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Research Article

Nurses Perception and Assessment Regarding False Alarms at Intensive Care Unit, Saudi Arabia

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ABSTRACT

Background *The Intensive Care Unit (ICU) is a critical component of the healthcare system, relying on advanced medical devices to monitor and manage critically ill patients. While clinical alarms are essential for patient safety, their excessive frequency often leads to alarm fatigue, which can reduce nurses' responsiveness to critical alerts. Alarm fatigue occurs when healthcare providers become desensitized to frequent, nonactionable alarms, increasing the risk of adverse patient outcomes. Despite global recognition of this issue, there is limited research on ICU nurses' knowledge and perceptions regarding false alarms in Saudi Arabia. This study aimed to assess ICU nurses' knowledge, perceptions, and assessment of false alarms at East Jeddah General Hospital.*

Methods *A descriptive cross-sectional study was conducted in May 2024 among 84 ICU nurses at East Jeddah General Hospital in the kingdom of Saudi Arabia. Data was collected using a structured questionnaire assessing demographic characteristics, nurses' knowledge of clinical alarms, and their perceptions of false alarms. The questionnaire was distributed electronically, and responses were analyzed using descriptive statistics and inferential tests, including correlation analysis and ANOVA, to examine associations between demographic variables and knowledge scores. A p-value threshold of <0.05 was applied to determine statistical significance.*

Results *The findings revealed a significant knowledge deficit among ICU nurses, with 92.9% demonstrating poor knowledge regarding alarm management. Only 33.3% had received ICU-specific training, and 32.1% had undergone alarm management training. Nurses aged 25–35 years had significantly higher knowledge scores (8.6) than those aged 45–55 years (6.1) ($p = 0.014$). Similarly, ICU-trained nurses scored higher (8.9) than those without ICU training (6.7) ($p = 0.003$). Most nurses (79.8%) reported frequent nuisance alarms, with 66.7% stating that false alarms reduced their trust in alarm systems. Additionally, 58.3% noted difficulty hearing alarms, and 66.7% struggled to identify active alarms when multiple devices were in use.*

Conclusion *The study highlights a significant gap in ICU nurses' knowledge and training regarding clinical alarms, contributing to alarm fatigue and potential patient safety risks. Younger and recently trained nurses exhibited better alarm management competencies, showing the importance of continuous education. To improve alarm management, hospitals should implement mandatory alarm training, optimize alarm configurations, and introduce technological solutions such as smart alarm systems and dedicated alarm administrators. Addressing these challenges is crucial for enhancing nurse efficiency, reducing alarm fatigue, and improving patient safety in ICU settings.*

Keywords *Alarm fatigue, false alarms, ICU nurses, clinical alarms, patient safety, alarm management, East Jeddah General Hospital, Saudi Arabia.*

Introduction

The Intensive Care Unit (ICU) is a fundamental component of the healthcare system, providing specialized monitoring and intensive treatment for critically ill patients (Wang et al., 2023). These units rely on advanced medical devices such as ventilators, physiological monitors, and infusion pumps, which assist healthcare professionals in making timely clinical decisions and delivering safe patient care. Over the past three decades, the number of medical devices equipped with alarm functions in the ICU has increased significantly, rising from approximately ten to around forty devices (Wang et al., 2023). This expansion has enhanced patient monitoring but has also contributed to an overwhelming frequency of alarms, creating challenges for ICU staff.

Clinical alarms play a crucial role in alerting medical staff when a patient's condition deteriorates, allowing them to intervene promptly. However, as Drew et al. (2014) stated, the frequent activation of alarms can result in alarm fatigue, a phenomenon where nurses become desensitized due to the excessive number of nonactionable alerts. This issue was highlighted in a study by Wang et al. (2023), which analyzed 2.55 million physiological monitor alarms from five adult ICUs over 31 days. The findings revealed that an ICU receives an average of 942 alarms per day, with one critical alarm occurring every 92 seconds (Wang et al., 2023). Similarly, Mendez et al. (2020) noted that an average of 43 alarms occur per hour in the ICU, with 52.8% coming from multiparameter monitors. However, 42.5% of these alarms are ignored, and only about 6.4% are linked to actual physiological abnormalities in patients.

The excessive number of alarms in ICU settings is often triggered by factors such as improper configuration of alarm thresholds, the high sensitivity of monitoring devices, and insufficient routine maintenance of equipment, leading to sensor or cable failures (Li et al., 2024). As Yousefinya et al. (2021) pointed out, nurses serve as the primary monitors of patient conditions, with physiological monitoring systems acting as supplementary tools. However, when nonactionable alarms become excessive, they disrupt workflow and lead to alarm fatigue, which, as Turmel et al. (2017) observed, results in nurses silencing or muting alarms, thereby increasing the risk of missing critical warnings.

As noted by Lewandowska et al. (2020), prolonged exposure to frequent alarms negatively affects nurses' well-being, causing stress, tension, and anxiety. This issue is not limited to specific regions; rather, it is a global concern. For instance, a Korean study found that alarm fatigue among ICU nurses was in the upper-middle range, highlighting the prevalence of the problem (Cho et al., 2016; Wang et al., 2023). Likewise, a Turkish study during the COVID-19 pandemic reported a significant rise in ICU alarm occurrences, intensifying the workload and exhaustion of ICU nurses (Akturan et al., 2022). As Winters et al. (2021)

showed, alarm fatigue is a major threat to patient safety in modern healthcare settings, making it imperative to establish structured alarm management systems, improve nurse training, and implement strategies to reduce alarm fatigue.

A major issue contributing to alarm fatigue is the high percentage of false alarms, which generate unnecessary noise and distractions, reducing the effectiveness of nurses in providing safe patient care. As Bach et al. (2018) pointed out, clinical alarms are designed to detect unsatisfactory patient conditions, malfunctioning medical equipment, or potential hazards. However, as Bosm (2022) explained, the parameters set by manufacturers are often generic and do not always align with individual patient needs, leading to excessive false alarms. Research has shown that ICU monitoring systems generate around 942 alarms daily due to their high sensitivity and low specificity (Bach et al., 2018; Bosm, 2022).

False alarms create a significant burden for nurses, increasing their workload and reducing efficiency. According to Bosma (2022), between 80% and 99% of alarms in ICUs turn out to be false, causing delays in response times and exacerbating alarm fatigue. As Pelletier (2013) reported, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) documented 98 alarm-related adverse events between 2009 and 2012, including 80 deaths, 13 cases of permanent disability, and five cases of prolonged hospitalization (Li et al., 2024). Given these serious consequences, addressing alarm fatigue and improving alarm management should be a priority in ICU settings.

Several studies have examined the impact of false alarms on ICU nurses and patient safety, showed the challenges associated with alarm fatigue. Asadi et al. (2023) and Dehghan et al. (2023) highlighted the critical role of ICU nurses in managing alarms while ensuring high-quality care for critically ill patients. Their findings align with the recommendations of the World Health Organization (WHO), which suggests maintaining hospital noise levels below 35 A-weighted decibels (dBA) to minimize distractions and improve patient outcomes (Obeid & Hassan, 2021).

According to Morton and Fontaine (2017), the function of medical device alarms is twofold: first, to alert nurses about changes in a patient's physiological condition, and second, to notify them when a specific parameter surpasses a predetermined threshold. However, as noted by Obeid and Hassan (2021), ICU nurses are often overwhelmed with an average of 150-400 alarms per patient per day, making it difficult to distinguish between critical and non-critical alarms. This high frequency of alarms not only increases cognitive load but also contributes to alarm fatigue, leading to potential delays in responding to real emergencies.

Similarly, studies by Huo et al. (2023) and Cobus & Heuten (2019) demonstrated that false alarms can be classified into three main categories: clinical, technical, and intervention-based. Clinical false alarms arise from misinterpretations of patient data, technical false alarms stem from device malfunctions, and intervention-based false alarms occur due to unintended staff actions. McCoy (2024) found that some ICUs report alarm rates as high as 350 per patient per day, further exacerbating the issue. The phenomenon known as the "cry wolf" effect, as discussed by Cobus & Heuten (2019), occurs when nurses become desensitized to frequent alarms, leading to decreased trust in alarm systems and a higher likelihood of missing true alarms. Sinno et al. (2021) showed the role of advanced ICU technology in improving patient monitoring but warned that without proper management, these systems could contribute to alarm overload. Additionally, Alkubati et al. (2024) investigated the Saudi Arabian context, focusing on how ICU nurses experience alarm fatigue due to high alarm frequency, workload intensity, and environmental stressors. Their findings suggest that to reduce alarm fatigue, hospitals must implement targeted interventions such as staff training, technological enhancements, and improved alarm management policies. As summarized by Ramlaul et al. (2021) and Paredath & Al Jarary (2023), integrating human-centered alarm management approaches can enhance patient safety, optimize nurse workflow, and reduce the overall burden of false alarms in ICU settings.

This study aim to explore the extent to which nurses recognize and assess false alarms in the ICU at East Jeddah General Hospital. It seeks to evaluate how nurses perceive false alarms, identify factors contributing to alarm fatigue, and propose strategies to improve alarm management. This study aims to assess nurses' perceptions of false alarms and provide recommendations to enhance alarm management systems in the ICU at East Jeddah General Hospital. Addressing this issue requires a comprehensive approach, including structured alarm training programs, improved device configurations, and the integration of smart alarm systems to reduce the burden of false alarms on ICU nurses.

Methods

This study applied a descriptive research design to examine nurses' perceptions and assessments of false alarms in the Intensive Care Unit (ICU) without manipulating any variables. The descriptive approach was chosen to provide a comprehensive understanding of the challenges associated with false alarms and their impact on nursing practice and patient care.

The research was conducted in May 2024 at East Jeddah General Hospital, in the kingdom of Saudi Arabia, a leading healthcare facility in Saudi Arabia known for its advanced critical care services. The study took place over a four-month period, from February to May 2024, ensuring adequate time for data collection and

analysis. The study population consisted of registered nurses actively employed in the ICU, all of whom had a minimum of one year of experience to ensure sufficient exposure to clinical alarm systems. A total coverage sampling method was employed, allowing the inclusion of all 84 eligible nurses. This approach ensured that the study captured the full range of perceptions and assessments regarding false alarms, thereby enhancing the reliability and validity of the findings.

Data were collected using a structured questionnaire designed to assess demographic characteristics, nurses' knowledge of clinical alarms, and their perceptions of false alarms in the ICU. The questionnaire was divided into three sections: the first section gathered demographic data such as age, gender, education, years of experience, and specialized training in ICU alarm management. The second section assessed nurses' knowledge of clinical alarms through 24 multiple-choice questions, each with one correct answer. Responses were categorized based on a scoring system adapted from Uehara (2011), with knowledge levels classified as good (≥75% correct answers), fair (50% to <75%), or poor (<50%). The third section measured nurses' perceptions and evaluations of false alarms using 24 yes/no questions that explored the frequency, impact, and management of alarms within the ICU. To ensure accessibility and ease of participation, the questionnaire was distributed electronically via Google Forms, with follow-up reminders sent to maximize response rates.

The collected data were analyzed using SPSS version 28.0. Descriptive statistics were used to summarize demographic variables, while inferential statistical methods, including correlation tests and Analysis of Variance (ANOVA), were conducted to examine relationships between nurses' demographic characteristics and their knowledge and perceptions of false alarms. A p-value threshold of <0.05 was applied to determine statistical significance. The study findings were presented using tables and graphical representations to enhance clarity and facilitate interpretation.

Ethical considerations were strictly followed to ensure compliance with research ethics and safeguard participant rights. Ethical approval was obtained from the Institutional Review Board (IRB) at East Jeddah General Hospital before the commencement of the study. Participants were informed of the study's purpose, procedures, and potential implications, and informed consent was obtained before data collection. Confidentiality measures were implemented to protect the identities of participants, and all data were anonymized and securely stored to prevent unauthorized access.

While the study provided valuable insights into the issue of false alarms in ICUs, several limitations were acknowledged. The reliance on a total coverage sampling method meant that the findings were specific to the nurses at East Jeddah General Hospital and may not be generalizable to other ICU settings. Additionally,

the use of self-reported data introduced the possibility of response biases, including social desirability bias, where participants might have provided responses they perceived as favorable rather than their actual experiences.

Despite these limitations, this study contributes to the growing body of research on alarm management in ICUs by offering empirical evidence on how nurses perceive and respond to false alarms. The findings showed the need for targeted interventions, such as improved training programs, optimized alarm settings, and the integration of smart alarm technologies to reduce nonactionable alarms.

Results

The demographic and professional characteristics of the participating nurses in the Intensive Care Unit (ICU) at East Jeddah General Hospital reveal a diverse workforce (Table 1). The majority of nurses (44%) were aged between 25 and 35 years, followed by 36.9% in the 36–44-year category and 19.1% in the 45–55-year range. The nursing workforce was predominantly female, comprising 88.1% of the participants, while males accounted for only 11.9%. In terms of education, the majority (78.6%) held a Bachelor of Science in Nursing, 9.5% had a diploma, and 11.9% held a Master of Science in Nursing. Regarding marital status, nearly half of the nurses (48.8%) were married, 42.9% were single, 6.0% were divorced, and 2.4% were widowed.

Professional experience among the nurses varied, with 45.2% having more than five years of experience, 31.0% having between two and five years, and 23.8% with less than two years of experience. When it came to specialized training, only 33.3% had received ICU-specific training, while the remaining 66.7% had not. Additionally, only 32.1% of nurses had undergone alarm management training, leaving 67.9% without formal training in handling clinical alarms. Most of the respondents (76.2%) worked as primary nurses, while 19.0% were assistant nurses, and only 4.8% held head nurse positions.

Table (1) Demographic and Professional Characteristics of ICU Nurses (n = 84)

Variable	Category	Frequency	Percent
Age (years)	25–35	37	44.0
	36–44	31	36.9
	45–55	16	19.1
Gender	Male	10	11.9

	Female	74	88.1
Education	Diploma in Nursing	8	9.5
	Bachelor of Science in Nursing	66	78.6
	Master of Science in Nursing	10	11.9
Marital Status	Married	41	48.8
	Single	36	42.9
	Divorced	5	6.0
	Widowed	2	2.4
Years of Experience	Below 2 years	20	23.8
	2 - 5 years	26	31.0
	Above 5 years	38	45.2
ICU Trained	Yes	28	33.3
	No	56	66.7
Alarm Management Trained	Yes	27	32.1
	No	57	67.9
Work Position	Assistant Nurse	16	19.0
	Primary Nurse	64	76.2
	Head Nurse	4	4.8

The detailed analysis of specific knowledge questions (Table 2) revealed that the majority of nurses struggled with key aspects of clinical alarms. For instance, only 23.8% correctly identified an example of a physiological patient alarm, and 44.0% understood the primary purpose of clinical alarms in the ICU. Furthermore, only 33.3% could correctly associate alarms with medication administration, while 35.7% knew how to respond to high-priority alarms. A particularly concerning finding was that only 25.0% could correctly identify alarms crucial for monitoring cardiac function, despite the critical role these alarms play in patient care.

When examining alarm fatigue management strategies, 33.3% of nurses understood their importance, while 39.3% recognized the significance of alarm customization. However, a large proportion (69.0%) failed to

identify the potential consequences of false alarms, and 67.9% were unaware of how healthcare organizations could mitigate alarm fatigue.

Other key deficiencies included understanding interdisciplinary collaboration in alarm management (22.6%) and recognizing the consequences of alarm desensitization (31.0%). One of the most alarming results was that only 8.3% of nurses knew the correct interventions to reduce false alarms, demonstrating a crucial area for improvement.

Table (2) Knowledge Assessment Findings Towards Clinical Alarms in Intensive Care Units (n = 84)

Knowledge Assessment Items	Correct Answer	Incorrect Answer
Physiological patient alarm example?	20 (23.8%)	64 (76.2%)
What is the primary purpose of clinical alarms at the ICU?	37 (44.0%)	47 (56.0%)
Which alarms are associated with medication administration?	28 (33.3%)	56 (66.7%)
How should nurses respond to a high-priority alarm?	30 (35.7%)	54 (64.3%)
What alarms are crucial for monitoring cardiac function?	21 (25.0%)	63 (75.0%)
Which alarms are associated with patient mobility and safety?	29 (34.5%)	55 (65.5%)
What is the purpose of alarm fatigue management strategies?	28 (33.3%)	56 (66.7%)
Why is it important to understand alarm customization?	33 (39.3%)	51 (60.7%)
What are the potential consequences of false alarms?	26 (31.0%)	58 (69.0%)
How can healthcare organizations mitigate alarm fatigue?	27 (32.1%)	57 (67.9%)
What is the purpose of regular alarm system assessments?	24 (28.6%)	60 (71.4%)
What is the recommended approach for managing alarm sounds?	39 (46.4%)	45 (53.6%)
How can nurses contribute to effective alarm management?	27 (32.1%)	57 (67.9%)
What is the purpose of alarm prioritization in clinical settings?	30 (35.7%)	54 (64.3%)
What are the consequences of ineffective alarm management?	21 (25.0%)	63 (75.0%)
What is the role of interdisciplinary collaboration in alarms?	19 (22.6%)	65 (77.4%)
What are the consequences of alarm desensitization?	26 (31.0%)	58 (69.0%)

How can organizations promote effective alarm management?	19 (22.6%)	65 (77.4%)
What are the benefits of implementing alarm customization?	24 (28.6%)	60 (71.4%)
Which strategies help nurses differentiate true and false alarms?	23 (27.4%)	61 (72.6%)
What does it mean if a clinical alarm is "nuisance" or "false"?	27 (32.1%)	57 (67.9%)
Which interventions can nurses implement to reduce false alarms?	7 (8.3%)	77 (91.7%)
Which action demonstrates proper alarm management in the ICU?	24 (28.6%)	60 (71.4%)
How should a nurse prioritize responding to clinical alarms?	38 (45.2%)	46 (54.8%)

The assessment of nurses' knowledge regarding clinical alarms (Table 2) indicated a significant gap in understanding. A vast majority (92.9%) demonstrated poor knowledge, with only 4.8% exhibiting fair knowledge and a mere 2.3% displaying good knowledge (Table 3). The mean overall knowledge score was 7.5 out of a possible 21, with a standard deviation of 3.3, further highlighting the need for improved education and training (Table 4).

Table (3) Overall Knowledge Assessment Findings Towards Clinical Alarms in Intensive Care Units (n = 84)

Overall Knowledge Level	Frequency	Percent (%)
Good (> 75% correct answers)	2	2.3
Fair (50 – 75% correct answers)	4	4.8
Poor (< 50% correct answers)	78	92.9
Total	**84**	**100.0**

Table (4) Quantitative Summary of the Overall Knowledge Assessment Score (n = 84)

Variable	Minimum	Maximum	Mean	Std. Deviation
Overall Knowledge Score	1.0	21.0	7.5	3.3

In assessing nurses' perceptions and experiences regarding false alarms (Table 5), it was found that 79.8% believed nuisance alarms occurred frequently, and 66.7% reported that nuisance alarms reduced their trust in the alarm systems, causing them to ignore or turn them off. Additionally, 58.3% indicated that alarms were often missed due to difficulty hearing them, and 66.7% reported difficulty in identifying which alarm was active when multiple monitoring devices were used simultaneously. Environmental noise was identified as a factor interfering with alarm recognition by 41.7% of the participants. Regarding technological solutions, 63.1% stated that their wards used alarm notification systems, such as pagers and wireless devices, while 59.5% believed having a dedicated alarm administrator would improve alarm management.

Table (5) Perceptions and Assessments Findings Regarding False Alarms in Intensive Care Units (n = 84)

Perception Assessment Items	Yes (Freq & %)	No (Freq & %)
Nuisance alarms occur frequently	67 (79.8%)	17 (20.2%)
Nuisance alarms disturb the nurses' care of patients	27 (32.1%)	57 (67.9%)
Nuisance alarms reduce nurses' trust, causing them to turn off alarms	56 (66.7%)	28 (33.3%)
The reasonable setting of alarm parameters is too complex	29 (34.5%)	55 (65.5%)
New equipment has solved most problems in clinical alarms	56 (66.7%)	28 (33.3%)
The alarm system is sufficient to alert nurses to patient conditions	31 (36.9%)	53 (63.1%)
Alarms often cannot be heard and are missed	49 (58.3%)	35 (41.7%)
Nurses are sensitive to alarms and respond quickly	33 (39.3%)	51 (60.7%)
Difficult to identify alarms when multiple devices monitor a patient	56 (66.7%)	28 (33.3%)
Environmental noise interferes with alarm recognition	35 (41.7%)	49 (58.3%)
Ward uses alarm notification systems (pagers, phones, wireless)	53 (63.1%)	31 (36.9%)
Alarm notification systems improve nurses' response to alarms	39 (46.4%)	45 (53.6%)
Special person (alarm administrator) manages alarms	50 (59.5%)	34 (40.5%)
It is meaningful to set up an alarm administrator	39 (46.4%)	45 (53.6%)
Nearly all alarms are actionable (require nurse intervention)	50 (59.5%)	34 (40.5%)

Ward uses smart alarm systems	45 (53.6%)	39 (46.4%)
Smart alarm systems effectively reduce false alarms	51 (60.7%)	33 (39.3%)
Smart alarm systems improve nurses' response to important alarms	43 (51.2%)	41 (48.8%)
Nurses have received education on alarm systems	50 (59.5%)	34 (40.5%)
Ward requires documenting alarm settings in nursing records	40 (47.6%)	44 (52.4%)
Clinical policies for alarm management are effectively implemented	47 (56.0%)	37 (44.0%)
Hospital developed alarm management improvement projects in the past year	40 (47.6%)	44 (52.4%)
Ward developed new technological solutions for alarm management	40 (47.6%)	44 (52.4%)
Alarm-related patient adverse events occurred in the past year	45 (53.6%)	39 (46.4%)

The analysis of relationships between demographic and professional characteristics and knowledge levels (Table 6) showed that knowledge was relatively low across all demographic groups. However, some factors were significantly associated with knowledge levels. Age showed a statistically significant relationship with knowledge scores ($p = 0.014$), with younger nurses (aged 25–35 years) scoring higher (8.6) compared to those aged 45–55 years (6.1).

Years of experience also had a significant impact on knowledge scores ($p = 0.034$), with nurses who had 1–5 years of experience scoring higher (8.0) than those with more than five years (5.8). This suggests that recent training or education plays a role in knowledge retention, whereas more experienced nurses may not have received continuous updates on alarm management.

ICU training was strongly associated with higher knowledge scores ($p = 0.003$), as nurses who had received ICU-specific training scored significantly higher (8.9) compared to those without such training (6.7). Similarly, alarm management training was a key factor ($p = 0.026$), with trained nurses scoring higher (8.6) than those who had not received training (6.9) (Table 7).

Table (6) Relation Between Nurse Characteristics and Knowledge Level Regarding False Alarms (n = 84)

Variable	Category	Good (n = 2)	Fair (n = 4)	Poor (n = 78)	Total (n = 84)	P-Value
Age	15–35 years	2 (100.0%)	3 (75.0%)	32 (41.0%)	37 (44.0%)	0.328
	36–44 years	0 (0.0%)	1 (25.0%)	30 (38.5%)	31 (36.9%)	
	45–55 years	0 (0.0%)	0 (0.0%)	16 (20.5%)	16 (19.0%)	
Gender	Female	2 (100.0%)	4 (100.0%)	68 (87.2%)	74 (88.1%)	0.646
	Male	0 (0.0%)	0 (0.0%)	10 (12.8%)	10 (11.9%)	
Education	Bachelor	2 (100.0%)	2 (50.0%)	62 (79.5%)	66 (78.6%)	0.168
	Diploma	0 (0.0%)	0 (0.0%)	8 (10.3%)	8 (9.5%)	
	Master	0 (0.0%)	2 (50.0%)	8 (10.3%)	10 (11.9%)	
Marital Status	Married	1 (50.0%)	1 (25.0%)	39 (50.0%)	41 (48.8%)	0.913
	Single	1 (50.0%)	3 (75.0%)	32 (41.0%)	36 (42.9%)	
	Divorced	0 (0.0%)	0 (0.0%)	5 (6.4%)	5 (6.0%)	
	Widowed	0 (0.0%)	0 (0.0%)	2 (2.6%)	2 (2.4%)	
Years of Experience	<1 year	0 (0.0%)	0 (0.0%)	20 (25.6%)	20 (23.8%)	0.344
	1-5 years	0 (0.0%)	1 (25.0%)	25 (32.1%)	26 (31.0%)	
	>5 years	2 (100.0%)	3 (75.0%)	33 (42.3%)	38 (45.2%)	
ICU Trained	Yes	2 (100.0%)	3 (75.0%)	23 (29.5%)	28 (33.3%)	0.022
	No	0 (0.0%)	1 (25.0%)	55 (70.5%)	56 (66.7%)	
Alarm Management Trained	Yes	2 (100.0%)	2 (50.0%)	23 (29.5%)	27 (32.1%)	0.080
	No	0 (0.0%)	2 (50.0%)	55 (70.5%)	57 (67.9%)	
Work Position	Primary Nurse	2 (100.0%)	4 (100.0%)	58 (74.4%)	64 (76.2%)	0.732
	Assistant Nurse	0 (0.0%)	0 (0.0%)	16 (20.5%)	16 (19.0%)	
	Head Nurse	0 (0.0%)	0 (0.0%)	4 (5.1%)	4 (4.8%)	

Table (7) Relation Between Nurse Characteristics and Knowledge Score Regarding False Alarms (n = 84)

Variable	Category	Mean Knowledge Score	Standard Deviation	P-Value
Age	15–35 years	8.6	4.0	0.014
	36–44 years	6.7	2.5	
	45–55 years	6.1	1.8	
Gender	Female	7.7	3.3	0.057
	Male	5.6	2.5	
Education	Bachelor	7.3	3.1	0.688
	Diploma	7.1	2.5	
	Master	8.3	4.9	
Marital Status	Married	7.4	3.1	0.185
	Single	8.0	3.4	
	Divorced	5.0	3.6	
	Widowed	5.0	0.0	
Years of Experience	<1 year	7.9	2.7	0.034
	1-5 years	8.0	4.0	
	>5 years	5.8	1.6	
ICU Trained	Yes	8.9	4.7	0.003
	No	6.7	1.9	
Alarm Management Trained	Yes	8.6	4.5	0.026
	No	6.9	2.4	
Work Position	Assistant Nurse	7.0	2.7	0.363
	Head Nurse	5.5	3.4	
	Primary Nurse	7.7	3.4	

Discussion

The demographic and professional characteristics of nurses in the Intensive Care Unit (ICU) at East Jeddah General Hospital revealed a diverse workforce, with a predominant representation of female nurses and those holding a Bachelor of Science in Nursing degree. These findings are consistent with those reported in similar studies, where ICU nursing staff tends to be predominantly female, a trend observed globally (Lewandowska et al., 2020). The age distribution of the participating nurses, where nearly half fell within the 25–35-year range, aligns with the findings of Alkubati et al. (2024) in Saudi Arabia, which indicated that younger nurses are increasingly populating ICU settings. The high percentage of married nurses (48.8%) is also notable and may influence work-life balance and job stress, as reported by Akturan et al. (2022) in their study on ICU nurses in Turkey.

Professional experience among the nurses varied, with a substantial proportion (45.2%) having more than five years of experience. However, despite their experience, the study revealed that a significant proportion lacked ICU-specific training (66.7%) and alarm management training (67.9%). These gaps in specialized education are concerning, particularly given the high reliance on medical alarms in ICU settings. Winters et al. (2021) showed the necessity of structured training programs to mitigate alarm fatigue, a recommendation supported by the current findings. The absence of formal alarm management training among most participants suggests a missed opportunity for improving nurses' competency in handling clinical alarms effectively.

The findings of this study underscore the significant knowledge deficit regarding clinical alarms, with 92.9% of nurses demonstrating poor knowledge. This aligns with the findings of Asadi et al. (2023) and Dehghan et al. (2023), who reported that ICU nurses often struggle with alarm management due to inadequate training. Similarly, a study by Cobus & Heuten (2019) found that knowledge gaps in alarm response strategies contribute to alarm fatigue and decreased efficiency in patient monitoring. The low mean knowledge score (7.5 out of 21) in this study further highlights the urgent need for educational interventions to enhance alarm literacy.

A particularly concerning finding was the limited ability of nurses to recognize key alarm functions, with only 25.0% correctly identifying alarms crucial for cardiac monitoring. This aligns with the results of Huo et al. (2023), who showed that poor recognition of critical alarms increases the risk of delayed responses and adverse patient outcomes. The poor understanding of alarm fatigue management strategies among 67.9% of nurses mirrors findings by Lewandowska et al. (2020), who noted that nurses often underestimate the consequences of false alarms, leading to improper alarm responses and increased risk of alarm-related

adverse events.

The study further revealed that most nurses perceived nuisance alarms as frequent (79.8%) and disruptive, reducing their trust in alarm systems (66.7%). This phenomenon has been widely documented. Wang et al. (2023) reported that an ICU receives an average of 942 alarms per day, with one occurring every 92 seconds, creating an environment prone to alarm fatigue. The current findings reinforce the conclusions drawn by Drew et al. (2014), who found that excessive alarms lead to desensitization, increasing the likelihood of nurses ignoring or silencing alarms. Similarly, Yousefinya et al. (2021) highlighted the negative impact of alarm fatigue on nurses' workflow, noting that it contributes to increased stress and errors in patient care.

The statistically significant association between younger nurses and higher knowledge scores ($p = 0.014$) suggests that recent graduates may have received more up-to-date training. This is consistent with findings from McCoy (2024), who reported that nurses with recent training demonstrated greater competency in alarm management. However, the lower scores among more experienced nurses (aged 45–55 years) suggest that ongoing professional development programs are needed to ensure that knowledge is continuously updated. Additionally, the significant relationship between ICU training and knowledge scores ($p = 0.003$) reinforces previous findings by Alkubati et al. (2024), who reported that structured training programs significantly improve nurses' alarm literacy.

Implications of these findings suggest that ICU training should be mandatory for all nurses working in critical care settings. The introduction of periodic refresher courses, simulation-based training, and interactive workshops can enhance nurses' competencies in alarm management. Furthermore, the integration of smart alarm systems and advanced technological solutions, as suggested by Obeid & Hassan (2021), could help mitigate alarm fatigue and improve response efficiency. Implementing a dedicated alarm administrator, as supported by 59.5% of nurses in this study, is another viable strategy for optimizing alarm management and reducing unnecessary noise.

In conclusion, this study highlights the critical need for structured educational interventions to address alarm management deficiencies among ICU nurses. The findings are consistent with global research on alarm fatigue and its impact on patient safety. Addressing these gaps through targeted training programs, policy reforms, and technological advancements will enhance nurses' ability to manage clinical alarms effectively and improve overall patient care outcomes.

Conclusion

The findings of this study underscore the critical challenges associated with alarm fatigue among ICU nurses at East Jeddah General Hospital. The majority of nurses exhibited poor knowledge of clinical alarms, with significant deficiencies in identifying false alarms, understanding alarm fatigue management strategies, and recognizing the consequences of excessive alarms. The study also revealed that younger nurses and those with fewer years of experience demonstrated better knowledge scores, suggesting that recent training plays a crucial role in knowledge retention. However, the overall lack of ICU-specific and alarm management training among participants highlights a significant gap in professional education. The high prevalence of false alarms, coupled with nurses' perceptions of alarm fatigue, raises serious concerns about patient safety, as excessive alarms can lead to desensitization, missed warnings, and increased cognitive load.

To address these issues, healthcare institutions should implement comprehensive alarm management training programs that are regularly updated to reflect technological advancements and best practices. Mandatory ICU-specific and alarm management training should be incorporated into both nursing curricula and continuing professional development programs. Additionally, hospitals should adopt evidence-based strategies to minimize false alarms, such as customizing alarm thresholds, integrating smart alarm systems, and assigning dedicated alarm administrators to oversee alarm management. Technological solutions, including wearable notification devices and improved noise reduction protocols, should also be considered to mitigate alarm fatigue and enhance response efficiency. Lastly, promoting an interdisciplinary approach to alarm management, involving collaboration between nurses, biomedical engineers, and hospital administrators, will be essential in creating a safer, more efficient ICU environment that prioritizes patient safety and nurse well-being.

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Author Contribution

This paper is based on original research conducted by Fatimah Al Magadi and Amira Mohammed as part of

their academic work. Fatimah Al Magadi was responsible for the study conception, data collection, and initial manuscript drafting. Dr. Amira Mohammed supervised the research and contributed to data analysis, interpretation of results, and manuscript revisions.

Conflict of Interest

The authors declare no conflict of interest regarding the publication of this paper. This study was conducted independently and did not receive any external funding.

Ethical Consideration

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of East Jeddah General Hospital before data collection. Written informed consent was obtained from all participants, ensuring confidentiality, anonymity, and voluntary participation. Participants were informed of their right to withdraw from the study at any time without consequences.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request. To protect the privacy of the participants, all data have been anonymized and securely stored in compliance with ethical guidelines.

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