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Alarm fatigue and its association with perceived stress, resilience, and coping behaviors among Palestinian nursing students during clinical internship in critical care units: a cross-sectional study

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Abstract

Background There is a lack of studies on alarm fatigue among nursing students during their internships in critical care units. Therefore, this study aimed to examine the association between alarm fatigue and perceived stress, resilience, and coping behaviors among Palestinian nursing students during their internships in critical care units.

Methods A cross-sectional study was adopted involving 141 nursing students during their internships in critical care units in Palestine. A self-reported online questionnaire was used to collect data. It included the Alarm Fatigue Questionnaire, Perceived Stress Scale (PSS), Brief Resilience Scale (BRS), and Coping Behavior Inventory (CBI). Descriptive statistics, correlation, and multiple linear regression were used for data analysis. The data were collected at the end of the internships in January 2024.

Findings : The results showed that the participants had moderate levels of alarm fatigue (M = 21.71, SD = 7.78 out of 52), perceived stress (M = 1.36, SD = 0.83 out of 4), and resilience (M = 3.25, SD = 0.60 out of 5). Problem-solving was the most frequent coping behavior. A weak positive correlation was found between alarm fatigue and perceived stress ($r = 0.22$, $p < 0.01$). In contrast, a negative moderate relationship existed between alarm fatigue and resilience (-0.40, $p < 0.001$) and problem-solving behavior ($r = -0.34$, $p < 0.001$). Resilience and problem-solving behavior were the main predictors of alarm fatigue.

Conclusion This study highlights the importance of recognizing the correlated factors of alarm fatigue among nursing students during their internships, especially in critical care units. Strategies that foster resilience and positive coping mechanisms and minimize the perceived stress should be implemented to minimize alarm fatigue among nursing students and enhance their well-being and clinical performance. Ongoing guidance and training on effective alarm control practices are vitally important. Implementing effective stress-reduction measures, such as mindfulness-based practices and adopting positive coping strategies are essential.

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Introduction

Alarms are common in high-intensity clinical care units, where patients are continuously monitored by devices designed to alert staff through specialized alarm systems [1]. These alarms play a crucial role in patient care by notifying staff of equipment malfunctions and changes in patient parameters [2]. However, the constant influx of alarms can be overwhelming [3]. Studies estimate that 85–99% of all alarms are either false alerts or clinically insignificant [4]. Nurses, particularly those in critical care units, are exposed to frequent alarms as they provide continuous care for critically ill patients [5]. This sensory overload can lead to a condition known as alarm fatigue, which may impact nurses' ability to respond effectively to alarms [6].

Alarm fatigue refers to a sensory overload that can lead to progressive alarm desensitization, stemming from exposure to a high volume of false or clinically insignificant alarms [7]. Alarm fatigue can lead to delayed responses or complete disregard of important alarms, which can seriously jeopardize patient safety [8]. When multiple alarms sound simultaneously in critical care units, nurses frequently feel overwhelmed, especially when monitors emit needless or erroneous alerts. This can lead to stress among critical care nurses, which is further exacerbated by excessive workloads [4, 9]. Studies indicate that many critical care nurses are unaware of effective strategies to prevent alarm fatigue [8]. Therefore, addressing this topic is important to improve the wellbeing of nurses and their patients.

The problem of alarm fatigue is not limited to healthcare professionals but also affects nursing students during their clinical internships [10]. A previous study found that nursing students experienced moderate levels of alarm fatigue during internships in critical care units [1]. Alarm fatigue can hinder students' ability to focus, engage, and retain important information, ultimately affecting their learning outcomes [3]. Additionally, alarm fatigue can lead to errors in performing procedures during clinical internships, with one-third of nursing students reporting mistakes due to alarm fatigue [1, 11]. In addition to experiencing alarm fatigue, nursing students are subjected to high physical and psychological stress during clinical internships in critical care units [12]. They are required to complete several assignments and tasks, manage a high workload, and perform numerous advanced procedures [13]. These challenges make internships in critical care units very challenging and anxiety-producing experiences [14]. The prevalence of high stress levels among nursing students during internships was estimated to range from 6.7 to 99.2% [13].

Perceived stress refers to an individual's subjective interpretation of the level of stress they are experiencing [15, 16]. It's based on how a person feels about the demands placed on them and their ability to cope with those demands [15, 16]. Perceived stress plays a crucial role in the development and experience of alarm fatigue. In high-stress settings, such as critical care units, both the perceived stress and alarm fatigue are high [17, 18]. The constant pressure and the sensory overload from alarms increase stress levels, making it harder for nursing students to stay alert and responsive [17, 18]. This can lead to cognitive fatigue, reduced decision-making ability, and ultimately lower quality of care or safety in critical situations [18].

Resilience is the ability to adapt and overcome challenges or difficult situations following periods of stress [19]. It involves maintaining mental toughness and emotional flexibility to cope with setbacks, stress, and unexpected changes. Rather than avoiding stress, resilience is about learning how to manage it in healthy ways [20]. In high-pressure settings, such as critical care units, resilience has a crucial role in combating alarm fatigue [17]. Resilient individuals are better equipped to handle stress and stay alert despite constant exposure to alarms [21]. They can manage the mental and emotional toll of alarm fatigue, and find ways to stay effective and responsive even in the face of overwhelming alarms [21]. For nursing students, resilience is key to managing stress and maintaining balance [12, 22]. Developing resilience helps nursing students navigate the challenges of internships and prepares them for future career success [12].

Coping behaviors are strategies or actions that individuals use to manage stress and challenging situations [23, 24]. When effectively applied, these behaviors can help mitigate the effects of alarm fatigue, improve performance, and enhance overall well-being [23, 24]. Coping behaviors play a crucial role in reducing the negative impacts of alarm fatigue [25]. By using coping behaviors, nursing students can maintain their alertness and effectiveness even under pressure by employing strategies that either directly address the root cause of alarm fatigue (problem-focused coping) or manage its emotional effects (emotion-focused coping) [25]. Moreover, effective coping behaviors can enhance students' academic performance [26]. A previous study found that the most effective coping behaviors used by nursing students during internships were problem-solving, transference, and optimism [27]. The choice of coping behavior can significantly influence students' perceived stress levels during internships [28]. Therefore, understanding and promoting effective coping behaviors among nursing students

is necessary for managing students' alarm fatigue and related stress during internships [27, 28]. This will ultimately provide safer and more supportive learning experiences, especially in critical care units [27, 28].

Previous studies found that nursing students' perceived stress levels positively correlated with alarm fatigue during internships in critical care units [6, 17, 29]. Moreover, resilience and effective coping behaviors negatively correlated with alarm fatigue [30–32]. Thus, addressing alarm fatigue by enhancing resilience and effective coping behaviors is essential for reducing perceived stress which can improve both the educational performance and the wellbeing of nursing students [3].

Numerous studies were conducted to assess alarm fatigue among nurses in critical care units both internationally and in Palestine [6, 17, 24, 33–36]. However, there is a notable lack of studies that examine alarm fatigue among nursing students. Therefore, this study aimed to provide baseline data to support policymakers, managers, and educators in developing strategies to mitigate the negative effects of alarm fatigue among nursing students. Additionally, this study purposed to explore the relationships between alarm fatigue, perceived stress, resilience, and coping behaviors among nursing students during their internship in critical care units. Specifically, this study was guided by the following questions:

- What are the levels of alarm fatigue, perceived stress, resilience, and coping behaviors among Palestinian nursing students during their internship in critical care units?
- What is the relationship between alarm fatigue and perceived stress, resilience, and coping behaviors among participants?
- What are the predictors of alarm fatigue among participants?

Methods
Design, setting, and sample
A cross-sectional design was used to perform this study. The nursing students at Arab American University in Palestine who were in an internship in a critical care unit were invited to participate. The total number of students in the internship was 200. A census sampling method was used to recruit the participants, where all eligible intern students ($N = 150$) were invited to participate. This sampling method was chosen to ensure a more focused and feasible approach, given the study's scope and resources. The inclusion criteria were being a full-time student currently enrolled in an internship in a critical care unit and willingness to participate. Part-time students were excluded.

The sample size was calculated using G*power software with alpha = 0.05, effect size = 0.15, and power = 0.90 with six predictors. According to regression analysis, a minimum sample of 123 participants was needed to conduct this study. An additional 10% was added to account for attrition, making the total minimum required sample size 136.

Study instruments
The data were collected using a structured self-reported online questionnaire. It consisted of the following instruments: the Alarm Fatigue Questionnaire [37], The Perceived Stress Scale (PSS) [38], the Brief Resilience Scale (BRS) [39], and the Coping Behavior Inventory (CBI) [40]. Furthermore, the following demographic data were collected: age, gender, number of wards during internships, and length of internship.

The Alarm Fatigue Questionnaire was developed by Torabizadeh et al. [37] and included 13 items. The response to each item was recorded using a 5-Point Likert scale ranging from 0 (never) to 4 (always). The scores of two items (1 and 9) were reversed. The total score of the questionnaire ranged from 0 to 52 and was categorized as follows: 0–7 indicating no alarm fatigue, 8–20 indicating low alarm fatigue, 21–32 indicating moderate alarm fatigue, and 33–52 indicating severe alarm fatigue. This questionnaire is valid and reliable with Cronbach's alpha of 0.91 [37]. The Cronbach's alpha in this study was 0.92.

The PSS was created by Sheu et al. [38] to examine nursing students' stress levels and types of stressors. It consists of 29 items rated on a 5-point Likert scale. The five possible responses range from 0 (never) to 4 (always). The items are grouped into six factors according to the sources of stress. They included stress from taking care of patients (8 items), teachers and nursing staff (6 items), assignments and workload (5 items), peers and daily life (4 items), lack of professional knowledge and skills (3 items), and the clinical environment (3 items). Higher scores mean higher levels of stress. Both total scores and individual subscale scores were measured. The cut-off points were as follows: 2.67–4.00 indicating a high stress level, 1.34–2.66 indicating a moderate stress level, and 0.0–1.33 indicating a low stress level [41]. This scale is valid and reliable, with Cronbach's alpha ranging from 0.87 to 0.93 [41, 42]. The Cronbach's alpha in this study was 0.94.

The BRS was developed by Smith et al. [39]. It consists of six items rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The scores of three items (2, 4, and 6) are reversed. The score is categorized as follows: 1.00–2.99 indicating low resilience, 3.00–4.30 reflecting moderate resilience, and 4.31–5.00 indicating high resilience [43]. This scale is valid and reliable with a Cronbach's alpha ranging from 0.80 to 0.91 [43]. The Cronbach's alpha in this study was 0.83.

The CBI was developed by Sheu et al. [44] to assess nursing students' coping behaviors. The CBI involves 19 items rated on a 5-point Likert scale ranging from 0 (never) to 4 (always). The items are grouped into avoidance behavior (6 items), problem-solving behavior (6 items), optimistic behavior (4 items), and transference behavior (3 items). A higher score means more frequent use and more effective coping behavior. This tool is valid and reliable with a Cronbach's alpha of 0.76–0.80 [40, 43]. The Cronbach's alpha in this study was 0.84. The original English versions of these measures were used since the participants were nursing students who could read and understand English.

Ethical considerations

Approval was obtained from the Ministry of Health, the Helsinki Committee in Palestine and the Arab American University with reference No# PHRC/HC/23. The questionnaire was provided on the first page with instructions regarding the purpose of the study and instructions on how to answer questions. To maintain anonymity and confidentiality in all stages of the study, the survey avoided collecting any personal information of the participants such as names, addresses, and contact details. Access to the completed questionnaires was possible only through the researchers' password-protected login. At the beginning of the questionnaire, it was clearly mentioned that the collected data would be anonymized and used solely for research purposes, and that participation was entirely voluntary.

Data collection procedure

First, meeting with the instructors of the internships were conducted to explain the study and facilitate the data collection procedure. The data were collected using an online questionnaire hosted on 'Google Surveys' platform. The link to the questionnaire was shared on a social media application (WhatsApp) group created by the research team for all students enrolled in the internships. The questionnaire form was displayed on scrollable

Table 1 Characteristics of the study sample (*N* = 141)

Characteristic	*N*	%
Age, **in years (mean ± SD)**: 22.9 ± 1.87		
Gender		
Male	75	53.2
Female	66	46.8
No of wards during internships		
1	65	46.1
>1	76	53.9
Length of internship		
≤ 30 days	58	41.1
>30 days	83	58.9

N: number; %: Percentage, SD: Standard Deviation

pages which a participant could move back and forth. This questionnaire link was pilot-tested, for usability and technical functionality with 10 participants and the data collected from this pilot testing was not included in the final report of this study. All the items were marked as compulsory, thereby, all submitted forms were complete. Furthermore, each participant had one chance to submit the survey, and a second trial was automatically denied. The data were collected at the end of the internships in January 2024.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) software version 26 was used to enter and analyze data. First, the data were screened for outliers using central tendency measures and frequencies. Additionally, normality was assessed using Kolmogorov-Smirnov which showed that the data were normally distributed. Descriptive statistics (means, standard deviations (SD), frequencies, and percentages) were used to summarize the study variables. A partial correlation test with control of demographic variables was used to examine the relationships between the study variables. Multiple linear regression analysis was used to determine the main predictors of alarm fatigue. The Cohen's guidelines were used to interpret the analysis of correlation, where 0.10–0.29 indicating weak correlation, 0.30–0.49 indicating moderate correlation, and 0.50-1.0 indicating strong correlation [44]. Eta Square η^2 was used to calculate effect size, in which a value of less than 0.01 reflected no effect, 0.01–0.06 indicated a small effect, 0.061– 0.14 reflected a moderate effect, and >0.14 indicated a large effect [44]. The significance level was ≤ 0.05.

Results

A total of 141 participants were included, where around half of them (53.2%) were male and had a mean age of 22.9 ± 1.87 years. Additionally, 53.9% of the participants were trained in more than one ward during their internships, and 58.9% had an internship duration of more than 30 days (Table 1).

Table 2 shows that the mean of alarm fatigue was 21.71 out of 52 (SD = 7.78), indicating a moderate level. Also, the mean of perceived stress was 1.36 out of 4 (SD = 0.83), indicating a moderate level. The mean of resilience was 3.25 out of 5 (SD = 0.60), indicating a moderate level. Concerning coping behaviors, the most frequently behavior was problem-solving (M = 2.53, SD = 0.18), while the lowest frequently behavior was avoidance (M = 1.59, SD = 0.20).

As shown in Table 3, the perceived stress had weak positive correlation with alarm fatigue (*r* = 0.22, *p* < 0.01). In contrast, a negative moderate correlation was found

Table 2 Levels of alarm fatigue, perceived stress, resilience, and coping behaviors

Variable	Categories	*N* (%)	M (SD)
Alarm fatigue	**No alarm (0–7)**	3(2.1)	21.71 (7.78)
	Low (8–20)	60(42.6)	
	Moderate (21–32)	66(48.6)	
	Severe (33–52)	12(8.5)	
Perceived stress	**Low (0.0-1.33)**	65(46.1)	1.36 (0.83)
	Moderate (1.34–2.66)	69(48.9)	
	High (2.67-4.00)	7(5.0)	
Resilience	**Low (1.00–2.99)**	34(24.1)	3.25 (0.60)
	Normal (3.00–4.30)	99(70.2)	
	High (4.31–5.00)	8(5.7)	
Coping behaviors			
Avoidance			1.59 (0.20)
Problem-solving			2.53 (0.18)
Optimistic			2.41 (0.48)
Transference			2.30 (0.39)

N: number; %: Percentage; M: Mean; SD: Standard Deviation

Table 3 Correlating factors of alarm fatigue

Factor	Alarm fatigue	
	r	*p*-value
Perceived stress	0.22	0.006**
Resilience	− 0.40	<0.001***
Avoidance	0.14	0.108
Problem-solving	-0.34	<0.001***
Optimistic	-0.16	0.063
Transference	-0.10	0.218

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p < 0.001$

- r: negative relationship; r: positive relationship

between alarm fatigue and resilience (-0.40, $p < 0.001$) and problem-solving behavior ($r = − 0.34$, $p < 0.001$).

The regression assumptions were examined. The multicollinearity was investigated using the variance inflation factor (VIF) and tolerance statistics. The VIF and tolerance were in the normal range, which means a positive and acceptable autocorrelation. The autocorrelation assumption was evaluated using the Durbin Watson (DW) coefficient, which was acceptable (1.147).

As explained in Table 4, the variables entered into the model of predictors of alarm fatigue included perceived stress, resilience and problem-solving behavior. The model was statistically significant (F = 14.626, $p < 0.001$, $R = 0.493$, $R^2 = 0.243$, df = 3). The model explained 49.3%

of the variance in alarm fatigue. The results revealed that resilience and problem-solving behavior were predictors of alarm fatigue (β= -0.486, $p < 0.001$, 95% CI: -6.120- -2.051; β= -0.366, $p < 0.01$, 95 CI: -0.569- -0.162), respectively. The effect size of resilience and problem-solving behavior on alarm fatigue was large, where Eta Square η^2 = 0.37 and 0.32, respectively.

Discussion

This study aimed to investigate alarm fatigue among undergraduate nursing students during their clinical internships in critical care units, and its association with coping behaviors, resilience, and perceived stress.

Levels of alarm fatigue, perceived stress, resilience, and coping behaviors

Our study found that participants had moderate alarm fatigue, which is consistent with a previous Italian study [1]. However, our result was lower than these among critical care nurses in previous national [17] and international studies in Italy [10] and Poland [6]. Our finding can be explained as exposure to alarms can rapidly escalate the severity of alarm fatigue, particularly for inexperienced individuals like undergraduate nursing students in critical care units. Their lack of clinical experience and professional self-doubt contributed to the swift onset of this phenomenon [1].

This study demonstrated that the participants reported moderate stress during their clinical internships, which is consistent with a previous national [45] and other Arab counties studies like Jordan [46] and Egypt [47], and Korea [48]. Previous studies revealed that nursing students experienced higher stress than their peers in other healthcare fields [48–50]. Other previous studies conducted in Italy [51], Saudi Arabia [52], and Taiwan [53] revealed that nursing students reported moderate to severe levels of stress during their clinical practice. This stress is compounded by the demanding nature of critical care units, where students witness patient suffering and death, face the risk of contracting infectious diseases, and endure extensive training sessions [54, 55]. Also, studies in different regions may reveal variations in stress levels due to cultural, organizational, or systemic factors. For instance, a study conducted in the United States may show higher stress levels in high-intensity clinical

Table 4 Predictors of alarm fatigue: multiple linear regression

Predictor	b	β	t-test	*p*-value	95.0% CI		Correlations	
					Lower	Upper	Partial	Part
Perceived stress	0.918	0.104	1.336	0.184	-0.441	2.278	0.113	0.099
Resilience	-0.486	-0.317	-3.970	<0.001	-6.120	-2.051	-0.321	− 0.295
Problem-solving	-0.366	-0.270	-3.556	0.001	-0.569	-0.162	-0.291	− 0.264
R= 0.493, R^2=0.243, F = 14.626, df= 3, p-value = < 0.0001								

b: Unstandardized beta; β: Standardized beta; CI: Confidence Interval

settings, such as emergency rooms, due to the fast-paced nature of care and the frequent exposure to life-threatening situations [56]. In the Middle East, nurses reported moderate stress levels due to long work hours and inadequate resources, which could apply to the Palestinian context [57].

Stress levels can also vary depending on the amount of clinical exposure. For instance, novice students with limited exposure may experience more anxiety and stress, especially when they face the high demands of a critical care unit or emergency setting. In contrast, more experienced staff members may develop coping strategies over time, which help them manage stress and reduce the impact of alarm fatigue. The less experienced students tend to report higher stress due to their inexperience and lack of confidence in decision-making [52]. Conversely, senior residents, although still stressed, exhibited better stress management skills, possibly due to developed resilience and problem-solving abilities. Students in Palestine encounter additional stressors due to training within a severely limited healthcare system under military occupation [58]. The ongoing conflict and political instability in the region may create unique stressors for Palestinian nursing students. Exposure to trauma, uncertainty, and socio-political tensions can affect mental health and resilience [17, 59]. Palestinian students might also face social expectations of performing well academically despite the challenges they face, which adds to their perceived stress. Moreover, the prevailing cultural norms in Palestine could lead to a reluctance in seeking help since mental health issues might be stigmatized or viewed as a sign of weakness [60]. The findings from this study, revealed a troubling trend of mental health challenges among nursing students, especially in conflict-affected regions.

Our results suggested that participants had moderate resilience level, which is congruent with previous international studies conducted in Italy [1], Saudi Arabia [61], Spain [62], UK and China [63, 64]. However, our result is lower than a previous national study that reported high resilience levels [65]. In contrast, previous studies demonstrated low resilience levels [46, 66, 67]. Resilience provides effective mechanisms among nursing students to manage a stressful environment. Resilience is a significant factor in stabilizing nursing students and facilitating their recovery from stressors [14, 68, 69], and it remains a cornerstone in stress management [59]. The critical situations created by internships are meant to improve students' resilience and enhance their management of difficulties [70–72]. Palestinian cultural values of perseverance and endurance might shape how our participants perceived and responded to adversity, fostering their resilience in the face of challenges [60]. Our finding highlights the importance of fostering resilience to help students navigate the complex challenges they encounter

in training environments, especially in conflict zones. Building resilience is a key factor in supporting the development of nursing students. Several strategies can promote resilience in nursing students, including managing time effectively, improving communication skills, maintaining positive attitudes at work, determining and managing stressors, enhancing emotional intelligence, and developing adaptability [73, 74].

Our findings indicated that participants' problem-solving and optimism were notably used as coping behaviors for managing problems. A prior study suggested that nursing students typically utilized individual or combined coping strategies for stress management [75]. Our result is consistent with previous studies demonstrating that problem-solving was the most common coping behavior followed by optimism, while avoidance was the lowest behavior [42, 43, 76]. These results contradict previous studies indicating that nursing students often avoid managing pressures from various sources, including peers, daily life, homework, patient care, teachers, and clinical training [75]. Despite being aware of effective coping strategies, nursing students may not always engage with them effectively [77]. Therefore, the role of teacher-implemented interventions in improving students' coping strategies and reducing stress needs to be emphasized [77]. Understanding how stress is experienced allows nursing students to identify effective relaxation techniques. Stress management strategies include seeking family support, fostering a positive self-image, engaging in enjoyable activities, maintaining regular physical activity, setting realistic goals, and accepting change as part of life [12, 78]. Additionally, nurse educators and academic coordinators should ensure nursing students are well-prepared for internships by orienting them to the environment of clinical areas and relevant policies [79, 80].

Correlating factors and predictors of alarm fatigue

Our study revealed a positive correlation between perceived stress and alarm fatigue. Similarly, earlier studies found a positive relationship between perceived stress and alarm fatigue and perceived stress is a predictor of alarm fatigue [6, 17, 29]. In contrast, another study found no significant association between perceived stress and alarm fatigue [81]. Our result could be interpreted as nursing students were exposed to many stressors during their internships in critical care units including stressful work environments, alarms, academic requirements, and extensive training, which increased their exposure to alarm fatigue [75].

This study demonstrated a negative relationship between resilience and alarm fatigue, and resilience was a protective predictor against alarm fatigue. There are no previous studies examining this relationship. Our result

could illustrate resilience's role in minimizing alarm fatigue and work stress [30], as resilience can minimize psychological problems such as stress.

[19] which is reflected in alarm fatigue. In critical care units, where alarm fatigue can arise from the constant exposure to alarm sounds and the pressure of making quick decisions, resilient individuals are better equipped to manage this stress without becoming overwhelmed. Resilient individuals are more likely to maintain a positive mindset and stay focused, which can help them mitigate the negative effects of alarm fatigue.

Our results found that problem-solving behavior was negatively correlated with alarm fatigue, and problem-solving was a protective factor from alarm fatigue. There are no previous studies examining this relationship. However, it is documented that positive coping behaviors can reduce stress and hazards of alarm fatigue, which could enhance patient safety and quality of care [31, 32]. Problem-solving behavior involves identifying issues and finding effective solutions. When intern students encounter alarm fatigue, those with strong problem-solving skills are more likely to actively address the problem by developing strategies to cope with or reduce the impact of alarm overload. They might implement changes to their work environment, modify alarm settings, or engage in team discussions to improve the system. Effective problem-solving reduces the likelihood of feeling helpless or stressed by the alarms, thereby decreasing alarm fatigue. Therefore, more targeted research is needed to specifically examine the relationship between problem-solving behavior and alarm fatigue.

Cultural factors can significantly influence resilience and coping behaviors among Palestinian nursing students. In Palestinian society, family plays a central role, and strong familial ties often provide emotional and practical support during times of stress. This sense of community can help foster resilience by offering a support network to navigate personal and academic challenges. Additionally, the collectivist nature of Palestinian culture emphasizes shared responsibility and solidarity, which may encourage nursing students to rely on each other for emotional and psychological support, strengthening their coping mechanisms [60]. The cultural context in Palestine, with its emphasis on family, community support, and religious practices, can positively influence how nursing students build resilience and manage stress. Understanding these cultural dynamics is crucial for providing effective support to students in their educational and professional development [60].

Limitations of the study
Despite the important findings of this study, it has the following limitations. The study was cross-sectional that did not examine the cause and effect of the variables.

The data were collected from one site using self-reported questionnaire which was based on the participants' beliefs. Self-reported online surveys can introduce response bias, as participants may not always provide accurate or truthful answers. They might exaggerate or downplay their stress and coping levels, either to appear more favorable or because it's challenging to accurately assess their experiences. Furthermore, social desirability bias could influence their responses, leading participants to answer in ways they think are socially acceptable or expected, rather than reflecting their true feelings or behaviors. As a result, the data may not fully capture the participants' actual experience. Thus, future studies should other data collection methods and include students from other universities. The study used a sample from one university which might limit the generalizability of findings, thus, future studies are recommended to recruit samples from several institutions and use randomization. Moreover, future studies are recommended to examine the correlation between demographic variables and alarm fatigue.

Implications for practice
It is necessary to assess alarm fatigue among nursing students during their internships in critical care units. Hospital administrators should implement policies and comprehensive alarm fatigue management protocols, including routine adjustment of alarm settings and integration of artificial intelligence technologies. Ongoing guidance and training on effective alarm control practices are vitally important. It is essential to apply evidence-based procedures and guidelines to support resilience and positive coping behaviors among nursing students to reduce their stress and improve patient care quality. Nurse educators, academic programs, and hospital risk management departments should provide strategies to raise awareness of alarm fatigue.

At the institutional level, interventions to manage alarm fatigue and reduce stress among healthcare professionals, such as faculty-led alarm management training, can play a crucial role in improving both clinicians' well-being and patient safety. Faculty-led training sessions focused on alarm management can reduce alarm fatigue among students. These training programs can inform students about the purpose of alarms, how to appropriately respond to different types of alarms, and how to avoid alarm desensitization. Faculty members can lead stress-relief workshops teaching techniques such as mindfulness meditation, deep breathing exercises, and cognitive restructuring to help students manage stress levels and improve emotional regulation. By fostering teamwork and collaboration, stress can be shared and managed more effectively. Team-building activities can be incorporated to enhance communication skills and emotional

support among staff members, which is crucial for resilience. Using simulation-based learning of high-stress scenarios can help staff practice managing alarms and critical situations in a controlled environment, which can help reduce anxiety and increase confidence in handling real-world stressors. Conducting regular evaluations of alarm management training and other interventions can help institutions assess their impact on reducing alarm fatigue and improving students' well-being. These evaluations can include surveys, interviews, or observational studies to gather data from students.

Conclusion

This study demonstrated that nursing students during their internships in critical care units had moderate levels of alarm fatigue. Perceived stress was positively correlated with alarm fatigue while resilience and problem-solving behavior were correlated negatively with alarm fatigue. Resilience and problem-solving behavior were the main negative predictors of alarm fatigue. Therefore, implementing interventions that address alarm fatigue among nursing students is necessary, and the adoption of alarm management solutions is essential. Strategies to lessen the negative impacts of alarm fatigue on nursing students' well-being and clinical performance should focus on fostering resilience and positive coping mechanisms. Additionally, future research should be performed to examine the effects of the developed interventions on alarm fatigue and patient outcomes.

Abbreviations

PSS	Perceived Stress Scale
BRS	Brief Resilience Scale
CBI	Coping Behavior Inventory
SPSS	Statistical Package for Social Sciences
SD	Standard deviations
VIF	Variance inflation factor
DW	Durbin Watson

Declarations

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