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Medication Errors in a Pediatric Intensive Care Unit: Incidence, Types and Outcome

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Abstract

Medication Errors (MEs) play a significant role in mortality and morbidity of hospitalized patients. Therefore, it seems advisable to determine types and consequences of such errors when addressing patient safety. The aim of this study was to determine the incidence, types and outcomes of errors, in a 10 bed pediatric Intensive Care Unit at a large teaching hospital from September 2013 to February 2014 in Shiraz, southern Iran.The occurrence of errors was detected with the direct observation method. A trained pharmacist selected 41 patients randomly in 41 working shifts. None of the patients were included in the study twice. In each shift, patient's medications were observed for prescription, administration, transcription, and dispensing. The pharmacist would intervene only if the ME could cause substantial harm to a patient. All data were reviewed by a clinical pharmacist and a pediatric intensivist to confirm the type of errors. Of the 512 drug dosages observed, 48.8 errors/100 orders were detected. Administration errors occurred on 148 occasions, with 28.9 chances to occur in each 100 orders. Prescription, transcription and dispensing errors came next with 14.25, 4.88 and 0.78 chances in each 100 orders, respectively. Wrong time, technique, and preparation were among the most common types of administration errors with the frequency of 14.1%, 5.7%, and 4.9%, respectively. The group of errors known as monitoring errors, was the most common type of prescribtion error, with a frequency of 11.3%. The results of this study highlight the high rate of medication errors in the pediatric ICU that was studied, with administration and prescription errors marking the highest share of them. Hence implementing effective strategies to reduce these errors, are crucially needed.

Keywords: Critical Illness, Intensive Care Unit, Medication Error, Patient Safety, Pediatrics.

1. Introduction

Medication Errors (MEs) are a global concern and can have serious consequences for patients, families and health care systems. MEs, occurring either in or out of the hospital, account for more than 7000 deaths annually(1). Considering the high burden of MEs on the health care system and the resulting increase in mortality and morbidity of patients, many studies have so far been conducted on this issue(1, 2).

MEs are defined as any avoidable event that harms or has the potential to harm a patient(3). According to the American Society of Health System Pharmacists (ASHP), MEs can occur at four stages: Prescription, administration, transcription, and dispensing(4, 5).

The severity of errors' outcome can be classified into seven levels, ranging from a "potential error without harm" (level 0) to "fatal complications" (level 6) (6).

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If MEs occur, certain patient groups, such as pediatrics, are more vulnerable to develop more serious side effects (4). Furthermore, MEs happen more often in certain hospital wards, such as intensive care units, because of their complex settings, high amount of medications administered for each patient, and use of more injectable drugs(4, 7, 8).

So far, few reports concerning MEs, from adult intensive care units, have been published from Iran (8-10). Nevertheless, no study has been carried out on pediatric population in Iran. Therefore, we conducted this study to determine the incidence, types, outcomes, and the associated risk factors of MEs in a pediatric intensive care unit (PICU) at a teaching hospital in Shiraz, southern Iran.

2. Materials and Methods

This cross-sectional study was conducted in a 10-bed medical PICU in Nemazi teaching hospital affiliated to Shiraz University of Medical Sciences, from September 2013 to February 2014. The study population comprised of patients aged between one month and 14 years admitted to PICU during the study period.

Daily ward round was done by the attending physician twice a day along with fellows, pediatric residents, a general practitioner, the in-charge nurse and ICU nurses. All nurses had a short course of training before starting work in PICU and intermittent continuing education courses during their practice. Medication was ordered by fellows and residents under the supervision of attending physicians. In addition, they monitored the prescription by reviewing the regimen for being appropriate and detection of problems. However, monitoring by an adequate assessment of patients' response to the treatment, using appropriate clinical or laboratory data, was not followed based on a special policy.

After each visit, the new orders were recorded on the patient's chart. Having been checked

Table 1. Epidemiological characteristics of study population in Pediatric Intensive Care Unit during the study

Hospital length of admission (mean±SD)		22±2.88
Length of admission before observation (mean±SD)		12.37±2.27
Length of admission after observation (mean±SD)		9.15±7.74
Number of drug doses administered per day (mean±SD)		12.49±3.56
Type of medication (%)	Antimicrobials	112 (21.9)
	Electrolytes	89 (16)
	Sedatives/ Analgesics	72 (14)
	CNS medications	61 (11.9)
	Vitamins	45 (8.8)
	Gastrointestinal	41 (8)
	Hormones	39 (7.6)
	Cardiovascular	35 (6.9)
	Respiratory	15 (2.9)
	Others	10 (2)
	Total Number (%)	**512 (100)**
Route of administration (%)	Intravenous bolus	296 (57.8)
	Oral	144 (28.1)
	Intravenous infusion	48 (9.4)
	Topical	11 (2.1)
	Ocular	6 (1.2)
	Inhalation	4 (0.8)
	Subcutaneous	3 (0.6)
	Total Number (%)	**512 (100)**

by the nurse, the orders were transferred to the patient's bedside chart and a copy was also sent to the hospital pharmacy where the drugs were prepared and provided to the ward. No unit-dose packaging system was used for distribution of medications. Apart from emergency medications stocked in the emergency box in the ward, other prescribed medications were distributed by the hospital pharmacy once daily. At the time of the study, no clinical pharmacist was auditing the process. There was a special safety guideline in the hospital regarding re-calculation of the drug dose after prescription order and double checking the administration dose. In addition, self-report policy of the errors had been practiced in the hospital and was assessed regularly by dependent auditors. Meanwhile, a special guideline was introduced by the PICU clinicians to be used for preparation and administration of continuous intravenous medications.

The patients receiving the medications were selected in each shift based on the table of random numbers, so that from the two patients selected in each working day, one was from the morning and another from the afternoon shift. The days of data collection were selected randomly during a 6 month period. No patient entered the study twice. In each day, just one working shift was observed.

A "medication" was defined as any prescribed drug or other form of medicine administered by a nurse to treat or prevent a disease, including continuous intravenous or stat medications, vaccines, supplements, and electrolytes.(11) Food, blood and herbal products were not considered as medication.

A trained pharmacist collected the data using a direct observational method during morning

Table 2. Number and frequency of medication errors per 100 orders in Pediatric Intensive Care Unit of the studied hospital

Type of errors		Number of errors	Error per 100 order
Prescription errors	Wrong dose	9	1.7
	Wrong drug	12	2.34
	Wrong route	1	0.19
	Drug interaction	4	0.78
	Wrong time	5	0.97
	Monitoring errors	39	11.30
Administration errors	Omission	3	0.58
	Wrong time	72	14.06
	Wrong dosage form	3	0.58
	Wrong dose	6	1.17
	Wrong preparation	25	4.88
	Wrong technique	29	5.66
	Un-ordered drug	3	0.58
	Inappropriate drug	2	0.39
Transcription errors	Omission	6	1.17
	Wrong time	7	1.36
	Wrong drug form	3	0.58
	Wrong dose	7	1.36
	Un-ordered drug	2	0.39
Total errors		250	48.8

*Monitoring error was calculated based on probable opportunities for this error. The number of opportunities that needs monitoring was 345 doses.

and afternoon shifts. The pharmacist intervened only if the ME could cause substantial harm to a patient (level 2-6).(6) Intervention was in the form of instruction about correct administration, prescription and transcription.

Demographic data, observed records including type of medication, dose, frequency, route, monitoring laboratory results, length of admission before and after observation and outcome of the patients were collected in a pre-designed data collection sheet. All data were reviewed by a clinical pharmacist and a pediatric intensivist.

The study protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences. The research was conducted as an audit for safety purposes in the hospital setting and waived from patients' informed consent by the university Research Ethic Board (REB). Patient safety policy has been implemented in the PICU since 2005.

Data were analysed using SPSS® version 21. Continuous variables were presented as mean±SD or median (interquartile range) and compared using independent samples t- test. Categorical variables presented in frequency and corresponding percentages and their relationships were assessed by χ^2 or Fisher exact test. A P-value less than 0.05 was considered significant. Errors were reported as cases per 100 medication doses. The rate of error was calculated by the number of errors divided by the total medication dosages administered (whether ordered or not) and the number of those omitted.

3. Results and Discussion

There were 512 doses of prescribed medications administered to 41 patients (21 females and 20 males) through 41 shifts; consisting of 21

Table 3. Examples of medication errors in Pediatric Intensive Care Unit, during the study.

	Type of error	Examples
prescription errors	Wrong drug	Having Ordered enalapril for a patient with hyperkalaemia (k: 5.2) to control hypertension
	Under-dose	Having forgetten to readjust the dose of ranitidine for a patient with normal clearance of creatinine who previously had acute renal failure
	Over-dose	Having forgetten to convert the dose of IV phenytoin to appropriate oral form (suspension)
	Wrong route	Having forgotten to define the route of administration of dexamethasone
	Wrong frequency	Having Ordered amikacin QD instead of Q24h
	Drug interaction	Having Ordered imipenem with ganciclovir. This can lead to generalized seizure
	Monitoring	Forgot Having forgetten to monitor liver enzymes for a patient on phenytoin
Administration errors	Omission	Having Stopped all intravenous and oral medications because of endoscopy
	Wrong time	Not having administered antibiotics on time
	Under dose	Administration of 20 ml zinc sulfate instead of 20 mg
	Wrong route	Administration of midazolam as intravenous infusion instead of a bolus dose
	Wrong drug preparation error	Having added 120 mg vancomycin to 30 ml of normal saline instead of 60 ml (high concentration)
	Wrong administration-technique error	Having mixed phenytoin suspension with feeding in feeding pump
	Unordered medication	Administration of midazolam as sedation to patient on non-invasive ventilation
Transcription errors	Omission	Potassium chloride having been prescribed as 40 mEq but transcribed as 4 mEq in bedside medication chart
	Wrong frequency	Lactulose having been prescribed as QD but transcribed as QID
	Wrong dose	Heparin having been prescribed as 5000 IU Q12 hrs but transcribed as 500 IU

morning and 20 afternoon shifts. The median age of the recipients was 2 years (IQR: 0.58-8.4 years). Mortality rate was 29.2%).

Mean±SD Pediatric Risk of Mortality III (PRISM III) score was 6.5±6.943. The four most frequent causes of admissions were infectious (22.1%), neurologic (19.4%), respiratory (15%) and cardiology (11.4%) disorders.

On average, every patient received 12 doses of different medications every day. Demographic data and drug characteristics are shown in Table 1. The nurse to patient ratio was 1:2. Accordingly, antimicrobial medications were the most commonly used medicine (21%) and intravenous route was the predominant method of administration in the PICU (67.2%).

Table 2 shows the types of MEs that took place in PICU. As seen, out of 512 drug dosages observed, 250 (48.8%) errors were detected. Administration errors occurred on 148 occasions, with 28.9 chances to occur in each 100 orders. Prescription, transcription and dispensing errors came next with 14.25, 4.88 and 0.78 chances in each 100 orders, respectively. Wrong time, technique, and preparation were among the commonest types of administration errors with the frequency of 14.1%, 5.7% and 4.9%, respectively. The group of monitoring errors with the rate of 11.3%, was the most common type of prescribing errors. Examples of different categories of errors are demonstrated in tables 3, and 4.

The severity of different categories of errors is shown in table 6. Most errors (72.4%) occurred, belonged to level 1 of harm category that does not result in any patient harm. Transcription errors with the frequency of 24% were the most frequent type of errors, leading to patient harm in levels 2, 3 and 4. There was no ME belonging to levels 5 and 6.

Prescription errors showed significant association with route of administration and length of PICU stay (P=0.02 and P<0.01,respectively) while administration errors showed significant relationship with medication type (P=0.02), route of administration (P=0.01), working shifts (P=0.01) and number of medications (P=0.00). In this group of MEs, errors due to wrong preparation showed the most frequent significant association with predisposing factors including patients' weight (P=0.02,), medication types (P=0.03), route of administration (P=0.01), working shifts (P=0.01) and number of medications (P=0.04).

Overall, 42 interventions were made after detection of substantial MEs; of which, 79.4% were nursing and physicians' errors, respectively. Also 80% of interventions led to the correction of errors (or were accepted and implemented by the health-care team).

Table 4. The severity categories of medication errors in Paediatric Intensive Care Unit during the study.

Harm category	Prescription errors	Administration errors	Transcription errors	Dispensing errors	Total
Level 0	10 (13.7)	7 (4.7)	10 (45)	0	27 (10.8)
Level 1	51(69.9)	117 (79.1)	9 (36)	4 (100)	181 (72.4)
Level 2	9 (12.3)	17 (11.5)	4 (16)	0	30 (12)
Level 3	2 (2.7)	5 (3.4)	1 (4)	0	8 (3.2)
Level 4	1 (1.4)	2 (1.4)	1 (4)	0	4 (1.6)
Level 5	0	0	0	0	0
Level 6	0	0	0	0	0
Total	73(100)	148 (100)	25 (100)	4 (100)	250 (100)

Data are presented as Number (%) of patients.

Note: Level 0 (no error occurred); Level 1 (Error occurred that did not result in patient harm); Level 2 (Error occurred that resulted in the need for increased patient monitoring, but no patent harm); Level 3 (Error occurred and resulted in the need for increased patient monitoring with a change in vital signs); Level 4 (Error occurred and resulted in the need for treatment or an increased length of stay); Level 5 (Error occurred that resulted in permanent patient harm); Level 6 (Error occurred that resulted in patient death).

4. Conclusion

In the present study, the rate of MEs was 48.8 /100 orders which is high compared to other studies carried out using similar methods in the same setting in the adult patient population which was 7.1- 9.4/100 orders(7, 8). As reported in different studies, MEs are more common in pediatric wards compared to adult ones (8, 12, 13). In a clinical review, the rate of MEs among critically ill adults using the observation method, ranges from 10 errors /100 orders to 53 errors/100 orders (14). Thus we believe that the large variability in the rates is due to differences in the standard definitions used for the same type of event and also in the methods used to detect the events. However, the rate of MEs in the present study seems to be much higher than the above mentioned rates.

Our results indicate administration errors having occurred in 28.9, prescription in 14.2, transcription in 4.88 and dispensing errors in 0.78 per 100 orders. The National patient Safety Agency revealed that MEs that have occurred in UK in all stages of medication treatment, were 16 in prescribing, 18 in dispensing and 50 in administration /100 orders.(15) In the pediatric age group, errors have been estimated to be 3-37/100 orders during prescribtion, 5-15/ 100 orders during dispensing and 72-75/100 orders during administration(15). The rates in the present study are almost consistent with the reported ones.

Observation method is the most sensitive and valid way to detect MEs (16). Nevertheless, this method is expensive and time consuming, compared to self-reporting or chart review methods. In addition, it was reported that sometimes the rate of true errors may be underestimated if physicians and nurses are aware of observation goals (17). Voluntary self-reporting is the most convenient method of ME detection which is performed on daily basis in health care centres. Although this method is cheap and practical, it requires educational and training programs to encourage health care professionals to report all MEs precisely(18-20).

In the present study, prescribtion errors were seen in 14.25% of errors mostly in the monitoring group section. The high rate of these errors is known to be an international problem (21). The incidence of 7- 90% has been reported from different studies in the Middle East (15). The most common errors occurred as incorrect drug dose, wrong frequency and wrong strength in this region (15). In accordance with this result, US and UK hospitals reported incorrect doses as the most frequent type of error in this group. (17, 22, 23). Based on this information, it seems that interventions such as computerized physician order entry with clinical decision support, precipitating a clinical pharmacist in physicians' rounds and improvement in facilities of health care systems, can help reduce prescribtion and monitoring errors in the present PICU.

All medicines were prepared in the unit by the nurses. Depending on the number of patients and nurses present in the ICU, on average each nurse was responsible for 2 patients. Most drug preparations took place between 12 noon and 2.00 p.m., which is at the time of high workload. When the number of IV medications are high, nurses should prepare several drugs for the patients in which they are in charge of. They are also frequently disturbed, which means they stop their preparations. The high number of medications and the interruptions increase the risk of wrong preparation and wrong technique error.

As shown, the IV route of administration had a significant association with prescription (P= 0.022), administration (P: 0.01), wrong time (P= 0.01) and wrong preparation errors (P= 0.01). Given the fact that intravenous route was the most common route used in the PICU (Table 1), it can be concluded that the high rate of MEs in the PICU might be due to the widespread use of intravenous medications in ICUs. Reports from UK and Germany revealed overall error rates of 49 and 48/ 100 orders, respectively, associated with intravenous medications.

It was revealed that working shifts had a significant association with MEs (Table 7). A higher error rate, especially during the day shifts, due to the intensity of work load, having been reported in previous studies, could be an explanation for this finding (24, 25). In the current study, 78% of errors led to no harm, which was consistent with the findings of previous studies. (10, 26-28).

This study has some limitations. It is noteworthy that the study was conducted in a single PICU, because Nemazi hospital was the only hospital in the city which has PICU. The impossibility of collecting data in overnight shifts, is another limitation of this study.

Probably many other factors (such as the training level of residents or nurses) can be contributing to MEs; however, further research is needed to identify them, and implementing actions to reduce the high rate of MEs.

5. Conclusions

The results of this study highlights the high medication error rates in pediatric ICU, with administration and prescription errors marking the highest share of them. The importance of implementing the effective error prevention strategies such as involvement of full-time, ward-based clinical pharmacists, increasing the nurse to patient ratio and participation of pharmacy department in drug preparation instead of preparation of drug admixtures by the nurses, are emphasized.

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Conflict of Interest

None declared.

6. References

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