

**ALARMS FATIGUE: INTEGRATIVE REVIEW****FADIGA DE ALARMES: REVISÃO INTEGRATIVA****FATIGA DE ALARMA: REVISIÓN INTEGRADORA***Adele Kuckartz Pergher¹, Roberto Carlos Lyra da Silva²***ABSTRACT**

Objective: to seek publications in online scientific journals about the phenomenon of alarms fatigue. **Method:** it is an integrative literature review, with data collection in the databases LILACS and MEDLINE, with the descriptors "Clinical alarms" and "Fatigue". We included articles published in full version in English or Portuguese, which were published in last ten years. **Results:** the final sample consisted of eight articles. All of them were in English and had been published between 2010 and 2011. The publications feature the alarm fatigue as a phenomenon related to excessive number of alarms that causes a desensitization of the team, which ends up ignoring them, jeopardizing the patient safety. The research papers show as solutions to reduce it the proper adjustment of threshold and staff training. **Conclusion:** only one publication is a research paper, the other ones are reviews or experience reports. Therefore, there is a great need for further surveys about the phenomenon, especially in Brazil. **Descriptors:** Clinical Alarms; Fatigue; Patient Safety; Review.

RESUMO

Objetivo: buscar publicações em periódicos *online* a respeito do fenômeno da fadiga de alarmes. **Método:** revisão integrativa de literatura, com coleta de dados nas bases LILACS e MEDLINE, com os descritores "*Clinical alarms*" and "*Fatigue*". Foram incluídos artigos publicados na íntegra em português ou inglês, publicados nos últimos dez anos. **Resultados:** a amostra final foi constituída por oito artigos. Todos estavam em língua inglesa e haviam sido publicados entre 2010 e 2011. As publicações caracterizam a fadiga de alarmes como um fenômeno relacionado ao excesso de alarmes que acarreta uma dessensibilização da equipe, que acaba por ignorá-los, prejudicando a segurança do paciente. Os trabalhos mostram como soluções para reduzi-la o ajuste adequado dos limites e o treinamento da equipe. **Conclusão:** apenas uma publicação é um artigo de pesquisa, as demais são revisões ou relatos de experiência. Portanto, é grande a necessidade de novos estudos sobre o fenômeno, especialmente no Brasil. **Descritores:** Alarmes Clínicos; Fadiga; Segurança do Paciente; Revisão.

RESUMEN

Objetivo: buscar publicaciones periódicas en línea sobre el fenómeno de la fatiga de alarma. **Método:** revisión integradora de la literatura con la recopilación de datos en LILACS y MEDLINE, con alarmas descriptores clínicos y fatiga. Se incluyeron artículos publicados en su totalidad en Portugués o Inglés publicados en los últimos 10 años. **Resultados:** la muestra final estuvo compuesta por ocho artículos. Todos estaban en Inglés y se publicaron entre 2010 y 2011. Publicaciones con fatiga alarma como un fenómeno relacionado con las alarmas excesivas que causa una desensibilización del equipo que termina haciendo caso omiso de ellos, poniendo en peligro la seguridad del paciente. Los documentos muestran cómo las soluciones para reducir para ajustarse a los límites y capacitación del personal adecuado. **Conclusión:** sólo una publicación es un artículo de investigación, los otros son revisiones o informes de experiencia. Tan grande es la necesidad de más estudios, especialmente en Brasil. **Descritores:** Alarmas Clínicos; La Seguridad del Paciente; Revisión; Fatiga.

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INTRODUCTION

The technology is increasingly becoming a part of the everyday life in the Intensive Care Units (ICUs).¹ Regarding the multi-parameter monitoring systems, it should be considered that they are technologies capable of expanding the natural ability of our senses.² Such systems allow, in invasive or non-invasive manner, monitoring the physiological variables, in a continuous or frequent way. The observed data are useful both for clinical diagnosis and for guiding the therapy, thus, they may contribute to the safety of critical patients.

In this context, the development of new technologies has increased the number of audible and visual alarms in the ICUs, in order to alert the professionals about the patient's conditions and equipment failures, by ensuring patient safety and quality of care. About 25 years ago, practically, there was no equipment with alarm system. Currently, most ICUs have some kind of alarm; however, there is not, on the part of manufacturers, any standardization on the sounds produced by them, leaving it to professionals the matter of distinguishing and reacting based on their perception on the importance or not of the event.³ Ironically, the alarms that are designed to provide safety to patients, end up increasing the noise in the units, bringing a false sense of security and favoring the occurrence of alarm fatigue.³

The issue of excess of alarms was recognized and studied in the last 20 years, particularly in ICUs. From this problem, it arose the concept of "alarm fatigue," a phenomenon often observed in intensive care units that is characterized, among other things, by delay in the response from health professionals to alarms or, even, if alarms are disabled, silenced or ignored, may jeopardize the patient safety.⁴

The Nursing often deal with false alarms (e.g.: alarm of tachycardia due to the patient movement) and alarms that do not indicate relevant clinical situations, such as the alarm of "high pressure" from the ventilator, while the patient is coughing.⁵ The large number of alarms ends up generating many false positives, predisposing to the phenomenon of alarms fatigue.⁶

In 2002, the Joint Commissions on Accreditations of Healthcare Organizations (JCAHO), a non-profit organization that oversees health services and considers them standard, published an urgent warning about alarms after 23 patients have passed away or

become comatose because of malfunctioning of breathing-masks.⁷ 65% of these cases were related to alarms. According to this study, the professionals did not respond to alarms from equipment malfunctioning, the alarms were bad configured or did not hear them play, since they were at low volume.⁷

Several studies have sought to find ways to reduce the number of false alarms, in order to ensure that the situations which truly require intervention are identified. The authors highlight the need for improvement in the alarm systems of the current monitors and staff training.^{3,4,6,8} It is also noteworthy that there seems no need for more monitors, information and alarms, but smarter systems, capable of correlating the various vital parameters.³ The complexity of managing alarms explains why, despite the large amount of available devices, still occurring adverse events related to them.

From the guiding question "what is already known about the alarm fatigue?" we traced the aim of this study: conduct a survey in the literature of publications on alarm fatigue, since this issue is still little known in Brazil. With that, it will be possible to contribute data capable of supporting measures to reduce the problems related to the excessive number of alarms and their low clinical relevance, pointing out ways to minimize the phenomenon "alarm fatigue" in intensive care.

For this purpose, we opted for performing an integrative review, since this method allows including theoretical and empirical literature, as well as studies with different methodological approaches.⁹ This method has an important role in evidence-based practice, as it allows a synthesis of knowledge and the incorporation of the applicability of significant study outcomes in practice.¹⁰

METHOD

It is an integrative literature review study. The general purpose of a literature review is to gather knowledge about a topic, helping with foundations of a meaningful study for Nursing.¹⁰ The first step consisted in formulating the research question: what has been published in online journals in the last ten years about alarm fatigue? Before this questioning, we set out for the second step whose purpose was to select publications that have constituted the sample.

The data survey was conducted in April 2012 in the following databases: Latin American and Caribbean Health Sciences (LILACS) and Medical Literature Analysis and

Retrieval System (MEDLINE). We used to search the combination of the descriptors "Clinical alarms" and "Fatigue". Inclusion criteria were: articles published in full version in English or Portuguese, related to the theme, which have been indexed in the last ten years and that were available through the portal of scientific journals of the Brazilian Coordination for the Improvement of Higher Education Personnel - *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES).

In the third stage, data were extracted from articles using a tool including: identification of the article, objective, publication type, theme and results. The use of this type of tool has like purpose to ensure that the entirety of the data is extracted, minimize transcription errors, ensure accuracy in checking the information and serve as a registration.¹⁰

The fourth step consisted in the organization of the articles in chronological order and drawing up tables with summary of each article.

Next, went up to the step of discussion of the results, comparing publications with each other and with the theoretical knowledge,

allowing us to identify possible gaps in knowledge and possibilities for future studies.¹⁰

RESULTS

The search for descriptors has generated 11 articles, but, three were excluded because they were not available in the CAPES Portal. The final sample was comprised of eight scientific articles. All were available in MEDLINE and were in English. Four were published in 2011 and four in 2010.

Of the eight articles, seven were published in the United States, being six in journals classified as thematic area of the Health Sciences and one was not classified. One article was published in Germany, with the thematic area with regard to Biomedical Engineering. Figure 1 presents the selected articles in chronological order, the classification of the publication type (according to the classification of the VHL-Virtual Health Library) and the general objective:

Article title	Authors	Scientific journal	Publication type /objective
Monitor alarm fatigue: standardizing use of physiological monitors and decreasing nuisance alarms. ⁴	Graham KC; Cvach M	Am J Crit Care 2010 Jan;19(1):28-34	Journal article: reports a task force to quantify the frequency of cardiac alarms and testing changes to reduce them.
Monitor alarm fatigue. ¹¹	Bell L	Am J Crit Care 2010 Jan;19(1):38	Journal article: published as a supplement to the article of Graham and Cvach 2010. ⁴
Alarm fatigue sets off bells. Mass. incident highlights need for protocols check. ¹²	McKinney M	Mod Healthc 2010 Apr;40(15):14	News: presents an account of a death in Massachusetts related to arrhythmia alarm and the solutions taken after notification.
Alarm fatigue linked to patient's death. Interview by Laura Wallis. ¹³	Bell L	Am J Nurs 2010 July;110(7):16	Interview: report on the death at Massachusetts General Hospital and the solutions proposed by the Institution.
Alert fatigue leads to OR fatalities. ¹⁴		Healthcare Benchmarks Quall Improv 2011 Jan;18(1): 9-11	Journal article: presents through interviews reports of situations where alarms fatigue occur, such as during surgical procedures, execution of medications prescription and industry.
Do you hear bells? The increasing problem of alarm fatigue. ¹⁵	Harris RM; Manavizadeh J; McPherson DJ; Smith L	Pa Nurse 2011 Mar; 66(1):10-3	Journal article: literature review of alarm fatigue and experience report on the creation of a team to identify and propose strategies to reduce alarms.
Medical device alarms. ¹⁶	Borowski M; Görges M; Fried R; Such O; Wrede C; Imhoff M	Biomed Tech (Berl) 2011 Apr;56(2):73-83	Journal article, review: in the field of Biomedical Engineering, presents a summary the results presented in a workshop performed in Germany about clinical alarm system.
Alarming: Joint Commission, FDA set to tackle alert fatigue. ¹⁷	Kreimer S	Hosp Health Netw 2011 June; 85(6):18-9	News: points out overall solutions for reducing the number of alarms.

Figure 1. Identification of the articles, classification by publication type and objective

Therefore, it can be seen that four items were classified as journal articles^{4,11,14,15}; two as news^{12,17}; one as interview¹³ and one as journal article-review.¹⁶

Regarding the considerations of each publication, the Figure 2 presents a summary:

Article title	Considerations/thematic
Monitor alarm fatigue: standardizing use of physiological monitors and decreasing nuisance alarms.	Study in a unit with 15 beds has classified the alarms as related to the patient or the system. After team training on how to adjust the threshold of the monitors, there was reduction in the number of alarms.
Monitor alarm fatigue.	Provides a summary of possible solutions to reduce alarm fatigue. Indicates relevant researches and manuals
Alarm fatigue sets off bells. Mass. incident highlights need for protocols check.	The notification of the adverse event allowed the institution to review processes and serve as an example for others. It created a committee responsible for assessing which patients really need to be monitored and adjust threshold in a realistic way.
Alarm fatigue linked to patient's death. Interview by Laura Wallis.	Addresses the phases that the institution used to correct the problem with alarms that included training on the new equipment and calibration according to the need of each patient.
Alert fatigue leads to OR fatalities.	Report of a patient who was in a vegetative state for 11 years and passed away as a result of a surgical procedure, since the alarms had been switched off and the team did not realize that the mechanical ventilator was disconnected.
Do you hear bells? The increasing problem of alarm fatigue.	Creation of a multidisciplinary team to study and reduce the number of heart alarms.
Medical device alarms.	Literature review about the various aspects of clinical alarms, such as: clinical relevance, classifications, time of response, adjustment of threshold, possibilities to reduce excess alarms and suggestions for further studies.
Quality & safety. Alarming: Joint Commission, FDA set to tackle alert fatigue.	Highlights that alarm fatigue was considered by ECRI as the 2 nd in the ranking of risk in 2011, losing only to the administration and dosage of radiation. Points out to the importance of creating a multidisciplinary team and suggests strategies to reduce the number of alarms.

Figure 2. Considerations and thematic of the publications

All publications show a similar definition of what would be alarms fatigue: a phenomenon related to excessive number of alarms that causes a desensitization of the team, which ends up ignoring them, jeopardizing the patient safety.

Only one publication⁴ is an unprecedented study, which aimed to survey the most common alarms and conduct a training to reduce them. The measures proposed by the aforementioned study included individualization of alarms and staff training with regard to the equipment. They created a checklist for the training of new nurses and routines standardization, which generated a 43% reduction in alarms of the unit.

Related to this article, in the same journal a supplement has been published¹¹ summarizing the possible solutions to reduce the alarms fatigue. In addition to those necessities presented in the original study, the author highlights the need for a joint effort with the Department of Biomedical Engineering, in order to review the alarms related to the technical problems and define if the response time to alarms should be included in the monitoring protocol.

Two articles published in 2010^{12,13} reported a case of death in a hospital in Massachusetts that occurred after a CRA of 20 minutes that was not identified because the alarm was switched off. Both studies put the importance of the notification on this type of event so that processes can be reviewed and that the errors serve as an example for other institutions. After the incident, some measures were taken: disabling of the function "off" from alarms, standardization of

volume, creating a training program and a committee of good practices.

In 2011, two articles were published in journals dedicated to quality.^{14,17} The first one starts¹⁴ of a report of a patient who was in a vegetative state for 11 years and passed away as a result of a surgical procedure, because the alarms had been switched off and the team did not realize that the mechanical ventilator was disconnected. Besides the example of the problems that occur in the operating room, the article addresses other situations where alarms are often ignored, as in the use of medical prescription systems and in the industry. The article points out that the neglect of alarms eventually becomes a culture, exposing the patient to a progressive increase of risks. This behavior lasts for a long time, until an incident occurs.

The second article¹⁷ reports on the efforts of the Joint Commission and FDA (Food and Drug Administration) to create strategies to reduce the alarms fatigue. Using as anchor interviews with various experts, the author states that each hospital has its vulnerabilities, should appoint multidisciplinary teams to review events related to alarms and observe the responses of professionals to those devices. Some hospitals have already tested the use of integrated systems where alarms of several equipments are filtered and, after it, are communicated to staff. It is also possible to program a delay from five to ten seconds, in cases in which the alarm sounds on conditions which generally are quickly resolved, such as a change in respiratory rate due to coughing of the patient. The article is concluded by

asserting the importance of standardizing the alarm tones according to the type of equipment and level of urgency.

In 2011, a study published in Pennsylvania¹⁵ also aimed to identify the most common alarms and propose strategies to reduce the phenomenon of alarms fatigue. The article does not present the methodology used for the survey, only states that were observed several alarms that have not been adequately met and many were considered repetitive alarms and, therefore, they were not attended by nurses. From this identified situation, the institution created a pocket guide on the functions of the monitors; began to send messages via Pager alerting staff if a high-priority was not answered in two minutes and also began to perform a daily monitoring of the team, answering questions and adjusting threshold individually.

The only publication found in the field of Biomedical Engineering¹⁶ provides a summary of the topics discussed in a workshop performed in 2009 in Germany. This is a comprehensive review of literature covering topics such as clinical relevance of alarms, adequacy in adjustments of the threshold, problems of excessive number of alarms, response time to alarms, standardization of monitoring systems and the importance of the nursing staff to be well trained. Some solutions to reduce the number of false alarms are cited: delayed activation of certain alarms, creating a "pre-alarm" system (when it is possible to predict a changing) and use of smart alarms with systems capable to compare the several vital parameters before generating an alert.

The authors argue that the large number of false alarms is related to the low specificity of the systems, especially when it comes to the patient movements. Furthermore, it is known that an improvement in monitoring systems and consequent increase in their specificity would cause a loss in sensitivity, but, this could be compensated by the reduction of false alarms. Finally, possibilities for future studies are discussed, which range from the definition of threshold for each patient to the technical improvement of the set of equipment.

DISCUSSION

Six papers^{4,11-3,15-6} believe that the proper adjustment of the alarm threshold, that is to say, in an individual form for each patient and that are within a range where usually interventions are generated by the team, is

one of the strategies to reduce the false alarms.

Five publications^{4,11,15-7} point out to the importance of knowing the incidence of alarms in the units. One article published in 2010⁴ found 942 alarms per day (a critical alarm for every 92 seconds) and the most frequent were related to the heart rate, followed by oxygen saturation. The review published in 2011¹⁶ presents several studies on excess alarms without clinical relevance, correlating them with the response time and the phenomenon of alarms fatigue. In the same year, a study¹⁵ reported about a task force that identified a large number of alarms that have been ignored, but does not present the used methodology or values. The other two publications^{11,17} only cite the relevance of each unit knowing the incidence of alarms, not bringing new researches on the matter.

The constant development of hard technologies into the daily work of Nursing requires from the healthcare professionals a constant upgrade process, aiming to follow-up the technological advances.¹ Accordingly, five publications point out to the importance of staff training in reducing the number of alarms. You can subdivide this training into three strategies: the correct choice of limits selected for the patient at the monitor,^{4,11-13} the technical knowledge of the set of equipment^{4,11-13} and ongoing education with monitoring team.¹⁵ Therefore, most of the publications indicate the guidance and the training of the staff as simple and efficient solutions to minimize the problem of alarm fatigue.

The news published in 2010¹² highlights that the flaws related to alarms should be reported as adverse events so that processes can be reviewed and serve as an example for other institutions.

CONCLUSION

The alarms fatigue showed up to be a very current topic, because although the search has included publications from the last ten years, all of them had been published, at most, two years ago. In Brazil, however, we found no studies on the phenomenon, revealing that this issue is still little known and studied in our country. Moreover, only one of the selected articles is a research paper, therefore, there is a great need for further surveys about the phenomenon of alarm fatigue.

This gap in knowledge can be related to the greater number of studies focused on adverse events related to the healthcare

professionals, rather than related to the use of technologies / electro-medical equipment and their consequences, among which, the alarms fatigue. In this context, we can consider that the nursing team constitutes the last barrier of protection against the occurrence of errors and adverse events, which is why we should increasingly discuss and investigate the theme.

All publications have the alarms fatigue as central topic, bringing similar definitions for this process. Nevertheless, this terminology is not yet considered a key word in MESH (Medical Subject Headings), which may have reduced the number of accessed articles.

Most of work shows some solutions to reduce the excessive number of alarms and, consequently, the alarm fatigue, such as: proper and individualized adjustment of threshold and the staff training. It seems there is still a need to better understand the types of alarms of each unit, incidence, response time and their clinical relevance.

The use of the integrative review as method was suitable, since it allowed us to gather publications with different approaches and identify gaps in knowledge.

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