Review

TECHNOLOGIES INVOLVED IN THE PROMOTION OF PATIENT SAFETY IN THE MEDICATION PROCESS: AN INTEGRATIVE REVIEW

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ABSTRACT: This study sought to identify technologies existing in the literature and their use in promoting patient safety in the medication process. An integrative review was performed in the following databases: Latin American and Caribbean Health Sciences Literature, Medical Literature Analysis and Retrieval System Online, Spanish Bibliographic Index of Health Sciences, Nursing Database, PubMed Central, Cumulative Index to Nursing and Allied Health Literature, Web of Science and SciVerse Scopus, including articles published between 2013 and 2017. Twenty international articles composed the final sample, ten (50%) published in the year 2014. Eleven technologies were identified, with prevalence of four regarding prescribed steps (36.3%) and four regarding drug administration (36.3%), with the technologies most investigated being: Radio Frequency Identification, Computerized Physician Order Entry and Bar-Code-Assisted Medication Administration.
DESCRIPTORS: Technology; Medication systems in the hospital; Patient safety; Technological development; Nursing.

TECNOLOGIAS ENVOLVIDAS NA PROMOÇÃO DA SEGURANÇA DO PACIENTE NO PROCESSO DE MEDICAÇÃO: UMA REVISÃO INTEGRATIVA

RESUMO: Este estudo buscou identificar na literatura as tecnologias existentes e seu uso na promoção da segurança do paciente no processo de medicação. Trata-se de uma revisão integrativa realizada nas bases de dados: Literatura Latino-Americana e do Caribe em Ciências da Saúde, *Medical Literature Analysisand Retrieval System Online*, Índice Bibliográfico Espanhol de Ciências da Saúde, Base de Dados de Enfermagem, PubMed Central, *Cumulative Index to Nursing and Allied Health Literature, Web Of Science* e *SciVerse Scopus*, abrangendo artigos publicados entre 2013 e 2017. Vinte artigos internacionais compuseram a amostra final, sendo dez (50%) publicados no ano de 2014. Onze tecnologias foram identificadas, com prevalência das etapas de prescrição quatro (36,3%) e administração de medicamentos quatro (36,3%), sendo as tecnologias mais abordadas: *Radio Frequency Identification, Computerized Physician Order Entry e Bar-Code-Assisted Medication Administration*.
DESCRITORES: Tecnologia; Sistemas de medicação no hospital; Segurança do paciente; Desenvolvimento tecnológico; Enfermagem.

TECNOLOGÍAS ASOCIADAS EN LA PROMOCIÓN DE SEGURIDAD DEL PACIENTE EN EL PROCESO DE MEDICACIÓN: UNA REVISIÓN INTEGRATIVA

RESUMEN: Este estudio tuvo el propósito de identificar, en la literatura, las tecnologías existentes así como su uso en la promoción de seguridad del paciente en el proceso de medicación. Es una revisión integrativa realizada en las bases de datos: Literatura Latinoamericana y de Caribe en Ciencias de la Salud, *Medical Literature Analysisand Retrieval System Online*, Índice Bibliográfico Español de Ciencias de la Salud, Base de Datos de Enfermería, PubMed Central, *Cumulative Index to Nursing and Allied Health Literature, Web Of Science* y *SciVerse Scopus*, abarcando artículos publicados entre 2013 y 2017. Veinte artículos internacionales hicieron parte de la muestra final, siendo diez (50%) publicados en el año de 2014. Once tecnologías fueron identificadas, con predominancia de las etapas de prescripción, cuatro (36,3%), y administración de medicamentos, cuatro (36,3%), siendo las tecnologías más abordadas: *Radio Frequency Identification, Computerized Physician Order Entry yBar-Code-Assisted Medication Administration*.
DESCRIPTORES: Tecnología; Sistemas de medicaciónen el hospital; Seguridad del paciente; Desarrollo tecnológico; Enfermería.

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INTRODUCTION

Throughout the entire process of the provision of healthcare, individuals have the right to receive quality care from the health services, which benefits them and provides satisfaction [1]. The undesirable effects of healthcare are caused by failures in the quality. The quality of the provision of care is understood as the efficient use of physical and human resources, with minimal risk to the client [2]. Among the dimensions outlined by the World Health Organization (WHO), the quality of health services is divided into six main groups: safety, effectiveness, attention focused on the patient, opportunity/access (internal and external), efficiency and equity [3].

Currently, patient safety, one of the dimensions of quality, is established as a key challenge to ensure the quality of excellence in the health sector [4], aiming to reduce the risk of unnecessary harm related to the healthcare to an acceptable minimum, according to the current knowledge, available resources and the context in which the care is provided [5].

Over the years there has been a rise in concerns regarding adverse events related to care practices. In this context, medication errors are the subject of studies aiming to evaluate and indicate ways to prevent and/or reduce adverse events, since these errors cause negative repercussions and damage in the lives of the individuals assisted. According to the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), the medication process has five steps: selecting and obtaining the medication, prescription, preparation and dispensing, administration of the medication, and finally, monitoring of the patient. Studies have shown that, over the years, errors have been highlighted throughout the execution of these steps [6].

The National Reporting and Learning Systems (NRLS) of England defines a "patient safety incident" (PSI) as any unintended or unexpected event. One study found that between the years 2005 and 2010, more than 525,186 incidents were reported. Of these, 86,821 (16%) cases generated real harm for the patient in the medication process, with 822 (0.9%) resulting in death or serious injury [7].

According to COFEN Resolution no. 311 of February 8, 2007, nursing professionals are prohibited from performing actions that compromise the safety of the person, such as administering or prescribing medications without knowing the action of the drug and without considering the possibility of risks[8].

New technologies arise daily, and health professionals need to understand and master them, using them in the service for the provision of safe and quality care to the client [9]. The technologies in health are grouped into three categories: hard (material such as permanent or consumable equipment and furniture); soft-hard (disciplines operating in health, such as epidemiological clinical medicine); and soft (identified as the production process of communication, of relationship and of bonds that lead to the fulfillment of the health action needs of the user). All have the same purpose: to provide broad and integral care [10].

In order to minimize the occurrence of adverse events in the medication process, one of the initiatives currently employed is to encourage the use of technologies, whether electronic or material, in order to subsidize the care practice and to strengthen the relationship of health professionals with these technologies [11-12]. Based on this, the present study aimed to identify technologies existing in the literature to promote patient safety in the medication process.

METHOD

The main aim of an integrative review is to construct an analysis of the literature, selecting and grouping studies that cover a particular subject and that have common features, obtaining deeper reflections to support further research in the area [13]. For the performance of this study, the following steps were used: identification of the theme and preparation of the research question, establishment of the inclusion and exclusion criteria of the studies, identification of the data to be obtained from the studies selected, categorization of the studies, analysis and interpretation of the results and presentation of the review, with the explanation of the steps taken to achieve the results [14].

In order to direct this review, the following research questions were formulated: What technologies

are used in the medication process? What impacts does the use of these technologies have on patient safety in the medication process?

The search for the publications in the scientific literature was conducted during the months of December 2016 and January 2017, in the following electronic databases: Virtual Health Library, Medical Literature Analysis and Retrieval System Online (MEDLINE), Latin American and Caribbean Health Sciences Literature (LILACS), Nursing Database (BDENF), Spanish Bibliographic Index of Health Sciences (IBECS) , PubMed Central, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Web Of Science and SciVerse Scopus (SCOPUS).

For a search for the publications, the following controlled descriptors of the Medical Subject Headings (MeSH) were used: "Medication Systems, Hospital" and "Patient Safety", searched jointly through the AND Boolean operator. The entire step of search and selection of the articles was performed using the in pairs methodology, with two pairs of researchers, and the assessment of a third researcher in the event of discrepancies between the pairs regarding the selection of the articles.

For the sample selection, the following inclusion criteria were adopted: articles published between 2013 and 2017 (restriction used as a result of the search being for technologies that are being currently used in the care) and that presented technologies used to ensure safe practices in the context of the medication process in their content. Studies in editorial format, letters to the editor, integrative and systematic reviews, and duplicate articles were excluded. Table 1 quantitatively presents the steps performed in the databases. Of the eight databases analyzed, LILACS, BDENF and IBECS did not contribute articles to the final sample.

Table 1 – Strategy of search and determination of the sample following the order: Number of Studies Localized (L), Relevant Studies (R) Duplicate Studies Excluded (D) Studies Read in Full (Rd) and Selection of Studies (S). Natal, RN, Brazil, 2017

CROSSING					
Medication Systems, Hospital AND Patient Safety					
DATA BASE	L	R	D	Rd	S
MEDLINE	234	36	11	25	4
LILACS	7	1	0	0	0
CINAHL	35	14	0	14	1
BDENF	2	0	0	0	0
IBECS	3	0	0	0	0
SCOPUS	1173	35	8	24	7
PUBMED	5194	9	2	7	2
WEB OF SCIENCE	378	48	17	31	6
TOTAL	7026	143	38	101	20

Following the database search procedure, the publications found (n=7026) were pre-selected based on reading the title and abstract. After reading the subsequently selected publications (n=101) in full, the final sample of articles was determined (n=20). They were then categorized in Microsoft Excel® and analyzed descriptively, including: identification of the article (title, authors, databases, place and year of publication), objectives, methodology of the article (technology discussed and medication process step) and results. They were grouped according to the classification of Mehry et al.[11] as: soft, soft-hard and hard. In this way, the results of the articles were analyzed regarding their applicability and effectiveness in the context of patient safety promotion in the medication process.

RESULTS

It was found that the 20 (100%) articles were published internationally, with 10 (50%) published in 2014. Among the articles, 19 (95%) had a descriptive, quantitative methodological approach. A total of 11 technologies used in the medication process were identified: Radio Frequency Identification (RFID), Bar-Code- Assisted Medication Administration (BCMA), Personal Digital Assistant (PDA), Electronic Medication Administration Record (eMAR), Internet of Things (IoT), Near Field Communication (NFC), Computerized Physician Order Entry (CPOE), Computerized Decision Support Systems (CDSS), HARMLESS; Electronic Prescribing and Decision Support System (ePDSS) and Healthcare Failure Mode and Effect Analysis (HFMEA). The Radio Frequency Identification (RFID) technology was the most mentioned among the articles studied, with five (25%) citations.

There was a predominance of technologies in the following steps: prescription, with four (36.3%) and administration, with four (36.3%), in the medication process. Only three (27.2%) of the technologies were applied in all stages of the medication process: HFMEA, IoT and NCF. According to the categorization of Menry [11], all were classified as hard technologies. Table 2 presents the distribution of the final sample of studies and their technological approaches, as well as their relative and absolute frequency, followed by their applicability.

Table 2 - Identification of the technologies covered by the selected articles, their application in the steps of the medication process and technological categorization. Natal, RN, Brazil, 2017

Technology	Sample n (%)	Medication Process	Technology category
Radio Frequency Identification[15-19]	5 (25)	Preparation/ADM**	Hard
Computerized Physician Order Entry[20-22]	3 (15)	Prescription	Hard
Bar-Code-Assisted Medication Administration[23-25]	3 (15)	Preparation/ADM**	Hard
Electronic Medication Administration Record[26-27]	2 (10)	ADM**	Hard
Healthcare Failure Mode and Effect Analysis[28]	1 (5)	EP*	Hard
Computerized Decision Support System[29]	1 (5)	Prescription	Hard
HARMLESS[30]	1 (5)	Prescription	Hard
Personal Digital Assistant[31]	1 (5)	ADM**	Hard
Internet of Things[32]	1 (5)	EP*	Hard
Electronic Prescribing and Decision Support System[33]	1 (5)	Prescription	Hard
Near Field Communication[34]	1 (5)	EP*	Hard
	20 (100)		

EP*: Entire process.
ADM**: Administration.

The Radio Frequency Identification (RFID) technology allows automatic data capture for the identification of objects provided with electronic devices, hardware (electronic labels, tags or transponders) that emit radio frequency signals for readers that capture this information[15-19]. The Bar-Code- Assisted Medication Administration (BCMA)[23-25] and Personal Digital Assistant (PDA)[31] are bar code reading systems designed to prevent medication errors in the administration and may be recorded by the Electronic Medication Administration Record (eMAR)[26-27]. The Internet of Things (IoT) [32] and Near Field Communication (NFC)[34] allow intercommunication of this information.

The Computerized Physician Order Entry (CPOE) is an electronic prescription system that transmits the order directly to the pharmacy, and supports the clinical decision of the medical team[20-22]. The Computerized Decision Support Systems (CDSS) is a data analysis program used to prepare a diagnosis and evaluate it[29]. Both can be associated with HARMLESS[30], the support system for clinical decision, equipped with prescription error alerts. The Electronic Prescribing and Decision Support System (ePDSS) allows communication of the information of prescriptions, clinical decision support, and has a warning system for interactions between medications [33].

The Healthcare Failure Mode and Effect Analysis (HFMEA), an extension of the Failure Mode and

Effect Analysis (FMEA), was developed specifically for healthcare, working with the analysis of risk and identification of faults [28].

The Internet of Things (IoT)[32] and Near Field Communication (NFC)[34] allow intercommunication of information among reading devices and generation of data through sensors.

Chart 1 shows the results obtained regarding the applicability of the use of the technologies covered by the articles selected in this study.

Chart 1 - Applicability evidenced by the articles selected. Natal, RN, Brazil, 2017

Technology	**Results**
	Applicability of the technology
Radio Frequency Identification (RFID)	The studies highlighted RFID as a crucial tool in the patient identification process, reducing errors related to medication changes.
Bar-Code-Assisted Medication Administration	These devices equipped with bar code readers did not show large positive differences between hospital sectors that use and those who do not use these devices.The medication error reduction rates were minimal.
Personal Digital Assistant	
Electronic Medication Administration Record	
Healthcare Failure Mode and Effect Analysis (HFMEA)	The HFMEA was found to be effective in the evaluation and early detection of possible errors that can affect certain processes, such as that of medication.
Computerized Decision Support System	As supports linked to the clinical decision and medication prescription, these technologies showed positive results when used in the hospital environment.The reduction of some factors was observed during the prescription, such as illegibility errors, use of inappropriate abbreviations and lack of information.
Electronic Prescribing and Decision Support System	
HARMLESS	
Computerized Physician Order Entry	
Internet of Things	These technologies involved in the intercommunication of portable devices that perform the manual verification of tags and bar codes have advanced integration and have a low cost when compared to other devices with the same purpose. They are adapted to not capture frequencies of other devices present in the hospital.
Near Field Communication	

The technologies, when introduced and tested in the hospital environment, generally showed good results in the hospital processes, facilitating the working dynamics of the professional and/or reducing adverse events derived from the care, contributing to patient safety.

DISCUSSION

Interest in the risks related to healthcare errors increases every day. Some educational institutions and hospitals are deploying technologies and monitoring systems in order to prevent these risks[32-36]. Traditional methods used are being replaced by technologies designed to prevent the incidence of medication errors in the process [37].

The application of information technology (IT) improves the quality and safety of healthcare, especially in the medication process[38]. The use of hard technologies has been intensifying, contributing to the concern of some professionals, regarding the operation, the lack of knowledge or the malfunctions that these technologies can present[39]. A descriptive analytical study of medication error reports indicated that the phases most affected by errors were those of the prescription (16.4%) and administration (71.5%), from a total of 359 medication errors[40], corroborating the findings of the present study.

Overdosing is one of the main errors committed regarding the prescription. The use and integration

of technologies, such as the CPOE, may reduce the incidence of new cases of incorrect dosages by 20%, establishing a greater margin of safety for the patient [20].

Other technologies can be linked to the prescription process, such as HARMLESS, a system developed to support the clinical decision in the prescription stage, warning of dosing errors and interactions between concomitant prescription drugs, as well as the ePDSS that, in addition to these characteristics, offers the possibility of interconnection of the information between prescriptions destined for the same patient [30,33].

Studies have shown that the application and integration of systems, such as these programs, provides a significant reduction in adverse effects to patients, even reducing their hospital stay, since the application of the correct treatment implies positive points in the recovery, as well as safety in the care [41].

A study showed that the BCMA is effective in significantly reducing administration errors by up to 80.7% and in reducing the time spent by staff performing the procedure. Associated with this software, the eMAR provides benefits in the administration stage, allowing the action to be documented in real time. Integrating these technologies, the PDA can provide mobility and practicality to the procedure[24].

Errors involving incorrect prescriptions are not alerted by the BCMA or the eMAR, which operate from the correction by the professional for the system to function normally[28-29]. A study carried out in some hospital units that did not use the eMAR barcodes, showed that the rate of medication errors was almost double (11.5%) that of the units that used the system (6.8%) [26].

Unlike the technologies mentioned above, used in the administration, the RFID technology presents advantages related to convenience of use. Some of these advantages are the ability to check without a reading line, reading of multiple tags per second, greater data storage capacity and resistance to environmental adversity, prevailing over the barcode devices. It facilitates the steps of preparation and administration of medications, through its efficient sensors that do not experience manual interference from the professionals [42].

In summary, this review showed that identification, in advance of possible harm, is essential to avoid negative repercussions for patient safety, with the use of the available technologies.

CONCLUSION

This integrative review identified, in the selected articles, 14 technologies involved in the promotion of patient safety in the medication process, the most common being the Radio Frequency Identification, Computerized Physician Order Entry and Bar-Code-Assisted Medication Administration, categorized as hard technologies and applied in the processes of medication, preparation/administration/prescription and preparation/administration, respectively.

New technologies and their implementation in the care context promote patient safety, by reducing the occurrence of errors, especially in the medication process. Thus, this study can serve as a foundation to guide, in general, the current field of information technology applied in healthcare, with regard to the medication process.

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