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Research Article

Investigation and Analysis of the Current Status of Clinical Alarm Knowledge, Attitudes, Practices, and Alarm Fatigue among Operating Room Healthcare Staff

Wang Renlong, Tang Xiaoqian, Xun Xiaoyan, Yao Dianye*

Department of Operating Room, The First Affiliated Hospital of Sun Yat-sen University, China

***Corresponding author:** Yao Dianye**,** Department of Operating Room, The First Affiliated Hospital of Sun Yat-sen University, No. 58 Zhongshan Second Road, Guangzhou 510080, Guangdong, China

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Abstract

Objective: To systematically evaluate the level of knowledge, attitudes, and practices (KAP) regarding clinical alarms and the degree of alarm fatigue among operating room healthcare staff, analyse influencing factors, and provide an evidence-based foundation for developing targeted alarm management strategies. **Methods:** A cross-sectional survey was conducted using a questionnaire among 87 operating room nurses, surgeons, anaesthesia nurses, and anaesthesiologists in a location in Guangdong from July to August 2025. The questionnaire covered demographic characteristics, a clinical alarm KAP scale, and an alarm fatigue scale. Data were analysed using SPSS 26.0 for descriptive statistics, Pearson correlation, and multiple linear regression. **Results:** The scores for knowledge, attitudes, practices, and total KAP were (8.25±2.70), (44.67±12.11), (57.75±11.21), and (110.67±16.12) points, respectively, indicating a moderate overall level. The alarm fatigue score was (20.13±4.80) points. Knowledge score was negatively correlated with the alarm fatigue score ($r=-0.224$, $p<0.05$). Attitude score was negatively correlated with the alarm fatigue score ($r=-0.254$, $p<0.05$). Practice score was positively correlated with the alarm fatigue score ($r=0.287$, $p<0.01$). Alarm fatigue was closely associated with factors such as high alarm frequency, insufficient human resources, and lack of training. **Conclusions:** Operating room healthcare staff demonstrate a moderate overall KAP level regarding clinical alarms and experience a certain degree of alarm fatigue. Targeted training should be strengthened, alarm management processes optimized, and staff's ability to identify and respond to alarms enhanced.

Keywords: Clinical alarms; Knowledge-attitude-practice (KAP); Alarm fatigue; Operating-room personnel

Introduction

With the proliferation of digital equipment in operating rooms, devices such as physiological monitors, anaesthesia machines, and infusion pumps can generate dozens of alarms per second. Monitoring instruments and alarm systems play a core role in ensuring patient safety. However, "alarm fatigue" caused by frequent, repetitive, and even false alarms is increasingly becoming a significant hidden threat to patient safety and care quality. A review indicated [1] an average of up to 700 alarms per day, with 80% being false. For example, during gynecological surgery, each patient triggers an average of 11.7 alarms, many of which lack clinical significance [2]. Alarm fatigue refers to the phenomenon where healthcare staff become desensitized, neglectful, or slow to respond due to long-term exposure to excessive alarms [3]. Studies have shown [4] that this can lead to delayed or missed responses to alarms, resulting in serious medical risks. Domestic research has largely focused on the intensive care unit (ICU) setting [5-7], with limited systematic studies on operating room staff-a group with high alarm exposure. Their KAP levels and fatigue status remain underreported. Therefore, based on the Knowledge-Attitude-Practice (KAP) theory, this study investigates and analyses the alarm-related cognition, attitudes, practices, and fatigue status of operating room healthcare staff to provide a basis for future interventions.

Materials and Methods

Study Design and Participants

This cross-sectional descriptive study was conducted in the operating rooms of a location in Guangdong Province from July to August 2025.

Participants included operating room nurses, surgeons, anaesthesiologists, and anaesthesia nurses. Convenience cluster sampling was used to distribute questionnaires. Eighty-seven questionnaires were distributed, and 87 valid questionnaires were returned, yielding a response rate of 100%.

Inclusion Criteria

1. Worked in the operating room of a Grade A tertiary hospital for ≥1 year; 2. Volunteered to participate. Excluded were those on advanced training, internships, or leave during the study period.

Survey Instruments

- General Information Questionnaire: Included gender, age, education level, profession, professional title, hospital grade, night shift frequency, and whether they had received alarm-related training.
- Clinical Alarm Knowledge, Attitudes, and Practices (KAP) Questionnaire [8]: A 40-item questionnaire comprising three dimensions: knowledge (12 items, score range 0–12), attitudes (11 items, score range 22–55), and practices (17 items, score range 17–69). A higher total score indicates a higher level of clinical alarm KAP. Scores were converted to a percentage scale: >85%, Good; 60–85%, Moderate; <60%, Poor.
- Alarm Fatigue Scale (AFS) [9]: Included 7 items rated on a 5-point Likert scale: 1, Strongly Disagree; 2, Disagree; 3, Uncertain; 4, Agree; 5, Strongly Agree. A higher total score indicates a higher level of alarm fatigue. The Cronbach's α coefficient was 0.78, and the content validity was 0.89, indicating good reliability and validity.

Statistical Methods

Data were analysed using SPSS 26.0 software. Measurement data are presented as mean ± standard deviation, and count data are described by frequency and percentage. Chi-square test was used to analyse differences in categorical variables. Pearson correlation analysis was used to explore the relationship between clinical alarm KAP and alarm fatigue. A P-value < 0.05 was considered statistically significant.

Results

General Characteristics

Among the 87 respondents, gender distribution was relatively balanced (male: 42, 48.28%; female: 45, 51.72%). The majority were aged 26-29 years (34, 39.08%). Education level was primarily undergraduate (58, 66.67%), with Master's degree or above accounting for 29.89% (26). Profession-wise, operating room nurses constituted the largest group (39, 44.83%), followed by anesthesiologists (17, 19.54%), surgeons (16, 18.39%), and anaesthesia nurses (15, 17.24%). Primary professional title was most common (46, 52.87%). 73.56% (64) worked in tertiary hospitals. Only 16.09% (14) "Always" set device parameters. 73.56% (64) had received alarm-related training (Details in Table 1).

Item	Category	n	%
Gender			
	Male	42	0.4828
	Female	45	0.5172
	≤25	11	0.1264
	26-29	34	0.3908
	30-35	18	0.2069
	36-39	7	0.0805
	≥40	17	0.1954
Highest Education			
	Associate Degree	3	0.0345
	Bachelor’s Degree	58	0.6667
	Master’s Degree or above	26	0.2989
Profession			
	Operating Room Nurse	39	0.4483
	Surgeon	16	0.1839
	Anesthesiologist	17	0.1954
	Anesthesia Nurse	15	0.1724
Professional Title			
	Junior	46	0.5287
	Intermediate	31	0.3563
	Senior	10	0.1149
Hospital Grade			
	Grade I	6	0.069
	Grade II	17	0.1954
	Grade III (Tertiary)	64	0.7356
Frequency of Setting Parameters at Work			
	Almost Never	21	0.2414
	Occasionally	26	0.2989
	Frequently	26	0.2989
	Always	14	0.1609
Received clinical alarm-related education/training	Yes	64	0.7356

Table 1: General Characteristics of the Participating Operating Room Healthcare Staff (n=87).

Clinical Alarm KAP and Alarm Fatigue Scores

All KAP dimensions and the total score were at a moderate level (60-85% after conversion to percentage): Knowledge dimension (8.25±2.70) points (68.75%), Attitude dimension (44.67±12.11) points (81.22%), Practice dimension (57.75±11.21) points (83.70%), Total KAP score (110.67±16.12) points (81.22%). The total alarm fatigue score was (20.13±4.80) points (57.51% of the maximum possible score), indicating moderate alarm fatigue (Details in Table 2).

Scale	n	Mean ± SD
Knowledge Score	87	8.25 ± 2.70
Attitude Score	87	44.67 ± 12.11
Practice Score	87	57.75 ± 11.21
Total KAP Score	87	110.67 ± 16.12
Total Alarm Fatigue Score	87	20.13 ± 4.80

Table 2: Scores for Clinical Alarm KAP and Alarm Fatigue (Points, $\bar{x}\pm s$, n=87).

Correlation Analysis between Alarm KAP and Alarm Fatigue among Operating Room Healthcare Staff

The knowledge score was negatively correlated with the total alarm fatigue score ($r = -0.224$, $P < 0.05$), indicating that better alarm knowledge was associated with lower alarm fatigue. The attitude score was negatively correlated with the total alarm fatigue score ($r = -0.254$, $P < 0.05$), indicating that a more positive attitude towards alarm management was associated with lower alarm fatigue. The practice score was positively correlated with the total alarm fatigue score ($r = 0.287$, $P < 0.01$), indicating that more frequent alarm response behaviours were associated with higher alarm fatigue. The frequency of setting machine parameters at work was positively correlated with the total alarm fatigue score ($r = 0.262$, $P < 0.05$), indicating that more frequent parameter setting was associated with higher alarm fatigue (Details in Table 3).

Variable	Knowledge Score	Attitude Score	Practice Score	Total KAP Score	Total Alarm Fatigue Score
Knowledge Score	1	-0.181	0.069	0.079	-.224*
Attitude Score	-	1	-0.044	.690**	-.254*
Practice Score	-	-	1	.674**	.287**
Total KAP Score	-	-	-	1	-0.029
Total Alarm Fatigue Score	-	-	-	-	1

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).

Table 3: Correlation Analysis between Alarm KAP and Alarm Fatigue among Operating Room Healthcare Staff.

Discussion

This study found that the "Knowledge-Attitude-Practice" (KAP) level regarding clinical alarms among operating room healthcare staff was moderate, and alarm fatigue was at a moderate level. This fatigue was primarily negatively correlated with knowledge and attitudes but positively correlated with response practices. The following discussion compares these findings with relevant domestic and international studies, analyses the underlying mechanisms, and explores improvement strategies.

Knowledge and Attitudes Reduce Alarm Fatigue

The results show that higher levels of knowledge and attitudes are associated with lower alarm fatigue. This aligns with the findings of Kibar et al. [10] in an ICU training intervention study, where systematic training effectively reduced nurses' alarm fatigue. Domestic scholar Li Xiaohong et al. [11] observed a significant decrease in alarm fatigue after improving nurses' alarm management knowledge and attitudes through an opinion leader education model. Studies by Shen Mengmeng et al. [12] indicate that education and training can enhance nurses' alarm management cognition and practical ability, effectively reducing the number of clinical alarms and alleviating alarm fatigue. Therefore, strengthening continuous training and team learning is an important measure to reduce alarm fatigue.

Positive Correlation between Practices and Alarm Fatigue

In this study, practices were positively correlated with fatigue, meaning that personnel who responded to alarms more frequently experienced higher fatigue levels. The randomized controlled trial by Bi et al. [13] pointed out that nurses increasing alarm response behaviours in the short term might experience increased workload due to high false alarm rates, thereby exacerbating fatigue. Uçak et al. [14] also noted that although ICU nurses adopt behavioural strategies like muting and delayed response, device complexity and frequent false alarms still contribute to fatigue. This suggests that in clinical practice, relying solely on individual effort is insufficient; reducing ineffective alarms must be addressed at the system level.

Positive Correlation between Alarm Frequency and Fatigue

Frequent parameter setting and high alarm trigger rates were significantly correlated with fatigue ($r=0.262$, $P<0.05$). Domestic researchers Wang Ling and Liu Hong [15] pointed out that participation in training and the frequency of parameter setting significantly affect fatigue levels, and job burnout is positively correlated with alarm fatigue. Furthermore, a systematic review [16] indicated that a high number of false alarms, clinical noise, and insufficient nursing resources significantly increase healthcare staff fatigue levels.

Potential Reasons behind the Differences

- Differences in Work Nature: The fast-paced, multi-process, high-urgency environment of the operating room, coupled with frequent teamwork, increases the psychological load associated with behavioural responses.
- The Double-Edged Sword Effect of Behavioural Interventions: Active response behaviours, if not coupled with alarm system optimization, can easily lead to fatigue-where behaviour appears active but is essentially passive pressure-bearing.
- Insufficient Training Coverage and Sustainability: Domestic studies indicate [17] that lack of systematic training is a key factor in fatigue development; behavioural improvement requires ongoing mechanism support, not one-off training.

Suggested Improvement Strategies

Institutionalize Continuous Education and Training: Establish a routine training system and maintain stable growth in knowledge and attitudes through training evaluation and feedback mechanisms.

Optimize Technical Systems: Integrating AI-driven alarm classification with psychoacoustic modelling can enhance alarm recognition, reduce false alarms, and shorten response times for the surgical team, ultimately contributing to a safer and more efficient operating room environment [18].

Combined Behavioural and System Interventions: Integrate behavioural improvements with system optimization to avoid increased behavioural pressure from single measures.

Study Limitations and Prospects

This study employed a single-center cross-sectional design with a limited sample size. Fatigue measurement relied on self-report, introducing potential subjective bias which may underestimate or overestimate alarm fatigue levels. Future research could adopt the following strategies: □ Multi-center, longitudinal cohort designs incorporating objective alarm data from electronic medical records (trigger frequency, response delay); □ Introducing wearable physiological indicators (heart rate variability, galvanic skin response) as objective markers of fatigue; □ Developing a machine learning-based multidimensional fatigue prediction model incorporating “individual-environment-equipment” factors for precise intervention.

Conclusion

This study further confirms the presence of moderate alarm fatigue among operating room healthcare staff. Knowledge and attitudes are protective factors, whereas merely frequent response practices, if unaccompanied by system optimization, may exacerbate fatigue. Future efforts should establish a comprehensive tripartite intervention strategy combining “continuous training - system optimization - behavioural support” to effectively reduce alarm fatigue and enhance patient safety.

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