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REVIEW

Technologies in intensive care: causes of adverse events and implications to nursing

Tecnologias na terapia intensiva: causas dos eventos adversos e implicações para a Enfermagem

Tecnologías en terapia intensiva: causas de eventos adversos e implicaciones para la Enfermería

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ABSTRACT

Objective: to identify the causes of adverse events affecting clients resulting from the use of equipment in intensive care services; to point out the main recommendations for clinical practice to minimize these events and, then, discuss the implications to nursing care. **Method:** integrative and descriptive review on the SciELO, Medline, LILACS, and PubMed databases. Articles were selected based on the inclusion criteria and the structured instrument was applied. **Results:** altogether, 11 articles were selected where three evidence units were outstanding: Equipment failure; inadequate use of equipment; and team failure. Permanent education of professionals; evaluation of production and availability of equipment; and use of checklists are recommended. **Conclusion:** preventing adverse events related to equipment is one of the nursing responsibilities and requires the establishment of defensive barriers to prevent these.

Descriptors: Biomedical Technology; Intensive Care Units; Nursing; Patient Safety; Nursing Care.

RESUMO

Objetivo: identificar as causas de eventos adversos no cliente relacionados aos equipamentos presentes no cenário de terapia intensiva; indicar as principais recomendações à prática clínica para minimizar tais eventos e, então, discutir as implicações na assistência de enfermagem. **Método:** revisão integrativa, descritiva, realizada nas bases SciELO, Medline, Lilacs e Pubmed. Para seleção dos artigos, foram adotados critérios de inclusão e aplicado instrumento estruturado. **Resultados:** captou-se um total de 11 artigos, nos quais sobressaem três unidades de evidência: falha do equipamento, uso inapropriado do equipamento e falha da equipe. Recomendam-se: educação permanente dos profissionais; avaliação da produção e disponibilidade dos equipamentos; e uso de *checklists*. **Conclusão:** a prevenção de eventos adversos com equipamentos é uma das responsabilidades da enfermagem e, nesse sentido, é relevante a criação de barreiras defensivas para evitá-los.

Descritores: Tecnologia Biomédica; Unidades de Terapia Intensiva; Enfermagem; Segurança do Paciente; Cuidados de Enfermagem.

RESUMEN

Objetivo: identificar las causas de eventos adversos del usuario, relacionados con los equipamientos presentes en el ámbito de terapia intensiva; indicar las principales recomendaciones a la práctica clínica para minimizarlos; y discutir consecuentemente las implicaciones en la atención de enfermería. **Método**: revisión integrativa, descriptiva, realizada en bases de datos SciELO, Medline, Lilacs y Pubmed. Artículos seleccionados por criterios de inclusión adoptados, aplicándose instrumento estructurado. **Resultados**: Se obtuvieron en total 11 artículos, sobresaliendo tres unidades de evidencia: falla de equipamientos, uso inapropiado del equipamiento y falla del grupo. Se recomendó: educación permanente de profesionales; evaluación de producción y disponibilidad de equipamientos; y uso de *check-list*. **Conclusión**: la prevención de eventos adversos por equipamientos es responsabilidad de la enfermería; en tal sentido, es importante la consideración de criterios para evitarlos.

Descriptores: Tecnología Biomédica; Unidades de Cuidados Intensivos; Enfermería; Seguridad del Paciente; Atención de Enfermería.

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INTRODUCTION

Today, healthcare errors, notably technology-related mistakes in intensive care units (ICUs), are a concern for the safety of patients. The goal is to reduce the risks of healthcare associated damage to an acceptable level. Damage, in turn, is understood as the compromise of the body structure or function and/or any resulting defect, including illness, lesion, suffering, disability, dysfunction, or death. Therefore, it can be physical, social, or psychological[1].

It is worth mentioning that when a circumstance that could result or does result in unnecessary damage to the patient occurs it is called an incident. Incidents that cause damage are defined as adverse events (AE)[1]. Data from the Institute of Medicine of the United States point out that healthcare errors cause from 44,000 to 98,000 of the deaths/year in North-American hospitals[2].

Because the results of investigations in Brazil are still limited to research hospitals, there are no data on the incidence of adverse events at the national level[3]. However, it is known that AEs affect, on average, 10% of patients admitted to hospitals, making them a challenge to the improvement of health quality[4].

It is common sense that patients hospitalized in intensive care units are more vulnerable to adverse events because of their clinical characteristics. This is supported by international evidence that signals the prevalence of these events among these clients. One of these studies monitored ICU physicians and nurses for one year, and found 390 incidents related to equipment, medications, or technical and administrative procedures where human error was the main cause[5].

Analysis of the characteristics of the events described in the studies places equipment as an important source of situations that compromise patient safety, challenging the impact of incorporating technologies into healthcare[5-6].

In this regard, the scientific production shows studies that evaluate the incorporation of technologies into health in terms of effectiveness, usefulness, benefits, and efficiency to assist managerial decisions about incorporating these or not into healthcare services[7]. Researchers also show the effects that incorporating technologies have on the work of professionals, notably nursing professionals, in high-complexity care[8].

Here, interests are focused on advocating for technological care in the ICUs, demanding proper knowledge from professionals to handle machines and interpret the information generated, in order to guide their care-related actions. A third line, in turn, is concerned about the challenges posed by the integration of new information technologies on behalf of humanized care[9].

Evidence shows a lack of clarity when technology is considered in the light of safety, mainly regarding knowledge about how and why incidents involving technology occur. Therefore, this kind of error is not yet well understood. In addition, definitions of the overall prevalence of technology-related errors and resulting damages remain scarce[10].

Despite that, some previous surveys show the magnitude of the equipment-related problem and suggest the need for new investigations, considering that previous reviews of critical incidents in intensive care have identified problems with equipment as an important cause of actual or potential risks to patients[11]. In a report published in 2002, the Food and Drug Administration (FDA) estimated that technology-associated errors account for hundreds and even thousands of deaths a year[12].

In Brazil, the Patient Safety Program (*Programa de Segurança do Paciente* or PNSP) ratifies this concern about safe use of equipment. The safe use of equipment is one of the PNSP's goals[3]. The program axes[3] foster the development of studies to subsidize the drafting of a protocol on the application of technologies; to contribute to raise awareness to discuss this issue in the field of education; and to understand how these kinds of adverse events takes place.

Considering the aforementioned, this study aimed to identify the causes of adverse events among clients resulting from the use of equipment in intensive care services; to point out the main recommendations for clinical practice to minimize these events; and, then, to discuss the implications to nursing care.

METHOD

This was an integrative review of a descriptive nature, part of an ongoing field research aimed to provide guidance to data production and to interventions. The survey showed the need for such guidance[13]. The following guiding questions were formulated for the review: How does the scientific literature characterize the causes of equipment-related adverse events in intensive care services? Which recommendations do these publications make for clinical practice to minimize these adverse events?

Firstly, articles were collected from the Virtual Health Library. Further, the following databases were accessed: Scientific Electronic Library Online (SciELO); Medical Literature Analysis and Retrieval System Online (Medline); and the Latin American and the Caribbean Center on Health Sciences Information (LILACS). Secondly, the search was deepened by directly accessing the National Library of Medicine (PubMed) online, from September 2013 to March 2014, using the following descriptors: intensive care unit; intensive care; critical care; safety of patient; iatrogenic disease; equipment failure; equipment safety; biomedical technology; associated with the operator AND.

Following were the inclusion criteria previously defined to select articles: publications in Portuguese, English and Spanish with full text available in the selected databases from 2004 to 2013, limited to the intensive care area, which allowed answering the research question and further establishment of links with nurses' work; and studies based on methodologies bringing strong evidence to understand the issue of this survey, according to the standardization adopted by the Agency for Healthcare Research and Quality of the United States. The selection process attached priority to articles ranked in levels 1–4. Level 1 was a meta-analysis of multiple controlled studies. Level 2 included studies with an experimental design. Level 3 included studies with a quasi-experimental design, such as a survey with no randomization with unique group pre- and post-tests, temporal series, or control-cases. Level 4 included studies with a non-experimental design, such as correlational descriptive and qualitative surveys or case studies[14].

After the previous analysis of compliance with the inclusion criteria and considering the exploratory reading (title and abstract),

21 articles were selected and further submitted to evaluation through an instrument designed to analyze to which extent the manuscript could contribute to understand the issue in question.

The tool approached the overall features of the study, methodological line, recommendations, and level of evidence. The evaluation process was performed by two independent reviewers, researchers from a group seasoned in studying this issue. Disagreements between reviewers were jointly decided, leading to a final sample of 11 articles, of which eight were in English and three in Portuguese.

Based on the information gathered through the instrument, a synoptic picture was assembled to enable the analysis of articles and further capture of evidence. The analysis was based on the content of the articles and the confluence of topics that were further organized.

RESULTS

According to the characterization of the studies selected for the review, the production of this topic is distributed as follows: regarding the publication year, half were dated between 2004 and 2008, and the other half were dated from 2009 to 2013. Regarding origin, they were mainly from the USA (36%), Brazil (27%), and Australia (18%). Regarding the methodological design, all surveys were of a quantitative and non-experimental nature.

The content analysis of the studies presented in Box 1 gave rise to three units that depict the evidence found, which served as the basis to outline the respective recommendations proposed. These are: equipment failure; inadequate use of equipment; and team failure.

Box 1 - Summary of studies included in the review

Country/year Title	Outlining	Objective	Results	Recommendations
USA/2013 The application of intermittent pneumatic compression devices for thromboprophylaxis: an observational study found frequent errors in application of these mechanical devices in intensive care units.	Observational/ Prospective. Total # of patients = 108	Observe the frequency of adverse events and describe the team's adherence to the prescription of mechanical thromboprophylaxis using intermittent pneumatic compression devices	Improper use of equipment	- To seek new evidence on the use of mechanical thromboprophylaxis - To raise awareness of the proper use of the compression device - To study the consequences of errors
USA/2010 Discrepancies between medication orders and infusion pump programming in a pediatric intensive care unit	Observational/ Prospective. Total # of beds = 30	Measure the discrepancies between medication orders for infusions and the medication being infused, evaluating the adjustments scheduled to the infusion pump in a pediatric intensive care unit	Improper use of equipment	- Coordination between health professionals and technology designers to provide intensive training in understanding how equipment works
France/2010 Adverse events with medical devices in anesthesia and intensive care unit patients recorded in the French safety database in 2005-2006	Quantitative/ Retrospective. Total # of notifications = 4,188	Define whether the quantity, seriousness, and causes of incidents with medical devices in anesthesia and critical care have changed over time (1998-2005)	- Equipment failure - Improper use of equipment	- Educational improvement among health professionals regarding safe use of medical devices - Elaboration of checklists - Dissemination of didactic reports in journals
Brazil/2009 *Transporte intra-hospitalar de pacientes sob ventilação invasiva: repercussões cardiorrespiratórias e eventos adversos*	Observational/ Prospective, non-randomized. Total # of transfers = 58	Check cardio-respiratory changes among patients transferred to diagnosis units or between sectors, and identify adverse events taking place during intra-hospital transfer	- Team failure - Equipment failure	- Transfer made by skilled professionals, preferably specialized in intensive care - Use of equipment to monitor vital signs and complications during transfer
Brazil/2009 *Eventos adversos na assistência de enfermagem em uma unidade de terapia intensiva*	Quantitative/ Cross-sectoral. Total # of events = 550	Identify nursing care adverse events in an intensive care unit	- Improper use of equipment - Team failure	- Survey of adverse events and analysis of causes - Permanent education for nursing professionals

To be continued

Box 1 (conclusão)

Country/year Title	Outlining	Objective	Results	Recommendations
United Kingdom/2008 Patient safety incidents associated with equipment in critical care: a review of reports to the UK National Patient Safety Agency	Quantitative/ Retrospective. Total # of incidents = 12,084	Identify and classify incidents associated with equipment use	- Equipment failure - Improper use of equipment	- Training the team to use new equipment - Proper technical assistance and maintenance - Check operational conditions before using the equipment - Planning for situations of power surges and peaks
USA/2007 Programmable infusion pumps in intensive care units: an analysis of corresponding adverse drug events	Quantitative/ Retrospective/ Documentary. Total # of patients = 4,604	Define the frequency of adverse events that could be prevented with intravenous medications in intensive care units to prevent errors when handling conventional and smart infusion pumps	- Equipment failure - Improper use of equipment	- Regular evaluation of infusion pumps to find potential manufacturing or handling errors - Raise awareness among the nursing team regarding the occurrence of device-related errors
Australia/2006 Adverse events experienced while transferring critically ill patients from the emergency department to the intensive care unit	Observational / Prospective jointly with retrospective audit. Total # of transfers = 290	Define the incidence and nature of adverse events during emergency transfer to the intensive care unit in a tertiary reference hospital	- Equipment failure	- Regular review of conduct as strategic to prevent the occurrence of errors through verification of equipment and goals during transfer between sectors
Austria/2006 Patient safety in intensive care: results from the multinational Sentinel Events Evaluation study	Observational/ Sectional. Total # of patients = 1,913	To access, at the multinational level, the prevalence and factors related to unintended events that compromise the safety of patients in intensive care units	- Equipment failure - Team failure	- Implementation of protocols for prevention and early detection of errors Improve safety related to equipment maintenance
Brazil/2006 *Ocorrências iatrogênicas em Unidade de Terapia Intensiva: análise dos fatores relacionados*	Quantitative/ Prospective. Total # of incidents = 113	Identify structural factors in the intensive care unit and conditions of patients regarding iatrogenic occurrences, checking the association between seriousness of these occurrences and related factors	- Equipment failure	- Nurses' education to prevent iatrogenic occurrences - Structural improvements in the intensive care unit - Monitoring of iatrogenic occurrences and studies about related factors
Australia/2004 Incidents relating to the intra-hospital transfer of critically ill patients. An analysis of the reports submitted to the Australian Incident Monitoring Study in Intensive Care	Quantitative/ Sectional. Total # of notifications = 176	During intra-hospital transfer of critically ill patients, identify incidents and establish the respective causes and contributing factors	- Team failure - Equipment failure - Improper use of equipment	- Provision of qualified labor force - Continued monitoring of these events - Permanent education to the team - Adoption of protocols and checklists for intra-hospital transfers.

Source: Produced by the researcher

DISCUSSION

As shown in the results analysis, the occurrence of adverse events related to equipment in ICUs is linked to three types of causes: inadequate use of equipment, when the professional mishandles it; equipment failure related to manufacturing problems that impact its functioning or proper use; and team failure involving behaviors that violate standardized practices for the proper use of equipment by professionals.

It is worth mentioning that today the analysis of errors in healthcare is supported by a systemic perspective according to which human beings are acknowledged as fallible. Based on this assumption, ensuring safety runs through the establishment of systems anticipates these failures, identifying them before they cause harm to patients. In this way, the focus is not on blaming the individual, but on analyzing underlying or latent conditions that enable the error[15]. In this proposal this perspective is the guiding axis to discuss the results.

Improper use of equipment

Finding evidence that the improper use of equipment implies the occurrence of adverse events to the client hospitalized in intensive care sectors highlights the influence of the human factor, and ratifies the findings of other investigations on the use of equipment in the field of patient safety[12,16].

A retrospective survey of adverse events associated with medical devices, including equipment, in the first half of 2010 in a Colombian surgery service, identified 29 adverse events: two classified as light; 17 as mild; four as serious; and six as potential AEs. The causes of 21 of these were analyzed and it was found that all potential adverse events could be prevented, while most of the remaining ones could also be prevented. In this way, the improper use of devices and equipment was considered to be the main cause of adverse events[16].

A literature review aimed at raising awareness among nurses regarding the improper handling of intensive care equipment identified the so-called "error of use of equipment" as the most typical typology to ICUs. The origin of this error could be related to the inadequate performance of the device[12].

The infusion pumps that the literature identifies as causing about 30% to 60% of all harmful damages with intravenous medication are some examples of these situations. Many of these errors happen during the stage of programming the infusion pumps, notably regarding the infusion velocity, which can cause the administration of an excessive dose and even overdose[12].

This corroborates the data from the included part of this review that found discrepancies between medication orders and pumping programming. In this way, many errors occur when using pumps to administer medicines, mainly with new technologies that demand more attention by professionals.

A conceptual review of errors in the field of health focusing on those related to medication has focused on the handling of infusion pumps to administer medications as one of the stages with the highest probability of failures and serious harm to patients. According to this study, these situations happen when the professional is not familiar with how the equipment works because there is no engineering technician to assist in handling the pump, or because the equipment manuals fail to provide full information to help solve problems in real situations[17].

In this context, the improper use of equipment should be thought of in the light of latent conditions that could favor improper handling such as, for example, training, and experience; problems with equipment; fatigue; and lack of attention. The international literature reports the relevance of these conditions to patient safety[18-19].

A study that aimed to investigate the links between sleep deprivation and errors among 289 female nurses working in the hospital night shift found that more than half of them suffered from sleep deprivation, and these professionals made more mistakes related to the care of patients. Results show the need for interventions to improve both the quality and the amount of sleep of nurses working the night shift in order to reduce errors[18].

A survey analyzed the association between the nursing team's lack of experience and the occurrence of adverse events in an intensive care unit and identified 1,472 incidents related to medications, airways, equipment, and procedures that evidenced the negative effect of inexperience on health-care quality[19]**.** These results are ratified by the national review on adverse events in nursing care to hospitalized adult patients, mostly related to: medicines administration; patient surveillance; cutaneous integrity; and equipment (material resources). Among the causes of these situations the study refers to overload; personnel dimensioning; lack of knowledge; professional inexperience; and unsuitable supervision[20].

In this way, the evidence of improper use of equipment attaches relevance to several initiatives focused on reducing errors of this nature by emphasizing the role played by permanent education to the team members for their theoretical-practical and scientific improvement. In France, hospitals check equipment from the moment of delivery and adopt the setups recommended by manufacturers[21].

Health professionals planning to us a new device should first be specifically trained by engineers and the manufacturer's commercial representatives. However, in practice, the scope and duration of training is limited, and it is rarely accessible to all users. In addition, in Brazil training delivered when introducing new equipment is not delivered again to new staff. Germany, for example, has stricter rules that extend formal training to all users[21].

In this sense, experiences from other countries lead to thinking that, for nursing teams, the ICU management should implement strategies to provide formal training to all the team members. Actions should comprise technical surveillance teams that, in turn, should be duly qualified by manufacturers to train active teams and new staff; clarify doubts; promote refresher courses; access the best scientific evidence; and take responsibility for the analysis of equipment to be purchased after discussion forums with users[21].

Other barriers that managers should consider regard the use of checklists for items, materials, and tasks focused on the regular evaluation of equipment to prevent oblivion, failures, and flaws, while standardizing and guiding the work; consider competences to perform duties in intensive care appraising the length of work and experience. Moreover, there is a need for reports on the technologies available[21].

Equipment failure

One evidence found by this survey regarded factors that generate adverse events. The studies analyzed showed that one moment of high risk of damage to patient regards transfers, as the batteries of handheld monitors, fans, and infusion pumps may fail even when they are shut off, and they get totally empty. Failures of equipment were also observed in another literature review in the line of patient transfer which proposed to identify complications among critically ill patients during intra-hospital transfer. Among the adverse events observed, the problem of the multidisciplinary team dealing with transfers and equipment failures is outstanding[6].

According to the device modality, equipment failures were categorized as follows: ventilation (system disconnection, empty cylinders, and bags with improper sealing); infusion (exhaustion of battery and medication); monitoring (malfunctioning, exhaustion of battery, interference with and malfunctioning of the arterial line)[6].

This aspect (equipment failure) was also identified by another study that categorized equipment-related errors, notably manufacturing problems during the design or production of a medical device, or malfunctioning during operations. In this way, manufacturing errors comprise equipment that is non-compliant with specifications and conceptual errors, that is, equipment with specifications that are non-responsive to the use conditions or the environment[12].

In this study, manufacturing errors were associated with the physical design and spacing of buttons; the size, format, and grouping of buttons; to which extent the device design is intuitive; reversion to the standard mode with no previous warning; overcrowding of the graphic interface; and degree of transparency of operations, among others[12].

In the surveys selected for this study, defects and malfunctioning of equipment were associated with damages to patients, including those classified as longer than temporary[22]. This fact has raised questions about the evaluation of effects ensuing from technologies. By determining the perceptions of nurses in charge of care to critically ill patients in a hospital in Greece about positive and negative effects of the use of equipment, researchers showed that positive effects were related to clinical practice, while the negative ones were associated with the risk of mechanical failures, human errors, and higher degrees of stress[23]. The nurses' experiences in the event of malfunctioning of equipment are described as astonishment, shock, questioning their own competencies, and comprised of their reliability and professional image[24].

It is worth mentioning that the equipment design is considered to be a contributing factor to improper use[12]. That is so because the interface with users of much of the equipment is unreliable and poorly designed which would be a problem related to human factors engineering—an area concerned with the interface among human beings, machines, and working space aimed to design systems, devices, and environments to minimize the risk of errors[25].

Human factors engineering has impacts on different spheres of healthcare. One aspect that could depict this influence concerns multiple connections of cables and wires of equipment placed around the client's bed, with similar colors and formats that enable connection with a wide range of equipment other than that for which they have been designed. Therefore, there is a huge risk of unintended connections, for example, connecting the electrocardiogram cable to an infusion pump, producing a lethal electrical discharge[26].

In this way, human factors engineering is an applied science that tries to understand the many and complex variables that affect users of technologies, such as environmental, functional, and individual characteristics. The technical evaluation of technologies seeks to reach an overview on the many risk variables implied, answering questions such as: Are the buttons easy to press? Can users wearing gloves feel the buttons? How does the alarm sound? Can configurations be viewed in a dark room? Are batteries fit to the intended use[12]?

Following this logic, the analysis can advance the design of equipment comprising improved reliability and interface with the patient's monitoring team, and improve the identification of unexpected problems. In this way the poor design of any equipment entails the risk of improper use, mainly when the design does not integrate interaction between users and the equipment interface[12].

These data refer to the need for professionals to be aware of the principles of human factors engineering and the characteristics of users and environments that might bring about risks to patient safety[12]. On the other hand, units should be equipped with the required infrastructure to reduce damage to patients, including care, technical maintenance, and verification of equipment before and during the transfer of shifts.

Considering the risk of equipment failure, the nursing team working in ICUs should evaluate and/or participate jointly in the process of designing these devices with the technology designers; undergo intensive training to understand how the equipment works; make periodic review of devices during inspections and when using them in working processes, applying structured instruments; participate in the equipment procurement process, comparing the equipment characteristics and the demands by the healthcare practice; work in partnership with a technical support team to ensure that any piece of equipment suspected of failure or defect is sent for evaluation, with feedback to the manufacturer; and prepare an action plan to handle situations of equipment failures[12].

Team failures

Whenever the team breaches standardized procedures to use equipment in healthcare, notably regarding verification and response to alarms, it favors the occurrence of incidents and potential damage. In this sense, team failures stand for evidence of the causes of equipment-related adverse events. Studies have pointed out such violations as responsible for incidents in ICUs, notably among anesthesiologists who do not check equipment prior to anesthesia, and disconnection of alarms, reaching rates close to lack of knowledge and experience[21].

According to the study, the team posture is one of not caring and providing late response to alarms, which is a critical point and explains the fact that in 2010 the monitors of patients and alarms were among the 10 highest risks involving technology[27]. Warnings have been issued for events where alarms are turned off and a cardiac incident is not detected, or when the central monitor fails to activate the alarm in the event of a heart attack, or even in situations where the alarm, located on the bed side, was set to the lowest volume and so cannot be heard[12].

Some examples of alarm-related situations were reported by researchers that measure the stimulus-response time of health teams to alarms of multi-parameter monitors in a coronary care unit. Over 60% of responses to alarms were considered to be the result of fatigue (with response time longer than 10 minutes) and less than 20% were responded to in up to five minutes. Inadvertently setting off alarms with no clinical relevance affects professionals and leads to behaviors of violation. This phenomenon is known as alarm fatigue, and is found in a large number of sound alarms; it can lead to sensory overload and desensitize the team about the urgency of the signal, resulting in hiding clinically relevant alarms through conducts like ignoring, muting or disabling the alarm[28].

Failure in checking the equipment can lead to some aspects of team failure, such as excessively relying on technologies, and poor communication between members to plan means to grant more autonomy to batteries, notably during the transfer of patients. Data show that communication problems interfere with the proper working of devices, such as lack of previous communication about the power generator test times to enable the due care to prevent further malfunctioning of the device[22].

There are similarities between this result from team failure related to equipment use and other safety spheres in intensive care. In an 18-month cohort study developed in an intensive care unit, communication failures among health professionals implied adverse events and raised the mortality rate in the sector[29]. At the international level, the ICU errors are estimated to result from communications failures[30].

Excessively relying on technology could give rise to incidents due to improper monitoring of equipment. Based on the experiences of airplane pilots where experienced and highly-reliable operators can report high-reliance on automation, a study investigated the work of ICU nurses and found that these professionals can be complacent about actual risks of damage to patients, as a result of this over-reliance[31].

When it comes to violation, the social context should be considered to understand the factors/motivations that gave rise to it. The search for causes also demands attention to organizational culture and the attitudes of stakeholders, rethinking strategies of change because errors remain even after technical training is provided, and non-technical skills are barely approached by the training[32].

One of these changes involves understanding the healthcare system as a complex system like that of aviation. Many plane crashes have been caused by team failures related to communications, violations, and lack of standard routines. An analysis of this kind of accident in the USA from 1970 to 1974 showed the core roles played by the human factor: among lethal accidents attributable to pilot error, 264 were related to procedural errors while 2,940 were related to decision-making[32].

This insight about the causes of aircraft crashes led to the elaboration of company resource management (CRM), applied to the training of crews to reduce errors throughout the production chain. The objective is to learn what, why, and how an accident happened for educational rather than punitive purposes[32]. CRM brings a set of tools applied to handle error in an attempt to understand the influence of a wide range of professional, organizational, and cultural factors[32].

Therefore, similarly to aviation, thinking about nursing team management in ICUs is crucial to improve achievements. Management will try to improve aspects such as communication, technical proficiency, decision-making, interpersonal relationships, and situational awareness to minimize adverse events mainly related to technologies. In this sense, the active participation of professionals in shared management contributes to build a culture of patient safety[33].

Here it is worth mentioning that the increasing development of technological innovations and their complexity bring about the need for establishing defensive barriers to favor system safety and prevent latent conditions from becoming active and leading to mistakes by those in charge of providing direct care to the patient. In this survey, this commitment runs through the application of evidence found in the clinical practice.

In this way, this survey recommends designing an instrument for the daily checking of equipment, so that this equipment can be monitored when nurses program the infusion pumps and monitors, in order to reduce failure parameters, registration failures, and inattention. In addition, it could allow evaluating the proper working of equipment. The limitation of this work is that, when characterizing the hierarchy of evidences, the corpus had to focus on Level 4, thus restricting the affirmative power thanks to the quality of the evidence. Moreover, the restricted number of articles used limited the analysis scope.

CONCLUSION

The analysis of the 11 studies that are part of this survey allowed organizing three units of evidence that depict the causes of equipment-related adverse events: improper use of equipment failure; equipment failure; and team failure.

Recommendations such as permanent education and professionals' upgrading, evaluation of production and availability of equipment, standardization of actions and use of instruments such as checklists are referred to in the studies as measures to minimize the occurrence of adverse events.

Results point out that debates on client safety also comprise thinking over the impact of incorporating technologies into healthcare settings. In this sense, adverse events are a challenge posed to nursing professionals seeking to provide quality care to critically ill patients, bearing the ethical commitment towards preventing such events.

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