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Alarm Fatigue in Nursing Students Undertaking Clinical Training in Intensive Care Units: A Multicenter Study

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Abstract

Background: *The frequency of alarms from monitors and other electro-medical devices is of great utility but can increase the professional's workload and expose nurses in the intensive care unit to Alarm Fatigue. A recent study suggested that students in training can also experience the problem during their first clinical experiences in intensive care. Unfortunately, no data are available about the Italian panorama. To explore Alarm Fatigue among Bachelor of Science in Nursing students at the end of their internship experience in intensive care settings.* **Methods:** *Multicenter cross-sectional design. A convenience sample of nurses from 3 Italian university hospitals was recruited. The students completed the revised version of the "Alarm Fatigue questionnaire-ita" at the end of the clinical internship in intensive care settings.* **Results:** *130 nursing students were enrolled (response rate 59.36%). The overall level of Alarm Fatigue was Me= 24.5 IQR [17.5, 30.5]. In addition, 9.23% of the sample reported errors or near misses related to Alarm Fatigue during the internship experience. The alarm fatigue level was higher in students who committed "errors/almost errors" (p=0.038) and in "student workers" (p=0.005).* **Discussion:** *The extent of alarm fatigue experienced by nursing students requires developing a preventive strategy.*

1. Introduction

The continuous advance in medicine and technologies nowadays allows healthcare organizations to benefit from a variety of equipment and devices to support day-to-day clinical practice; this can be found in every care setting, but particularly in high-intensity clinical care settings such as intensive care, where patients are subjected to continuous monitoring, often with devices capable of alerting staff with special alarm systems [1-4]. Although a prompt response to alarms coming from monitors and other electro-medical devices is of great utility to healthcare professionals, supporting them in the rapid recognition of potentially dangerous situations, the International literature shows that the rising use of the devices themselves may represent, even paradoxically, a risk factor for patient safety: the frequency of "false alarms" is often very high and represents a danger because it can increase the professional's

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workload, and above all, because it can make him progressively less sensitive and therefore responsive to all alarms [1, 4, 5].

The occurrence and progression of this status can expose any practitioner and particularly the nurses, to the risk of developing "Alarm Fatigue" (AF) [2, 4, 6, 7], which can be defined as a sensory overload capable of causing progressive desensitization to alarms due to exposure to a high number of alarms that turn out to be false or not clinically significant [8].

Higher levels of AF may be associated with the behavioral responses of nurses being inappropriate, such as setting alarms out of safe limits, turning down the volume, or even turning off the alarm signals, thus constituting a possible risk to patient safety [3, 9, 10]. Therefore, the improvement of AF management is an area of increasing interest, and in 2022, the accreditation organization for excellence Joint Commission reaffirmed it as one of the international goals for patient safety [11].

Understanding the exact character and extent of AF in nurses is just the first step in a multidimensional approach aimed at improving work processes and consequently reducing the risk for patients and increasing the safety of the healthcare facilities performed; [12] the topic is therefore increasingly being investigated worldwide [2, 13-15]. Carelli et al. (2022) [3] first documented its prevalence in the Italian healthcare scenario and showed the association between specific AF behaviour and professional errors.

A recent study [7] has also pointed out that the problem of Alarm Fatigue is not limited to professionals but can also be experienced by students in training during their first clinical experiences in intensive care. However, the lack of in-depth investigations on this subject in the Italian academic panorama suggests the need to investigate the phenomenon in nursing degree courses as well to provide health and education systems with early guidance for a better understanding and consequent proactive management of the problem.

This study aimed to explore the phenomenon of Alarm Fatigue among students of the Bachelor of Science in Nursing at the end of their internship experience in intensive care settings.

2. Methods

2.1. Design and Setting

The administration of a research questionnaire developed a cross-sectional multicenter study. Students of three Italian schools of nursing (the University of Milan, the University of Roma - La Sapienza, University of Foggia) were enrolled. In addition, all students who undertook at least one internship experience in an intensive care unit during the study period were enrolled.

Since this is the first research investigating the FA of students in the Italian context, the estimated sample size was based on the prior study by Week et al. [7], in which 89 students were enrolled. Based on their results, a minimum of 100 students was initially hypothesized.

2.2. Sample and Data Collection

For each nursing school, two research team members were identified to explain the purpose of the survey, how to fill out the instrument and to organize data collection from March 1 to July 31 2022. At the end of the presentation, the research team members sent a web link generated via an online application to the student's e-mail address of the school of nursing, which included the research instrument.

Students were invited to participate after their clinical experience in an intensive care unit. All students who undertook at least one internship experience in an intensive care unit during the study period were enrolled; those who interrupted the experience before seven days were excluded.

2.3. The Instrument

The instrument was composed of two sections: (i) socio-demographic and academic data collection form (age, gender, work commitment, if any, university, unit and length of the internship experience, direct or indirect AF-related errors/errors during the clinical experience); (ii) the modified Alarm Fatigue Questionnaire-ita survey instrument.

1. I adjust/I should adjust alarm settings based on the patient's condition
2. I turn off/I should turn off alarms at the beginning of each shift
3. In general, I hear a certain amount of noise in the ward
4. I believe that much of the noise in the ward is due to alarms from monitoring equipment
5. I pay more attention to alarms on certain shifts
6. On some shifts, the heavy workload in the department prevents me from responding quickly to alarms
7. When alarms go off repeatedly, I become indifferent to them
8. The sound of the alarm makes me nervous
9. I react differently if the alarm shows a high (high volume or red) or low priority (low volume or yellow/green)
10. When I am angry and nervous, I am more bothered by alarm sounds
11. When alarms go off repeatedly and continuously, I lose patience
12. Alarm sounds prevent me from focusing on my professional activities
13. During visiting hours, I pay less attention to equipment alarms

Torabizadeh developed the "Alarm Fatigue Questionnaire" in 2017 [15], and it was recently validated in Italian by Carelli et al. confirming its good validity and reliability properties.

It comprises 13 items; the participants are asked to quantify the frequency of any of the behaviours regarding alarm management described in each item. The total score of the tool ranges from 0 (lowest impact of fatigue) to 52 (highest impact of fatigue). In agreement with the original study, for each item, a median score ≥ 3 indicated an Alarm Fatigue behaviour.

Since the instrument was validated on a different population, it was necessary to test its properties on students as well; the scale was submitted to 4 nursing students and four tutor nurses to evaluate face and content validity. They were asked for their opinion regarding the level of understanding of the statements, the relevance of each item (on a ten-point Likert scale), and the need for changes. Based on the judgement of the evaluators involved, it proved necessary to modify two items of the scale: item 1, "I adjust alarm settings based on patient condition", was modified to "I adjust/I would adjust alarm settings based on patient condition"; item 2 "I turn off alarms at the beginning of each shift" was modified in "I turn off/I would turn off alarms at the beginning of each shift". Finally, the content validity of each statement (I-CVI) and the tool (S-CVI) were calculated.

2.4. Ethical Considerations

The directors approved the study of every center involved in the study under the Helsinki Declaration as revised in 2008. We complied with the rules of each local Ethical committee, which did not require approval for studies on this topic and this type of data at the time of data collection. Informed consent was collected for each participant prior to participating in the study. Anonymous double-blind survey administration allowed a reduction of the risk of social-desirability bias.

2.5. Statistical Analysis

Continuous variables were described as mean and standard deviation if normally distributed or with median and interquartile range otherwise. The Kolmogorov-Smirnov test assessed the normality of data distribution.

Internal consistency was assessed by measuring Cronbach's Alpha coefficient.

The significance level was set at 5% for all calculations. The analyses were conducted with SPSS 24 edition. The relation of alarm fatigue scores with different variables was assessed using the non-parametric Mann-Whitney test.

3. Results

3.1. Sample Characteristics

One hundred thirty students were enrolled (response rate 59.36%). The median age was

22 years, IQR [22, 24], between 21 and 31 years. The majority of them were female (n=94, 72.31%). 46 (35.38%) attended the course at the University of Milan, 39 (30.0%) at the University of Roma – La Sapienza, and 45 (34.62%) at the University of Foggia. One hundred eight students were not employed (83.08%), 21 had part-time jobs (16.15%), and only 1 had full-time employment (0.77%). Eight student-workers (6.15%) had jobs in an environment where alarms were regularly present.

All the students had just finished their internship experience in the intensive area; 28 (21.54%) had already had at least one other experience in the same setting during their academic career. The units where the last internship experience was carried out were mainly ICU and First Aid (Table 1). The median length of the internship was 45 days, IQR [30, 60], with no differences between settings (p=0.259).

3.2. Errors and Alarm Fatigue

28.46% of the sample (n=37) reported that errors or near misses related to Alarm Fatigue by healthcare professionals or other nursing students had occurred during the internship experience they had just completed. In addition, 9.23% (n=12) also stated that they had made or nearly made errors themselves (Table 2).

Table 1. Sample characteristics.

UNIVERSITY, n (%)	
Milan	46 (35.38)
Roma/ La Sapienza	39 (30.0)
Foggia	45 (34.62)
Prior experience in the critical area, n (%)	
None	102 (78.46)
1	22 (16.92)
2	6 (4.62)
Ward of the ongoing internship experience, n (%)	
Emergency room	41 (31.54)
Resuscitation	53 (40.77)
Cardiac Intensive Care Unit (CICU)	15 (11.54)
Neonatal Intensive Care	8 (6.15)
Covid intensive care unit	6 (4.62)
Post-operative intensive care unit	5 (3.85)
Operating room	2 (1.54)

Table 2. Direct and indirect experiences of adverse events during clinical practice and related, in students' perception, to alarm fatigue.

Alarm Fatigue accidents committed by professionals or other students, n (%)	
No	63 (48.46)
Yes	37 (28.46)
I do not know/ I do not remember	30 (23.08)
Alarm Fatigue accidents by the sample, n (%)	
No	93 (71.54)
Yes	12 (9.23)
I do not know/ I do not remember	25 (19.23)

3.3. Tool Properties

The modified version of the Alarm fatigue questionnaire-ita obtained an S-CVI of 98.5%; all items obtained an I-CVI >90.0%. The Cronbach's alpha coefficient was 0.856; removing every item yielded a minimum value of 0.828.

3.4. Alarm Fatigue in Nursing Students

The overall level of Alarm Fatigue was Me=24.5 IQR [17.5, 30.5] compared to a theoretical range of 0 to 52. Table 3 shows the number of subjects with a median score ≥ 3 for each item on the scale representing a fatigue alarm condition. Over 50% of the sample achieved median scores ≥ 3 in items 2, 5, 7, 11, and 13.

3.5. Alarm Fatigue and Socio-demographic and Academic Variables

The level of alarm fatigue increased significantly between the variables "errors/almost errors committed" and "student worker": the 12 students who reported having committed errors/almost errors during their internship experience in the critical area showed an Alarm Fatigue score of Me=29.

Table 3. Relationship between behaviours assumed and experiences of alarm fatigue incidents.

	AF Me≥ 3	No AF Me<3
	n (%)	n (%)
1. I adjust/I should adjust alarm settings based on the patient's condition	62 (47.69)	68 (52.31)
2. I turn off/I should turn off alarms at the beginning of each shift	76 (58.46)	54 (41.54)
3. In general, I hear a certain amount of noise in the ward	37 (28.46)	93 (71.54)
4. I believe that much of the noise in the ward is due to alarms from monitoring equipment	35 (26.92)	95 (73.08)
5. I pay more attention to alarms on certain shifts	68 (52.31)	62 (47.69)
6. On some shifts, the heavy workload in the department prevents me from responding quickly to alarms	31 (23.85)	99 (76.15)
7. When alarms go off repeatedly, I become indifferent to them	76 (58.46)	54 (41.54)
8. The sound of the alarm makes me nervous	33 (25.38)	97 (74.62)
9. I react differently if the alarm identifies a higher (high volume or red colour) or lower priority (low volume or yellow/green colour)	61 (46.92)	69 (53.08)
10. When I am angry and nervous, I am more bothered by alarm sounds	46 (35.38)	84 (64.62)
11. When alarms go off repeatedly and continuously, I lose patience	66 (50.77)	64 (49.23)
12. Alarm sounds prevent me from focusing on my professional activities	54 (41.54)	76 (58.46)
13. During visiting hours, I pay less attention to equipment alarms	83 (63.85)	47 (36.15)

5 IQR [23.0, 33.3], significantly higher (p=0.038) than those who had not committed any (Me=24.0 IQR [17.5, 29.4]).

Similarly, the 22 student-workers showed significantly higher levels of fatigue (Me=29.5 IQR [24.25, 33.0] vs Me=23.5 IQR [17.5, 30.0] p=0.005); furthermore, the eight students who reported working in an environment where sounds and alarms are regularly present scored even higher Me=30.5 IQR [26.0, 38.5].

No significant differences regarding gender (p=0.203), University Hospital (p=0.535), referred errors or near misses (p=0.292), and the number of clinical experiences in the critical area (p=0.301). Moreover, the overall length of the internship (p=0.083) was detected (Table 4).

4. Discussion

AF is an emerging problem in all clinical areas that make extensive use of the equipment and electromedical devices equipped with acoustic alarm systems; improving knowledge and understanding of the phenomenon and developing preventive policies can be a potential way of ensuring patient safety [16, 17].

Trainee students and nurses are highly exposed to the alarms; therefore, fatigue can be a stressful aspect of their clinical and academic experience. The overall level of fatigue in our sample obtained a median value of 24.5; it can be considered a medium if We consider a theoretical range from 0 to 52.

Since this is a student sample, i.e., people with less exposure to alarms than nurses given the limited period of training experience, the finding indicates a situation worthy of attention as the level of Alarm Fatigue achieved is only mildly lower than that found in professionals [3].

It suggests the hypothesis that the phenomenon may present itself very quickly and at a level of seriousness that is already significant in the event of the subject's exposure to alarms and that this situation may worsen further over time. In addition, the level of Alarm Fatigue experienced by the student suggests the idea that the distress also has in the reduced clinical experience and professional self-doubt of

Table 4. Relationship between Alarm Fatigue and socio-demographic and academic variables.

Variable		Alarm Fatigue Me [IQR]	p
Errors	Yes	29. 5 [23.0, 33.3]	*0.038*
	No	24.0 [17.5, 29.4].	
Referred errors	Yes	26.0 [19.0, 30.5]	0.292
	No	24.5 [17.25, 30.]	
Gender	Female	24.5 [17.5, 30.5]	0.203
	Male	24.0 [18.0, 30.0]	
Worker	Yes	29.5 [24.25, 33.0]	*0.005*
	No	23.5 [17.5, 30.0]	
University Hospital	Unimi	24.5 [18.0, 29.5]	0.535
	Uniroma	25.0 [18.25, 30.25]	
	Unifo	24.5 [17.5, 30.5]	
Clinical experience	1	24.5 [17.5, 30.0]	0.301
	2	25.5 [18.25, 32.0]	
Length	<45 days	23.5 IQR [17.0, 30.5]	0.083
	=>45 days	25.0 IQR [18.0, 30.5]	

the nursing student, who for the first time is undertaking training in a highly complex setting such as the critical care area, two significant causes for the rapid onset of Alarm Fatigue.

Following the results of Carelli et al. [3], the alarm-fatigue behaviors shown by the majority of the students were reported in items 2, 7 and 13; item 2, "I turn off alarms at the beginning of each shift", showed the adoption of a very hazardous behaviour as it has, as a logical consequence, the reduced possibility of being alerted to potentially dangerous clinical situations for patients. Instead, items 7, "When alarms go off repeatedly, I become indifferent to them", and 13, "During visiting hours, I pay less attention to equipment alarms", describe negative attitudes of students regarding the indifference generated by alarm fatigue in two different situations which could influence the clinical practice and patient safety.

About 30% of the student nurses reported indirect experience of errors potentially associated with AF during their clinical internship. This data, only seemingly low, agrees with previous work [3] and offers further evidence regarding the frequency of the phenomenon among healthcare professionals. Also of interest is the finding concerning direct errors: 9.23% of the students reported direct experience of errors; this result is only apparently of little concern, but it does frame, albeit preliminarily, how even the student is not free from committing errors due to the initial Fatigue Alarm discomfort. This result is only apparently of little concern, but it does frame, albeit preliminarily, how even the student is not free from committing errors due to the initial Fatigue Alarm discomfort; it is also necessary to underline that the data may be affected by significant under-reporting (many episodes may potentially not be reported due to shame or fear of being judged) which therefore precludes, at the current level of knowledge, a full understanding of the phenomenon. Perhaps not surprisingly, the 12 students who reported having made errors/almost errors had a significantly higher median Alarm Fatigue score than those who reported having made no errors: the relationship between these two constructs seems very reasonable and represented by a two-way direction, i.e. of mutual influence. Furthermore, the fact that higher levels of Alarm Fatigue are found among working students also demonstrates that stressors external to the student's academic pathway may further expose him to the risk of AF [16].

The relationship with the variables "gender", "operational unit" and "university" did not lead to any significant differences, confirming the findings on nursing staff [3]; the absence of differences in AF scores for the variable 'university' further supports the idea that the diffusion of the problem concerns the nursing students population as a whole, independently of the location of study, and logistic and structural characteristics that may differ in each setting. However, an in-depth study considering these variables' potential influence is desirable.

Finally, the Alarm Fatigue scores obtained by those who had already carried out at least one other clinical experience in the critical area were higher (although not reaching the threshold of statistical significance); in these subjects, the exposure to alarms was more prolonged in duration and therefore higher than in those who had carried out their experience in the critical area for the first time, it is therefore plausible that the levels of alarm fatigue are higher; in the literature, the influence of the duration of exposure on nurses offers discordant results; for example, the study by Lewandowska et al. [2] suggests that nurses with more experience in the critical care area should show more comfort in setting alarms while Carelli et al. [3] shown that longtime experience was associated with higher levels of Alarm Fatigue.

Finally, we found that the modified version of the "Alarm Fatigue Questionnaire-ita" is valid and reliable and thus able to assess the phenomenon in Italian nursing students.

We enrolled nursing students from three University hospitals in different Italian areas; however, the research was limited by a small sample size, even though it was larger than the study by Week et al. [7], which represents only a small portion of the Italian student population; in-depth studies on larger samples may also add to the generalizability to the findings and are therefore recommended. Furthermore, the absence of further investigation regarding AF into the student population, except for the study of Weeks et al. [7] carried out, however, with a different tool, does not allow for a comparison with the results obtained. It will also be interesting to study the association between alarm fatigue levels and other psychological disturbances, such as burnout and moral distress, which have already been extensively studied in nurses [18, 19].

5. Conclusions

Alarms are an unavoidable element in the intensive care unit that exposes not exclusively nurses but also students to the risk of Alarm Fatigue. The negative consequences on the individual's psychological well-being and the effects on patient safety require the introduction of alarm management strategies and support for the need for programs to address alarm fatigue in nursing students.

Therefore, nurse educators, academic education programs, and hospital risk management departments should provide evidence-based tools and strategies to increase awareness of alarm fatigue among students. Furthermore, research and daily clinical experience can support the identification of solutions and increase awareness and responsiveness among nursing students to prepare them for clinical practice better and, consequently, improve patient safety and quality of care.

Declaration of Interest: No conflict of interest has been declared by the authors.

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