procedures and Policy (DPP) related safety culture in reducing fatigue alarm were created by the hospital management and implemented on primary nurses in ICU for three months. The project was conducted on the principles of Six Sigma DMAIC (Define, Measure, Analyze, Improve and Control). In general, this mini study was conducted to establish the performance of alarm fatigue in the Adult Intensive Care Unit as an effort to maintain and improve an optimal safety culture in the study hospital. Therefore, specifically, the purpose for this study was to identify a means of reducing the number of false alarms and evaluate the interventions implemented.

### Significance of the study

A number of factors, including organizational, workplace, and individual characteristics, contribute to fatigue in nurses. This should provide substantial advantages for nurses and hospital



administrators in relation to the study's goal, which is to determine alarm fatigue performance in the adult intensive care unit. These advantages include a decrease in desensitization, an increase in staff development and retention, and an improvement in staff satisfaction, a reduction in staff workload, an improvement in patient comfort, and an improvement in patient satisfaction. By encouraging a "silent ICU," patients will heal more rapidly, which can shorten their stay in the intensive care unit. This study project will indirectly contribute to the creation of a more peaceful work environment.

### Methodology

This quantitative pilot study of the action research type using the cross-sectional method was conducted from June 2019 until November 2020 at Adult ICU, NGH A Dammam. Education training and Departmental Policy and Procedures (DPP) were provided and Central Monitor Nurse Daily checklist was used in identifying true alarms and false alarms as instrument to gather the data as showed in Figure 3.

The Intensive Care Unit nurses received verbal and email instructions and information about the project processes prior to its implementation. By using BestCare deployment, the central monitor daily checklist is completed. The primary nurse must respond to the alarms, check on them, and, if necessary, step in to speak with the doctor and gauge how loud they are. The team leader will speak with the biomed if the sound levels are outside of hearing range.

Item	Done	Not Done	N/A
<input checked="" type="checkbox"/> Patient Identification Check: Correct MRN & Name	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input checked="" type="checkbox"/> MRN & Name in Electronic documentation, Bedside monitor and Central monitor correspond	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="checkbox"/> Empty Room: Discharged from monitor, sector cleared	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
<input checked="" type="checkbox"/> Alarm Parameter set and all alarms are ON	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input checked="" type="checkbox"/> Arrhythmia alarms, RED "ALL ON" record & store	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input checked="" type="checkbox"/> Arrhythmia alarms, YELLOW "ALL ON" set appropriately	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input checked="" type="checkbox"/> Rhythm analysis done per shift	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input checked="" type="checkbox"/> Abnormal rhythm saved and reported	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
<input type="checkbox"/> All Telemetry devices functioning and in good condition	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
<input type="checkbox"/> KN Number and PPM sticker up to date for ALL Telemetry devices	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

Figure 3. Central Monitor Nurse Daily checklist

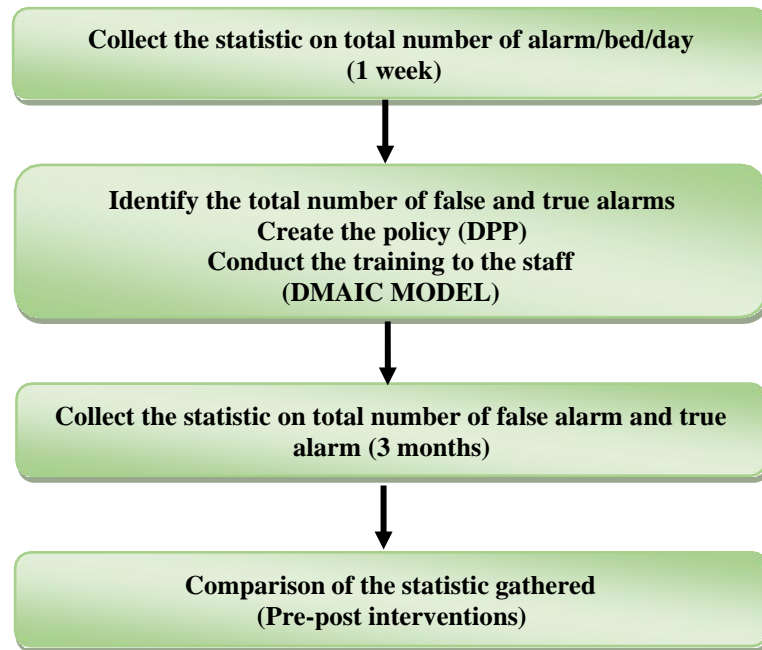


Figure 4. Study Framework

### Data Collection and Result

A total of 820 alarms/patient/day (716 bedside and 104 telemetry). The project's peak alarm measurement was three months into the project and was 1503 alarms/patient/day. Since this peak, and due to project improvement actions, the project demonstrated a consistent trend in alarm declinations to the lowest measured alarms in November 2020 with 226 alarms, a 72% decline from the initial 820 alarms. However, the downward trend for the last 3 months demonstrated a decrease in total alarms by 22%, 42% and 48% as shown in Figure 6 below.

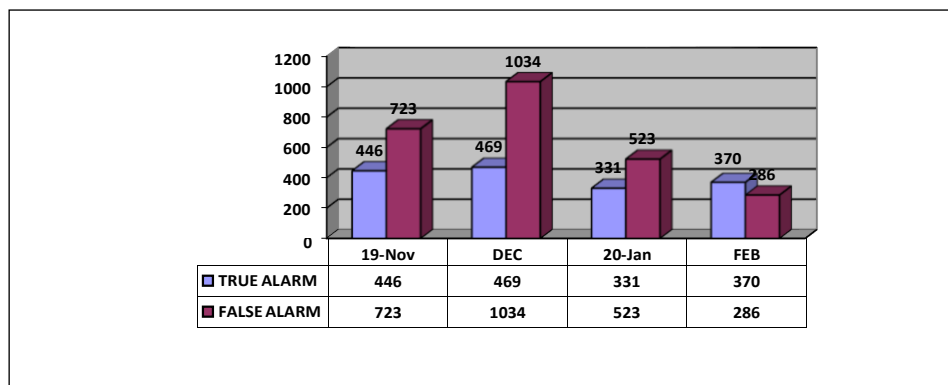


Figure 5. Post intervention statistic on total number of 'true alarm' and 'false alarm'



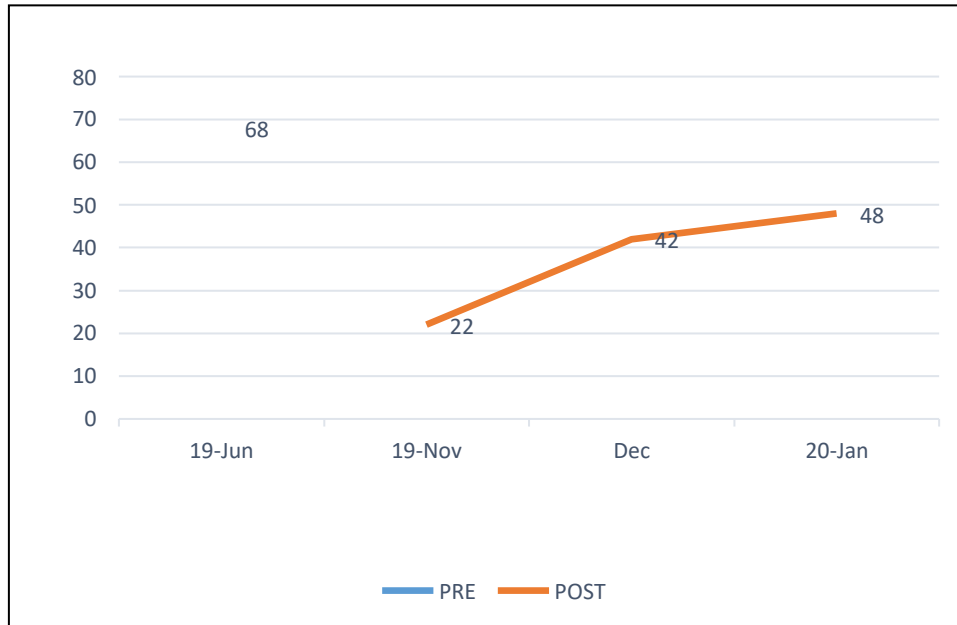


Figure 6. Pre-post intervention percentage of total number of alarms in Intensive Care Unit, November 2019 until January 2020

### Discussion and Implications

A harmonious and safe work culture is very important in achieving the standard patient safety goals set. In addition to ensuring the well-being and safety of patients, this issue also needs to be focused on a group of health workers, including nurses, physicians and other healthcare workers. Basically, the provision of bedside alarms for each patient unit in critical wards such as the ICU is an efficient initiative so that nurses and physicians are alert to the patient's condition and can provide advanced management according to the patient's needs and situation. However, excessive alarm frequency of false alarms has negative effects on nurses, such as 'alarm fatigue' and disrupts patient comfort as well. Previous studies have also debated the adverse complications of the 'alarm fatigue' effect as dangerous to patients as well as health care worker safety if excessive alarm frequency coupled with a high prevalence of false alarms leads to alarm fatigue.

Overall, this study had a significant impact on the reduction of 'false alarms' and successfully achieved the set target within the first two months of its implementation. This means that the implemented intervention is effective and should be continued. Finally, the project's improvement plan includes collaboration with medical device companies, policy creation, staff training, and an overall cultural shift towards alarm security awareness. This action is in line with best practice recommendations from international Best in Class organizations, thus making this project and its improvement plan replicable to other sites in the Kingdom of Saudi Arabia.



### Conclusion and recommendations

Critical care nurses in NGHHA Dammam experienced higher levels of alarm fatigue, which is affected by multiple factors inclusive safety culture practice. This study findings provide important guidance for future intervention programs to improve critical care nurses' alarm fatigue by introducing policies on alarm management and improving nurses' psychological health and providing patient's therapeutic environment. This study also offers a preliminary understanding of how false alarm management can help reduce the subjective exposure to alarm fatigue experienced by ICU staff and potentially patients. The study's findings emphasize how important it is to establish alarm fatigue performance in intensive care units to promote a good safety culture. Future research should focus on the characteristics of adherence and leadership, management, barriers that support continued use of interventions and false alarm reduction techniques by ICU staff.

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