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REVIEW ARTICLE

Medication errors in pediatrics

Errores de medicación en pediatría

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What do we know about the subject matter of this study?

Medication errors (MEs) can be related to professional practice, products, procedures, or systems, including failures at any stage of medication use.

What does this study contribute to what is already known?

This study allowed us to identify the occurrence of medication errors in the pediatric population, as well as their classification according to the stage of medication use when they occurred.

Abstract

Medication errors (ME) are preventable incidents of inappropriate use of medications by health personnel or by the patient. These events can occur at any stage of drug use generating significant costs to the health system and, in some cases, these can even lead to death. The pediatric population is considered susceptible to ME with a prevalence 3 times higher than adult patients. **Objective:** To identify the prevalence of medication errors in hospitalized pediatric patients, as well as their classification according to the stage of use of the medication when they occurred. **Method:** A literature review of ME in pediatrics was carried out through a Pubmed / Medline search using Mesh terms ("Medication Errors" and "Pediatrics") in the last 10 years. Three investigators reviewed independently the identified articles considering the STROBE checklist for observational studies. **Results:** 192 bibliographic references were identified, 22 of them were eligible for review and data collection. Studies reported an error rate between 1% and 58% of the evaluated medication indications, with errors reported in different processes of drug use. 9 articles (41%) described errors related only to prescription, mainly associated with incorrect dosage, 6 (27%) errors related to prescription, administration, and other processes, 3 (14%) related to prescription and administration, 2 (9%) related only to administration, 1 (4%) article reported errors related to conciliation, and 1 (4%) described errors related to preparation and administration. **Conclusion:** The studies reported different medication errors in the pediatric population. Most of them reported ME related to prescription followed by ME in the administration. Knowing the proportion of ME allows focusing interventions aimed at reducing their prevalence.

Keywords:
Medication Errors;
Pediatrics;
Patient Safety;
Medical Errors

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Introduction

Medication errors (MEs) are defined as any preventable incident that may harm the patient or result in inappropriate use of medications when these are under the control of healthcare professionals or the patient her/himself. They can be related to professional practice, products, procedures, or systems, including failures at any stage of medication use including prescribing, transcribing, medication orders review, dispensing, preparation, labeling, administration, education, and patient monitoring[1].

In general, MEs account for around 37% of the errors in health care that cause adverse events or incidents[2], generating additional expenses in health systems. The World Health Organization (WHO) estimates an annual global cost of US$ 42 billion associated with medication errors, almost 1% of health expenditure worldwide[4].

Different factors have been identified as causes of MEs, some related to the drug, such as drugs with similar names and appearance, drugs with a narrow therapeutic margin and those with special conditions for their administration, other factors related to the patient such as altered renal or hepatic function, cognitive impairment, and polymedication, and finally, factors related to health professionals such as the degree of training and level of study, excessive workload, among others[5].

The pediatric population is considered vulnerable to the occurrence of MEs, with a prevalence 3 times higher compared with the data reported in adult patients. Approximately 100 to 400 prescribing errors occur for every 1,000 hospitalized pediatric patients[3,6].

Among the main causes of error described in this age group are[3-6]:

– Need to calculate doses according to weight, age, body surface area, and small calculation errors such as the use of decimals, which can trigger serious consequences.

– Most drugs have not been approved for use in pediatric patients and appropriate prescribing guidelines have not been developed for this population, thus extrapolating the information described for adults.

– Lack of dosage forms designed for pediatric patients, requiring adjustments and greater handling of the drugs at the time of administration.

Bearing in mind the importance of MEs in healthcare systems around the world and the negative health effects they generate, in 2017, the WHO launched a global initiative to reduce medication-related errors by half within five years, calling on healthcare institutions and authorities to incentivize the development of strategies to meet this goal[4].

As a starting point for the prevention of MEs, it is necessary to identify them and determine the causes of their occurrence. In this context, the objective of this study was to identify the prevalence of medication errors in hospitalized pediatric patients, as well as their classification according to the stage of medication use when they occurred.

Methods

A literature search was performed in the PubMed/Medline database of articles published from June 2009 to May 2019, in English and Spanish, and with full-text access. The search was performed with the following Mesh terms: "*Medication Errors*" and "*Pediatrics*", filtering by studies in humans, in Spanish and English, published in the last 10 years. The inclusion criteria were articles that described in the title or abstract information on medication errors in hospitalized pediatric patients. We excluded articles without any relation to the objectives of the review, without full-text access, studies of patients in simulated scenarios, and those that did not quantify the reported medication errors or did not allow calculating the prevalence of MEs.

The articles identified were reviewed independently by three investigators, considering the STROBE guidelines for observational studies. The titles and abstracts of all the identified publications were reviewed to decide their eligibility, then the selected articles were analyzed all together, and, by consensus, we defined their inclusion or not. Errors were classified according to the stage of drug use when they occurred, i.e., prescription, medication orders review, administration, among others.

Results

192 bibliographic references were identified, 22 were eligible for review and data extraction. Figure 1 shows the process of selection and exclusion of the articles. On reviewing compliance by sections of the items suggested in the STROBE guidelines in the articles included, we observed that in general 84% of the recommendations included in the "Title and Abstract" section, 95% in the "Introduction", 42% in the "Methods", 50% in "Results", and 73% in the "Discussion" section were complied with. Less than 50% of the articles complied with the recommended methodological aspects, reaching only 14% compliance regarding the control of potential sources of bias and the statistical methodology used to control confounding factors, and 36% compliance when describing the calculation of the sample size.

The selected studies reported a proportion of

errors between 1% and 58% of the medication indications evaluated. Of the 22 included articles, 9 (41%) described errors related only to prescribing[7-15] (table 1); 6 articles (27%) described errors related to prescribing, administration and other processes[16-21] (table 2); 3 (14%) described errors related to prescribing and administration[22-24] (table 3); 2 (9%) articles described errors related only to administration[25,26]; 1 (4%) article reported errors related to reconciliation[27], and 1 (4%) described errors related to preparation and administration[28] (table 4).

Errors related to the prescribing process were the most prevalent, mainly related to prescribing incorrect doses. Most of the errors related to administration reported the administration of incorrect medication, administration by an incorrect route, incorrect concentration, error in the preparation, and omitted doses. In the medication reconciliation, there were errors related to the lack of prescription of necessary medication.

Discussion

The different studies included in the review allow us to identify the occurrence of medication errors in the pediatric population, as well as their classification according to the stage of medication use when they occurred. The results reported errors in prescribing, medication orders review, dispensing, preparation, administration, patient monitoring, reconciliation, and involved different health professionals such as the physician, pharmacist, nurse among others, suggesting vulnerability in the prevalence of these errors without differentiating actor or profession[1].

The STROBE guidelines provide valuable recommendations that help authors to report the results of their observational studies, editors and reviewers who consider publishing these papers, as well as readers who value such research[29]. The 22 articles included in the final review complied 100% with recommendations 2 and 18 of the "introduction" and "discussion" sections, respectively. These findings were expected since recommendation 2 refers to the scientific basis of the research and generally, all papers should know the basis for posing the question and what are the aspects that justify the work to be carried out. Jeeline et al. evaluated 80 cross-sectional studies published in an Indian journal, found that 100% complied with recommendation 2 and 78 (98%) with the recommendation 18[30]. None of the included studies complied with item 12e which refers to the "sensitivity analyses", similar to what Poorolajal et al. found in 60 evaluated papers[31].

The calculation of the sample size was one of the items with lower compliance since in many of the

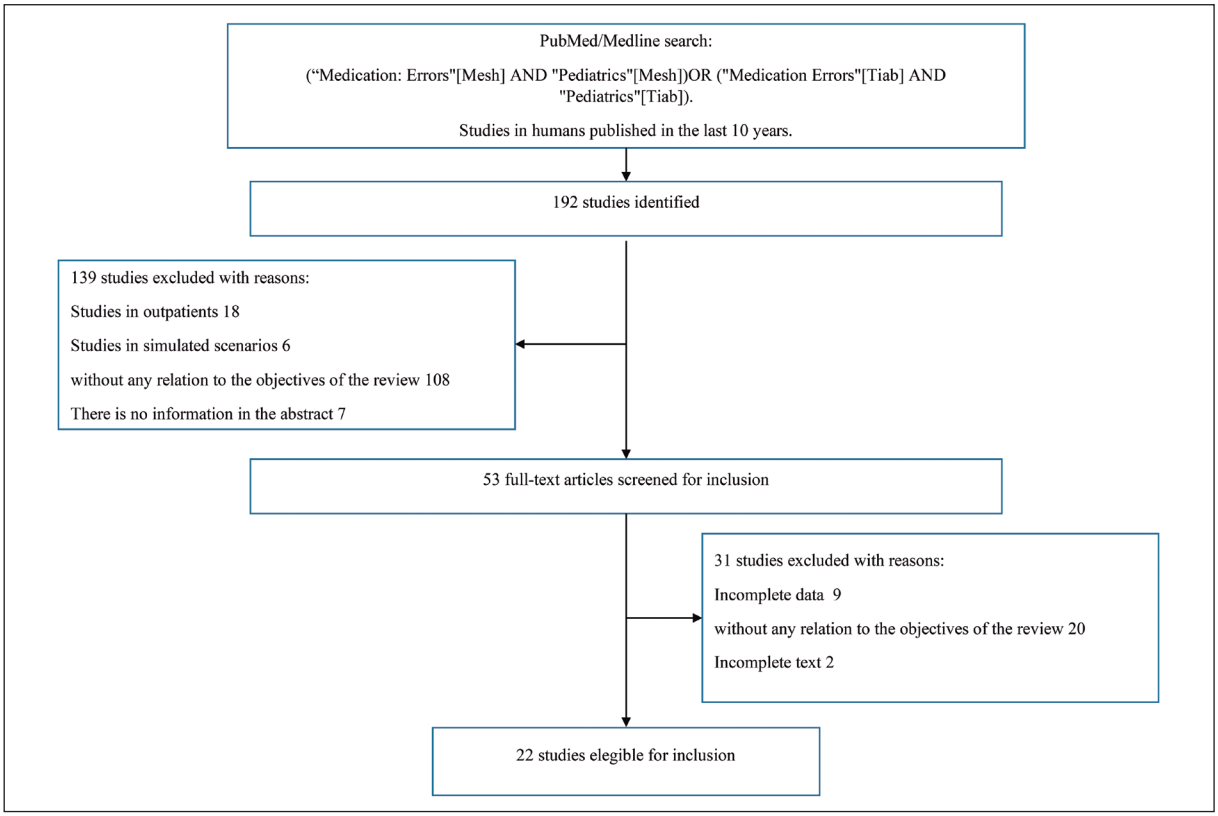

Figure 1. Selection and exclusion of the articles.

studies included in the review, they used convenience sampling because they were studies of spontaneous reporting systems of MEs and cross-sectional studies that described the MEs detected in a specific period.

Although most of the studies included in the final review were from the United States (7 out of 22), there were studies from different countries such as France, Israel, Spain, England, among others, which shows that, as described by the WHO, medication errors are a global problem affecting the different health systems in the world, jeopardizing the quality of care and even compromising the lives of patients. This issue deserves special attention, especially in the pediatric population, considering that the prevalence has been reported to be 3 times higher when compared with adult patients[3,4].

The WHO reported that only in the United States, medication errors in the general population cause at least one death per day and damage in approximately 1.3 million people per year[4]. The studies included in this review did not describe in detail data on mortality or outcome of MEs, they only reported the process when they occurred with their respective proportion. Regarding the above, it is necessary to carry out studies that allow a more precise estimation of the impact on patient safety as well as the additional costs generated by MEs in health systems and patient care.

The total proportion of MEs reported in the medication orders evaluated in the different studies was variable, as was the study period. Additionally, it was found that the way of reporting and classifying the MEs was not homogeneous, observing that some studies described reports from the institutions' patient

Table 1. Medication errors (ME) related to prescribing

Study type	Date of publication	Country	Study time (month)	# medication orders	% Medication orders with ME	Total ME	# ME (%)	Type of ME	Reference
Cross-sectional	2015	USA	12	350	13	46	17 (37) 22 (48) 7 (15)	- Other - Wrong dosage - Wrong frequency	(7)
Quasi-experimental	2012	Spain	ND	2.228	0,72	16	16 (100)	- Wrong dosage	(8)
Cross-sectional	2009	USA	ND	374	11	41	16 (39) 12 (29)	- Wrong dosage - Wrong frequency - Wrong route of administration	(9)
Cross-sectional	2014	Ethiopia	1	384	58	223	70 (31) 16 (7) 10 (5) 4 (2) 2 (1) 121 (54)	- Wrong dosage - Wrong pharmaceutical form - Wrong frequency - Wrong drug - Wrong route of administration - Other	(13)
Cross-sectional	2011	Spain	0,2	1.906	5	92	50 (54) 42 (46)	- Wrong drug - Wrong dosage	(10)
Case control-study	2014	USA	2	1.361	15	201	201 (100)	- ND	(12)
Cross-sectional	2015	USA	5	2.941	6	173	4 (2) 102 (60) 7 (4) 5 (3) 11 (6) 44 (25)	- Wrong drug - Wrong dosage - Wrong pharmaceutical form - Wrong route of administration - Wrong concentration - Wrong frequency	(14)
Cross-sectional	2011	USA	27	360	34,72	125	125 (100)	- Wrong dosage	(15)
Cohort study	2011	Iran	ND	7.137	29,61	2.113	2.113 (100)	- ND	(11)

ME: Medication errors; ND: No data.

Table 2. Medication errors related to prescribing, administering and others stages of medication use

Study type	Date of publication	Country	Study time (month)	# medication orders	% Medication orders with ME	Total ME	# ME (%)	Stage of medication use	Type of ME	Reference
Cross-sectional	2017	Francia	7	4722	4	179	60 (34)	Prescribing	- Wrong frequency	(16)
							57 (32)		- Wrong dosage	
							30 (17)		- Wrong concentration	
							12 (7)		- Contraindicated drug	
							10 (5)	Monitoring	- Non monitoring	
							10 (5)	Medication orders review	- Drug interaction	
Cross-sectional	2012	EEUU	2	5432	6	322	237 (74)	Prescribing	- ND	(17)
							55 (17)	Transcribing	- ND	
							21 (6)	Other	- ND	
							7 (2)	Administering	- ND	
							2 (1)	Dispensing	- ND	
Cohort study	2014	China	36	1474	5	71	35 (49)	Prescribing	- Wrong dosage	(18)
							19 (27)		- Wrong drug	
							7 (10)	Administering	- Drug omission	
							7 (10)	Other	- ND	
							3 (4)	Medication orders review	- Wrong drug	
Cross-sectional	2012	España	36	61458	2	1.494	363 (24)		- Wrong drug	(19)
							88 (6)	Prescribing	- Wrong route of administration	
							945 (63)		- Wrong dosage	
							43 (3)		- Drug omission	
							11 (1)	Monitoring	- Non monitoring	
							41 (3)	Administering	- Wrong route of administration	
							3 (0)		- Wrong frequency	
Cross-sectional	2016	Etiopía	1	1115	46	513	235 (46)	Prescribing	- ND	(20)
							21 (4)	Dispensing	- ND	
							202 (39)	Administering	- ND	
							12 (2)	Transcribing	- ND	
							43 (8)	Monitoring	- Non monitoring	
Cross-sectional	2015	Korea	276	1222	19	236	15 (6)	Prescribing	- Wrong drug	(21)
							62 (26)		- Wrong dosage	
							134 (57)	Administering	- Wrong drug	
							4 (2)		- Wrong dosage	
							3 (1)		- Wrong pharmaceutical form	
							10 (4)		- Wrong route of administration	
							8 (3)	Other	ND	

ME: Medication errors ND: No data

Table 3. Medication errors related to prescribing and administering

Study type	Date of publication	Country	Study time (month)	# medication orders	% Medication orders with ME	Total ME	# ME (%)	Stage of medication use	Type of ME	Reference
Cross-sectional	2010	USA	3	1802	9	161	112 (70)	Prescribing	-Wrong dosage	(22)
							45 (27)		-Wrong drug	
							4 (3)	Administering	-Wrong route of administration	
Cross-sectional	2018	France	5	11573	1	102	57 (55)	Prescribing	-Wrong treatment duration	(23)
							20 (20)		-Wrong dosage	
							9 (9)		-Prescribing omissions	
							8 (8)		-Wrong drug	
							5 (5)		-Wrong pharmaceutical form	
							1 (1)		-Non monitoring	
							1 (1)	Administering	-Wrong route of administration	
							1 (1)		-Incorrect technique	
Cross-sectional	2017	Israel	12	3780	8	310	3 (1)	Prescribing	-Prescribing omissions	(24)
							16 (5)		-Wrong dosage	
							12 (4)		-Wrong route of administration	
							51 (16)		-Wrong drug	
							17 (5)		-Wrong frequency	
							120 (39)	Administering	-Wrong frequency	
							2 (1)		-Wrong route of administration	
							81 (26)		-Drug omission	
							8 (3)		-Wrong dosage	

ME: Medication errors

Table 4. Medication errors related to different stages of medication use

Study type	Date of publication	Country	Study time (month)	# medication orders	% Medication orders with ME	Total ME	# ME (%)	Type of ME	Reference
Studies related with medication errors in administering									
Quasi-experimental	2015	Germany	2	1920	58	1113	1113 (100)	- ND	(25)
Cross-sectional	2010	Malaysia	3	857	12	104	14 (13)	- Wrong dosage	(26)
							7 (7)	- Wrong drug	
							36 (35)	- Wrong concentration	
							30 (29)	- Wrong route of administration	
							17 (16)	- Drug omission	
Studies related with medication errors in drug reconciliation									
Cross-sectional	2018	Jordan	3	411	3	13	8 (61)	- Prescribing omissions	(27)
							5 (39)	- Wrong drug	
Studies related with medication errors with preparation and administration									
Quasi-experimental	2012	Netherlands	1	595	44	263	65 (25)	- Wrong preparation	(28)
							198 (75)	- Wrong administration	

EM: Errores de medicación.

safety systems and others described data reported by pharmacists in the process of reviewing medication orders, which hinders the comparison between the results obtained. In this regard, Falconer et al carried out a review that described the numerous terms used to describe drug-related events, finding a lack of consistency in definitions, classifications, and applications, including ambiguous words, lack of clarity, and consensus in subclassifications. Finally, there is an urgent need for further international discussion and consensus on this issue through the adoption of standard descriptors by professional groups, and regulatory and governmental organizations that promote quality improvement and patient safety[32].

The prescription process was the one that gathered the largest number of studies that reported associated MEs, where the main cause was medication orders with incorrect doses. Dosing errors in the pediatric population occur mainly when making calculations in relation to the weight and/or body surface area of patients, as well as converting units in the prescription process (milliliters to drops, micrograms to grams, milliequivalents to milligrams)[15]. In addition, most of the drugs on the market have not been approved for use in pediatric patients, thus extrapolating the information described for the adult population and sometimes there has been a lack of knowledge and experience of health personnel to care for this age group[3,33]. Therefore, and according to the data from the above-mentioned studies, it is necessary to focus especially on the process of prescribing medications. It has been described that the training and education of health personnel, as well as the standardization and implementation of medical management protocols, decrease the incidence of MEs[14].

Regarding the MEs in administration, incorrect concentration was the most frequent type of error associated with a lack of knowledge of the adequate concentrations for a safe administration and errors in calculating dilutions[24]. Calculation errors could also occur when fractioning doses, converting dosage units, as well as when estimating infusion rates. Other administration-related MEs are improperly fractioning drugs with special pharmaceutical properties such as enteric-coated or extended-release tablets for enteral administration, as well as concomitant intravenous administration of incompatible drugs[21,25,26].

Knowing the causes of medication errors, as well as the details of their distribution in the stages of medication use, allows sizing the error and targeting interventions to improve the system and prevent the incidence of similar errors in the future. Learning more about MEs can improve the ability of health care professionals to provide safer care to patients[5].

Different recommendations to prevent MEs have been published by institutions working on patient safety, such as the American Hospital Association (AHA), the Institute for Healthcare Improvement (IHI), the Institute for Safe Medication Practices (ISMP), and the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), among others[34]. Among these recommendations are the development and standardization of medical prescriptions through the use of electronic medical records (EMR), which has reported a reduction of up to 40% of the MEs[35]; the incorporation of clinical decision support systems in the EMR, which in a hospital in the United States showed an 86% reduction in severe MEs[36]; the use of intelligent intravenous infusion pumps, which has shown a significant reduction in errors related to the calculation of infusion rates; the active involvement of pharmacists in the interdisciplinary patient care team, which has resulted in greater detection and reduction of prescription errors through medication orders reviewof medication orders and monitoring of drug therapy; standardization of treatment protocols, mainly in special procedures; establishment of institutional policies and guidelines for the management of high-risk medications; use of bar code technology in the dispensing and administration of medications; standardization in the prescription and preparation of high-risk medications such as concentrated electrolytes, opioid and sedative drugs, benzodiazepines, inotropes; encouraging continuous and specific training of personnel in the safe and appropriate use of medications as well as in pediatric patient care; identifying and segregating in storage medications with similar appearance and name that could be confused when dispensed and administered; control working conditions such as light, stress, workload, and interruptions; encourage collaboration and multidisciplinary assistance among the different groups involved in the use of medications, as well as educate and involve the patient and family members in the management of the disease and pharmacological treatment[37].

The limitation of this study is that the search was restricted to the PubMed/Medline database and only used the terms "*Medication Errors*" and "*Pediatrics*", hindering the identification of other studies containing data of interest obtained in Latin American countries; however, the information analyzed in this study allows us to provide relevant data on this problem in the pediatric population.

Conclusions

This review allowed us to identify studies that report different medication errors in the pediatric population, as well as their distribution in the stages of medication use. Most of the studies reported MEs related to prescription followed by MEs in administration.

Knowing the proportion of MEs allows targeting interventions aimed at reducing their prevalence.

Spontaneous reporting systems are an important source of information on adverse events and medication errors in healthcare institutions. Therefore, their implementation and permanence should be encouraged, aiming at designing programs and processes that consider the active participation of the personnel, assuming reporting as part of the healthcare tasks with a vision of continuous improvement, encouraging attitudinal change, and working towards quality and safe patient care.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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