Irish Journal of Medical Science (1971 -) (2019) 188:591–600
https://doi.org/10.1007/s11845-018-1860-8

ORIGINAL ARTICLE

Pharmacy quality improvement project to enhance the medication management process in pediatric patients

Nermeen Abuelsoud[1]

Received: 20 May 2018 / Accepted: 26 June 2018 / Published online: 14 July 2018
© Royal Academy of Medicine in Ireland 2018

Abstract

Background Improvement in the quality of the medication management process is a crucial component of twenty-first-century medicine.

Aim To improve the quality of medication management process within pediatric specialty through designing a quality improvement project for the pharmaceutical care services in a children' hospital to solve the drug-related problems during drug prescribing, administration, and monitoring.

Methods A total of 900 medical files were evaluated (100 file/month) from the pediatric medical ward to detect any medication errors during prescribing, administration, or monitoring of the drugs. Three pharmacy quality indicators were designed to detect any medication errors during prescribing, administration, or monitoring of the drugs, then a collective datasheet was designed to record any defect in the system during drug management process within the hospital. A quality improvement project was designed using many quality improvement techniques to decrease the rates of medication errors in each drug handling stage. Brainstorming, fishbone chart, questionnaire, and voting were the main quality tools used to detect the causes of medication errors problem in pediatric patients. Certain actions were implemented which included educational program, implementation of clinical pharmacy, intravenous admixture, and drug information services.

Results The quality improvement interventions succeeded in decreasing the rates of medication errors in each stage. These interventions succeeded in decreasing the rates of medication errors in prescribing, administration, and monitoring stages from 47, 60, and 56% respectively to ≤ 15% within 9 months.

Conclusion Pharmacists can have a key role in improving the health-care system's quality in developing countries' health-care systems.

Keywords Drug-related problems · FOCUS-PEDCA · Medication management · Pediatric specialty · Quality improvement

Background

The twenty-first-century medicine development necessitates improvement in the quality of the medication management process. Patient safety and improvement in the quality of the medication management process are associated to each other. Organizations of the health-care systems often use the methods of quality improvement to create patient safety systems and establish safe practices. Medication prescribing for pediatrics necessitates special knowledge in the quality improvement concepts, tools, and methods to improve clinical care, patient safety, efficiency, and the overall patient experience. The main objective of quality improvement is initiation of incremental change and measurement of the consequences of these changes over time. Changes in health care occur within health-care organizations, society, and sometimes in smaller office settings. The effect of this quality improvement initiative can therefore differ greatly across health-care environments. These changes in health care should be measured by specific indicators, tracked and monitored regularly to assess how both the expected and unexpected factors affected the desired outcomes [1]. Providing health-care services is a complicated process involving many integrated and interdependent steps, each of these steps has the potential to fail. Failure at any step can result in a chain of adverse events to the patients and increases the patient's morbidity and mortality [2]. Medication errors (MEs) are a major cause for serious adverse events. MEs can occur during any stage starting from writing the drug order, transcribing the order, dispensing the

✉ Nermeen Abuelsoud
nersoud09@gmail.com

[1] Department of Clinical Pharmacy Practice, Faculty of Pharmacy, The British University in Egypt, Misr-Ismalia Road, Postal No. 11837, P.O. Box 43, El Sherouk City, Cairo, Egypt

drug, drug administration, and monitoring. All professionals in the health-care team have a responsibility toward identification of the factors that may contribute to any medication error and to explore this collected data for further reduction of their occurrence. The prevalence and types of different medication errors in different countries were analyzed to identify the main contributory factors involved and concluded that developing countries in an urgent need for development of professional strategies to improve the skills and knowledge of the prescribers, and to encourage nurses to enhance their skills in drug administration [3]. The medication prescribing, preparation, and administration is a complicated process with multidisciplinary tasks. These tasks require multiple check-points and safeguards to be considered to prevent any error from reaching the patient and cause patient's harm. The involvement of pharmacists and their leadership in the medication management's process are very effective in improving patient's safety and medication's efficiency throughout the hospitalization period [2]. Improvement of the quality of the medication management's process requires various tools and techniques. These tools may help in information communication, data analysis, and facilitating decision-making process. Tools can also be used to briefly describe information, explain a process, identify the areas associated with major problems, recommend solutions, evaluate the effects of change, identify customers and their needs, and explore process or output variations [4]. Tools may include group process such as consensus decision-making tools (e.g., multiple voting; each team member rates, not ranks, the relative importance of choices by distributing a value (e.g., 100 points) across options). Each team member can distribute this value among as many or few choices as desired. This process should be repeated for an agreed upon many parameters until the choice is clear, rank ordering, and structured discussion is achieved. Brainstorming is an idea-generating tool which can help a team to develop many ideas in a short period of time and encourages all the members of the team to participate. It may also generate previously unconsidered ideas. Tools may also include analysis tools such as affinity diagrams and cause-and-effect diagrams (Ex. Fishbone diagram). These diagrams show the relationship between the possible causes and effects and assist in identifying and organizing the factors which might contribute to the problem. Other tools include: decision matrices, root-cause analysis, error or failure modes, effects analysis, flowcharts, force field analysis, histograms, Pareto diagrams, relations diagrams, run charts, scatter plots, and control charts [5]. Another technique used in quality improvement projects is FOCUS_PDCA technique; F stands for finding a problem, O set an objective, C find the causes, U understanding the problem, S set solutions, P set a plan to solve the problem, D do actions necessary to solve the problem, C check (study the effect of the test change), and A act (select which change(s) to implement). This cycle is also known as the Plan-Do-Study-Act cycle [6]. Patient's safety and improved quality health-care services are the main primary goals of any health-care system. Pharmacists are the most experienced member in the medication management process among other health-care team members. Pharmacists can have a key role in improving the health-care system's quality through MEs prevention, and there is a need to broaden their responsibilities by taking on roles in quality improvement projects. Pharmacists are well positioned to help in the quality improvement performance projects with other health-care team members in health-care systems [2]. The objectives of this study are to improve the quality of medication management process in pediatric specialty through using the FOCUS_ PEDCA technique to solve the drug-related problems during prescribing, administration, and drug monitoring and to decrease the MEs rates in drug prescribing, administration and monitoring to $\leq 15\%$ within 9 months.

Methods

Study design

This is a prospective study conducted in a pediatric medical ward in the maternity and children's hospital in Saudi Arabia.

FOCUS_PDCA technique

This technique was used to find a problem related to medication use and then design a quality improvement project inside the pharmacy practice department to solve this problem.

F: finding a problem

Three pharmacy quality indicators were designed based on the Saudi Central Board for Accreditation of Healthcare Institutions (CBAHI) recommendations to detect any MEs during prescribing, administration, or monitoring of the drugs, then a collective datasheet was designed to record any defect in the system during drug management process within the hospital.

Definitions of medication errors:

I. A prescribing medication error means	any error occurred during prescribing (inappropriate drug selection, wrong doses, wrong frequency of administration, contra-indications, drug-drug interactions, avoidable adverse drug reactions)
II. An administration medication error means	any error occurred during drug administration (wrong intravenous (IV) diluent, IV

	admixture concentration or IV infusion rate, or wrong instructions for use)
III. A monitoring medication error means	any error occurred due to lack of drug monitoring (monitoring serum levels for antiepileptics and aminoglycosides, vancomycin, or monitoring of specific drug parameters)

A total of 100 medical files were selected randomly from the pediatric medical ward (PMW) to detect any MEs during prescribing, administration, or monitoring of the drugs. Prescribing errors included the following: drugs should be added, drugs should be removed, drugs should be replaced, doses should be adjusted based on kidney or liver functions, doses should be adjusted based on the body weight, under/overdoses, inappropriate frequency of administration, inappropriate length of treatment, avoidable adverse drug reaction, drug-drug interaction, and contraindication.

Administration errors included the following: wrong instructions for drug use, wrong rate of drug administration, wrong IV diluent, wrong drug and concentration in the IV admixture.

Monitoring errors included the following: lack of adjusting the serum levels for certain medications (e.g., aminoglycosides, antiepileptics…) or lack of monitoring for certain parameters related to each drug (e.g., electrolytes with diuretics, complete blood picture with specific antibiotics…etc)

O: set an objective for the quality improvement project

The objective of this quality improvement project is to reduce the incidence of MEs in each drug handling stage (prescribing, administration, and monitoring) to ≤ 15% within 9 months. This rate was set by the quality improvement department based on the recommendation of the Central Board for Accreditation of Health-care Institutions in Saudi Arabia.

C: find the causes

A flow chart was designed to describe the steps of medication order entry to the pharmacy after prescribing until its administration. Figure 1 shows the detailed steps from order entry until drug administration.

U: understanding the problem

The brainstorming technique was used by the team (the investigator, the pharmacy director, the director of quality department in the hospital, and the head of the pediatric department) to detect the possible causes for the problem. All of the following causes were recorded among the possible causes for this problem: (i) lack of knowledge regarding the detected MEs, (ii) lack of pharmacy supervision and/or clinical pharmacy services, (iii) the pharmacy structure does not contain an intravenous admixture unit to prepare IV therapy, (iv) the pharmacy structure does not contain a drug information center to answer drug-related questions, (v) the pharmacy does not provide auxiliary labels with the dispensed medications, (vi) poor documentation in the medication sheets which may lead to plenty of prescribing errors, (vii) lack of accuracy during prescribing and administration (no double check), (viii) limited number of medications available in the hospital's formulary,(ix) staff overload prevents them from searching for drug information, (x) the hospital structure does not contain a clinical pharmacokinetics laboratory to monitor drugs levels (blood samples were sent to another pharmacokinetics laboratory in another hospital in the same city), and (xi) lack of policies and procedures governing drug management and conducting correction (disciplinary) actions to prevent drug-related errors. Figure 2 shows the fishbone chart which was designed to understand the possible causes of this problem. Another tool was used to dig deep in the most possible causes of this problem which was a questionnaire. The questionnaire was designed and distributed to all the medical staff (physicians, pharmacists, and nurses) as shown in Table 1. A voting technique was also used to find the most possible causes of this problem. Figure 3 illustrates a Pareto chart that explains the main causes of this problem.

S: set solutions

As shown in Fig. 3, more than 90 % of the MEs problem can be solved by avoiding the first 5 causes. The first cause was lack of knowledge regarding the appropriate use of medications; the suggested solutions were as follows: (i) establishing a library in the PMW and (ii) conducting an educational program to PMW staff regarding the detected medication errors. A prioritization matrix was done, and the final suggestion was conducting an educational program to pediatric staff (physicians and nurses) regarding the detected medication errors. There was no need for testing the other causes because all of these services were recommended by national and international quality improvement organizations.

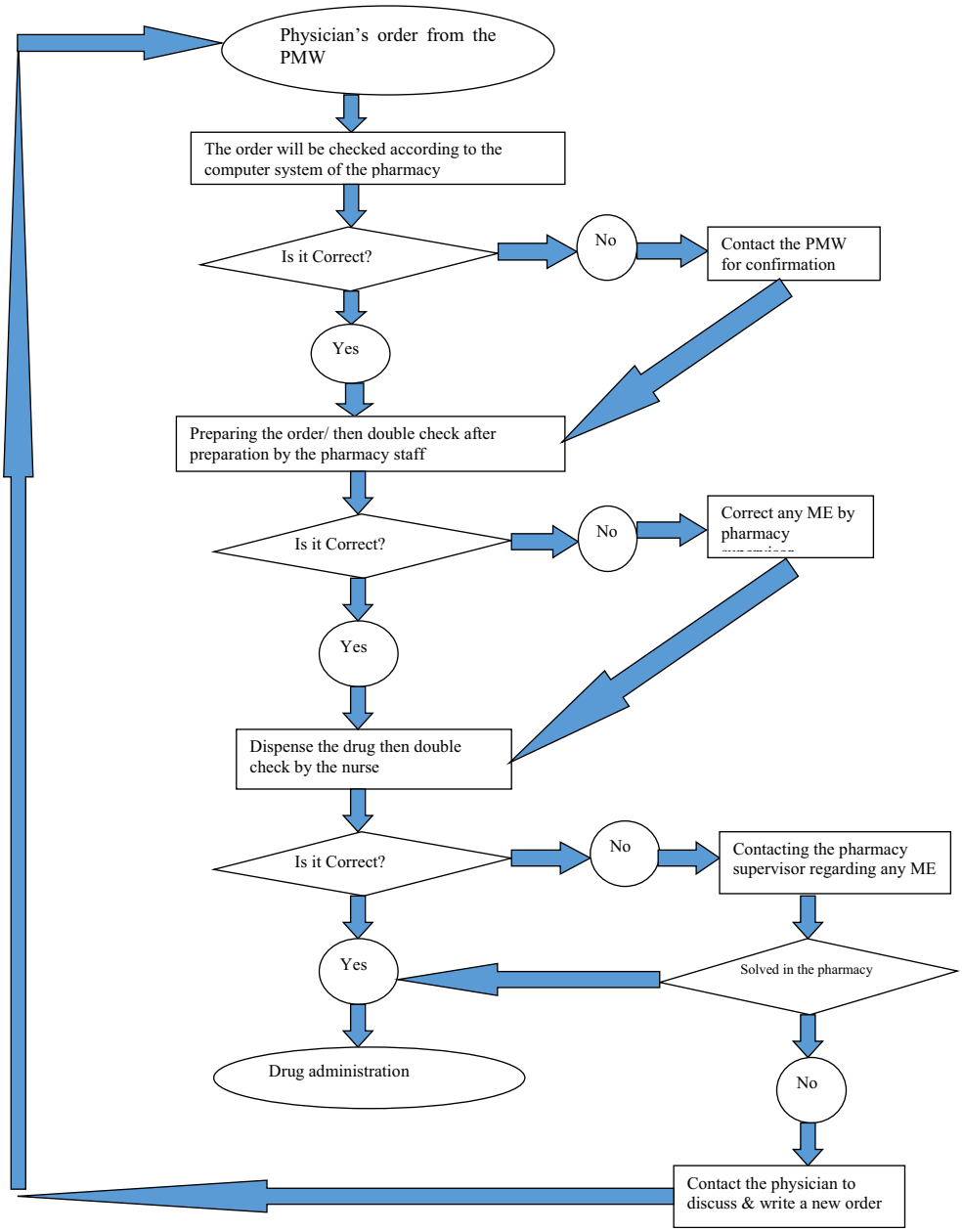

Fig. 1 The flow chart illustrates the steps from order entry until drug administration

P: set a plan to solve the problem and D: do actions necessary to solve the problem

Table 2 shows the different action plans (steps and expected times) for achieving these solutions. After 2 months of implementing these services, the rates of drug-related problems were detected again by using the same pharmacy indicators and were recorded monthly over a 9-month period.

C: check (study the effect of the test change)

Monitoring the effects of the selected solutions was done by recording the rates of MEs again every month. A total of 100 files were reviewed monthly to detect the rates of MEs in each drug handling stage. A plan was designed to check the incidence of MEs every 6 months to make sure that the rates are the same.

A: act (select which change(s) to implement)

To achieve the sustainability of the achieved actions, it was decided that the educational programs will be continued and will focus on any new detected MEs. The other solutions (implementation of clinical pharmacy services, opening an IV admixture unit, opening a drug information center, and using axillary labels) were already implemented during the study period.

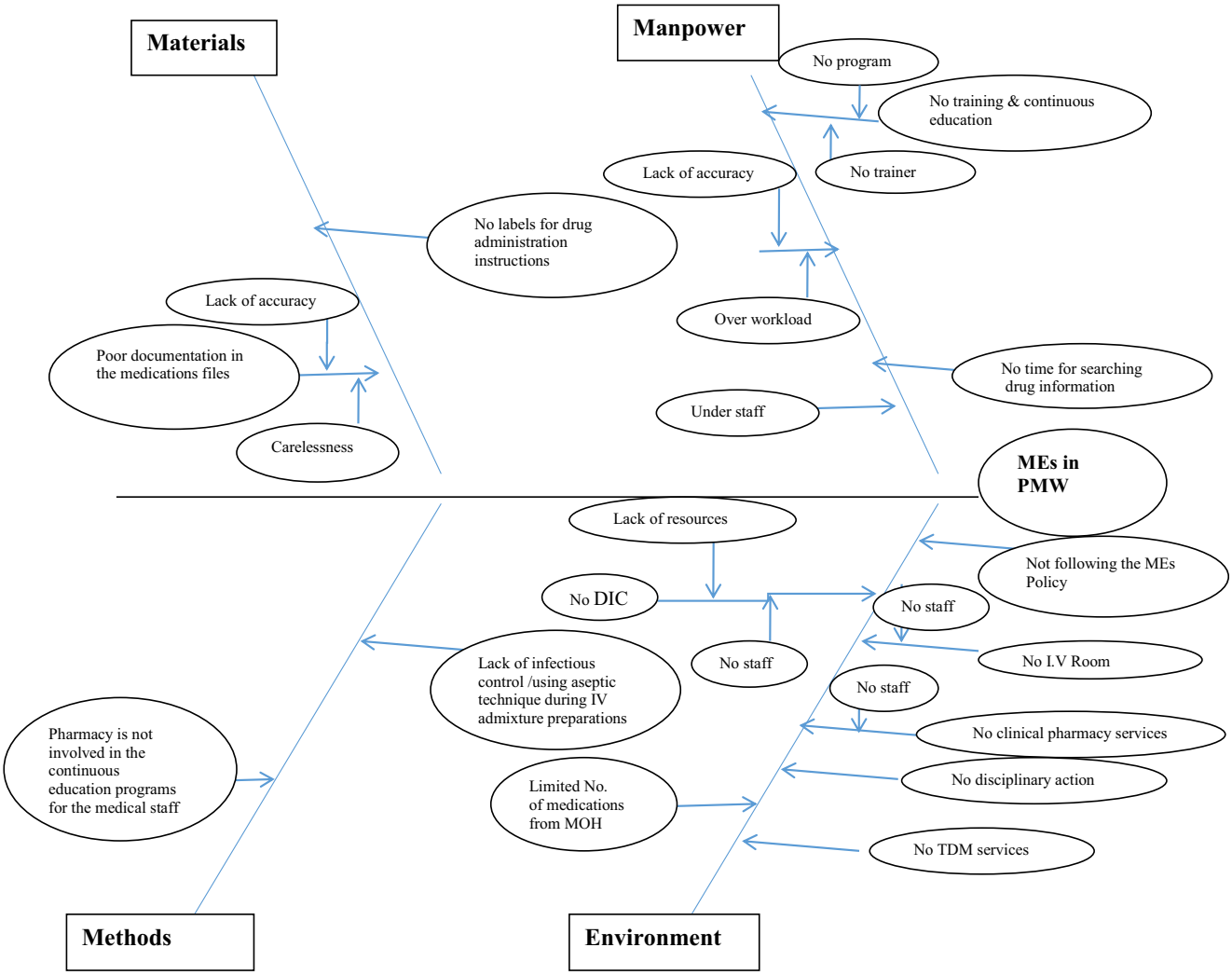

Fig. 2 Fish bone chart illustrates the most common causes of the problem. DIC, drug information center; IV, intravenous admixture; TDM, therapeutic drug monitoring; No., number

Results

A total of 900 medical files were reviewed (100 files/month) to detect the rates of drug-related problems in each drug handling stage (prescribing, administration, and monitoring stages). Figures 2 and 3 show the different possible causes of the detected MEs. The solutions suggested during this improvement project succeeded in decreasing the rates of MEs in each drug handling stage as shown in Fig. 4. The rates of MEs during the prescribing and monitoring stages decreased from 47 to 10% and from 56 to 15% respectively within 9 months after conducting the educational program to the treating physicians in the PMW and discussing the most common detected drug-related problems. Antiepileptics and antibiotics were associated with many drug-related problems, so a series of lectures were designed to outline the following topics: the most common antiepileptic- and antibiotic-related errors during the last 6 months, general principles for epilepsy management, treatment options based on seizure's type, therapeutic monitoring for antiepileptic drugs, antimicrobial resistance, principles for the appropriate use of antibiotics, aminoglycosides pharmacokinetics, rational for monitoring of aminoglycosides and vancomycin serum levels, factor affecting the pharmacokinetics of aminoglycosides, aminoglycoside toxicity assessment, pediatric dosing errors, drugs not approved by FDA for use in pediatrics, drugs not available in hospital's formulary, therapeutic duplications of antiepileptics, the most common drug-drug interactions detected in the PMW, mechanisms by which drug interactions occur, and general strategies for preventing drug interactions. Implementation of clinical pharmacy and drug information services also had a great impact in reducing the errors during drug prescribing in the PMW. The baseline rates of administration errors and monitoring errors were 60 and 56% respectively. Establishment of IV admixture unit and the presence of a pharmacist in this unit to ensure that the order is correct and complete, review the instructions for use section in the order chart, supervise the preparation of the admixture using the right compatible

Table 1 Questionnaires regarding the causes of MEs

Questions to physicians	Yes	No
1. You know how to check the medical information but you do not have the access to it?		
2. Do you feel that there is a need for more training and awareness programs for updating medical information?		
3. Do you feel that checking the doses by the pharmacy staff is an effective (safe) system for preventing medication errors?		
4. Do you think that checking the doses by the pharmacy staff is not important?		
5. Do you know how to use the hospital's formulary?		
6. Do you always facing drug-related questions?		
7. Do you have enough time to search for drug-related information because of the work overload?		
8. You are in need for drug information center in the hospital to answer your drug-related questions?		
9. You are in need for toxicology and pharmacokinetics laboratory in the hospital to monitor the serum levels of medications and avoid delaying through sending the samples to other hospitals?		
10. The limited number of medications makes you prescribe inappropriate medication which may cause medication errors?		
11. Do you aware of the consequences of medication errors?		
12. Did you receive any disciplinary action because of making any medication errors in the past?		
13. You are in need for clinical pharmacy services in the hospital to answer your drug-related question?		
14. Have you ever prescribed wrong medications, under or over doses before?		
Questions to pharmacists	Yes	No
1. You know how to check the doses but there are not any references to go through them?		
2. Do you feel that there is a need for more training and awareness programs for detecting wrong doses?		
3. Do you feel that checking the doses is an effective system for preventing medication errors?		
4. Do you know how to use the hospital's formulary?		
5. Do you believe that checking doses is a part of your job?		
6. Do you think that checking doses is not important?		
7. You do not have enough time to check the doses because of the work overload?		
8. You cannot check the doses because of the medication sheets and prescriptions containing incomplete data (weight/diagnosis/…etc.)?		
9. You are not checking the doses because the physicians will refuse to correct the doses?		
10. You are not checking the doses because you are afraid from correcting an error to the physicians?		
11. You are not checking the doses because you believe that physicians are more expert than you in calculating doses?		
12. You are not checking the doses because when you try to contact physicians, they are not answer?		
13. You are not checking the doses because there is no easy way to contact doctors in a short time?		
14. Do you aware of the consequences of supplying under or overdoses of drugs?		
15. Have you ever dispensed under or overdoses before?		
16. Did you receive any disciplinary action because of dispensing any wrong dose in the past?		
Questions to nurses	Yes	No
1. Do you know how to check the information related to drug administration and compatibilities?		
2. You know how to check these information but you do not have the access to it?		
3. Do you feel that there is a need for more training and awareness program for drug administration?		
4. Do you feel that the pharmacy staff should monitor the drug administration process?		
5. Do you feel that all IV medications should be prepared in the IV admixture unit?		
6. Do you know how to use the hospital's formulary?		
7. Do you always facing drug-related questions?		
8. You do not have enough time to search for drug-related information because of the work overload?		
9. You are in need for drug information center in the hospital to answer your drug-related questions?		
10. You are in need for clinical pharmacy services in the hospital to answer your drug-related questions?		
11. Do you aware of the consequences of medication errors related to drug administration?		
12. Have you ever made any medication error while administrating medications?		
13. Did you receive any disciplinary action because of making any medication errors in the past?		

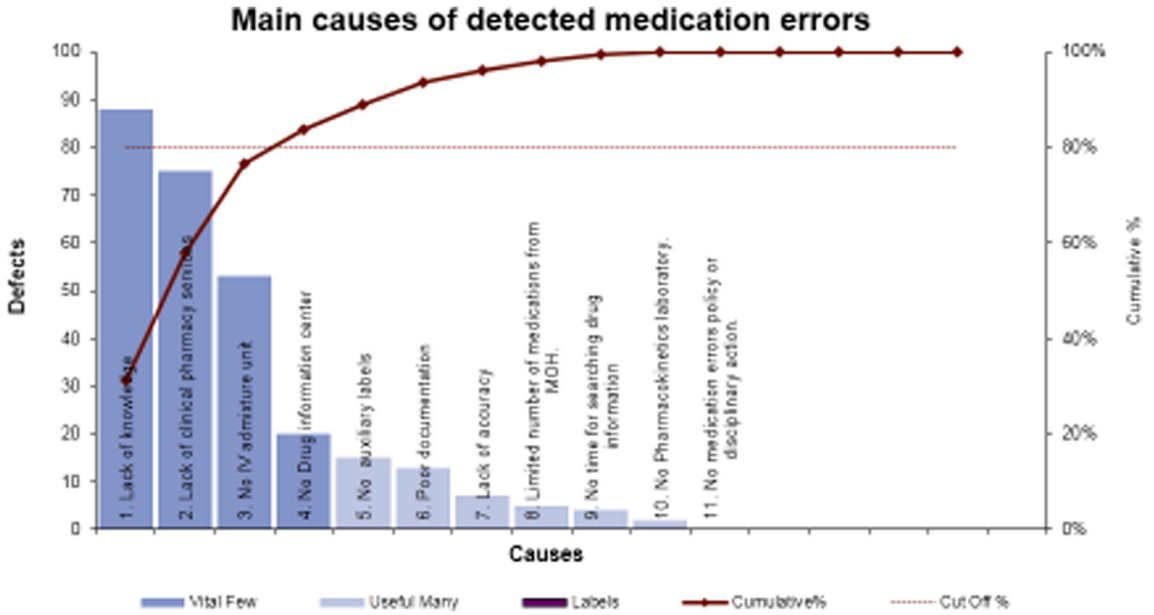

Fig. 3 Pareto chart illustrates the main causes of the problem. MOH: Ministry of health

Table 2 Action plan for implementing the suggested solutions

Actions	Steps	Resources	Achieved after
1. Conducting an educational program to pediatric staff (physicians and nurses)	Preparation of the scientific materials (summary of the detected drug-related problems and updated guidelines discussing the pharmaceutical care planes for each involved disease) for physicians Preparation of scientific materials (stability and compatibility charts) to be distributed in the wards and explained to the nursing staff Reservation for the conference room Putting the schedule for the lectures Distributing the schedule Post test	All the required educational materials were printed from the pharmacy and quality improvement department budget. The clinical pharmacy consultant (the main investigator of this study) conducted a 2 hours lecture / month to the medical team	1.5 months
2. Implementation of clinical pharmacy services	Preparation of job description for the new job Assigning the staff Putting a schedule Sending a memo for initiating the service Conducting a lecture for staff orientation	One clinical pharmacy consultant (the main investigator of this study) was included in the medical team of the PMW	2 months
3. Establishment of drug information center	Preparation of policies/procedures and drug information request form Collecting drug information resources Assigning the staff Putting the schedule to cover 24 h Sending a memo for initiating the service	Many free Internet drug information sources and databases were used to answer the drug information questions (e.g., Medscape, BNF). The clinical pharmacy consultant (the main investigator of this study) trained 3 of the pharmacy staff to implement the service	2 months
4. Establishment of IV admixture unit	Preparation of policies/procedures, stability charts, compatibility charts and labels Requesting IV diluents Assigning and training new staff Sending a memo for initiating the service in the PMW	A laminar airflow hood was already available in the pharmacy for preparing total parenteral nutrition for neonates, and then it was used for IV admixtures preparations. The clinical pharmacy consultant (the main investigator of this study) trained 2 of the pharmacy staff to implement the service	2 months
5. Using auxiliary labels	Preparation of the labels Approval from pharmacy and therapeutics committee to start using these labels Printing the labels Using the labels	The designed labels were printed from the quality improvement department budget	1 month

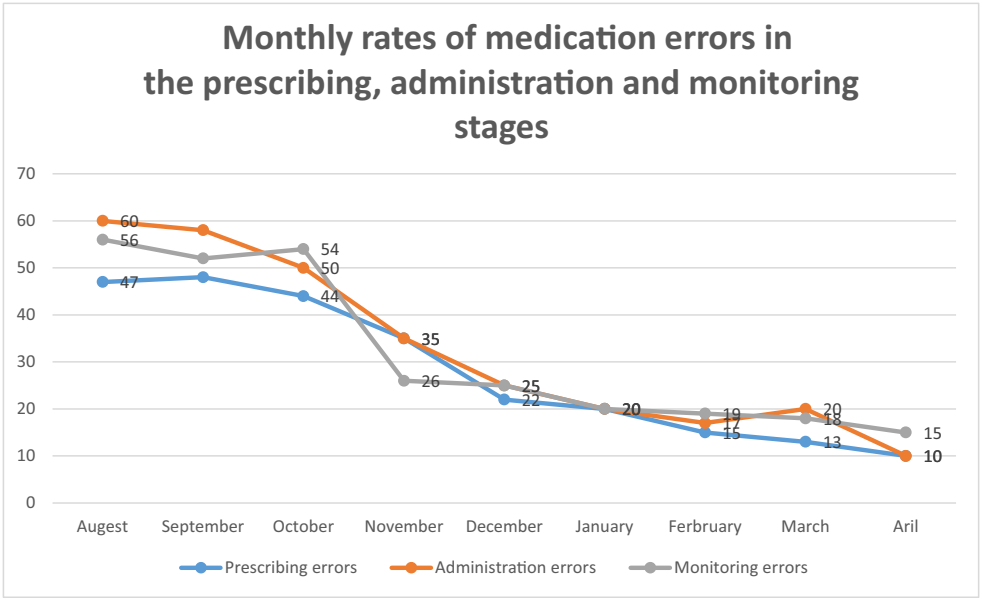

Fig. 4 Monthly rates of medication errors in the prescribing, administration, and monitoring stages

diluent, drug concentration in the admixture, and specify the infusion rates and stability hours succeded in reducing these types of errors. Moreover, providing auxiliary labels include all instructions for drug use succeeded in reducing MEs during administration stage from 60 to 10% as shown in Fig. 4. Figure 5 shows the different types of errors related to drug's prescribing and administration detected at the beginning of the study.

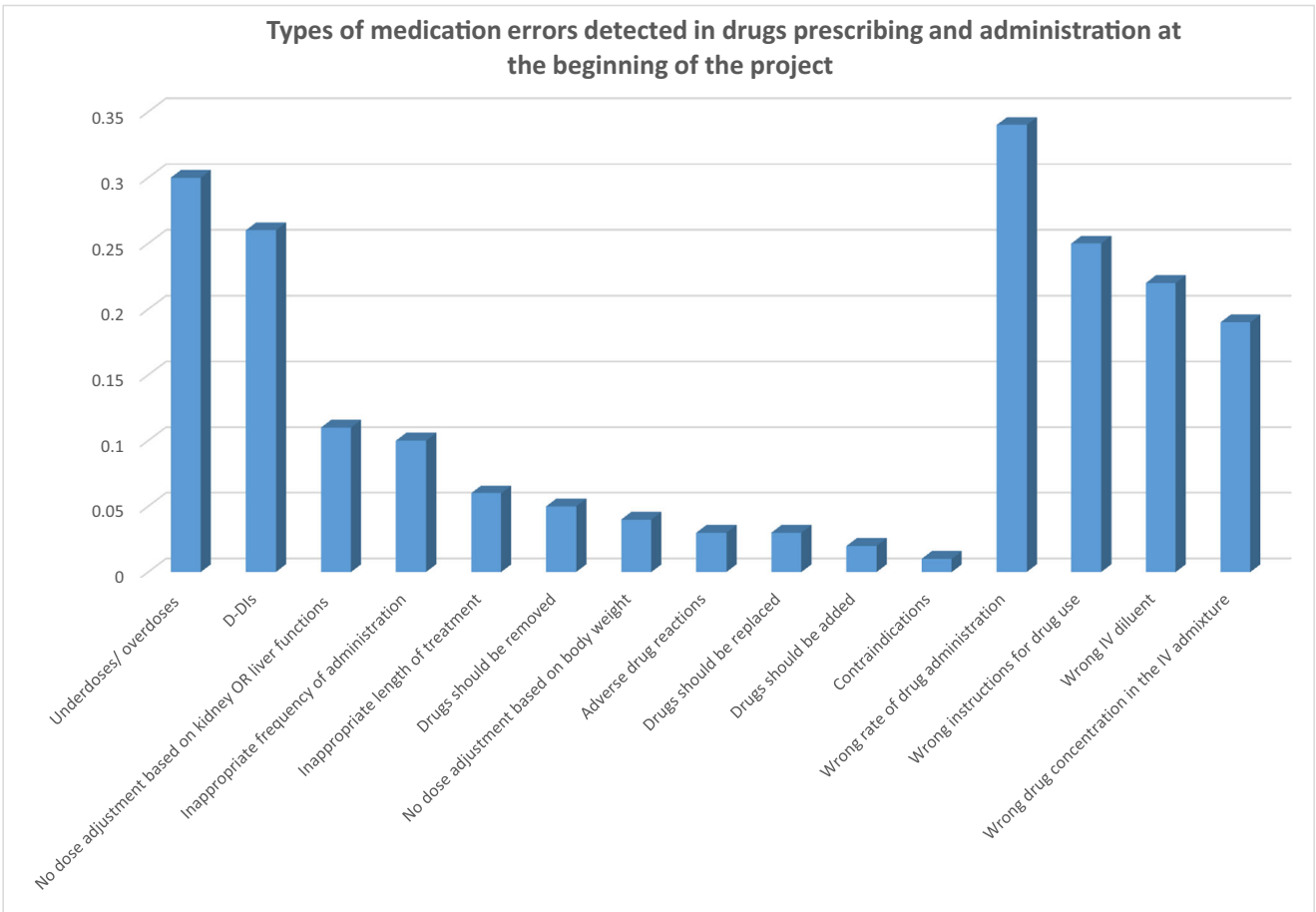

Fig. 5 Types of medication errors detected in drugs prescribing and administration at the beginning of the project

Discussion

In this current study, the detected baseline rate of prescribing errors was 47%. This rate was very high compared with the other rates in many other studies that used the same methods in calculating the rates of errors. Kozer and colleagues [7] resulted in a 16.6% rate of errors per intervention. Their criteria for errors detection were very limited, they included only these types of errors: incorrect dosing, incorrect administration's frequency and incorrect administration's route. This present study included more detailed criteria in detecting and analyzing the detected errors. This study also included the factors related to the internal environment inside the hospital that might affect the medication errors raters. Many types of errors were included in this current study that are not commonly included in other prescribing error studies. Figure 5 shows the different types of prescribing errors detected at the beginning of the study. All of these errors are included in the American Society of Health System Pharmacist definitions [8]. Another study conducted by Miller and colleagues on the incidence of medication errors in pediatrics concluded that it has been estimated that 3–37% of medication errors occur during prescribing, 5–58% during dispensing, and 72–75% during administration, and 17–21% are documentation errors [9]. In this current study, the baseline rates of administration errors and monitoring errors were 60 and 56% respectively. Figure 4 shows the different types of baseline MEs detected during the prescribing and administration stages in this current study. Inappropriate drug selection accounted for about 9% of the detected drug-related problems in our study because some drugs did not have approval for use in pediatric patients. This cause of errors during prescribing for pediatric patients is common among prescribing errors studied in pediatric population. Another study conducted by Sangera and colleagues concluded that in pediatric medicine, many drugs are often used without license, appropriate formulations, or strengths [10]. About 11% of the detected errors were due to lack of dose adjustment based on the kidney or liver functions and 29% were due to dosing errors, which was expected because many studies concluded that all drug doses should be calculated based on patients' weights in this age group, and thus medication prescribing requires more calculations than that in adults, leading to elevated chance for dosing errors [11, 12]. Adverse drug effects accounted for about 3% of the drug-related problems in this current study, and the other factor that may cause harm due to adverse events of these drug-related problems is the inability of neonates and infants to communicate with the health-care providers. These young patients cannot warn the health-care staff members about errors in drug administration or about adverse events that they may experience [13]. Number of studies reported that the rates of errors in the prescription writing are very small in the pediatric population. The error rate reports in these studies have many variations because of differences in methodologies, definitions included, and the range of different settings of these studies [14, 15]. There are also various measures that were used to prevent these errors. Many studies were conducted to evaluate these measures, but most of them were performed in adult settings. Examples of these measures include conducting an educational programs [16], availability of clinical pharmacist in the setting of the study [17], using a computerized entry system during prescribing [18], using a unit-dose system [19], and using personal digital assistants to help during prescription writing [20] and preprinted order forms [7]. There are many components in the prescribing process: cognitive and decision-making component which depends mainly on the prescriber educational level. The other component is the technical—writing the prescription component which may involve errors in transcribing or communicating of the prescribed drug. Measures to improve medication order writing must, therefore, focus on increasing the educational level of the prescribing to prescribe safe and effective medications, as well as other strategies to ensure clear communication of the order itself [21]. The aim of this current study was testing the best solutions to prevent MEs in pediatric patients; as shown in Fig. 2, the main causes for this problem were lack of knowledge regarding the appropriate use of medications, lack of pharmacy supervision and/or clinical pharmacy services, the pharmacy structure didn't contain an intravenous admixture unit to prepare IV therapy, the pharmacy structure didn't contain a center for drug information to response to drugs' questions, and the pharmacy didn't provide auxiliary labels with the dispensed medications. During the study period, the multiple educational interventions to improve physician's prescribing skills succeeded in reducing the rates of MEs and their severity potential. These interventions focused on increasing the awareness of the treating physicians about the detected MEs and their associated adverse events. This was accomplished by conducting multiple lectures for the physicians and continuous feedback during the clinical pharmacy rounds. Besides, providing the necessary drug/dosing information to the health-care professionals assisted the medication prescribing process as it became more accurate and efficient. By the end of the study, conducting an educational program to pediatric staff (physicians and nurses) regarding the detected medication errors, implementation of clinical pharmacy services in the PMW, and establishment of drug information center in the hospital succeeded in reducing the rates of drug-related problems during prescribing and monitoring stages from 47 to 10% and from 56 to 15% respectively as shown in Fig. 4**.** Another study [14] was conducted to evaluate errors in the prescribing stage in critically ill pediatric patients in nine hospitals using similar interventions. Their interventions included predominantly physician's education and providing recommendations about drug dosing and resulted in a 31% reduction in errors' rates in the prescribing stage. Moreover, clinical pharmacist-led educational sessions decreased the prevalence of MEs in critically ill neonates from 24 per 1000 patient days to 5 per 1000 patient days in another

study [22]. In this current study, such a role was investigated in the pediatric patients taking into consideration the most common types of baseline administration errors detected, which were wrong or missed instructions, wrong rate of drug administration, wrong IV diluent, and wrong drug concentration in the IV admixture. It was difficult for nurses to consider all the IV admixture preparation techniques and instructions for all drug uses because of restriction of time and increased workload. Establishment of IV admixture unit in the hospital and providing auxiliary labels to illustrate instructions for medication administration succeeded in reducing MEs during the administration stage as shown in Fig. 4. This study concluded that: Quality improvement of the medication management's process and patient's safety should be initiated in the health-care systems of the Middle East countries. These initiatives should focus on (i) enhancing the knowledge of ME detection of health-care team members; (ii) physicians need to be very cautious during drug's prescribing and dosing especially for neonates and infants; (iii) improving ME reporting system strategies among health-care systems by deleting the barriers, exploring the impact of reporting, and encouraging health-care staff member team to report MEs; (iv) the clinical consequences of MEs should be further assessed in another future studies; (v) regular comprehensive training and educational programs in therapeutics for undergraduate medical and para-medical students should be conducted; and (vi) clinical pharmacist's involvement in the continuous education programs about drug therapy for physicians and nurses is urgently needed.

Acknowledgements The author would like to acknowledge the pharmacy practice department and the quality department of the maternity and children's hospital for supporting this study.

Compliance with ethical standards

Conflict of interest The author declares that she has no conflict of interest.

Ethical approval This article does not contain any studies with human participants.

References

1. Hughes RG (2008) Patient safety and quality: an evidence-based handbook for nurses https://archive.ahrq.gov/professionals/clinicians-providers/resources/nursing/resources/nurseshdbk/nurseshdbk.pdf. Accessed 17 April 2017
2. The ASHP Discussion Guide on the pharmacist's role in quality improvement, American Society of Health-System Pharmacists (ASHP) http://pharma-smart.com/wp-content/uploads/2015/03/ASHP-The-Pharmacists-Role-in-Quality-Improvement.pdf. Accessed 1 April 2017
3. Karthikeyan M, Balasubramanian T, Khaleel MI, Sahl M, Rashifa P (2015) A systematic review on medication errors. Int J Drug Dev Res 7:009–011
4. Department of the Navy (1992) Fundamentals of total quality leadership: student guide. U.S. Government Printing Office http://www.dtic.mil/dtic/tr/fulltext/u2/a278327.pdf Accessed 10 April 2017
5. Plsek PE (1999) Section 1: evidence-based quality improvement, principle, and perspectives. Quality improvement methods in clinical medicine. Pediatrics 103:203–214
6. Beecroft GD, Grace LD, John WM (2003) The executive guide to improvement and change. ASQ press, Milwaukee, pp 17–19
7. Kozer E, Scolnik D, MacPherson A, Rauchwerger D, Koren J (2005) Using a preprinted order sheet to reduce prescription errors in a pediatric emergency department: a randomized controlled trial. Pediatrics 116:1299–1302
8. Myers CE (1993) ASHP guidelines for preventing medication errors. Am J Hosp Pharm 50(2):305-314
9. Miller M, Robinson K, Lubomski L, Rinke M, Pronovost P (2007) Medication errors in paediatric care: a systematic review of epidemiology and an evaluation of evidence supporting reduction strategy recommendations. Qual Saf Health Care 16:116–126
10. Sangera N, Chan PY, Khaki ZF, Planner C, Lee KKC, Cranswick NE et al (2006) Interventions of hospital pharmacists in improving drug therapy in children. A systematic literature review. Drug Saf 29:1031–1047
11. Kaushal R, Bates DW, Landrigan C, McKenna KJ, Clapp MD, Federicoet F et al (2001) Medication errors and adverse drug events in pediatric inpatients. JAMA 285:2114–2120
12. Fortescue EB, Kaushal R, Landrigan CP, McKenna KJ, Clapp MD, Federico F et al (2003) Prioritizing strategies for preventing medication errors and adverse drug events in pediatric inpatients. Pediatrics 111:722–729
13. Wang JK, Herzog NS, Kaushal R, Park C, Mochizuki C, Weingarten SR (2007) Prevention of pediatric medication errors by hospital pharmacists and the potential benefit of computerized physician order entry. Pediatrics 119:e77–e85
14. Cimino MA, Kirschbaum MS, Brodsky L, Shaha SH (2004) Assessing medication prescribing errors in pediatric intensive care units. Pediatr Crit Care Med 5:124–132
15. Ghaleb MA, Barber N, Franklin BD, Yeung VW, Khaki ZF, Wong IC (2006) Systematic review of medication errors in pediatric patients. Ann Pharmacother 40:1766–1776
16. Franklin BD, O'Grady K, Parr J, Walton I (2006) Using the internet to deliver education on drug safety. Qual Saf Health Care 15:329–333
17. Leape LL, Cullen DJ, Clapp MD, Burdick E, Demonaco HJ, Erickson JI, Bates DW (1999) Pharmacists participation on physician rounds and adverse drug events in the intensive care unit. JAMA 282:267–270
18. King WJ, Paice N, Rangrej J, Forestell GJ, Swatrz R (2003) The effect of computerized physician order entry on medication errors and adverse drug events in pediatric inpatients. Pediatrics 112:506–509
19. Fontan JE, Maneglier V, Nguyen VX, Brion F, Loirat C (2003) Medication errors in hospitals: computerized unit dose drug dispensing system versus ward stock distribution system. Pharm World Sci 25:112–117
20. Rothschild JM, Lee TH, Bae T, Bates DW (2002) Clinician use of a palmtop drug reference guide. JAMIA 9:223–229
21. Leonard MS, Cimino M, Shaha S, McDougal S, Pilliod J, Brodsky L (2006) Risk reduction for adverse drug events through sequential implementation of patient safety initiatives in a children's hospital. Pediatrics 118:24–29
22. Simpson JH, Lynch R, Grant J, Alroomi L (2004) Reducing medication errors in the neonatal intensive care unit. Arch Dis Child Fetal Neonatal Ed 89:F480–F482