Review

MEDICATION ERRORS IN PEDIATRICS AND PREVENTION STRATEGIES: AN INTEGRATIVE REVIEW

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ABSTRACT: An integrative review was undertaken to analyze the strategies, safety incidents and the phase of the medication process intended to prevent adverse events in pediatrics. Data collection took place between November/2015 and February/2017 in the databases: Latin American Literature in Health Sciences, Cumulative Index of Nursing and Allied Health Literature, U.S. National Library of Medicine and Web of Science. The following descriptors were used: medication errors, patient safety and child. Twenty-seven articles were selected, published between 2004 and 2016. The most investigated phase of the medication process was the drug prescription. The safety incident rates varied between 0.91% and 54%. No methodological standardization could be identified in the studies. The reported prevention strategies were: use of electronic drug prescription, clinical simulation, dosing protocol and incident reports. It is important for the risk identification and planning of prevention strategies to support the global analysis of the medication process.
DESCRIPTORS: Patient safety; Medication errors; Child; Nursing.

ERROS DE MEDICAÇÃO EM PEDIATRIA E ESTRATÉGIAS DE PREVENÇÃO: REVISÃO INTEGRATIVA

RESUMO: Trata-se de revisão integrativa com o objetivo de analisar as estratégias, os incidentes de segurança e a etapa do processo medicamentoso para prevenção de eventos adversos na pediatria. Realizou-se a coleta entre novembro/2015 e fevereiro/2017, nas bases: Literatura Latino-Americana em Ciências de Saúde, *Cumulative Index of Nursing and Allied Health Literature*, *U.S. National Library of Medicine* e *Web of Science*. Utilizaram-se os descritores: erros de medicação, segurança do paciente e criança. Foram selecionados 27 artigos, publicados entre 2004 e 2016. A etapa do processo medicamentoso mais pesquisada foi a prescrição médica. As taxas de incidentes de segurança variaram entre 0,91% e 54%, não sendo identificada padronização metodológica nos estudos. As estratégias de prevenção relatadas foram: uso da prescrição médica eletrônica, simulação clínica, protocolo de doses, e notificações de incidentes. É importante que a identificação de riscos e o planejamento das estratégias de prevenção subsidiem a análise global do processo medicamentoso.
DESCRITORES: Segurança do paciente; Erros de medicação; Criança; Enfermagem.

ERRORES DE MEDICACIÓN EN PEDIATRÍA Y ESTRATEGIAS DE PREVENCIÓN: REVISIÓN INTEGRATIVA

RESUMEN: Esta es un revisión integrativa cuya finalidad fue analizar las estrategias, los incidentes de seguridad y la etapa del proceso medicamentoso para prevención de eventos adversos en la pediatría. Los datos fueron obtenidos entre noviembre/2015 y febrero/2017, en las bases: Literatura Latinoamericana en Ciencias de Salud, *Cumulative Index of Nursingand Allied Health Literature*, U.S. *National Library of Medicine* y *Web of Science*. Fueron utilizados los descriptores: errores de medicación, seguridad del paciente y niño. Se eligieron 27 artículos publicados entre 2004 y 2016. La etapa del proceso medicamentoso más investigada fue la prescripción médica. Las tajas de incidentes de seguridad variaron entre 0,91% y 54%, no siendo identificada estandarización metodológica en los estudios. Las estrategias de prevención relatadas fueron: uso de la prescripción médica electrónica, simulación clínica, protocolo de dosis, y notificaciones de incidentes. Es importante que la identificación de riesgos y el planeamiento de las estrategias de prevención subsidien el análisis global del proceso medicamentoso.
DESCRIPTORES: Seguridad del paciente; Errores de medicación; Niño; Enfermería.

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INTRODUCTION

Medication use is the primary treatment used in medical therapeutics, making medication errors more frequent[1]. These errors can happen in any phase of the process: prescription, dispensing, storage, preparation, among others. Their prevention involves the entire health team, particularly the nursing team, being the main responsible for the drug preparation and administration.

Medication error is considered to be any avoidable event that actually or potentially interferes inappropriately in the medication process and may provoke patient damage or not[2]. In this context, Patient Safety is the reduction of the risk of unnecessary healthcare-related damage. This damage can be physical, psychological or social; implying losses in the body structure or function and/or diseases, injuries, suffering, disability or death. Hence, an incident is an event that can cause unnecessary damage to the patient or not. When an incident with damage occurs, an adverse event takes place[3].

The concern with patient safety and care quality in health services mobilized the World Health Organization (WHO) in 2004 to launch the Global Patient Safety Alliance. Its goal was to improve care safety by proposing measures to reduce risks, organizing concepts and definitions on patient safety and recommending that countries pay greater attention to the theme[4].

In that sense, children are particularly vulnerable to damage, mainly due to the peculiarities of their metabolism, such as age, weight and height. In addition, the lack of standardized drugs for pediatrics makes the medication process even more susceptible to errors[5].

Promoting actions and strategies to further qualify the professionals, standardize the process and provide continuing education are fundamental to prevent adverse events caused by medication errors[2]. When the professional understands what an adverse event is, its causes and consequences, it becomes easier to admit that errors are possible and can be present in care. This understanding is the first phase towards prevention[6]. Hence, knowing what has been studied and what is being done in this sense is extremely important, justifying this research.

In view of this problem, the question guiding this review was: what strategies are proposed to prevent medication errors in care for hospitalized children? The objective was to analyze the strategies, safety incidents and phase in the medication process to prevent adverse events in pediatrics.

METHOD

An integrative literature review (IR) was undertaken, involving the following phases: formulation of the problem, data collection, data assessment, research analysis and presentation of results[7].

In the first phase of the IR, the following guiding question was proposed: what strategies are proposed to prevent medication errors in care for hospitalized children?

The data were collected between November/2015 and February/2017 in the following databases: Latin-American Literature in Health Sciences (LILACS), Cumulative Index of Nursing and Allied Health Literature (CINAHL), U.S. National Library of Medicine (PubMed)and Web of Science, selected for being important international scientific and technical literature indices with strict journal indexation standards. The Health Sciences Descriptors (DeCS) used were: medication errors, patient safety and child, in English, Spanish and Portuguese according to the database, using the Boolean operator AND in each combination.

The following inclusion criteria were adopted: being an original article – primary study; scientific articles on the specific theme, medication errors, in the title and abstract; texts written in Portuguese, Spanish, English, whose full version was published online between 2004 and 2016.

The exclusion criteria were: reviews, books, dissertations and theses; general studies on patient safety; and studies that did not discuss medication error prevention strategies in pediatrics. The flowchart of the combinations of descriptors and search results has been displayed in Figure 1 and followed the Prisma recommendations[8].

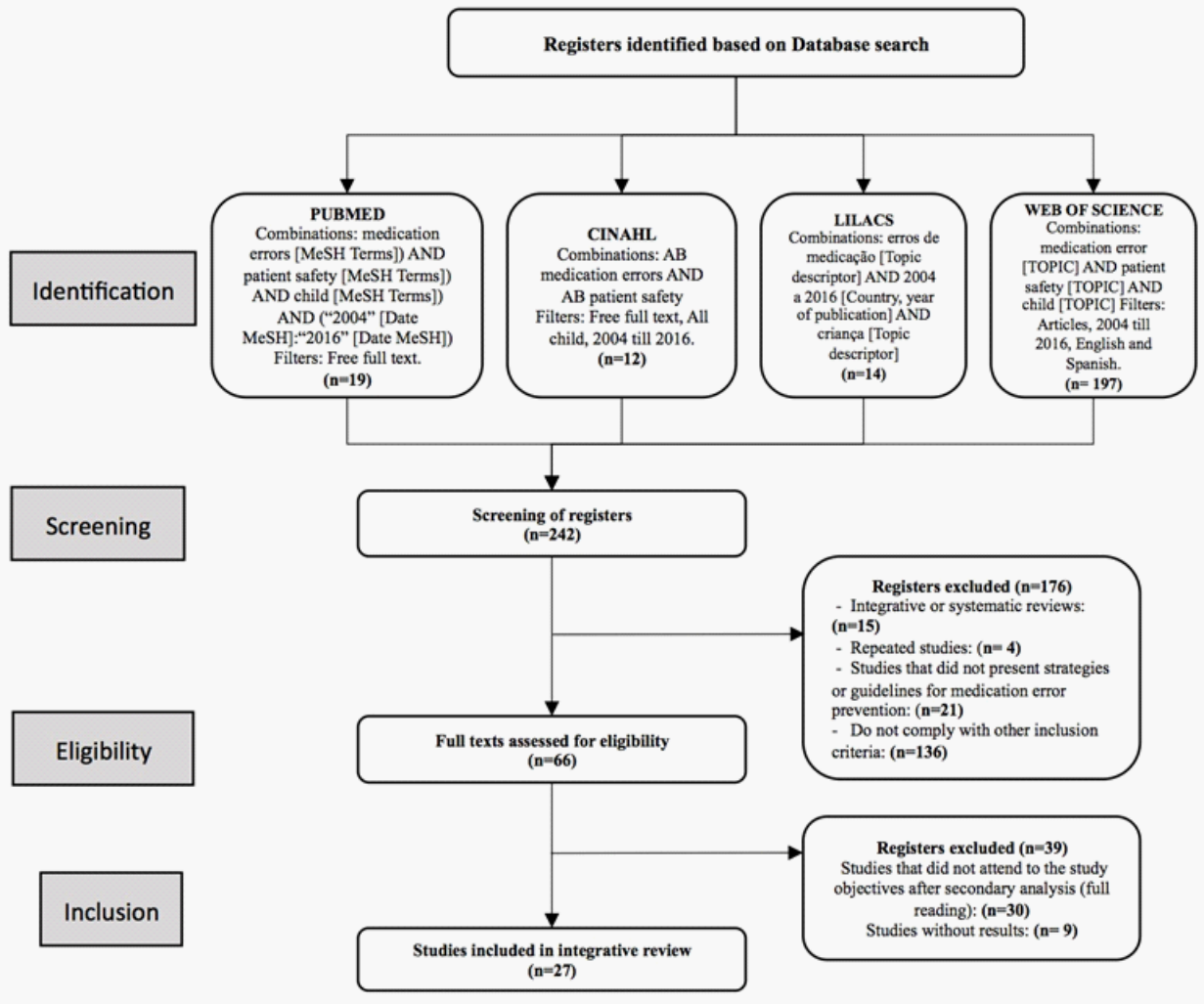

Figure 1 – Flowchart of selection of scientific articles on medication error prevention in care for hospitalized children according to selected databases. Porto Alegre, RS, Brazil, 2004-2016

To analyze and interpret the data, the information from the selected articles was summarized, aiming to identify what strategies are proposed to prevent medication errors, the number of incidents and in which phase of the medication process errors occur. The instrument used consisted of the following items: article title; authors; journal the article was published in; country and year; method; medication error prevention strategies in pediatrics; number of incidents involving medication; and phase of the process the error occurred in. The extracted and summarized data are presented in two pictures, one to characterize the studies and the other to display the results related to the guiding question.

RESULTS

Twenty-seven articles were selected that discuss the strategies proposed to prevent medication errors in pediatrics, safety incident rates and phases of the medication process in which the errors happened. The characteristics of the studies included in this IR are displayed in Table 1.

Table 1 – Characteristics of studies according to database, year, country, journal, type of study and research sector. Porto Alegre, RS, Brazil, 2004-2016. (continues)

No	Database	Year	Country	Journal	Study design	Research sector (place)
1	LILACS	2011	Brazil	Acta Paulista de São Paulo	Retrospective and descriptive with quantitative approach[9]	General pediatric units

2	LILACS	2007	Brazil	Revista Brasileira de Enfermagem	Quasi-experimental[10]	Infectious diseases, Surgical Unit and Pediatric Intensive Care Unit
3	CINAHL	2008	USA	American Journal of Health-System Pharmacy	Quantitative, descriptive, cross-sectional[11]	General pediatric units
4	CINAHL	2006	USA	Journal of Pediatric Nursing	Quantitative, transversal[12]	General pediatric units
5	WEB OF SCIENCE	2015	USA	International Journal for Quality in Health Care	Prospective and intervention[13]	General pediatric units
6	WEB OF SCIENCE	2013	USA	Pediatric Blood Cancer	Prospective and intervention[14]	Oncology clinic
7	WEB OF SCIENCE	2013	USA	Emergency Medicine Journal	Qualitative[15]	Emergency
8	WEB OF SCIENCE	2013	Japan	Journal of Food and Drug Analysis	Prospective and intervention[16]	Hospital outpatient clinic
9	WEB OF SCIENCE	2013	USA	Pediatric Blood Cancer	Cross-sectional with intervention[17]	General pediatric units
10	WEB OF SCIENCE	2013	Canada	Journal of Pediatric Nursing	Descriptive, prospective[18]	General pediatric units
11	WEB OF SCIENCE	2012	Spain	Archives of Disease in Childhood	Epidemiological cross-sectional[19]	Pediatric unit and maternity
12	WEB OF SCIENCE	2012	Australia	Pediatrics	Prospective time series[20]	General pediatric units
13	WEB OF SCIENCE	2012	Italy	British Medical Journal Open	Quantitative comparative with intervention[21]	General pediatric units
14	WEB OF SCIENCE	2011	USA	Pediatrics	Prospective and intervention[22]	General pediatric units
15	WEB OF SCIENCE	2011	USA	Applied Clinical Informatics	Retrospective analysis study[23]	Inpatient Units
16	WEB OF SCIENCE	2011	Iran	Journal of Medical Systems	Prospective and intervention[24]	Neonatal Intensive Care Unit
17	WEB OF SCIENCE	2009	USA	Journal of Clinical Nursing	Qualitative descriptive[25]	General pediatric units
18	WEB OF SCIENCE	2009	Israel	Pediatrics	Quantitative retrospective[26]	Pediatric Intensive Care Unit
19	WEB OF SCIENCE	2008	USA	Pediatrics	Quantitative[27]	General pediatric units
20	WEB OF SCIENCE	2008	USA	Pediatrics	Prospective and intervention[28]	General pediatric units
21	WEB OF SCIENCE	2006	USA	Pediatrics	Quantitative, prospective[29]	General pediatric units
22	WEB OF SCIENCE	2004	USA	Quality and Safety in Health Care	Prospective and intervention[30]	Pediatric Intensive Care Unit
23	WEB OF SCIENCE	2016	USA	Journal of Pediatric Surgery	Methodological (instrument construction)[31]	Surgical Units
24	WEB OF SCIENCE	2016	Canada	Journal of Pediatric Nursing	Quantitative, prospective[32]	General pediatric units
25	WEB OF SCIENCE	2016	USA	Academic Pediatrics	Quantitative (modified Delphi)[33]	Hospital outpatient clinic

26	WEB OF SCIENCE	2016	Spain	Enfermería Clínica	Quantitative, descriptive, cross-sectional[34]	Pediatric emergency
27	WEB OF SCIENCE	2016	Canada	Journal of Evaluation in Clinical Practice	Quantitative, descriptive, cross-sectional[35]	Maternal-Infant Hospital

Two studies were developed in Brazil[9-10]. Most research on the proposed theme was developed abroad, particularly in the United States[11-15,17,22-23,25,27-31,33]. As regards the year of publication, most studies were published as from 2011[9,13-24,31-35]. General pediatric units are the main focus (66.6%), including clinical inpatient units and surgical units[9,11-13,17-23,25,27-29,31-32,35]. The Intensive Care Unit (ICU) was the most studied isolated sector[18.5%)(2,10,24,26,30].

Few studies that proposed intervention followed a classical methodological proposal with statistical analysis. Quantitative and prospective intervention studies[13-14,16,18,20-22,24,28-30,32] corresponded to (48.1%). The journal Pediatrics stood out with four publications on medication error prevention in pediatrics[20,22,26-29]. In Table 2, the results related to the review objective are presented.

Table 2 – Characteristics of studies according to article title, authors and results (prevention strategies, number of incidents and process phases) in the publications analyzed. Porto Alegre, RS, Brazil, 2004-2016 (continues)

Article Title	Authors	Results
Notificação espontânea de erros de medicação em hospital universitário pediátrico[9]	Yamamoto MS, Peterlini MAS, Bohomol E.	**Prevention strategies:** Reporting system and "Nursing Division" team responsible for reports.
		Number of incidents: 120 medication error events reported, being 45.8% errors in 2007 and 54.2% in 2008.
		Process phases: Dose omission in 2007; infusion speed in 2008.
Redesenho de atividades da enfermagem para redução de erros de medicação em pediatria[10]	Yamanaka TI, Pereira DG, Pedreira MLG, Peterlini MAS.	**Prevention strategies:** Construction of prevention flowchart and development of education program.
		Number of incidents: Errors present in 21.1% of the 8152 drugs or solutions analyzed.
		Process phases: Dose omission was most frequent error type.
Characteristics of medication errors and adverse drug events in hospitals participating in the California Pediatric Patient Safety Initiative[11]	Takata GS , Taketomo CK, Waite S.	**Prevention strategies:** Intervention through three methods: Pharmacy intervention medication errors (PIMEs)[a], Validated pediatric trigger methods (TADEs)[b], Voluntary incident reports (VADEs)[c].
		Number of incidents: PIMEs 349 adverse drug events (ADEs)[d] identified. TADEs 79 ADEs identified and, VADEs 278 ADEs identified.
		Process phases: not informed
Harmful medication errors in children: a 5-year analysis of data from the USP's MEDMARX Program[12]	Hicks RW, Becker SC, Cousins DD.	**Prevention strategies:** Implementation of system to assess medication error records.
		Number of incidents: 19,350 medication error records during five years.
		Process phases: Dosing error was the most frequent error type.
Electronic medication reconciliation and medication errors[13]	Hron JD, Manzi S, Dionne R, Chiang VW, Brostoff M, Altavilla SA, et al.	**Prevention strategies:** Implementation of electronic medication conciliation tool and regular completion of reports for inpatient units.
		Number of incidents: 146 medication conciliation errors during admissions.
		Process phases: not informed

The use of a checklist in a pediatric oncology clinic[14]	McLean TW, White GM, Bagliani AF, Lovato JF.	**Prevention strategies:** Implementation of checklist at oncology outpatient clinic.
		Number of incidents: Drug prescription errors in electronic history dropped from 21% during 1st month to 12% during 5th month.
		Process phases: not informed
Reported medication events in a pediatric emergency research network: sharing to improve patient safety[15]	Shaw KN, Lillis KA, Ruddy RM, Mahajan PV, Lichenstein R, Olsen CS, et al.	**Prevention strategies:** Incident reporting system to qualify and quantify adverse event notifications.
		Number of incidents: 597 (19%) medication errors in 3,106 incident reports analyzed in one year.
		Process phases: Highest occurrence of dosing errors.
The effect of a computerized pediatric dosing decision support system on pediatric dosing error[16]	Jing-Yi Hou, Kuei-Ju Cheng, Kuan-Jen Bai, Hsiang-Yin Chen, Wen-Hao Wud, You-Meei Lin, et al.	**Prevention strategies:** Implementation of computerized drug prescription and pediatric dosing decision support system.
		Number of incidents: Drug prescription error rate dropped from 2.23% to 0.66% after the intervention.
		Process phases: not informed
Chemotherapy medication errors in a pediatric cancer treatment center: prospective characterization of error types and frequency and development of a quality improvement initiative to lower the error rate[17]	Watts RG, Parsons K.	**Prevention strategies:** Implementation of computerized prescription, verification and chemotherapy drug order system.
		Number of incidents: Global error rate dropped by 50%.
		Process phases: Most common error types: dosing (overdose and/or underdose), measuring units, drug, incorrect administration technique or route.
The relationship between the nursing work environment and the occurrence of reported pediatric medication administration errors: a pan Canadian study[18]	Sears K, O`Brien-Pallas L, Stevens B, Murphy GT.	**Prevention strategies:** Elaboration of questionnaire to collect medication error data.
		Number of incidents: 372 errors were reported over three months.
		Process phases: not informed
Impact of clinical pharmacist interventions in reducing pediatric prescribing errors[19]	Fernández-Llamazares CM, Calleja-Hernandez MA, Manrique-Rodriguez S, Pérez-Sanz C, Duran-García E, Sanjurjo-Saez M.	**Prevention strategies:** Clinical pharmacists analyzed pediatric pharmaceutical activities related to pediatric prescriptions.
		Number of incidents: 1,391 interventions – out of 1,357 prescription errors, 833 were dosing errors.
		Process phases: Prescription errors.
Long-term reduction in adverse drug events: an evidence-based improvement model[20]	Gazarian M, Graudins LV.	**Prevention strategies:** Implementation of guidelines for safe multiprofessional pediatric prescription.
		Number of incidents: Total medication errors dropped from 4.51 per 100 prescriptions to 2.78 per 100 prescriptions over four years.
		Process phases: Physician order.
Use of FMEA analysis to reduce risk of errors in prescribing and administering drugs in pediatric wards: a quality improvement report[21]	Lago P, Bizzarri G, Scalzotto F, Parpaiola A, Amigoni A, Putoto G, et al.	**Prevention strategies:** Implementation of proactive tool to assess risks, identify possible errors and prioritize prevention measures.
		Number of incidents: not informed
		Process phases: Drug prescription and preparation emerged as phases most vulnerable to errors.

Sustaining and spreading the reduction of adverse drug events in a multicenter collaborative[22]	Tham E, Calmes HM, Poppy A, Eliades AB, Schlafly SM, Namtu KC, et al.	**Prevention strategies:** Implementation of intervention package to improve safety culture.
		Number of incidents: Adverse drug event rate dropped 42% in the final term of the project (22.4 ADE 1,000 patients-day).
		Process phases: not informed
Response to medication dosing alerts for pediatric inpatients using a computerized provider order entry system[23]	Perlman SL, Fabrizio L, Shaha SH, Magid SK.	**Prevention strategies:** Dosing alerts in computerized physician order with clinical decision support for pediatric inpatients.
		Number of incidents: Out of 1,024 dosing alerts by the system, 91% were for overdosing and 9% for underdosing.
		Process phases: Physician order.
The effect of computerized physician order entry and decision support system on medication errors in the neonatal ward: experiences from an Iranian teaching hospital[24]	Kazemi A, Ellenius J, Pourasghar F, Tofighi S, Salehi A, Amanati A, et al.	**Prevention strategies:** Computerized order and clinical decision support system.
		Number of incidents: 53% (before implementation of computerized physician order with clinical decision support) and 34% (after implementation).
		Process phases: Physician order (dose calculation).
Pediatric nurses' understanding of the process and procedure of double-checking medications[25]	Dickinson A, McCall E, Twomey B, James N.	**Prevention strategies:** Understanding of nursing practice, facilitators and barriers regarding independent double-checking medication procedure at pediatric services.
		Number of incidents: not informed
		Process phases: Drug preparation and administration.
Computerized order entry with limited decision support to prevent prescription errors in a PICU[26]	Kadmon G, Bron-Harlev E, Nahum E, Schiller O, Haski G, Shonfeld T.	**Prevention strategies:** Electronic prescription and clinical decision support system.
		Number of incidents: 5,000 prescriptions analyzed, 273 (5.5%) contained prescription errors. After implementation, error rate dropped by 83%.
		Process phases: Physician order.
Effect of computer order entry on prevention of serious medication errors in hospitalized children[27]	Walsh KE, Landrigan CP, Adams WG, Vinci RJ, Chessare JB, Cooper MR, et al.	**Prevention strategies:** Implementation of electronic physician order.
		Number of incidents: Incidence of avoidable adverse drug events dropped from 7.9 events before implementation to 6.5 events after implementation.
		Process phases: Physician order.
Reevaluating the safety profile of pediatrics: a comparison of computerized adverse drug event surveillance and voluntary reporting in the pediatric environment[28]	Ferranti J, Horvath MM, Cozart H, Whitehurst J, Eckstrand J.	**Prevention strategies:** Concomitant use of computerized adverse drug event surveillance and voluntary safety incident reporting systems.
		Number of incidents: 1.8 incidents per 1,000 pediatric patients-day according to voluntary reporting system of safety incidents; 1.6 incidents per 1,000 patients-day according to computerized adverse drug event surveillance system.
		Process phases: Order and administration.
Risk reduction for adverse drug events through sequential implementation of patient safety initiatives in a children's hospital[29]	Leonard MS, Cimino M, Shaha S, McDougal S, Pilliod J, Brodsky L.	**Prevention strategies:** Sequential implementation of education and behavioral change initiatives for prescribing professionals.
		Number of incidents: The absolute prescription error risk reduction corresponded to 38 per 100 orders, with a relative risk reduction by 49%.
		Process phases: Physician order.
Design of a safer approach to intravenous drug infusions: failure mode effects analysis[30]	Apkon M, Leionard J, Probst L, DeLizio L, Vitale R.	**Prevention strategies:** Development of set of standardized procedures for continuous drug infusion.
		Number of incidents: not informed
		Process phases: Order, preparation and administration.

Implementation of a pediatric surgical quality improvement (QI)-driven M&M conference[31]	Cromeens B, Brilli R, Kurtovic K, Kenney B, Nwomeh B, Besner GE.	**Prevention strategies:** for all types of errors, focus on education; in cases of professional errors, optimization of communication, establishment of criteria for interdisciplinary consulting, problem solving with equipment; removal for high-risk drugs from procedure protocols, modification of sets of orders/prescriptions, restructuring of care transfers by physicians.
		Number of incidents: 107 patients. 142 errors were identified: 78.9% individual errors and 21.1% system errors. Case report of one child with respiratory failure due to use of capsaicin spray (oropharyngeal anesthetic drug) for nasogastric tube passage at radiology sector. The analysis showed that a system error happened – lack of protocol for medication use.
		Process phases: Drug prescription.
The relationship between nursing experience and education and the occurrence of reported pediatric medication administration errors[32]	Sears K, O'Brien-Pallas L, Stevens B, Murphy GT.	**Prevention strategies:** insert safety incident reporting in nursing education (e.g., laboratory simulation of adverse event); use error reporting as feedback system to improve drug administration process (pro-active institution); construction of reporting confidentiality culture; educate nurses with less experience at a certain unit.
		Number of incidents: mean 29.18 (SD = 9.86) errors at each unit during three months of data collection based on nurses' self-report (limitation identified by the authors: underreporting of errors by nurses for different reasons). Minimum: one error; maximum: 43 errors.
		Process phases: not informed
Evaluating the potential severity of look-alike, sound-alike drug substitution errors in children[33]	Basco WT, Garner,D SS, Ebeling M, Freeland KD, Hulsey TC, Simpson K.	**Prevention strategies:** automatic electronic alerts.
		Number of incidents: for 207 pairs (34%) of drugs with similar spelling or sound, it was estimated that none of the patients received the wrong drug. For 298 pairs (49%) of drugs with similar spelling or sound, it was estimated that the total number of subjects who received the wrong drug was 3,610 (approximately 1 error/day over 10 years). In contract, among the remaining 103 pairs (17%) of drugs with similar spelling or sound, it was estimated that 97,163 subjects received the wrong drug (27 potential errors/day over 10 years).
		Process phases: prescription and dispensing.
Conocimiento de las enfermeras de las dosis de medicamentos en urgencias de pediatria[34]	Guerrero-Márqueza G, Martínez-Serranob A, Míguez-Navarroa C, López-Mirónc JA, Espartosa-Larrayadd M.	**Prevention strategies:** education, elaboration and implementation of drug management and dose protocols.
		Number of incidents: not informed
		Process phases: drug administration (right dose).
Medication errors room: a simulation to assess the medical, nursing and pharmacy staffs' ability to identify errors related to the medication-use system[35]	Daupin J, Atkinson S, Bédard P, Pelchat V, Lebel D, Bussières JF.	**Prevention strategies:** awareness raising of professionals about risks of medication process through simulation/ simulation as a professional education tool. Permanent availability of simulation game online.
		Number of incidents: not informed
		Process phases: prescription, dispensing and administration.

Legend: [a]Pharmacy intervention medication errors (PIMEs); [b]Validated pediatric trigger method (TADEs): validated method to detect potential pediatric adverse events in patient histories; [c]Voluntary incident reports (VADEs); [d]Adverse drug events(ADEs).

DISCUSSION

Strategies to prevent medication errors

The identification of prevention strategies was the main objective in this study. The implementation or improvement in the computerized physician order system was the most investigated type of strategy (25.9%) in the studies assessed, showing a drop in the drug error rates after the interventions[16-17,23-24,26-27,33]. The use of this tool reduces readability errors and facilitates the communication among the teams. In a study involving nursing academics to identify their knowledge on patient safety, the electronic prescription was one of the most mentioned strategies to prevent and reduce drug errors[36].

The studies used a clinical dosing decision support system, automatic electronic alerts for similar names and the implementation of pediatric dosing protocols as allies for the electronic prescription. This computer system is similar to a calculator, inserting the child's weight and age, when the system calculates the medication dose, alerting in case of an overdose or underdose for example[16,23-24,26,33-34]. In another study, a standardization of dose, time and infusion pump programming calculations was implemented for continuous infusion drugs at a Pediatric Intensive Care Unit (PICU), as a strategy to prevent adverse events[30].

The standardization and development of protocols for pediatric dosing management was the focus of a study developed in Madrid/Spain, showing that one third of the nursing professionals do not check the usual dose prescribed[34].

In a study developed at a teaching hospital in the USA, a computerized tool was developed to improve the drug conciliation when the patient is admitted. The tool shows, side by side, the drug list the patient was using before the admission and the list of prescribed drugs while in hospital. This strategy permitted the identification and quantification of the reduction in incidents after the intervention, through the analysis of medication error reports[13].

Double checking is essential to prevent errors in the most critical phases of the medication process. It was highlighted in only one study though, which assessed the nurses' understanding of this procedure[25]. In addition, some studies aimed to implement prevention strategies, such as the use of a checklist, clinical protocol, drug administration flowchart and dose management protocols[10,14,34]. These actions were intended to restructure and organize the medication process to reduce medication errors.

The spontaneous reporting system of adverse drug events is a prevention strategy in the studies analyzed[9,11-12,15,28]. In a study developed in the USA over a five-year period, it was concluded that analyzing drug error reports is a way to encourage others to learn from the errors, avoiding their repetition in the future[12]. Other studies looked for actions to implement error screening strategies through trigger tools or specific questionnaires[11,18]. Important recommendations were identified, such as: increased professional preparation level for pediatric nurses; improved quality of communication on safe drug administration in the interdisciplinary team and between team and families; and acknowledgement of safe drug administration challenges[18].The restructuring of processes based on errors, including educational actions and improved communication in the team, inclusion of reporting in nursing education, using laboratory simulation, development of confidentiality and feedback culture, importance of awareness raising on errors in online virtual games also favor the development of educational strategies to prevent medication errors in child healthcare[31-32,35].

What the health professionals' participation is concerned, the pharmacists stand out as fundamental professionals in the medication process and in the prevention of adverse events. A study developed in Spain demonstrated the significant impact of the clinical pharmacist's intervention in the prevention of prescription error events[19].

Continuing education on drug administration was implemented in a recent study in Brazil. A reduction in dosing errors and a higher error identification rate were identified at the PICU after the intervention[10]. In addition, educational strategies, mediated by focus groups or educational websites and online simulation games, demonstrated to be important interventions to improve the multidisciplinary communication, develop the safety culture and reduce drug-related incident

rates[20,25,29,34].

The analysis of the studies showed a lack of prevention strategies to reduce errors in the medication administration phase. The importance of setting up barriers in all phases of the process is emphasized, but administration, being the final barrier, needs further research to understand the main weaknesses in this process and seek prevention strategies.

Number of patient safety incidents involving drugs

The studies analyzed did not present a standardized method, making comparisons and replications difficult. A standardized research protocol in pediatric patient safety incidents would enhance the consistency of the data and conclusions.

In this IR, the drug error incident rates ranged between 0.91% and 54%, reported in studies that took between three months and ten years[9,16,33]. Only one study, developed in the USA, did not demonstrate a significant reduction in the medication error rates after the implementation of a computerized prescription system[27].

Among the 27 studies analyzed, 10 presented pre and post-intervention drug incident rates. The majority presented a lesser number of incidents after the proposed intervention[10,13-14,16-17,20,22,24,26,29]. In a recent study developed in Japan, the drug error incident rate dropped from 2.23% to 0.66% post intervention within 14 months. The correction rate of near misses increased tenfold after the implementation of the computerized physician order system with clinical decision support[16]. The use of clinical simulation and online virtual games to detect errors was measured in a study developed in Canada, demonstrating that 78.4% of the pharmacists obtained a correct response rate for medication errors. Nurses and physicians reached similar rates (67%). It was concluded that awareness raising about the risks is a fundamental educational action to strength the safe use of medication[35].

In a study developed in the United States, which assessed 608 pairs of drugs with similar names, concerning data were presented on the incident rate, estimating that no switched drug administration occurred in only 34% of the pairs. In 49% (298 pairs) of the drugs with similar writing or sound, the drug was switched on 3,610 occasions, corresponding to a cumulative rate of 01/day over ten years. In 17%, the estimated rate amounted to 27 errors/day, representing 97,163 patients who received switched drugs[33].

In 40.7% of the studies, only the incident rates were measured after the implementation of the educational actions[9,11-12,15,18-19,23,28,31-32,35]. A spontaneous reporting system at a pediatric teaching hospital in São Paulo demonstrated 120 medication error events, being 45.8% in 2007 and 54.2% in 2008[9]. The increased reporting is considered a good result in terms of the development of the safety culture.

The knowledge and follow-up of the drug error incident rates should support the implementation of prevention strategies, demonstrating their efficacy and permitting adjustments. The statistics involving the medication process contribute to dimension the problem and highlight the importance of developing educational strategies to prevent medication errors.

Phases of the medication process with more error records

The prescription is the phase in the medication process with the largest number of adverse events (40.7%)[11,19-21,23-24,26-27,31,33,35]. The medication errors in pediatric patients are directly related with the need for dosing based on exact weight. A computerized prescription system, combined with a clinical decision support system and automatic electronic alerts, are important tools to prevent errors[23,33].

Errors involving wrong drug dosing were also observed in four studies[12,15,17,34]. A study of opioidanalgesics and anti-diabetic agents showed a large number of dose errors[12].

In two studies developed in Brazil, dose omission stood out. The causes can be related to a lack of attention, work burden, stress and lack of staff, but the errors in the prevention systems should be taken into account[9-10].

A study presented the three phases of the medication process (prescription, dispensing and administration), emphasizing that the error problem was related to the system. The participants in the simulation correctly detected 67.5% of the errors related to the medication system[35].

In 37% of the studies analyzed, the objective was not to identify in what phase of the medication process the errors happen[13-14,16,18,22,25,28-30,32]. Most studies analyzed focused on the prescription errors. It is emphasized that all phases of the medication process are interrelated and all health professionals, particularly the nursing team, have responsibilities during this process.

CONCLUSIONS

In this study, the main strategies to prevent drug errors for pediatric inpatients was the implementation of a computerized physician error system, use of clinical simulation, implementation of dose management protocols and adverse event reporting systems.

The incident rate involving the medication process was high and the physician order phase was studied in most of the research. These results appoint the need to develop studies on adverse event prevention strategies in all phases of the medication process for pediatric inpatients.

The analysis of the selected studies underlines the importance of engaging the entire multiprofessional team in the awareness raising and development of the reporting and recognition culture of the risks/factors contributing to errors in the medication process/system.

This study came with some limitations regarding the bibliographic searches, one of them related to the choice of the descriptor "child", which was very broad, resulting in a large number of studies. Another limitation was the great methodological diversity of the selected studies, making in-depth comparisons among the studies difficult.

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