Heliyon 9 (2023) e15375

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Medication errors and associated factors among pediatric inpatients in public hospitals of gamo zone, southern Ethiopia

Agegnehu Bante [a,*], Abera Mersha [a], Zeleke Aschalew [a], Aklilu Ayele [b]

[a] School of Nursing, College of Medicine and Health Sciences, Arba Minch University, Arba Minch, Ethiopia
[b] Department of Pharmacy, College of Medicine and Health Sciences, Arba Minch University, Arba Minch, Ethiopia

ARTICLE INFO

Keywords:
Incidence of medication errors
Risk factors
Predictors
Determinants
Children
Ethiopia

ABSTRACT

Background: Medication errors are the most common medical errors in the world. In particular, pediatric patients are more susceptible to severe injuries and death. Despite their multidimensional impact, medication errors are not recognized well in developing nations, including Ethiopia. Thus, this study aimed to assess the prevalence of medication errors and associated factors among pediatric inpatients in public hospitals of Gamo zone, southern Ethiopia.
Methods: A facility-based cross-sectional study was conducted among 416 pediatric inpatients from August 1, 2020, to February 30, 2021. Open data kit tools and Stata version 16.0 were used for data collection and analysis, respectively. Bivariable and multivariable analyses were performed to identify factors associated with medication errors. An adjusted odds ratio with a 95% confidence interval was computed and a P-value of <0.05 in the multivariable analysis was set to declare statistical significance.
Results: Overall, 69.5% (95% CI: 64.80, 73.86) of pediatric inpatients experienced medication errors. Unsuitable working environment (aOR: 2.40, 95% CI: 1.48, 3.91), child weight <5 Kg (aOR: 3.72, 95% CI: 1.79, 7.73), medication administered by diploma professionals (aOR: 2.10, 95% CI: 1.31, 3.36), parent involvement (aOR: 0.55, 95% CI: 0.33, 0.95), non-adherence with medication administration rights (aOR: 2.68, 95% CI: 1.32, 5.44) and hospital stay for >5 days (aOR: 1.83, 95% CI: 1.15, 2.93) were significantly associated with medication errors.
Conclusion: Medication errors were high among pediatric inpatients as compared to previous national studies. To reduce the occurrences of medication errors, it is critical to create a suitable working environment, arrange education and training opportunities for providers, involve families in the medication administration process, and strictly adhere to medication administration rights.

1. Introduction

Medication error is defined as any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is under the healthcare professional, patient, or consumer's control. These occurrences could be related to professional practice, healthcare products, procedures, and systems, such as prescription, order, communication, labeling, packaging and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use [1–3].

* Corresponding author.
E-mail address: agegnehubante@gmail.com (A. Bante).

https://doi.org/10.1016/j.heliyon.2023.e15375
Received 12 July 2022; Received in revised form 30 March 2023; Accepted 4 April 2023
Available online 11 April 2023
2405-8440/

Medication errors (MEs) are the most common medical errors worldwide, especially in pediatrics [4]. In a review article involving 113 intensive care units (ICUs) from 27 countries, 74.5% of the participants experienced MEs [5]. A study in India found that 68.5% of the medication end up with errors [6]. Similar to many developing countries MEs are common in Ethiopia; a study conducted at Jimma University Specialized Hospital (JUSH) and Tigray found that 89.9% and 62.7% of pediatric inpatients encountered medication errors, respectively [7,8]. Furthermore, 75.5% of children in western Ethiopia experienced MEs [9].

Previous empirical studies reported that lack of adequate staffing, medical complications, lack of therapeutic training, inadequate drug knowledge, minimal experience, work overload and poor communication, distractions, interruptions, lack of standardized protocols and procedures, and insufficient resources are associated with MEs [10–14].

Pediatric inpatients require medication to be prescribed individually based on their age and body weight [15]. They are the most vulnerable group of clients, susceptible to a wide range of errors; particularly, low birth weight and preterm babies are more vulnerable to the adverse squeal of medication inaccuracies due to their limited ability to 'buffer' such errors [16,17]. Furthermore, the scarcity of pediatric formulations and a lack of manufacturer information on how to prepare these medications raises the risk of errors in children [17–20].

Medication errors can result in either preventable or unpreventable adverse drug events [21,22]. A systematic review of 51 studies from nine African countries found that 8.4% of children experience adverse drug events [23]. According to a South African study 16% of children died as a result of adverse drug reactions [24]. Similarly, a study in Nigeria discovered 40 suspected adverse drug reactions out of 53 medications administered [25]. Although the majority of errors are minor, some fatal errors result in serious injury or death [26,27]. Evidence revealed that 1.5–71% of pediatric inpatients experience adverse drug events [9,28–31] and 2.9% died [24] as a result of MEs. Furthermore, MEs increase the length of hospital stay, medical costs, parental distress, and erode public trust in healthcare services [32].

Safe medication administration is the foundation for proper patient care [33]. Understanding how and why MEs occur, as well as working as a team in a "culture of safety", and providing employees with a working environment that protects them from human fallibility, is critical to implementing a successful intervention to reduce MEs [34,35]. Medication review and reconciliation (MedRec) automated information systems, in-service training, and multicomponent interventions have a significant impact on ME reduction [14, 34]. Furthermore, medication administration rights serve as a foundation for improving MEs. The Food, Medicine, and Health Care Administration and Control Authority (FMHACA) also emphasizes avoiding excessive drug use and assisting health institutions at various levels in the development and dissemination of standard treatment guidelines [36]. However, in low and middle-income countries these standards are not effectively implemented [14,33].

Despite studies focused on MEs have been conducted in developed countries, such evidences are insufficient in the context of Sub-Saharan Africa. As far as our knowledge concerned there is no concrete evidence regarding MEs and their associated factors among pediatric inpatients in Ethiopia. Thus, the purpose of this study was to determine the prevalence and associated factors of medication errors among pediatric inpatients in public hospitals of Gamo zone, southern Ethiopia.

2. Methods and materials

2.1. Study design, setting, and period

A facility-based cross-sectional study was conducted in public hospitals of Gamo zone, Southern Ethiopia from August 1, 2020, to February 30, 2021. In Gamo zone, there were six hospitals (one general and five primary hospitals), of which this study was conducted in two hospitals: Arba Minch general hospital (AMGH) and Chencha primary hospital (CPH). AMGH, located in Arba Minch town, is the Gamo zone's largest hospital with an annual admission of 2313 pediatric patients. The hospital had 33 nurses and five pediatricians that serves in pediatrics units and NICU, and 97 beds. On the other hand, CPH is located in Chencha town and provides pediatric care with 15 nurses, one pediatrician and 28 beds. The hospital admitted approximately 956 pediatric patients per year.

2.2. Study population

All pediatric patients admitted to AMGH and CPH were considered as the study population for this study. Those who took at least one medication and stayed in the hospital for at least 24 h were included. Pediatric inpatients with major congenital anomalies, such as hepatic and kidney disorders, were excluded.

2.3. Sample size determination

The sample size was determined using a single population proportion formula by considering the following assumptions: 95% level of confidence, 5% margin of error, 46% proportion of MEs from the study conducted in west Ethiopia [9].

$$\mathrm{n}=\frac{(\boldsymbol{Z\alpha}/\mathbf{2})^{2}*\boldsymbol{p}(\mathbf{1}-\boldsymbol{p})}{\boldsymbol{d}^{2}}=\frac{(\mathbf{1.96})^{2}*\mathbf{0.46}(\mathbf{1}-\mathbf{0.46})}{\mathbf{0.05}^{2}}=\sim\ \mathbf{382}$$

Where; n: minimum sample size for a statistically significant survey; Z: is the significance level at 95% level of confidence = 1.96; P: proportion of MEs (0.46) and d: margin of error (It had been taken as 5%). After adding a 10% nonresponse rate, the final sample size was 421.

2.4. Sampling technique

Of the six hospitals in Gamo Zone, two (AMGH and CPH) were involved in this study. The sample size was proportionally allocated based on the previous year case flow of each hospital. Systematic random sampling technique was used to select the participants. The sampling interval (k) was computed by dividing the total annual admission by the sample size 3269/416 = ~7. The first participant was selected by using a lottery method; 2 was taken at random and used as a sampling interval. Then, based on their admission order participants was selected with an interval of two until the target sample size achieved.

2.5. Data collection methods

A structured questionnaire was used to collect all necessary information for this study. The tool was developed after reviewing scholarly articles, WHO medication administration standards, and National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) safe medication administration recommendations [3,37]. It includes background information, healthcare provider characteristics, child medical conditions, facility conditions, and medication orders and administration-related information. Finally, the tool was organized in XLSForm using excel spreadsheet and uploaded to Google Drive to collect the data using Open Data Kit (ODK) tools [38].

Six BSc and two MSc professionals who did not work in the study hospitals were involved as data collectors and supervisors, respectively. The data collection team received two days of theoretical and practical training on the study's objectives, data collection techniques and procedure using the ODK collect. Furthermore, one month before the actual data collection, the tool was pretested on 21 pediatric inpatients at AMGH. The child was involved in the study after his or her parents provided voluntary informed written consent. A variety of data collection methods were used, including parent interviews, observation of the healthcare provider while reconstituting and administering medication, and retrieval of the child's medical records. MEs that may have contributed to fatal problem were immediately reported to the provider in charge. Furthermore, depending on the error, providers were asked to provide an antidote to the error. Supervisors checked the data collection process regularly and assisted data collectors in sending completed data to the server via a wireless connection.

2.6. Study variables and measurements

The outcome variable was medication errors, which is a composite variable derived from prescribing, preparation, dose, duration, frequency, administration, omission, and unauthorized drug administration errors, which were operationally defined under Table 1 [7–9,20,39,40]. The Ethiopian pocketbook of pediatric hospital care, and the WHO pocket book of hospital care for children were used to determine MEs [37,41]. The independent variables include healthcare professionals' related variables such as educational status, experience, training, qualification, communication, and workload. Child-related variables such as age, weight, medical diagnosis, and involvement of family members, hospital stay, and the number of drugs taken during the hospital stay. Variables such as medication preparation room leveled medication shelf, availability of computer or calculator machine to calculate drug dose, medication card index, fluid perfuse machine, medication administration protocol, standard weight measurement and documentation system, and any

Table 1
Description of variables and measurements for the study conducted in public hospitals of Gamo Zone, Southern Ethiopia, 2021.

Variables	Measurements
Medication preparation error	When the medication was prepared or manipulated incorrectly. This includes an incorrect method of reconstitution or dilution, not shaking the suspension thoroughly and crushing of specially coated tablets.
Dose error	A dose that was prescribed or administered was >10% above or below the correct dose based on the patient's weight.
Duration error	Medication administered for a longer period than was prescribed, or prescribed medication that was not discontinued when indicated.
Frequency error	Medication was administered at incorrect intervals (e.g., 8-hourly instead of 6-hourly).
Medication administration error	Administration of medication that was not prescribed, misread prescription, or medication administered to the wrong patient.
Time Error	There was a> 1-h difference between the scheduled time and time of administration.
Omission Error	Failure to administer prescribed medication, or medication that was being administered without noting that it had been dispensed.
Unauthorized error	When the prescriber did not authorize the medication administered
Prescribing Error	Elements of good prescribing practice were observed and each medication prescribed was evaluated for compliance with pharmacy legislation as stipulated in good pharmacy practice, i.e., the correct name, dosage, units, route, frequency, and duration of treatment.
Wrong route	Includes order written for the wrong route, transcribed for wrong route and medication administered to a patient using a different route than ordered.
Medication error	An occurrence of a single or combination of the above-listed errors while administering a medication to a child.
Medication errors per 100 admission	It is the number of errors per hundred admissions/participants and calculated as total number of medication errors divided by total number of participants/admission times hundred.
Medication errors per 100 order	It is number of errors per hundred medication orders and calculated as total number of medication errors divided by total medication orders times hundred.
Medication errors per 100 patient-days	Patient days is the number of days that patients stay in the hospital. Medication error per 100 patient days was calculated as total number of medication errors divided by total number of patent days times hundred.

interruption during medication administration were included under the facility's infrastructure. In addition, medicine-related variables such as route of administration, drug-drug interaction, type of drug, time of administration, labeling, and packaging were included.

2.7. Statistical analysis

The data set was downloaded as an excel file from Google Drive and imported into Stata version 16.0 for analysis. To describe the characteristics of participants, descriptive statistical analyses such as simple frequencies, mean, and standard deviation were used. MEs were counted and described as per 100 orders, admissions, and patient days. Bivariable analysis was used to examine the relationship between each independent variable and the outcome variable. Variables with a P-value of ≤0.25 in the bivariable analysis were included in the multivariable analysis. Multicollinearity and model goodness of fit were assessed using standard error and Hosmer-Lemeshow, respectively. Finally, an adjusted odds ratio with a 95% CI was calculated, and variables with a P-value of <0.05 were considered as factors significantly associated with MEs.

2.8. Ethical considerations

Arba Minch University's College of Medicine and Health and Sciences Institutional Review Board granted ethical approval (IRB) for this study. Furthermore, permission was obtained from the respective hospital administrators. Before beginning data collection, the child's parents were given written consent after explaining the purpose of the study. Code numbers were used throughout the study to protect the confidentiality of information gathered from study participants. When fatal MEs were noticed, the provider in charge was immediately notified, and appropriate management was initiated.

Table 2
Background characteristics of pediatric inpatients in Gamo zone public hospital, Southern Ethiopia, 2021 (n = 416).

Variables	Category	Frequency	Percentage
Age category	≤28 days	101	24.28
	29–365 days	116	27.88
	1–3 years	75	18.03
	4–6 years	43	10.34
	7–10 years	48	11.54
	≥10 years	33	7.93
Sex	Male	260	62.50
	Female	156	37.50
Residence	Urban	117	28.12
	Rural	299	71.88
Weight in Kg	<5	124	29.81
	5 to 10.99	154	37.02
	11 to 19.99	75	18.03
	≥20	63	15.14
Family involvement in childcare	Yes	280	67.31
	No	136	32.69
Level of consciousness	Conscious	385	92.55
	Unconscious	31	7.45
Severity of the disease	Healthy looking	94	22.65
	Acute sick looking	102	24.60
	Sub-critical	127	30.53
	Critical	79	19.00
	Severe	14	3.37
Previous history of medical illness	Yes	103	24.76
	No	313	75.24
Diagnosis criteria	Empirical	75	18.03
	Laboratory investigation	18	4.33
	Both empirical and laboratory investigation	323	77.64
Number of diseases per patient	1	192	46.15
	2	138	33.17
	≥3	86	20.67
Number medications per patient	≤2	189	45.43
	3–4	165	39.66
	≥5	62	14.90
Hospital stays in days	≤5	185	44.47
	>5	231	55.53

3. Results

3.1. Participant's characteristics

A total of 416 pediatric inpatients were involved in this study, with a response rate of 98.8% and a total hospital stay of 2601 patient days. Among the participants, 116 (27.88%) were within the age group of 29–365 days, 260 (62.5%) were male, 299 (71.88%) were rural dwellers, and 280 (67.31%) of the child's family were involved in the medication administration process. The patients' mean weight was 10.64 Kg (SD ± 8.64). Most, 385 (92.55%) of the participants were conscious, 102 (24.60%) appeared acutely ill, 103 (24.76%) had a history of medical illness, 62 (14.9%) received five and above medications, and 231 (55.53%) stayed in the hospital for more than 5 days (Table 2). Over 137 medical conditions were identified as reasons for admission; one-fifth (19.5%) were admitted due to pneumonia. Furthermore, 74 (17.8%), 69 (16.6%), and 54 (13.0%) were admitted due to meningitis, severe acute malnutrition, and sepsis, respectively (Fig. 1).

3.2. Medication prescription-related characteristics

During the study period, 1253 medications were prescribed, with 1174 (93.69%) ordered by physicians and medical interns. The healthcare provider in charge of the medication prescription had an average experience of 14.43 (SD of ±27.56) months. Two-thirds of the medications, 790 (63.1%) were prescribed by male providers. None of the prescription papers contain all the standard prescription form components recommended by national guidelines; patients' weight (8.9%), address (8.7%), and gender (5.3%) were the most missed components to be written on the prescription papers (Fig. 2). Of the prescribed medications; 345 (27.53%), 324 (25.86%) and 178 (14.21%) were antibiotics, fluids, and analgesics/antipyretics, respectively. Moreover, 226 (32.47%) of the antibiotics, 148 (21.26%) of the fluids, and 98 (14.08%) of the analgesics/antipyretics ends up with errors **(Table 3)**.

3.3. Medication administration-related characteristics

More than half of the medications, 225 (54.05%) were administered by diploma healthcare providers. The mean experience of those in charge of medication administration in that service unit was 19.69 (SD ± 23.12) months. Every day, the healthcare providers care for 7 (SD ± 4.7) patients. More than half, 223 (53.6%), of the patients were treated by male providers, and only 43 (10.3%) of the medications were administered by following the medication administration rights. Nearly half of the patients' medications, 201 (48.3%), were prepared in a suitable working environment. Majority, 876 (69.91%), of the medications were administered via IV, and 1063 (84.84%) drugs were available within the hospital pharmacy (Table 4).

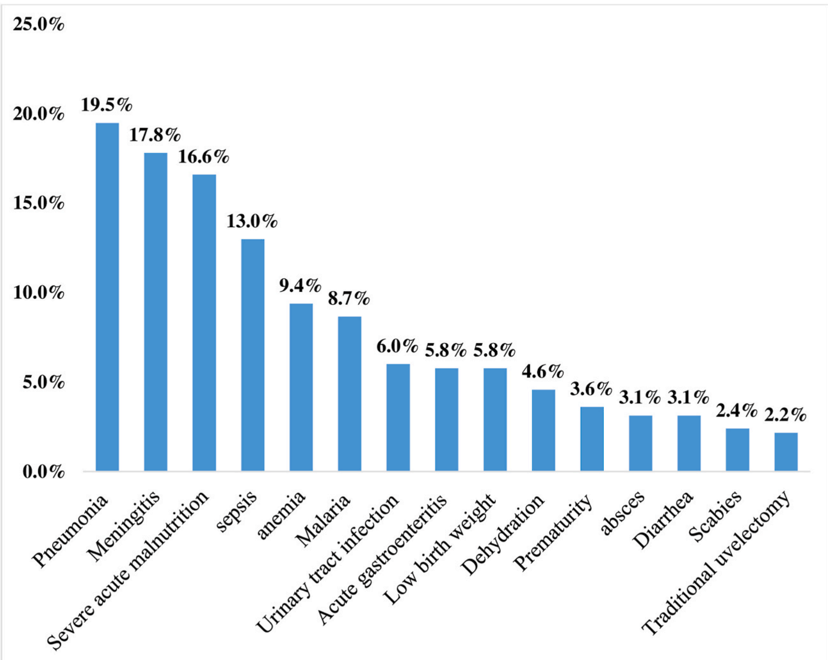

Fig. 1. Top fifteen reasons for pediatric patient admission in Gamo Zone public hospitals, Southern Ethiopia, 2021 (n = 416).

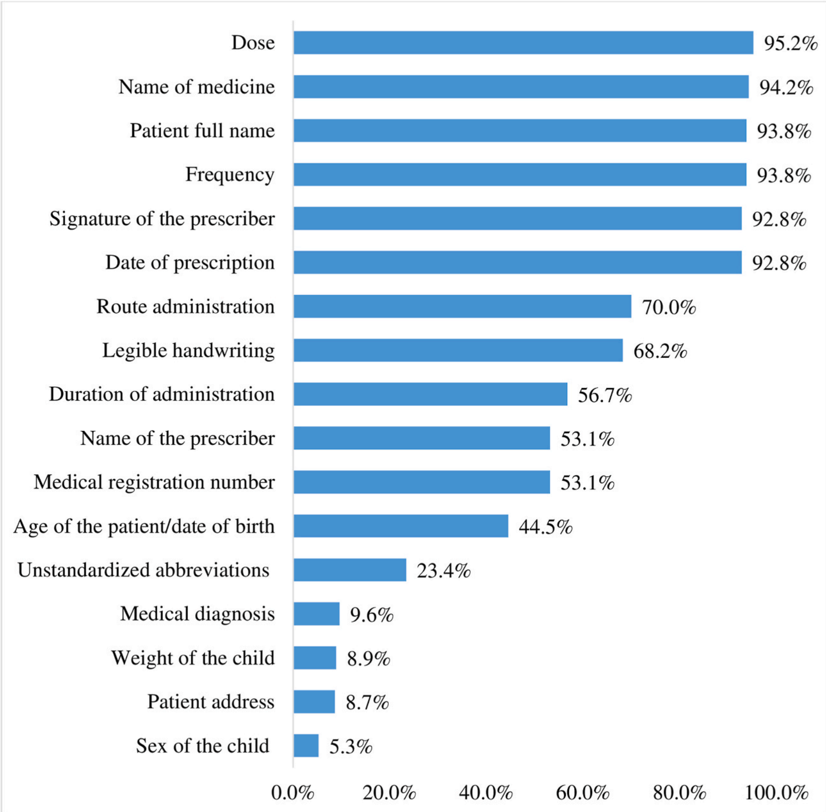

Fig. 2. Information included in the prescription of pediatric inpatients in Gamo zone public hospitals, southern Ethiopia, 2020 (n = 416).

Table 3
Therapeutic categories of medications associated with medication errors in Gamo zone public hospitals, southern Ethiopia, 2020 (n = 1253).

Drug category	Medication errors		Total, N (%)
	Yes	No	
Antibiotics	226 (32.47)	119 (21.36)	345 (27.53)
Fluids	148 (21.26)	176 (31.60)	324 (25.86)
Analgesia/antipyretics	98 (14.08)	80 (14.36)	178 (14.21)
Antimalarial	35 (5.03)	22 (3.95)	57 (4.55)
Cardiovascular drugs	26 (3.74)	25 (4.49)	51 (4.07)
Vitamins and minerals	31 (4.45)	22 (3.95)	50 (3.99)
Central nervous system drugs	23 (3.31)	46 (8.25)	69 (5.51)
Gastrointestinal drugs	14 (2.01)	29 (5.21)	43 (3.43)
Antifungal	20 (2.87)	8 (1.44)	28 (2.23)
Steroid	17 (2.44)	6 (1.08)	23 (1.84)
Bronchodilators	12 (1.72)	8 (1.44)	20 (1.60)
Metabolic drugs	2 (0.29)	4 (0.72)	6 (0.48)
Antivirus	4 (0.57)	2 (0.36)	6 (0.48)
Other	40 (5.75)	13 (2.33)	53 (4.23)
Total	696 (100)	557 (100)	1253 (100)

3.4. Prevalence of medication errors

Medication errors occurred at a rate of 55.55, 167.31, and 26.76 per 100 orders, admissions, and patient days, respectively. Prescription and administration errors occurred in 247 (59.38%) and 175 (42.07%) of the participants, separately. Overall, 289 [69.5%, 95% CI: 64.80, 73.86] of pediatric inpatients experienced MEs. Among those who had MEs, 221 (53.13%), 61 (14.66%), and 48 (11.54%) encounter dosing, duration, and preparation errors, respectively (Fig. 3).

Table 4
Medication administration-related characteristics for pediatric inpatients in Gamo zone public hospitals, Southern Ethiopia, 2021 (n = 1,253$^{\alpha}$).

Variables	Category	Frequency	Percentage
Route of administration	Intravenous (IV)	876	69.91
	Per Os (PO)	262	20.91
	Intramuscular (IM)	44	3.51
	Suppository	41	3.27
	Other[a]	30	2.39
Frequency of administration	Once-daily (QD)	227	18.12
	Two times a day (BID)	389	31.05
	Three times a day (TID)	179	14.29
	Four times a day (QID)	189	15.08
	As needed (PRN)	54	4.31
	Stat (once immediately)	51	4.01
	Other	164	13.09
Duration of administration (in days)	1	254	20.27
	2–5	680	54.27
	≥5	319	25.46
Availability of the drug within the hospital pharmacy	Yes	1063	84.84
	No	190	15.16

α total number of prescribed medications for 416 participants.
[a] Subcutaneous, intradermal, topical, inhalation.

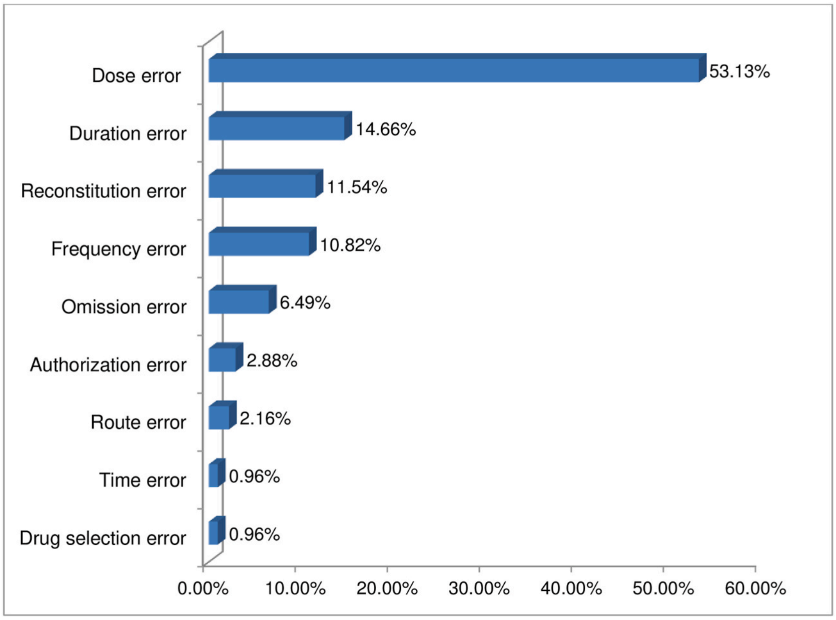

Fig. 3. Types of medication errors among pediatric inpatients in Gamo zone public hospitals, Southern Ethiopia, 2021 (n = 416).

3.5. Factors associated with medication error

Following adjustment, six variables were significantly associated with MEs: medication reconstitution working environment, child weight, qualification of medication administrator, and parent involvement in the medication administration process, adherence with medication administration rights, and length of hospital stay. A hazardous working environment for medication preparation/reconstitution doubles the risk of MEs (aOR = 2.40, 95%CI: 1.48, 3.91). Participants weighing less than 5 Kg, 5–10.9 Kg and 11–19.9 Kg had 4 times (aOR = 3.72, 95% CI: 1.79, 7.73), 3 times (aOR = 2.78, 95% CI: 1.39, 5.52), and 2 times (aOR = 2.38, 95% CI: 1.10, 5.19) higher odds to experience MEs compared to those weighing 20 Kg or more. Participants whose medications were administered by diploma holders had a twofold (aOR = 2.10, 95% CI: 1.31, 3.36) higher odds to encounter MEs compared to their counterparts whose medications were administered by degree-qualified providers. Parent involvement in the child medication administration process decreases the odds of MEs by 45% (aOR = 0.55, 95% CI: 0.33, 0.95) compared to their counterparts. Noncompliance of healthcare providers with medication administration rights triples the risk of MEs (aOR = 2.68, 95% CI: 1.32, 5.44). Furthermore, those who stayed for more than 5 days had 2 times (aOR = 1.83, 95% CI: 1.15, 2.93) higher risk of MEs compared to those who stayed for less than or equal to five days (Table 5).

Table 5
Bivariable and multivariable analysis of factors associated with medication errors among pediatric inpatients in public hospitals of Gamo Zone, Southern Ethiopia, 2021 (n = 416).

Variables	Medication error		cOR (95% CI)	P-value	aOR (95% CI)	P-value
	Yes (N, %)	No (N, %)				
Providers' work experience in the unit (in months)						
<12	158 (72.2)	61 (27.9)	1		1	
≥12	131 (66.5)	66 (33.5)	0.77 (0.50, 1.16)	0.212	0.84 (0.52, 1.34)	0.459
Interruption during medication administration						
Yes	62 (78.5)	17 (21.5)	1.78 (0.99, 3.17)	0.056	1.39 (0.73, 2.67)	0.320
No	227 (67.4)	110 (32.6)	1			
Number of medications administered per patient						
≤3	190 (65.3)	101 (34.7)	1		1	
>3	99 (79.2)	26 (20.8)	2.02 (1.23, 3.32)	0.005	1.24 (0.71, 2.17)	0.450
Suitable working environment for medication reconstitution						
Yes	120 (59.7)	81 (40.3)	1			
No	169 (78.6)	46 (21.4)	2.48 (1.61, 3.82)	<0.001	2.40 (1.48, 3.91)*	<0.001
Weight of the child in Kilogram						
<5	89 (71.8)	35 (28.2)	1.91(1.01, 3.60)	0.046	3.72 (1.79, 7.73)*	<0.001
5–10.9	110 (71.4)	44 (28.6)	1.88(1.02, 3.45)	0.043	2.78 (1.39, 5.52)*	0.004
11–19.9	54 (72.0)	21 (28.0)	1.93 (0.95, 3.92)	0.070	2.38 (1.10, 5.19)*	0.029
≥20	36 (57.1)	27 (42.9)	1		1	
Qualification of the medication administrator						
Diploma	172 (76.4)	53 (23.6)	2.05 (1.34, 3.14)	0.001	2.10 (1.31, 3.36)*	0.002
Degree	117 (61.3)	74 (38.7)	1		1	
Child's parents' involvement in the medication administration process						
Yes	182 (65.0)	98 (35.0)	0.50 (0.31, 0.81)	0.005	0.55 (0.33, 0.95)*	0.030
No	107 (78.7)	29 (21.3)	1		1	
Providers' compliance with medication administration principles						
Yes	21 (48.8)	22 (51.2)	1		1	
No	268 (71.8)	105 (28.2)	2.67 (1.41 5.07)	0.003	2.68 (1.32, 5.44)*	0.006
Length of hospital stay in days						
≤5	113 (61.1)	72 (38.9)	1		1	
>5	176 (76.2)	55 (23.8)	2.04 (1.34, 3.11)	0.001	1.83 (1.15, 2.93) *	0.011

*significant at P-value <0.05.

4. Discussion

Pediatric inpatients are more vulnerable to MEs due to inadequate buffering systems, resulting in severe disability and death [42]. In this study, 69.5% of the participants had at least one type of MEs. Unsuitable medication reconstitution environment, small weight, medication administered by diploma providers, non-involvement of parents in their child's medication administration process, non-adherence to medication administration rights, and prolonged length of hospital stay increase the likelihood of MEs.

In this study, 69.5% (95% CI: 64.80, 73.86) of pediatric inpatients experience MEs. The finding of the current study is higher than the studies conducted in Jimma University Medical Center, Ethiopia (41.8%) [43], JUSH (51.8%) [39], Tigray, Ethiopia (62.7%) [8] and tertiary hospitals in southwestern Nigeria (40.9%) [44]. However, this finding is lower than the studies conducted in JUSH (89.9%) [7], west Ethiopia (75.1%) [9], and South Africa (78%) [45]. This disparity could be attributed to work overload, healthcare providers' experience and qualification, availability of medication safety-specific pieces of training, facilities infrastructure, medication administration guidelines, and computerized prescription and dose calculation machines.

According to our study, 59.4% of participants experienced prescription errors. This is higher than the results of studies conducted in Malaysia (7.3%) [46] and Brazil (43.5%) [47]. The possible justification is that the absence of electronic prescription, a large number of patients, absence of continuous training, and lack of a medical error-monitoring system could all be cited as contributing factors to this error. Evidence suggests that computerized provider order entry with electronic medication alert systems reduces prescription errors [48]. This study also found that 42.07% of participants encountered MAEs. This is higher than the study conducted at Addis Ababa, Black Lion Specialized Hospital, and Zewditu Memorial Hospital (35.5%) [49]. This variation may be due to the nature of the hospitals; specialized hospitals have senior professionals, relatively better infrastructure, training accessibility, and medication error reporting systems than general and primary hospitals. This finding, however, is lower than that of studies conducted in Tigray, Ethiopia (62.7%) [8] and JUSH (89.9%) [7]. This disparity may be due to a time difference; the JUSH study was conducted nearly ten years ago, and there have been significant improvements in healthcare provision over these years.

Participants treated by diploma professionals were 2.1 times higher risk to experience MEs compared to those treated by health professionals with at least a BSc level of education. This is in contrast to the study conducted in Tigray, Ethiopia, which found that medications administered by degree professionals had a 1.52 higher chance of error [8]. The possible justification is that knowledge or skill alone is insufficient to ensure medication administration safety; rather, the integration of these two domains is imperative. The study conducted at the University Hospitals of Cairo showed that 26.3% and 22.5% of MEs were committed by untrained and new staff respectively [50]. Furthermore, Wondmieneh et al., demonstrated that a lack of adequate training triples the likelihood of medication administration errors [51]. Evidence also suggests that inadequate knowledge and a lack of continuous training for healthcare providers are the main associated factors of various MEs [23].

The odds of MEs were 2.4 times higher among patients whose medications were reconstituted in an unsuitable working environment. Previous research has also shown that hospitals that adhere to the minimum standard of care reduce the occurrence of MEs [52,53]. A study in Tigray, Ethiopia, also found that MAEs were 13.5 and 4.1 times higher in facilities lacking a medication preparation room and medication administration guidelines, respectively [8]. This is because qualified healthcare providers alone cannot ensure medication safety without the availability of the bare minimum of hospital infrastructure.

Participants with a weight of less than 5 kg, 5–10.9 kg, and 11–19.9 kg have a 3.72, 2.78-, and 2.38 times higher risk of MEs than those with a weight of twenty and above. This is supported by the study in Tigray, which found that MAEs were inversely proportional to age [8]. This is most likely due to a lack of child doses; calculating a single dose for those with lower weight/age is difficult for healthcare providers, and they are more prone to errors.

Involvement of the child's parent in the medication administration process reduces the risk of MEs by 45%. This is consistent with a study that found involving family members in medical care reduced the occurrence of MEs and its associated harms by 30% [52]. This is because healthcare providers care for a large number of patients every day. Thus, involving parents in the child's medication administration process is critical to ensuring the care process and reminding the healthcare provider about the time of medication administration and any changes in the child's health condition.

Noncompliance with medication administration rights by healthcare providers increases the risk of MEs by 2.68-fold. Previous research backs this up: Tsegaye et al., discovered that failing to adhere to medication administration rights increases the likelihood of MAEs by 1.6 times [54]. Furthermore, a lack of knowledge about medication administration rights raises the risk of MEs [23]. The possible justification is that health professionals must have adequate knowledge, skills, and therapeutic communication; any break in the mediation process results in MEs. Poor nurse-physician communication, according to Aboshaiqah and colleagues, is also a major contributing factor to the high incidence of MEs [55].

Participants who stayed for more than five days had a 1.83 higher risk of MEs compared to those who stayed for less than or equal to five days. This is supported by a study conducted in western Ethiopia, which revealed that participants who stayed for five days or more had a 4.24 times higher risk of ME [9]. The possible justification is that the parent's ability to cover medical costs may decrease as the number of hospital stays increases, and the risk of omitting some prescribed drugs and leaving the hospital against medical advice is high.

In general, the incidence of MEs was high in the study hospitals; great emphasis should be given to improving medication safety. The findings of this study will assist clinicians to adhere to the national treatment guideline in prescription, medication selection, dose, frequency, and duration for a specific medical condition. The study also provides invaluable information to nurses to strictly adhere to medication administration rights. Furthermore, the study generates critical information for hospital administrators to meet the minimum requirements for medication administration, initiate mediation safety-specific training for healthcare providers, develop medication error reporting systems, and launch electronic charting systems that reduce MEs. Furthermore, the study generates critical information for interested scholars and stakeholders to use in designing appropriate interventions to reduce the occurrence of medical errors among pediatric inpatients.

The study has several strengths, which include: I) validated data collection tool with a repeated assessment for each prescribed medication; II) use of various data collection techniques such as interviewer-administered questioners, facility supervision, medical recorded review, and direct observation; and III) use of ODK tools for the data collection. Despite its strength, this study encountered limitations in observing medication administration during the night shift and in intensive care units. In those cases, we relied solely on recorded data, which may underestimate the occurrence of MEs. Moreover, the study only included general hospitals with high patient flow and the results do not represent other health facilities. Furthermore, observer bias and documentation errors may under or overestimate MEs.

5. Conclusions

Medication errors among pediatric inpatients were found to be high in the study hospitals as compared to similar studies in the country; dosing, duration, and preparation errors were common. Unsuitable working environment, low child weight, medication administered by diploma providers, involving the parent in the medication administration process, nonadherence with medication administration rights, and a prolonged length of hospital stay were significantly associated with MEs. Creating suitable working environment for medication reconstitution and administration, facilitate education and training for providers, involving families in the medication administration process, and strict adherence with medication administration rights are imperative to minimize medication inaccuracies.

Nationally harmonized treatment guidelines, electronic prescription/charting and dose calculation using machines, extensive medication safety training for healthcare providers, and the establishment of regular monitoring and medication error reporting systems are all required to reduce the occurrence of medication errors.

Author contribution statement

Agegnehu Bante; Abera Mersha; Zeleke Aschalew; Aklilu Ayele: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no competing interests.

Acknowledgments

We would like to thank Arba Minch University (www.amu.edu.et) for funding this study with a grant ID of GOV/AMU/TH14/CMHS/NUR/01/11. Our thanks also go to the staff at Arba Minch General Hospital and Chencha Primary Hospital for providing all necessary baseline data. Finally, no one deserves more credit than the study participants and data collectors; without them, this study would not have been possible.

Abbreviations

MEs Medication Errors
NCCMERP National Coordinating Council for Medication Error Reporting and Prevention
NICU Neonatal Intensive Care Unit
WHO World Health Organization

References

[1] S.H. Chalasani, M. Ramesh, P. Gurumurthy, Pharmacist-initiated medication error-reporting and monitoring programme in a developing country scenario, Pharmacy 6 (4) (2018) 133.
[2] Food and D. Administration, Medication Errors Related to CDER-Regulated Drug Products, Food and Drug Administration, Silver Spring, MD, 2020. Published January.
[3] National Coordinating Council for Medication Error Reporting and Prevention, What is a Medication Error? National Coordinating Council for Medication Error Reporting and Prevention, New York, NY, 2015.
[4] C.M. Clancy, Ten years after to err is human, Am. J. Med. Qual. 24 (6) (2009) 525–528.
[5] A. Valentin, et al., Errors in administration of parenteral drugs in intensive care units: multinational prospective study, BMJ 338 (2009) b814.
[6] M. Parihar, G.R. Passi, Medical errors in pediatric practice, Indian Pediatr. 45 (7) (2008) 586.
[7] Y. Feleke, B. Girma, Medication administration errors involving paediatric in-patients in a hospital in Ethiopia, Trop. J. Pharmaceut. Res. 9 (4) (2010).
[8] Z. Baraki, et al., Medication administration error and contributing factors among pediatric inpatient in public hospitals of Tigray, northern Ethiopia, BMC Pediatr. 18 (1) (2018) 321.
[9] M.G. Dedefo, A.H. Mitike, M.T. Angamo, Incidence and determinants of medication errors and adverse drug events among hospitalized children in West Ethiopia, BMC Pediatr. 16 (1) (2016) 81.
[10] S.P. Slight, et al., The causes of prescribing errors in English general practices: a qualitative study, Br. J. Gen. Pract. 63 (615) (2013) e713–e720.
[11] R.T. Rothwell, Reducing Medication Errors in the Acute Care In-Patient Setting: an Integrative Review, 2016.
[12] V.K. Kimeu, Factors Influencing Medication Administration Practice Among Nurses at Kenyatta National Hospital General Critical Care Init, 2015. University of Nairobi.
[13] A.A. Avery, et al., Investigating the Prevalence and Causes of Prescribing Errors in General Practice: the PRACtICe Study, 2012.
[14] S. Mercer, et al., Multimorbidity: Technical Series on Safer Primary Care, 2016. World Health Organization.
[15] A. Campino, et al., Medication errors in a neonatal intensive care unit. Influence of observation on the error rate, Acta Paediatr. 97 (11) (2008) 1591–1594.
[16] M. Ruano, et al., New technologies as a strategy to decrease medication errors: how do they affect adults and children differently? World J. Pediatr. 12 (1) (2016) 28–34.
[17] R.M. Rishoej, et al., Medication errors in pediatric inpatients: a study based on a national mandatory reporting system, Eur. J. Pediatr. 176 (12) (2017) 1697–1705.
[18] M.A. Ghaleb, et al., The incidence and nature of prescribing and medication administration errors in paediatric inpatients, Arch. Dis. Child. 95 (2) (2010) 113–118.
[19] S.B. Bavdekar, Off-label drug use in neonatal intensive care unit, Indian Pediatr. 52 (2) (2015) 167.
[20] S. Jain, S. Basu, V.R. Parmar, Medication errors in neonates admitted in intensive care unit and emergency department, Indian J. Med. Sci. 63 (4) (2009).
[21] C.S.A. Belela, S.A.M. Peterlini, G.L.M. Pedreira, Disclosure of Medication Error in a Pediatric Intensive Care Unit. University of Brazil Thesis, 2010, pp. 257–263.
[22] A.H. Lavan, et al., Adverse Drug Reactions in an Oncological Population: Prevalence, Predictability, and Preventability. The Oncologist, 2019 theoncologist. 2018-0476.
[23] A.B. Mekonnen, et al., Adverse drug events and medication errors in african hospitals: a systematic review, Drugs Real World Outcomes 5 (1) (2018) 1–24.
[24] J.P. Mouton, et al., Mortality from adverse drug reactions in adult medical inpatients at four hospitals in South Africa: a cross-sectional survey, Br. J. Clin. Pharmacol. 80 (4) (2015) 818–826.
[25] K.A. Oshikoya, et al., Incidence and cost estimate of treating pediatric adverse drug reactions in Lagos, Nigeria, Sao Paulo Med. J. 129 (3) (2011) 153–164.
[26] W.D. Bates, Medication errors: what is their impact? Mayo Clinic 89 (2014).
[27] R. Ofosu, P. Jarrett, Reducing nurse medicine administration errors, Nurs. Times 111 (20) (2015) 12–14.
[28] W. Tumwikirize, et al., Adverse drug reactions in patients admitted on internal medicine wards in a district and regional hospital in Uganda, Afr. Health Sci. 11 (1) (2011).
[29] M. Letaief, et al., *Adverse events in a Tunisian hospital: results of a retrospective cohort study*, International journal for quality in health care 22 (5) (2010) 380–385.
[30] R.M. Gallagher, et al., Adverse drug reactions causing admission to a paediatric hospital, PLoS One 7 (12) (2012), e50127.
[31] R. Gallagher, et al., Adverse drug reactions causing admission to a paediatric hospital: a pilot study, J. Clin. Pharm. Therapeut. 36 (2) (2011) 194–199.
[32] S.A. Feleke, M.A. Mulatu, Y.S. Yesmaw, Medication administration error: magnitude and associated factors among nurses in Ethiopia, BMC Nurs. 14 (2015) 1–8.

[33] Z. Alsulami, I. Choonara, S. Conroy, Paediatric nurses' adherence to the double-checking process during medication administration in a children's hospital: an observational study, J. Adv. Nurs. 70 (6) (2014) 1404–1413.
[34] A.B. Mekonnen, et al., Medication reconciliation as a medication safety initiative in Ethiopia: a study protocol, BMJ Open 6 (11) (2016) e012322.
[35] A.B. Mekonnen, et al., Hospital survey on patient safety culture in Ethiopian public hospitals: a cross-sectional study, Saf. Health 3 (1) (2017) 11.
[36] Food, M.a.H.A.a.C.A.o.E., Standard Treatment Guidelines for General Hospital. Third Edition, 2014. Food, Medicine and Healthcare Administration and Control Authority of Ethiopia.
[37] World Health Organization, Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Childhood Illnesses, 2013. World Health Organization.
[38] H. Singh, Mobile data collection using an android device, Int. J. Comput. Sci. Technol. 4 (1) (2013) 200–202.
[39] A. Agalu, et al., Medication administration errors in an intensive care unit in Ethiopia, Int. Arch. Med. 5 (1) (2012) 15.
[40] N. Falconer, et al., Defining and classifying terminology for medication harm: a call for consensus, Eur. J. Clin. Pharmacol. 75 (2) (2019) 137–145.
[41] Ministry of Health of Ethiopia and World Health Organization, Guidelines for the Management of Common Illnesses in Hospitals, Pocket Book of Pediatric Hospital Care, Ethiopia, 2010.
[42] P.J. Gates, et al., Prevalence of medication errors among paediatric inpatients: systematic review and meta-analysis, Drug Saf. 42 (11) (2019) 1329–1342.
[43] D. Feyissa, et al., Medication error and its contributing factors among pediatric patients diagnosed with infectious diseases admitted to Jimma University Medical Center, Southwest Ethiopia: prospective observational study, Integrated Pharm. Res. Pract. (2020) 147–153.
[44] A.A. Ajemigbitse, M.K. Omole, W.O. Erhun, An assessment of the rate, types and severity of prescribing errors in a tertiary hospital in southwestern Nigeria, Afr. J. Med. Med. Sci. 42 (4) (2013) 339–346.
[45] A. Truter, N. Schellack, J.C. Meyer, Identifying medication errors in the neonatal intensive care unit and paediatric wards using a medication error checklist at a tertiary academic hospital in Gauteng, South Africa, South African J. Child Health 11 (1) (2017) 5–10.
[46] J.L. Lee, Prescribing errors in pediatric outpatient department at a tertiary care hospital in Malaysia, Int. J. Clin. Pharm. 42 (2) (2020) 604–609.
[47] A.P. Machado, et al., Prescribing errors in a Brazilian neonatal intensive care unit, Cad. Saúde Pública 31 (12) (2015) 2610–2620.
[48] U. Sethuraman, et al., Prescription errors before and after introduction of electronic medication alert system in a pediatric emergency department, Acad. Emerg. Med. 22 (6) (2015) 714–719.
[49] H. Fekadu, Assessment of Prescribing and Adminstration Errors in Pediatric Inpatients in Black Lion Specialized Hospital and Zewditu Memorial Hospital, Addis Ababa, Ethiopia, 2013. Addis Ababa University.
[50] E. Abusaad, E.A. Etawy, Medication administration errors at Children's University hospitals: nurses point of view, J. Nur. Health Sci. 4 (1) (2015) 51–60.
[51] A. Wondmieneh, et al., Medication administration errors and contributing factors among nurses: a cross sectional study in tertiary hospitals, Addis Ababa, Ethiopia, BMC Nurs. 19 (2020) 4.
[52] E. Manias, et al., Medication error trends and effects of person-related, environment-related and communication-related factors on medication errors in a paediatric hospital, J. Paediatr. Child Health 55 (3) (2019) 320–326.
[53] A.N. El-Shazly, et al., Medical errors in neonatal intensive care unit at Benha University Hospital, Egypt, East. Mediterr. Health J. 23 (1) (2017) 31–39.
[54] D. Tsegaye, et al., Medication administration errors and associated factors among nurses, Int. J. Gen. Med. 13 (2020) 1621–1632.
[55] A.E. Aboshaiqah, Nurses' perception of medication administration errors, Am. J. Nurs. Res. 2 (4) (2014) 63–67.