ABSTRACT

Objective: to identify the electro-medical equipment that generates the higher number of sound signals of alarms. Method: descriptive-observational study with quantitative approach, case study type, with convenience sampling and non-probability, held in 2012, in an Intensive Care Center (ICU) in Rio de Janeiro/RJ, Brazil. The data were collected after the project approval by the Research Ethics Committee, Protocol No. 46898, and then presented and analyzed with the assistance of tables and figures discussed in the light of the literature. Results: it was shown a high incidence of ICC alarms. The mechanical fan was the most that generated sound signals of alarms, followed by non-invasive pressure. Conclusion: the alarm fatigue is evident in the study scenario and can be explained by the lack of sensitivity of professionals in relation to sound alarms. Descritores: Clinical Alarms; Intensive Care; Health Staff; Nursing.

RESUMO

Objetivo: identificar os equipamentos eletromédicos que mais geram sinais sonoros de alarmes. Método: estudo descritivo-observacional com abordagem quantitativa, tipo estudo de caso, com amostragem de conveniência e não probabilística, realizado em 2012, em um Centro de Terapia Intensiva (CTI) no Rio de Janeiro/RJ, Brasil. Os dados foram coletados após a aprovação do projeto pelo Comitê de Ética em Pesquisa, Protocolo nº 46898, e, em seguida, apresentados e analisados com auxílio de tabelas e figuras, discutidas à luz da literatura. Resultados: foi evidenciada uma elevada incidência de alarmes CTI. O ventilador mecânico foi o que mais gerou sinais sonoros de alarmes, seguido pela pressão não invasiva. Conclusão: a fadiga de alarmes é evidente no cenário do estudo, podendo ser explicada pela falta de sensibilidade dos profissionais em relação aos alarmes sonoros. Descritores: Alarmes Clínicos; Terapia Intensiva; Pessoal de Saúde; Enfermagem.

RESUMEN

Objetivo: identificar los equipamientos electro-médicos que generan un mayor número de señales sonoras de alarmas. Método: estudio descriptivo y de observación con enfoque cuantitativo, tipo estudio de caso, con muestras de conveniencia y no probabilística, realizado en 2012, en un Centro de Terapia Intensiva (CTI) en Río de Janeiro/RJ, Brasil. Los datos fueron recogidos después de la aprobación del proyecto por la Comisión de ética en Investigación, Protocolo nº 46898, y enseguida presentaron y analizaron con la auxilio de tablas y figuras, discutidas a la luz de la literatura. Resultados: se demostró una alta incidencia de alarmas CTI. El ventilador mecánico fue el que mas generó señales sonoras de alarmas, seguidos por la presión no invasiva. Conclusión: la fatiga de alarmas es evidente en el escenario del estudio, y puede explicarse por la falta de sensibilidad de los profesionales en relación a las alarmas sonoras. Descriptores: Alarmas Clínicas; Terapia Intensiva; Personal de Salud; Enfermería.
INTRODUCTION

Is the use of alarms a really good deal in intensive care? This is an issue that, although it may seem inappropriate, it has been made among the health professionals concerned with patient safety on the use of electro-medical equipment. Such equipment has as basic premise, to continually monitor different physiological variables or give life support, alerting the health team, through sound and light alarms systems if a problem occurs.1,2

The alarms are resources that equip massively all electro-medical equipment, constituting one of the main features founded by the industry to alert health professionals to the deviations from a predetermined state of normality, denoting supposedly the improved patient safety. However, this false sense of security could contribute to the fatigue phenomenon of alarms, that manifests itself when a large number of alarms is overloading the team, contributing to a true life-threatening event to get lost in a cacophony of noises of competing alarms, which in vain, try to get someone’s attention without proper clarity of why and what is supposed to do. As effect, inconsistent alarms fail to alert or provide reliable information, contributing negatively in stimulus-response time delay of professional and, consequently, committing the actions to be taken by the team.1, 2

Studies are showing evidence that the high number of alarms clinically irrelevant or false alarms lead professionals to reduced alertness, which may result in the delay of time or lack of response to relevant or true alarms, fatigue alarms, thereby committing patient safety in intensive care.1

In a university hospital, we conducted a study in an ICU of 12 beds, which demonstrated a high rate of false alarms of current cardiovascular monitoring systems, on the basis of these systems that have high sensitivity and low specificity.1 In another study, 5,934 alarms were noted during 982 hours of observation, corresponding to six alarms per hour. Approximately 40% of all alarms did not describe correctly the patient’s condition and have been classified by researchers as technically false. Only 885 (15%) of all the alarms were considered clinically relevant.2 There is evidence that the high sensitivity and low specificity of alarms are competing for alarm fatigue.2

In a study conducted in an ICU of 12 beds in a university hospital, where patients undergoing monitoring heart rate, invasive medium arterial pressure and oxygen saturation were included in the sample, numerical data, physiological, alarms of monitors and limit alarms were extracted to a surveillance network through recordings made on the edge of the bed with a video camera. The data were evaluated by an experienced doctor and the alarms were categorized according to their technical validity and clinical relevance. A total of 3,682 alarms were recorded: 2,512, corresponding to 68.2%, were limit alarms, 535 (14.5%) dangerous alarms, 535 (14.5%) technical alarms and 100 (2.7%) alarms of arrhythmia. Of the total number of alarms, 54.5% were judged technically true and 43.6% technically false; 1.9% could not be judged.3

Of the vital parameters, systolic blood pressure (invasive), with 45.4 percent, was the most generated alarm signals, followed by saturation of O₂, with 29.5% of alarms. A high percentage of 44.2% was caused by team handling. Only 16.6% of all alarms were judged as relevant, while 46.5% were judged as not relevant.3

There is concern with the excessive number of alarms that sound in the intensive care units and with the negative impact of fatigue of alarms on patient safety of the monitor, and this fact impulsed the development of a master's thesis, whose object has to do with the stimulus-response time assessment of health professionals, in intensive care, to the alarms of mechanical ventilators.

Understanding the need to meet the profile of alarms sounding inside the intensive care units, used as a setting for the production of research data of the dissertation of master degree in nursing, an observational descriptive study was performed, with 32 hours of observation and recording of alarms, which allowed to characterize the profile of alarms that sound in that unit. Therefore, this study has electro-medical equipment alarms as an object of study, and aims to:

- To identify the electro-medical equipment that generates the higher number of sound signals of alarms.

METHOD

Article drawn from the Dissertation << Stimulus-response time in predisposition to fatigue of mechanical ventilators alarms: implications for patient safety >>, presented in 4/17/2013, by the 1st author of this article, to the Postgraduate Program of the School of Nursing Alfredo Pinto, of the Federal University of the State of Rio de Janeiro EEAP/UNIRIO, Rio de Janeiro/RJ, Brazil.
This is a descriptive-observational study with quantitative approach, case study type, with convenience sampling and non-probability. The data production started from the free observation, in an Intensive Care Center, from August to October 2012, in a large state public hospital of health network, with a capacity of 24 beds, located in the city of Rio de Janeiro, being the main pathologies and diseases that affect patients assisted in this unit: the lung infections, trauma, metabolic syndromes unbalanced, among others.

The multidisciplinary health team consists of nurses, doctors, physiotherapists and assistants and nursing technicians, who alternate in the unit as day-workers and on duty, distributed as follows: day-workers – daytime service (12 hours) - a nurse responsible technician, two nurses, three doctors, two nursing technicians, three physiotherapists; on duty (12 hours) five nurses (Monday-Friday), four nurses (Saturday and Sunday), eight nursing technicians (Monday-Friday), seven nursing technicians (Saturday and Sunday), two doctors (Monday-Monday), three physiotherapists (Monday to Saturday), two physiotherapists (Sunday). Also integrate the multidisciplinary team, nutritionists, audiologists, psychologists and social workers who act upon request of opinion.

It should take into consideration that the nurse who works in intensive care spends a peculiar time in every activity that competes and the relationship time X quantitative of professionals must be respected in order to have a secure care, which can become difficult, if we take into consideration the RDC 26, which establishes the minimum criteria for the operation of an intensive care unit. The RDC guides that, in the intensive care, there should have a nurse for every 10 beds and a nursing technician for every two beds. The severity of patients increases the hours of nursing intended for their care, which in turn entails consequences that interfere in the care, raise costs and health risks of the customers and workers.4

The adjustment of human resources to supply the demands of nursing work and the tasks assigned to them should consider the activities that must be performed, the complexity and the need for specific technical qualification, the dependency of nursing of the customers, the needed technology, the technical resources and materials available and, also, the characteristics of technical, scientific and personal order of workers that compose the staff.5

The adoption of a System of Classification of Patients (SCP) in ICU extends the knowledge about the served clients, their real needs, as well as the development of skills and competences of professionals to ensure the assistance and the management of a safer mode, innovative, autonomous and participatory.6

The COFEN Resolution n° 293/2004 orients the realization of the dimensioning of nursing staff in accordance with a SCP. Each patient will have a classification of care and an insurance assistance time of nursing care, necessary in 24 hours, according to their classification. After acquiring all the information relating to the classification, it is possible to determine the number of working hours in the nursing unit and, consequently, the minimum number of nursing professionals to meet the demand. The resolution directs that, in an ICU, there is a percentage of 52% to 56% of nurses on the nursing workers in total.7

It have to be consider the Regulation of Law of the Nursing Exercise, where it is reportedly privately to nurse the realization of direct nursing care to patients with life-threatening, as well as nursing care of greater technical complexity which require appropriate scientific knowledge and ability to make immediate decisions.8

It is believed that it is possible to develop health care through the minimum criteria established by the RDC 26, however the chance of physical and psychological wear of professionals and care become insecure to patient is too large. However, according to the laws in vigor, stresses the importance of a readjustment in the number of professionals of the nursing staff in ICU, in order to offer the patient a greater security assistance, stressing that for such a change is required the collaboration and investment not only of the managers of the institution, but the state government agency responsible.

The data were produced after approval by the Ethics and Research Committee of the UNIRIO, in June 28, 2012 (Protocol number 46889). The alarms were timed and recorded during 32 hours of observation in the Intensive Care Unit, being 16 hours in the daytime service and other 16 in the evening service. For the record, were considered the multi-parameter monitor alarms, infusion pump and the mechanical ventilator, in addition to the timing of the time when each alarm remained sounding until some professional answer. However, for observation, were selected six of the 24 beds.

For the timing of the response time, we used a digital stopwatch, which was fired...
immediately after the sounding of an alarm and paused immediately after the answer of any professional team, with a view to resolving the problem which resulted in alarm. The alarms that have not been answered within ten minutes were considered unresponsive and thus, fatigued.

The selection and registration of the alarms were given by non-probability sampling of erratic type. Thus, it was not guaranteed that each sampling unit in the universe of alarms that sounded in an instant of time in the researched scenario had a known probability and nonzero to belong to the sample. In this study, it was considered as sampling unit the smallest possible number of alarms from monitoring equipment in an ICU that was identified as a unit that can be sampled, among which there were alarms of pulse oximetry, ECG, non-invasive blood pressure (NIBP), Mean Arterial pressure (MAP), auxiliary temperature (AXT), respiratory rate (RR) and central venous pressure (CVP), infusion pump and mechanical ventilator.

When using the non-probability sampling of erratic type, it was considered, for the purposes of inclusion, an alarm at a time. Thus, alarms raised while another recorded previously raised were not registered and therefore not included in the study.

RESULTS AND DISCUSSION

The data generated were treated statistically, with views to the simple frequency analysis, and organized into figures, presented below.

According to figure 1, it can be seen that the incidence of alarms from the electro-medical equipment in the ICU is high. From these data, if it is carried out the calculation of how many alarms sounding in the ICU per hour, would result in seven alarms/h, whereas the six beds surveyed, but, considering the 24-bed in the unit, would result in 28 alarms/h. Notwithstanding, if it takes into consideration what says the RDC 26, nursing professionals, in addition to make many assignments, would have to meet and resolve at least two alarms each, considering a number of 12 nursing technicians and three nurses, as guides to RDC, 26 having greater chance of being affected with the fatigue of alarms. Although, in the ICU environment, there is the multidisciplinary team for, among other functions, help meet the alarms, the nurses and nursing technicians are in number, most within the ICU and are a greater time to the patient’s bedside, passing these professionals to have more opportunities to meet the alarms with relation to other professionals.

It is worth pointing out that the incidence of electro-medical equipment alarms can be underestimated, by the fact that the main goal in the record of the alarms was to describe the time stimulus response by these professional alarms, where had the concern not to show how many alarms rang an hour and the time at which the alarm was sounding, according to the methodology presented already. However, at this time, it was appropriate to show the incidence of alarms in general, even being underestimated, in order to focus on how the alarms predominate in ICU environment.

In the world, the incidence of false alarms is high, relating to electro-medical equipment in ICU, which is the main factor of the generator alarm fatigue in health professionals who act in this kind of environment. In fact, what is seen through the scientific evidence is that the alarm has lost its function to draw attention and flag to health care professional any relevant changes from the patient or equipment malfunction. The real alarm function at the present is to cause stress and fatigue due to the lack of awareness of the professional who already has in mind that most alarms are false.

The awareness on the part of all the professionals, that are related and/or involved with the process of care to the patient who uses electro-medical equipment, should be aroused in the interests of patient safety. The alarms of the electro-medical equipment, by causing worldwide alarm fatigue in health professionals, entered, once again in 2012, as first place in the dangers related to technology in the environment of care to the patient.
To determine if the alarm was fatigued or not, it was necessary that this stay alarming for more than ten minutes without any health professional is the answer. If you compare Figure 1 with 2, it can be observed that no VM alarm was fatigued, that’s because most of the shots of the VM had short duration, some up to 4s. It was noticeable, in the researched environment, that the VM’s sound draws more attention and that health professionals demonstrate greater attention to this alarm if compare to others. Although these alarms are not fatigued, because of the large number, compete significantly to fatigue of other alarms. Still comparing figure 1 with 2, showed that all the alarms of the ECG, SPO2, NIBP, MAP, AXI, CVP and RR were fatigued. This finding is worrying with regard to patient safety.

As cited, most of the identified alarms was false, but some were found with clinical relevance. From this moment, it can be said that the alarm fatigue is present on the stage of the study, a phenomenon characterized due to most the evidenced alarms are sounding for a while at least ten minutes without any professional’s response to its signal.

For the resolution of problems related to fatigue phenomenon of alarms in the ICU, health workers must be properly trained and committed, and the number of employees should be suitable. The lack of training has as a consequence the misuse of technology by the team and can justify the high incidence of false alarms, being the professional unprepared for handling the electro-medical equipment, generating difficulties in setting of various functions of these devices.

To be effective, the clinical alarm should be triggered by a problem that negatively affects the patient and the team must identify the origin and meaning of the alarm, correcting the problem before an adverse event happens to the patient.

In 1974, the ECRI Institute already had publications in scientific journals related to the subject. Although studies related to problems with clinical alarms exist since the advent of monitoring and the use of health care devices, today this problem is influencing greatly on patient safety.

People have difficulty in learning more than six different alarm signals. A patient in ICU environment will often have more than six different alarm sounds associated with their care, as well as the sound will have different meanings when coming from different devices. One study showed that experienced care providers couldn’t identify even half of the common alarms raised in ICU when played.

The perceived urgency of some sound alarms can be inconsistent with the patient’s clinical condition. This happens when the parameters of the equipment are not properly adjusted.

A study published in 2006 in the American Journal of Emergency Medicine showed that 99.4% of ECG alarms were false. In the USA, the main strategy used to reduce problems with clinical alarms was the implementation of the management of alarms in the ICU. Ideally, is that the ICU has a team responsible only for managing alarms, but this should not exempt the caregivers to participate in such management. Despite all these positives...
points, the Americans are still experiencing problems with alarms.\textsuperscript{12 - 14}

According to the data presented in Figure 2, we can come to the conclusion that the alarms present in the ICU searched are not handled safely. From the moment that a health professional takes longer than ten minutes to answer an alarm or simply not answering promptly, this could at some point, fail to meet an alarm of clinical relevance. The professional is not touched in answer the alarm due to numerous factors, including the presence of numerous alarms without clinical significance, as noted in this study, contributes a lot to the fatigue of alarms. It is worth pointing out that in this study was considered ready-response as being the attendance and efficaciousness of the professional alarm added to act to silence it.

Also observed during the data collection that, sometimes, the professionals met and solved what the sound of certain relevant alarms signaled, managing, for example, an antihypertensive medical discretion to normalize a hypertension, according to the alarms in the NIBP and MAP multi-parameter, however, they do not silence the alarm of the equipment. It is important to highlight that if the parameters of the patient, either by reason or not clinical, are not in accordance with the limits established by the professional who set up the equipment, their alarms, if they are not turned off, will only silence if the professional enable this function or if the parameters of the patient return to the limit of the parameters configured. It was considered the act of not silencing an alarm as unsafe, because it predisposes even more alarm fatigue, by the fact that an alarm be sounding unnecessarily, whereas the amendment signaled by the alarm is already being solved by somebody.

The results of this study indicate that alarm fatigue is a reality within the intensive care unit investigated, which can be detected by the high number of alarms fatigued, especially, non-invasive blood pressure (NIBP), O\textsubscript{2} saturation and ECG. Although the alarms of the fans hadn’t fatigued during the 32 hours of observation, there was a significant number of alarm signals generated by this electro-medical equipment, which competes, particularly, to alarm fatigue.

An explanation for the fact of not having been registered any alarms fatigued mechanical fan is related to the fact that such equipment generate alarm signals that remain sounding only while are kept changing the physiologic variable changed, unlike the other equipment, whose alarms, once changed the physiological variable monitored, will remain sounding until the professional come to serve them.

Furthermore, it drew attention the high number of NIBP alarms logged and fatigued. NIBP monitoring requires that health care professionals who work in intensive care are very familiar with the equipment for this purpose, especially with regard to their configuration. In this sense, it has to be emphasize that many of such equipment when connected, automatically enable this feature of monitoring (NIBP), even if this variable is

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.jpg}
\caption{Fatigued alarms or unresponsive. Rio de Janeiro (RJ). Brazil, 2013.}
\end{figure}

\section*{FINAL REMARKS}

The results of this study indicate that alarm fatigue is a reality within the intensive care unit investigated, which can be detected by the high number of alarms fatigued, especially, non-invasive blood pressure (NIBP), O\textsubscript{2} saturation and ECG. Although the alarms of the fans hadn’t fatigued during the 32 hours of observation, there was a significant number of alarm signals generated by this electro-medical equipment, which competes, particularly, to alarm fatigue.

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not in the interest of the professional. So, they do not put in those patients the cuff that will make automatic gauging of arterial pressure at preset intervals. That's exactly what happened during the observation period, when many patients monitored had enabled the NIBP feature on multi-parametric monitor, but physically this feature wasn't being used for the sick.

From the perspective of solving the problem of alarm fatigue, it is necessary the training of health professionals, as for electro-medical equipment used in the unit, its operation, configuration, application and troubleshooting. It has to be highlighted also, the important role of the risk management team on minimizing fatigue of alarms.

In addition, it is necessary to conduct new research alarm fatigue-themed and focus for the settings of the parameters from the electro-medical equipment alarms, configured by the health care professional, with the motivation that the alarm fatigue can occur when one takes into account that possibly the alarms of clinical relevance in the ICU are being undetectable due to its bad fit by the team, compromising patient safety and increasing risks of adverse events.

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