ORIGINAL RESEARCH

An Assessment of Medication Errors Among Pediatric Patients in Three Hospitals in Freetown Sierra Leone: Findings and Implications for a Low-Income Country

Onome T Abiri [1,2], Alex Ninka[3], Joshua Coker[4], Fawzi Thomas [2,5], Isaac O Smalle[6], Sulaiman Lakoh [4], Foday Umaro Turay[7], James Komeh[2,3], Mohamed Sesay [2,7], Joseph Sam Kanu [8], Ayeshatu M Mustapha[9], Nellie VT Bell [9], Thomas Ansumus Conteh [2,5], Sarah Kadijatu Conteh[10], Alhaji Alusine Jalloh[10], James BW Russell [4], Noah Sesay[3], Mohamed Bawoh [1], Mohamed Samai[1], Michael Lahai[7]

[1]Department of Pharmacology and Therapeutics, College of Medicine and Allied Health Sciences, University of Sierra Leone, Freetown, Sierra Leone; [2]Department of Pharmacovigilance and Clinical Trials, Pharmacy Board of Sierra Leone, Freetown, Sierra Leone; [3]Department of Clinical Pharmacy and Therapeutics, College of Medicine and Allied Health Sciences, University of Sierra Leone, Freetown, Sierra Leone; [4]Department of Internal Medicine, College of Medicine and Allied Health Sciences, University of Sierra Leone, Freetown, Sierra Leone; [5]Department of Pharmaceutics, College of Medicine and Allied Health Sciences, University of Sierra Leone, Freetown, Sierra Leone; [6]Department of Surgery, College of Medicine and Allied Health Sciences, University of Sierra Leone, Freetown, Sierra Leone; [7]Department of Pharmaceutical Chemistry, College of Medicine and Allied Health Sciences, University of Sierra Leone, Freetown, Sierra Leone; [8]Department of Community Medicine, College of Medicine and Allied Health Sciences, University of Sierra Leone, Freetown, Sierra Leone; [9]Department of Pediatrics, Ola During Children Hospital, Freetown, Sierra Leone; [10]Department of Pediatrics, King Harman Road Maternity and Children Hospital, Freetown, Sierra Leone

Correspondence: Onome T Abiri, Department of Pharmacology and Therapeutics, College of Medicine and Allied Health Sciences, University of Sierra Leone Freetown, Sierra Leone/Department of Pharmacovigilance and Clinical Trials, Pharmacy Board of Sierra Leone, Freetown, Sierra Leone, Tel +23276370315, Email berylonome@gmail.com

Background: Pediatric patients are prone to medicine-related problems like medication errors (MEs), which can potentially cause harm. Yet, this has not been studied in this population in Sierra Leone. Therefore, this study investigated the prevalence and nature of MEs, including potential drug-drug interactions (pDDIs), in pediatric patients.

Methods: The study was conducted in three hospitals among pediatric patients in Freetown and consisted of two phases. Phase one was a cross-sectional retrospective review of prescriptions for completeness and accuracy based on the global accuracy score against standard prescription writing guidelines. Phase two was a point prevalence inpatient chart review of MEs categorized into prescription, administration, and dispensing errors and pDDIs. Data was analyzed using frequency, percentages, median, and interquartile range. Kruskal–Wallis H and Mann–Whitney U-tests were used to compare the prescription accuracy between the hospitals, with $p<0.05$ considered statistically significant.

Results: Three hundred and sixty-six (366) pediatric prescriptions and 132 inpatient charts were reviewed in phases one and two of the study, respectively. In phase one, while no prescription attained the global accuracy score (GAS) gold standard of 100%, 106 (29.0%) achieved the 80–100% mark. The patient 63 (17.2%), treatment 228 (62.3%), and prescriber 33 (9.0%) identifiers achieved an overall GAS range of 80–100%. Although the total GAS was not statistically significant (p=0.065), the date (p=0.041), patient (p=<0.001), treatment (p=0.022), and prescriber (p=<0.001) identifiers were statistically significant across the different hospitals. For phase two, the prevalence of MEs was 74 (56.1%), while that of pDDIs was 54 (40.9%). There was a statistically positive correlation between the occurrence of pDDI and number of medicines prescribed (r=0.211, P=0.015).

Conclusion: A Low GAS indicates poor compliance with prescription writing guidelines and high prescription errors. Medication errors were observed at each phase of the medication use cycle, while clinically significant pDDIs were also reported. Thus, there is a need for training on prescription writing guidelines and medication errors.

Keywords: pediatrics, prescription, medication errors, drug-drug interactions, Sierra Leone

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Introduction

Medication error (ME) is any preventable event that may lead to inappropriate use of medicines or patient harm while the patient or health professional controls it. Such events may be correlated to professional practice, including prescribing, order communication, product labeling, packaging, dispensing, administration, education, monitoring, and use.[1]

Pediatric patients are especially vulnerable to medication errors, which have the potential to cause harm at a rate three times greater than that observed in adults.[2,3] Prescribing for pediatric patients can be a quagmire due to the small body mass, necessitating specialized formulations that entail dosage calculation based on weight, height, age, and clinical condition. This intricate process significantly amplifies the likelihood of errors.[4–6] These errors are preventable incidents that may arise from the improper utilization of medication and have the potential to cause harm to the child.[7] Prudent prescribing, dispensing, administration, and monitoring are, therefore, crucial in preventing medication errors.[8,9]

Medicines laws, such as the Sierra Leone Pharmacy and Drugs Act 2001, and guidelines, such as the WHO prescription guide, are important for good prescription practice. Adhering to prescription regulations and guidelines is crucial for enhancing patient safety, improving treatment results, avoiding medication errors, promoting rational prescribing practices, and complying with legal and regulatory requirements.[10,11] Several studies have assessed adherence to prescription writing guidelines among pediatrics and reported incomplete prescriber, medicine, and patient information and illegible handwriting.[12–15] Additionally, experienced and inexperienced healthcare professionals can commit medication errors such as prescription, transcription, dispensing, and administration errors.[16–19] Clinically significant potential drug-drug interactions (pDDIs) have also been reported in pediatric patients in Turkey, the United States of America, India, and Nigeria hospitals, which may require avoiding combinations, switching to an alternate medicine, or careful patient monitoring.[20–23] Drug-drug interactions and adverse drug reactions (ADRs) are consequences of ME.[24,25] These may lead to significant health-related implications such as hospitalization, death, and economic loss, which can negatively affect patient confidence in the healthcare delivery system.[26,27] Unfortunately, data in Africa is scarce, and these adverse effects are primarily under-reported in low-income countries like Sierra Leone with an embryonic pharmacovigilance system.[28,29]

Although Coker et al[30] have previously conducted a study to determine adherence to prescription writing guidelines among adults in Sierra Leone, no study has specifically assessed the prevalence and nature of MEs, including pDDIs, in pediatric patients. As medication errors can arise from poor quality prescription writing and errors in dispensing and administration, this study provides baseline data on the prevalence and characteristics of medication errors. The data obtained will provide valuable insights for developing and implementing quality improvement initiatives pertaining to prescription writing, prescribing, dispensing, and administration programs in hospitals. Furthermore, the study findings can offer significant insights and evidence-based recommendations to enhance the national pharmacovigilance system, resulting in the safer use of medicines and improved patient outcomes.

Materials and Methods
Study Setting

This study was conducted in the pediatric departments of the Ola During Children's Hospital (ODCH), Rokupa Government Hospital (RGH), and King Harman Maternity and Children Hospital (KHMCH) located in Freetown, the Capital city of Sierra Leone. Ola During Children's Hospital (ODCH) is a national referral pediatric hospital located in the capital city of Freetown. The hospital provides both in-patient and outpatient pediatric services to about 600 children per month and has a capacity of 139 beds. It comprises high dependence, intensive care, therapeutic feeding, Special Care Baby, Infectious disease, cancer, and cardiology units. The Rokupa Government and KHMCH are secondary hospitals containing approximately 20 beds per hospital, and they provide comprehensive emergency obstetric and newborn care, inpatient and outpatient pediatric, and maternity services. Each hospital provides pediatric services to about 200 children per month. At the time of this study, all hospitals lacked an electronic health record (EHR) system.

Study Design and Duration

This study had two phases and was conducted from April 2021 to July 2021. Phase one was a descriptive cross-sectional retrospective study of pediatric prescriptions from the respective pharmacy departments from May 1 to May 31, 2021, for completion and accuracy against standard prescription writing guidelines. In phase two, we conducted a point prevalence descriptive inpatient chart review that lasted for one week among pediatric patients to identify MEs that were categorized into prescription, administration, and dispensing errors, including pDDIs.

Study Population

Pediatric prescriptions from the respective pharmacy departments in May 2021 were included in phase one of the study. Phase two included a medical chart review of inpatients <18 years irrespective of their working diagnosis and gender.

Sample Size Determination and Sampling

For phase one of the study, the sample size was determined using Fisher's formula for single population studies where p=proportion of non-adherence to prescription writing guidelines from a previous study (38%),[12] z = confidence level at 95%, and d = degree of precision of 5%. The minimum sample size was 362. Therefore, a second formula, nf=n/(1+n/N), was used to get the final sample size since the prescription population for May 2021 was 3848 (< 10,000) where; nf =final sample size; ni=initial sample size; N=study population. A final sample size of 366 was obtained after adding 10% for methodological inconsistencies. The Ola During Children's Hospital had ten times more prescriptions for the period under review than the other two hospitals. This implies that ODCH would have received about 300 of the sample. Hence, the final sample size was divided equally among the three hospitals to distribute the prescriptions better.[12] Simple random sampling was applied using the Research randomizer software, where prescriptions were allocated unique codes.[31] In phase two, all 132 inpatients were included in this study which was dependent on the number of patients admitted to the hospitals during the study.

Data Collection Procedure and Tool

For phase one of the study, the data collection tool was adapted from the Sierra Leone Pharmacy and Drugs Act 2001, the World Health Organization (WHO) guidelines for prescription writing, and a previous study, as shown in Table 1.[10–12] Seventeen essential elements were selected for this study and compiled into a single data collection tool, as shown in Table 1. The global accuracy score (GAS) employed in this study is validated and reliable and has been used in two studies in South Africa, although one is unpublished.[12,32] Six researchers manually extracted all data by reviewing

Table 1 Comparative Summary of Essential Elements of a Prescription, as per International and Local Standards

Prescription Elements	Pharmacy and Drugs Act 2001	WHO Guideline	Ravagen et al (2019)[10]	Used for Assessment in this Study
Date of prescription	√	√	√	√
Patient Identifiers				
Name	√	√	√	√
Age		√	√	√
Sex			√	√
Diagnosis	√			√
File number[a]			√	
Address[a]	√	√	√	
Weight[b]			√	√

(*Continued*)

Table 1 (Continued).

Prescription Elements	Pharmacy and Drugs Act 2001	WHO Guideline	Ravagen et al (2019)[10]	Used for Assessment in this Study
Treatment Identifiers				
Medication name[c]		√	√	√
Strength	√	√	√	√
Dosage	√	√	√	√
Formulation	√	√	√	√
Duration			√	√
Quantity[d]		√		
Repeats			√	
Generic name		√	√	√
Abbreviations and decimal points[e]		√	√	√
Prescriber Identifiers				
Prescriber name	√	√	√	√
Address[a]	√	√		
Qualification	√		√	√
Professional registration number			√	
Signature	√	√	√	√
Legibility	√		√	√
Contact number[a]		√		
Warnings[f]		√		

Notes: [a]The study did not include the file number, patient, and prescriber addresses, as well as the prescriber contact number, even though they are required. The omission was because all prescriptions were internally distributed through the hospital outpatient department, where the patient and prescriber were. No external prescriptions were considered. Similarly, the professional registration number was not included as the prescribers are all public servants working at the facility. [b]The inclusion of the patient's weight is crucial for pediatric cases, and situations where the dosage is contingent upon weight. This practice serves to facilitate a dual verification process by the pharmacist. [c]The medication's complete name is examined to ensure that it is not truncated, and the generic name is scrutinized separately. [d]The omission of medicine quantity in the given context can be attributed to the fact that the dosage, frequency, and treatment duration serve as surrogate measures. In many cases, determining the quantity of medication to dispense is typically assigned to the pharmacy. [e]It is important to note that no officially sanctioned acronyms exist for pharmaceutical substances. The WHO's Guide to Good Prescribing[31] advises against potentially perplexing acronyms due to the potential for misinterpretation. Likewise, decimal points should be limited to situations when they cannot be avoided. [f]Pharmacists usually provide verbal warnings during the dispensing process. √ (Elements available in the document).
Abbreviation: WHO, World Health Organization.

prescriptions accessed from the pharmacies. The data collection tool for phase two was adapted from the WHO guide on reporting and learning systems for medication errors, American Society of Health System Pharmacists (ASHP) guidelines for preventing medication errors in hospitals, and previous studies.[8,9,17,33] The treatment charts were reviewed by five researchers, and the following were extracted and entered into the data collection tool: wrong patient, wrong dose, wrong route, wrong medicine, wrong dosage form, wrong time of administration, contraindication including allergy, wrong duration, dose omitted or delay, wrong frequency, wrong indication, unnecessary medicine therapeutic duplication, number of medicines prescribed and potential drug-drug interactions. Data collection tools were piloted, and feedback was used to develop the final versions used in the study. In addition, nurses were accompanied during the medicine administration rounds, and patients were monitored and observed.

Ethical Consideration

Clearance to conduct the study was obtained from the Research, Innovation, and Publication Review Committee of the Faculty of Pharmaceutical Sciences, College of Medicine and Allied Health Sciences, University of Sierra Leone (RIPC-008-21). The management of the hospitals permitted the study to be done in their facilities. Informed consent was obtained from parents/caregivers after explaining the study's purpose and procedures. Parents gave consent before data was collected and were not coerced to participate in the study. Patient information was coded and kept confidential.

Data Analyses

The researchers evaluated the completion of the essential elements for each prescription, such as the use of generic names, recommended abbreviations, and prescription legibility. We determined the accuracy score out of 34 total points. Each element was assessed, scoring 0, 1, or 2 for "not completed", "partially completed", or "fully completed". Legibility was scored subjectively according to the prescription quality index (PQI) as 0, 1, or 2 for "illegible", "barely legible", or "legible", respectively, by two or more persons.[34] The global accuracy score (GAS) for each prescription was determined by calculating the percentage achieved out of 34 possible points for the 17 prescription elements considered and broadly categorized as date, patient, treatment, and prescriber identifiers. The GAS was then classified into one of four scores: 100%, 80–99%, 40–79%, and less than 40%. The desired prescription-writing accuracy score, or gold standard, is 100%. However, from previous studies, attainment of the gold standard was negligible because 100% compliance with any standard is physically and cognitively impossible.[12,32] Therefore, the accuracy score ranges from 80–100%, 40–79%, and less than 40% were employed, which are descriptive. The definition and severity categorization of the National Coordinating Council of Medication Error Reporting and Prevention (NCCMERP) was used.[1] The definition states that medication errors are preventable incidents that can result in harm to the patient or inappropriate medication use while under the control of a healthcare professional, patient, or consumer. These errors can occur due to various factors such as prescribing, order communication, product labeling, packaging, nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use. The prevalence of ME was defined as the percentage of the total number of pediatric patients who had at least one error at the time of the study against the number of patients on admission.

The errors were also classified based on the severity of the outcome into nine categories (A-I) and broadly into four types: No Error, No error no harm, Error harm, and Error Death. Potential drug-drug interactions (pDDIs) were assessed using the Drug.com interaction checker and classified into no interaction, minor, moderate, and major, and pharmaco-kinetic and pharmacodynamic interactions.[35] Major interaction is depicted as a highly clinically significant interaction that requires avoidance of combination, while moderate is described as clinically significant, but medicines can be used in special situations and can be avoided based on the risk. Minor describes a minimally clinically significant interaction that requires risk assessment, considering an alternate medicine, and instituting a monitoring plan. Descriptive statistics were applied, and results were presented as frequencies, percentages, median, and interquartile range. A Kruskal–Wallis *H*-test was used to show if there was a statistically significant difference in prescription accuracy scores among the different hospitals. The Mann–Whitney *U*-test was used to determine if there is a statistically significant difference in the GAS between the tertiary hospital and the secondary hospitals. Pearson's correlation was used to assess the relationship between the number of medicines prescribed and the occurrence of pDDIs. The p-value of < 0.05 was considered statistically significant.

Results

Essential Elements of Prescriptions

We assessed 366 prescriptions from the three hospitals, each having approximately 33% of the entire sample. Figure 1 shows the level of completion in percentages of the 17 essential elements of a prescription across the hospitals. Prescribers achieved rates of over 90% for the date of prescription, name of the patient, medication strength, formulation, medication dosage, and legibility. Relatively high rates were also seen with the use of generic names 268 (74.3%), the use of recommended abbreviations and decimal points 280 (76.5%), and prescriber signature 291 (79.5%). Conversely,
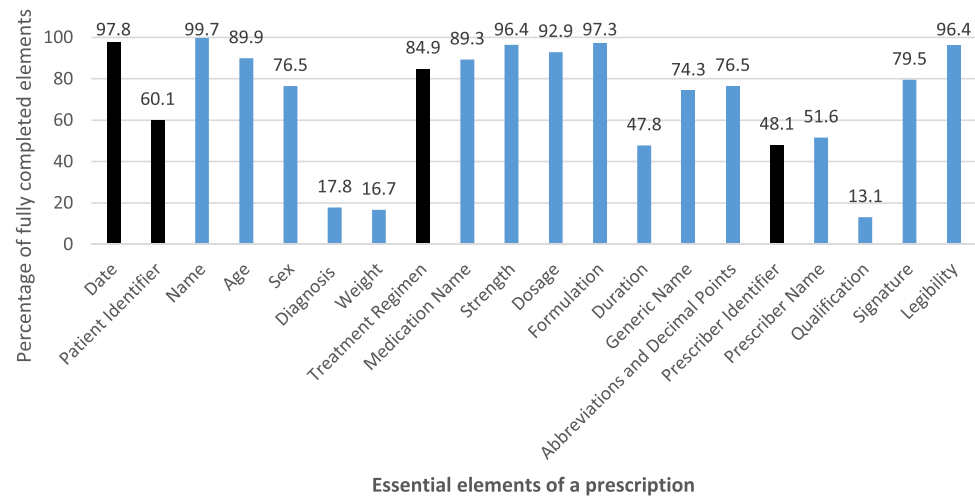
Figure 1 Scores of Prescription Completeness and Accuracy across 17 Essential Elements for King Harman Maternity and Children Hospital, Ola During Children's Hospital, and Rokupa Government Hospital, 2021, (N=366). The 17 Elements are represented by the Blue bars, and the Black bars represent the four Broad Categorizations.

lower completion levels were seen for treatment duration 175 (47.8%), patient's diagnosis 65 (17.8%), weight 61 (16.7%), and prescriber qualification 48 (13.1%).

Global Accuracy Score (GAS) of Prescription Elements

While no prescription attained the gold standard of 100%, 106 (29.0%) prescriptions achieved the 80–100% mark. In addition, the patient identifiers 63 (17.2%), treatment details 228 (62.3%), and prescriber identifiers 33 (9.0%) achieved the overall GAS range of 80–100%. Also, the attainment of the 80–100% GAS range was more prevalent for patient identifiers (25.4%) for ODCH, treat identifier 91 (74.6%) for RGH and prescriber identifiers 19 (15.5%) for KHMCH.

A Kruskal–Wallis H-test showed no statistically significant difference among the hospitals regarding the overall global accuracy of prescription writing score: $\chi^2 = 5.471$, $P = 0.065$ (Table 2). However, there was a statistically significant difference in prescription accuracy scores among the different hospitals in terms of date: $\chi^2 = 6.372$, $P = 0.041$; patient identifiers: $\chi^2 = 19.807$, $P = <0.001$; treatment identifiers: $\chi^2 = 7.662$, $P = 0.022$; and prescriber identifiers: $\chi^2 = 49.702$, $P = <0.001$ (Table 2). As a result, the overall median global accuracy of prescription writing score was 25.00

Table 2 Global Accuracy Scores per Prescription and by Elements for King Harman Maternity and Children Hospital, Ola During Children's Hospital, and Rokupa Government Hospital, 2021

Variables	Overall		Hospitals						K-value	P-value
			KHMCH		ODCH		RGH			
	n (366)	%	n (122)	%	n (122)	%	n (122)	%		
Global accuracy of prescription writing: Score out of 34										
100%	0	0	0	0	0	0	0	0	5.471	0.065
80–100%	106	29.0	49	40.2	34	27.9	23	18.9		
40–79%	257	70.2	73	59.8	85	69.7	99	81.1		
0–39%	3	0.8	0	0	3	2.5	0	0		
Score out of 34: Median |IQR|	25.00	6.00	26.00	4.00	24.00	8.00	26.00	2.00		

(Continued)

Table 2 (Continued).

Variables	Overall		Hospitals						K-value	P-value
			KHMCH		ODCH		RGH			
	n (366)	%	n (122)	%	n (122)	%	n (122)	%		
Date of prescription										
100%	358	97.8	121	99.2	121	99.2	116	95.1	6.372	0.041
80–100%	358	97.8	121	99.2	121	99.2	116	95.1		
40–70%	0	0	0	0	0	0	0	0		
0–39%	8	2.2	1	0.8	1	0.8	6	4.9		
Patient identifiers										
100%	31	8.5	0	0	31	25.4	0	0	19.807	<0.001
80–100%	63	17.2	0	0	63	51.6	0	0		
40–79%	271	74.0	122	100.0	28	23.0	121	99.2		
0–39%	32	8.7	0	0	31	25.4	1	0.8		
Score out of 10: Median |IQR|	6.00	0.00	6.00	0.00	8.00	8.00	6.00	0.00		
Treatment identifiers										
100%	112	30.6	42	34.4	28	23.0	42	34.4	7.662	0.022
80–100%	228	62.3	76	62.3	61	50.0	91	74.6		
40–79	133	36.3	46	37.7	58	47.5	29	23.8		
0–39	5	1.4	0	0	3	2.5	2	1.6		
Score out of 14: Median |IQR|	12.00	4.00	12.00	4.00	11.50	3.00	12.00	4.00		
Prescriber identifiers										
100%	31	8.5	17	13.9	1	0.8	13	10.7	49.702	<0.001
80–100%	33	9.0	19	15.6	1	0.8	13	10.7		
40–79%	293	80.1	88	72.1	101	82.8	104	85.2		
0–39%	40	10.9	15	12.3	20	16.4	5	4.1		
Score out of 8: Median |IQR|	4.00	2.00	6.00	2.00	4.00	0.00	4.00	2.00		

Abbreviations: K-value, Kruskal Wallis test value; χ^2, Chi-square; IQR, Interquartile Range; KHMCH, King Harman Maternity and Children Hospital; ODCH, Ola During Children's Hospital; RGH, Rokupa Government Hospital.

(IQR =6.00); patient identifier was 6.00 (IQR =0.00); treatment identifier was 12.00 (IQR =4.00); and prescriber identifiers was 4.00 (IQR = 2.00) (Table 2).

Furthermore, using the Mann–Whitney U-test, we investigated the differences in prescription accuracies between the hospitals. The comparison between KHMCH, a secondary healthcare facility, versus ODCH, a tertiary and teaching hospital, showed that there was a statistically significant difference in prescription accuracy scores in terms of patient identifiers (P =0.001) and prescriber identifiers (P<0.001). However, the overall accuracy of prescription writing (P=0.055), date of prescription (P=1.000), and treatment identifiers (P= 0.057) were not significant. Similarly, the comparison between RGH, a secondary level facility versus ODCH showed that there was a statistically significant difference in prescription accuracy scores in terms of patient identifiers (P=0.001), treatment identifiers (P=0.007), and

prescriber identifiers (*P*<0.001). However, the overall global accuracy of prescription writing (*P*=0.122) and prescription date (P=0.056) were insignificant.

Types and Severity of Medication Errors

We reviewed 132 inpatient charts across all three hospitals, with ODCH having 104 (79%), RGH 15 (11%), and KHMCH 13 (10%). Table 3 showed that of the 132 charts, 74 (56.1%) had at least one medication error, and a total of 89 medication errors were observed. Of the 89 errors, 1 (1.1%) was a prescription error and 25 (28%) were dispensing

Table 3 Types and Severity of Medication Errors for King Harman Maternity and Children Hospital, Ola During Children's Hospital, and Rokupa Government Hospital, 2021

Type of Medication Error	KHMCH n (%)	ODCH n (%)	RGH n (%)	Total n (%)
Prescription Error	0	I (1.5%)	0	I (1.1%)
Wrong medicine	0	0	0	0
Duplicate therapy	0	I (1.5%)	0	I (1.1%)
Contraindication	0	0	0	0
Unnecessary medicine	0	0	0	0
Dispensing Error	I (7.7%)	23 (34.8%)	I (10%)	25 (28%)
Medicine omitted	I (7.7%)	23 (34.8%)	I (10%)	25 (28%)
Administration Error	12 (92.3%)	42 (63.6%)	9 (90%)	63 (70.7%)
Wrong route of administration	0	0	0	0
Wrong dose	I (7.7%)	7 (10.6%)	0	8 (9%)
Wrong frequency	4 (30.8)	18 (27.3%)	4 (40%)	25 (28.1%)
Wrong time of administration	4 (30.8%)	8 (12.1%)	3 (30%)	16 (17.9%)
Wrong patient	0	0	0	0
Wrong dosage form	0	0	0	0
Medicine delay	3 (23.0%)	9 (13.6%)	2 (20%)	14 (15.7%)
Total number of medication errors	13 (14.6%)	66 (74.2%)	10 (11.2%)	89 (100%)
Severity of medication error				
Category A	0	0	0	0
Category B	4 (30.8%)	32 (48.5%)	3 (30%)	39 (43.8%)
Category C	9 (69.2%)	34 (52.5%)	7 (70%)	50 (56.2%)
Category D	0	0	0	0
Category E	0	0	0	0
Category F	0	0	0	0
Category G	0	0	0	0
Category H	0	0	0	0
Category I	0	0	0	0

Abbreviations: KHMCH, King Harman Maternity and Children Hospital; RH, Rokupa Government Hospital; ODCH, Ola During Children's Hospital.

Table 4 Potential Drug-Drug Interactions for King Harman Maternity and Children Hospital, Ola During Children's Hospital, and Rokupa Government Hospital, 2021

Potential Drug-Drug Interaction	Effects	Type of Interaction (PD/PK)	Number of Interactions (%)
Major			
IV Gentamycin + IV Furosemide	Increase the risk of oto- or nephrotoxicity	PD	2 (3.1%)
Ibuprofen +IM Diclofenac	Increase the potential of serious gastrointestinal toxicity	PD	1 (1.6%)
Moderate			
IV Gentamycin + IV Ampicillin	Ampicillin reduces the effect of Gentamycin	PK	41 (64.1%)
IV Ceftriaxone + IV Furosemide	Furosemide increases the risk of nephrotoxicity of some cephalosporins.		17 (26.6%)
Minor			
IM Diclofenac + IV Ceftriaxone	Diclofenac increases biliary excretion and reduces renal excretion of ceftriaxone	PK	3 (4.7%)

Abbreviations: PD, Pharmacodynamics; PK, Pharmacokinetics; IV, Intravenous; IM, Intramuscular.

errors, specifically errors of omission. Most of the medication errors were administration errors, 63 (70.7%) with wrong frequency 25 (28.1%), followed by a wrong time of administration, 16 (17.9%) being the most common ones. Assessment of medication error severity based on the NCCMERP classification revealed that 50 (56.2%) were in category C.

Potential Drug-Drug Interactions

Of the 132 inpatient charts, 54 (40.9%) had at least one pDDI. The number of pDDIs recorded was 64, and the maximum number of interactions, 28 (43.8%), occurred with prescriptions containing four medicines, followed by 19 (29.7%) interactions with three medications and 17 (26.6%) with five medicines. There was also a statistically significant correlation between the number of medicines prescribed and occurrence of pDDIs (r=0.211, P=0.015).

Table 4 showed that most of the interactions were moderate in severity 58 (90%), followed by 3 (5%) major and 3 (5%) minor. The major clinically significant pDDIs involved Furosemide and Gentamycin 2 (3.15%), followed by Diclofenac and Ibuprofen 1 (1.6%). The moderate clinically significant pDDIs were Gentamycin and Ampicillin 41 (64.1%) and Ceftriaxone and Furosemide 17 (26.6%). The 20 pharmacodynamic interactions observed were additive and could increase the potential for serious gastrointestinal toxicity (bleeding, ulceration, inflammation, and perforation) 1 (1.6%) and a synergistic mechanism that could increase the risk of ototoxicity and nephrotoxicity 2 (3.1%), and increase risk of nephrotoxicity 17 (26.6%). Of the 44 pharmacokinetic interactions, 41 (64.1%) could affect absorption through complexation, and 3 (4.7%) could affect excretion.

Discussion

This study assessed the prevalence and nature of MEs, including pDDIs, in pediatric patients. Missing prescription elements and a low GAS were observed. At least one medication error occurred at each stage of the medication use cycle, of which category C MEs based on severity were more prevalent. Also, potential clinically significant drug-drug interactions occurred.

Our study showed that essential elements were missing from all the prescriptions. This is comparable to studies conducted in India, Sudan, and Nigeria, where patient details such as age, weight, diagnoses, and medication duration were omitted in prescriptions.[15,36,37] The availability of age and weight has implications in the pharmacodynamics and pharmacokinetics of the medicine as they aid the pharmacist in calculating the correct dose, whereas the diagnosis is vital in determining the prescription rationality.[38–40]

Furthermore, although pediatric doses can be calculated from adult doses using age or weight, pediatric patients usually require higher doses of water-soluble drugs than adults on a mg/kg basis.[41,42] In situations where therapy duration

is not available, it is challenging to monitor patient outcomes as this can result in over or under-dosing, predisposing patients to toxicity or sub-optimal therapeutic effects. Overall, an ideal prescription should contain vital elements such as date, patient, medicine, and prescriber details since incomplete information may lead to adverse consequences such as adverse drug reactions, suboptimal patient adherence, and poor quality of life.[25] These consequently may cause dire economic consequences, preventable medication-related hospital admissions, and death since children are particularly prone due to the need for specialized formulations and their inability to communicate.[26,27]

The GAS obtained in this study further corroborates the findings of the essential elements of a prescription as close to a third of the prescriptions met the 80–100% standard; thus, it is similar to a study done in South Africa.[12] The possible reason could be the poor infrastructure and resources for healthcare delivery, including inadequate staffing levels, stressful working conditions, a heavy workload, and poorly equipped healthcare facilities in our setting. Consequently, hospitals tend to be overcrowded and lack necessary resources such as computers or electronic health records, which are crucial in facilitating error-free prescription writing processes.[43] Healthcare professionals frequently have substantial workloads and face time constraints when attending to patients, resulting in expedited prescription writing and heightened susceptibility to errors.[19] There may also be weak regulatory oversight of professional practices and ensuring adherence to prescription-writing guidelines.[44] Therefore, resolving these concerns necessitates a comprehensive and diverse strategy, encompassing enhancing healthcare infrastructure, strengthening continuous professional development, and enhancing regulatory oversight. There was also no statistically significant difference in the overall GAS between the tertiary and teaching (ODCH) and the secondary hospitals (KHMCH and RGH). The explanation for this could be attributed to the adherence of the tertiary and secondary hospitals to standardized treatment and prescription protocols that the national healthcare system has established.[10,11] Healthcare personnel in both facilities usually undergo comparable training, particularly concerning prescription writing. This uniformity in adhering to guidelines can lead to similar prescribing practices. Notably, the absence of a statistically significant disparity in the quality of prescription writing does not automatically imply an equivalent quality of healthcare across different establishments. There may be notable variations in specialist and consultant service availability, access to modern diagnostic technologies, and patient outcomes between tertiary and secondary healthcare facilities.

This study reported that over half of the patients were exposed to at least one medication error, the most common being administration errors followed by dispensing errors. Most medication errors in our study were classified as NCC-MERP category C, indicating actual errors but no harm to the patients. Our study is consistent with those conducted in Kenya[45] (75.8%), Western Ethiopia[46] (68.0%), and Northeast Ethiopia[47] (58.1%). However, lower values of 5.7% and 0.9% have been reported in the United States of America[48] and France,[49] respectively. Medication errors can occur at any point in the medicine's use cycle, from prescribing, dispensing, transcribing, and administration, resulting in increased economic loss, morbidity, and mortality of patients.[26] Low-income settings like ours typically have limited access to advanced technologies, such as computerized physician order entry systems and barcode medication administration systems. These technologies can help to reduce medication errors by providing real-time information and alerts about drug interactions, allergies, and dosing errors.[3] In addition, healthcare professionals in our jurisdiction have poor awareness and limited access to extensive education and training resources on pharmacovigilance and medication error reporting systems.[28] Furthermore, studies have reported that the involvement of clinical pharmacists in ward rounds, which is missing in our settings, can result in prompt identification, reporting, and reduction in MEs.[50]

In our study, about two-fifths of the reviewed charts had at least one pDDI, similar to studies done in the United States of America[21] (49%) and Turkey[20] (42%). Drug-drug interactions are responsible for morbidity, mortality, and economic loss and represent an essential and hugely unidentified source of medication errors.[51,52] Children may exhibit increased vulnerability to negative consequences as a result of ethnic variances in pharmacokinetics and pharmacodynamics, organ functionality, and developmental stages, potentially leading to adverse outcomes.[51–54] To address these concerns, healthcare practitioners must thoroughly evaluate the likelihood of drug-drug interactions and engage in vigilant monitoring to detect and manage any potential adverse effects or interactions swiftly. In this study, the maximum number of interactions occurred with prescriptions containing four medicines, similar to a study done in Pakistan.[55] Polypharmacy could be detrimental and should be avoided in children to minimize the risk of DDIs.[56] However, lower pDDI prevalence has been reported in the Czech Republic[57] (3.8%) and Bangladesh[58] (17%). On the

other hand, higher values were reported in India[59] (66.2%) and Brazil[60] (70.0%). These variances in prevalence from our study and other studies could be due to differences in the study design and the software employed to detect pDDIs.

Most pDDIs were moderately clinically significant, implying that clinicians should avoid combinations or use them only under exceptional circumstances. This result is consistent with research conducted in India[22] and Iran,[61] which requires close monitoring to prevent adverse effects.[52] Most of the pDDIs reported in this study were pharmacokinetic and could alter medicine absorption by increasing or decreasing it. Altered absorption due to DDIs can reduce the concentrations of other medicines. Although Gentamycin and Ampicillin are considered the first-line antibiotics for managing sepsis in children, this combination was the most common interaction observed and could reduce bioavailability.[62] Ampicillin can deactivate aminoglycosides in vitro and in vivo by complexation, though their concurrent use confers the therapeutic advantage of enhancing bactericidal efficacy through synergistic effects in children with sepsis.[63] This effect is substantial when healthcare professionals mix Gentamycin and Ampicillin in the same intravenous (IV) line or container for administration to patients, a common practice at the study sites or among patients with renal failure. As a result, lower serum concentrations of aminoglycosides may be seen, and dosage titration may be required.[64,65] We advised the medical teams to ensure that Aminoglycosides like Gentamycin and Ampicillin are given separately during combined therapy since the reduction in absorption in such cases may result in therapeutic failure and antibiotic resistance.

The pharmacodynamic interactions observed were due to either synergism or additive effect. Potential nephrotoxicity and ototoxicity were observed for Furosemide and Gentamycin, Ceftriaxone, and Furosemide, while an increased risk of serious gastrointestinal toxicity was observed for Diclofenac and Ibuprofen.[66–69] In such cases, we advised close monitoring of patients and dose titration. We further recommended that these combinations be circumvented or substituted with another medicine to prevent major clinically significant interactions like Gentamycin and Furosemide, Ibuprofen, and Diclofenac.

Limitations of the Study

This study has some limitations. Firstly, we intended to employ the probability proportional to size sampling. However, when we did, the samples we got for the two other hospitals were small since Ola During Children's Hospital had ten times more prescriptions. As a result, this may not give a good picture of the situation at the two other hospitals. Therefore, we conducted a retrospective review of selected prescriptions that were not distributed by probability proportional to size sampling in the hospitals, which may not represent the entire picture. The sample size is small and period is short for the study such that it does not allow the evaluation of the influence of seasonality on the occurrence of medication errors. Because a point prevalence descriptive chart review design was employed, this might have contributed to the identification of only category B and C MEs. Thus, using a prospective study design in the future would aid in identifying other categories of MEs.

Although the results may not be representative of all pediatric hospitals in Freetown, Sierra Leone, this data can be inferred to other hospitals with similar characteristics as the study sites. The study was conducted in a few hospitals; therefore, the results cannot be generalized. Furthermore, the clinician's viewpoint was not considered for the medication error component, which would have differed from the reported observations. The DDI software provided only a "potential" estimate of pDDI; therefore, prospective studies can be done to identify adverse effects. Finally, although this study was conducted at two different levels of care, it did not capture data from primary care facilities or private medical institutions.

Conclusion and Recommendation

The low GAS obtained indicates poor conformity with prescription writing guidelines, resulting in high prescribing errors. The optimum standard was not attained for all prescriptions due to the omission of fundamental elements. Medication errors occurred at each phase of the medication use cycle. In addition, potential clinically significant drug-drug interactions occurred, with pharmacokinetics interactions being the most common. Therefore, in-service prescription writing training should be enhanced, a quality improvement programs implemented, and the hospital management should provide standard prescription forms that contain the essential elements of a prescription. More studies with

prospective designs and those considering the clinician's viewpoint should be done. Pharmacists should be involved in routine medicine monitoring and review, ward rounds, conducting frequent prescription and medical chart audits, and providing feedback to other healthcare professionals. This could raise clinicians' awareness of MEs and pDDIs and improve treatment outcomes and patient well-being.

Data Sharing Statement

The datasets analyzed in this study are available at https://doi.org/10.5281/zenodo.8185857.

Ethics Approval and Informed Consent

Clearance to conduct the study was obtained from the Research, Innovation, and Publication Review Committee of the Faculty of Pharmaceutical Sciences, College of Medicine and Allied Health Sciences, University of Sierra Leone (RIPC-008-21). The management of the hospitals permitted the study to be done in their facilities. Informed consent was obtained from parents/caregivers after explaining the study's purpose and procedures. Parents gave consent before data was collected and were not coerced to participate in the study. Patient information was coded and kept confidential.

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Disclosure

We declare no competing interests.

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