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Drug Calculation Cards and Medication Errors in the Neonatal Intensive Care Units

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Abstract

Introduction: Medication administration errors are the most common medication errors. One of the most important causes of medication administration errors is a mistake in calculating the dose of medication by nurses. This study was conducted to evaluate the effects of using the Drug Calculation Cards on the amount and type of medication administration errors in the Neonatal Intensive Care Units (NICUs).

Methods: This quasi-experimental study was conducted with one-group before-after design to examine the effects of using the Drug Calculation Cards on the amount and type of medication administration errors. Eligible NICU nurses in selected centers affiliated to Qazvin University of Medical Sciences were registered (n = 33) in the study within three months. Then, before intervention data were collected using "medication administration errors reporting" questionnaire. Three months later the intervention (drug calculation card) was done and the same medication administration errors reporting questionnaire was dispersed. The data were entered to the SPSS version 14 and was analyzed using descriptive statistics.

Results: The mean medication administration error during the three months before and three months after the intervention were 12.41 ± 14.48 and 9.62 ± 12.72, respectively, which had a statistically significant difference (P = 0.004).

Conclusions: Using the Drug Calculation Cards by nurses in NICUs had a positive effect on the reduction of medication administration errors.

INTRODUCTION

Errors are considered natural phenomena in human performance, even optimal performances even may sometimes have an error[1]. A medication error is any preventable event due to inappropriate medication use that may cause or lead to patient harm while it can be controlled by the medical team or the patient [2, 3].

Medication errors are the most common medical errors [4]. During the construction, prescription, administration, preparation and implementation of the drug [5]. Medication administration errors are the most common medication errors that occur when there is a difference between the drug that the patients receive and the drug prescribed for them [6]. Medication errors account for about 19.1% of all medical errors [7]. The rate of medication administration errors is high [8], and accounts for fifty percent of medication errors [9]. A study showed that that medication administration errors were more than other types of medication errors in Iran [10]. Although only ten percent of these errors result in adverse events, they lead to death and diseases [11]. They increase health care costs as well as the duration of hospitalization [12].

Medical errors are classified into five categories by the American Medical Association (AMA) [13]. Classification of Medication Errors was Prescription, Delivery, Availability, Patient, and Report [14]. Medical

errors incidence rate are 6.5 cases per 1,000 patients among the adults and 14.8 cases per 1,000 patients in the pediatric ward [15]. Medical errors incidence in the Neonatal Intensive Care Unit (NICU) are reported to be 8 times more than other wards [4]. Most of these errors occur for premature infants with gestational age less than 30 weeks and weighing less than 1500 grams [16]. The amount of medication error is 57% in premature infants and 3% in term infants which is a noteworthy rate. The three important variables that make the medication administration process in the NICU risky are the vulnerability nature of the patients, the complexity of the drugs, and environment-related challenges. Since the infants in NICU have underdeveloped systems including immature gastrointestinal, hepatic and renal systems, which gradually evolved during the time of hospitalization, their responsiveness toward drugs is different. In fact, prematurity of drug absorption and excretion systems, the long duration of hospitalization of the infants [17], inability to communicate, inability to participate in the self-identification process during drug administration and receiving several different drugs at the same time [18], can increase the risk of medication error in newborns admitted to NICU [19]. Since the drug doses prescribed for infants is calculated based on their weight, they cannot have a standard administration like the adults [20]. Thus the most common medication errors are errors related to the time of drug administration, drug calculations, and neglecting drug interactions [21, 22]. Therefore, a risk factor for the occurrence of medication errors in children is errors during drug calculation [23].

Nawwer et al. found that the most frequent medication error was the error in the frequency of drug administration and drug administration technique [24]. Medication administration errors will negatively affect the personal and professional lives of nurses [25]. They spent 40 percent of their time on drug administration and are the last link in the chain of medication, so they have a key role in the preparation and administration of the drugs and their performance requires extensive care and caution and a structured method to prevent medication errors [26]. Nurses should be able to calculate drug doses correctly, but they usually do not. A study showed that over 77% of nurses perform poorly or moderately in the calculation of the drug dose as a factor that can lead to errors [27]. Besides, the particular form of soluble drugs that are in the concentration/percentage or mEq form reduces the calculation power of nurses. The results of a study in 2012 showed that the calculation error of the injectable drug was 51-60% [21]. Studies have shown that the most common types of medication errors include prescribing wrong drugs, miscalculation of the drug dose, and prescription of non-consumable, drugs most of which occur in injectable drug [21, 27]. Although the damage resulting from medication administration errors has not diminished in the last 15 years [21], solutions such as simplification, standardization, and the use of information technology have been presented to reduce errors [28]. The right has stressed the improvement of nurses' computational skills as a means of reducing errors [29]. Using drug calculation cards is one of the methods to reduce dependence on memory, simplification, training to improve access to information, and standardization to improve safety in drug administration in NICUs.

Given the importance of the issue, lack of enough research in this field and the point that medication administration errors pose a significant risk to infants, any tool that can potentially prevent errors might be beneficial. Therefore, the present study was conducted to evaluate the effects of using the drug calculation cards on the amount and type of medication administration errors in the NICUs in selected centers affiliated to Qazvin University of Medical Sciences.

METHODS

This was a quasi-experimental study with one-group before-after design to examine the effects of using the Drug Calculation Cards on the amount and type of medication administration errors in the NICUs in selected centers affiliated to Qazvin University of Medical Sciences. The study population consisted of all nurses in NICUs of Qods and Kowsar Hospitals. In this study, 33 eligible nurses in NICU were selected by census (20 from Qods and 13 from Kowsar Hospitals). The recruited nurses were officially employed or had a covenant or contractor were in a staffing plan, had at least one year of experience in NICU, and had at least a bachelor's degree in nursing. Nurses that had paid or sick leave for more than three shifts or were sent to other wards for any reason within three months of the intervention were excluded.

The tool has 29 items in the first section and 16 items in the second section, which measure the causes of medication errors and lack of reporting the medication errors, respectively. The third section of the tool which was used in this study estimates the percentage of different types of medication errors from the perspective of nurses, of which 9 items are related to non-injectable drugs and 11 items are related to injectable drugs. The nurses express their views based on the estimated percentage of each error type with numbers from 1 to 5 (a five-point scale); where 1 equals to 0-30 percent (too low), 2 equals to 31-50 percent (low), 3 equals to 51-70 percent (moderate), 4 equals to 71-90 percent (high), and 5 equals to 91-100 percent (very high). Also, in this section, the participants are asked to estimate the total number of medication errors (injectable and non-injectable) in the past month [25].

After obtaining informed consent, data were collected using two "demographics" and "self-reporting medication administration errors" questionnaires. The first questionnaire included 12 questions about characteristics such as age, marital status, education, and type of employment, which was completed by the participants. The second questionnaire was the "self-reporting medication administration errors" tool has 14 items that type and frequency of measure medication administration errors and designed by Wakefield et al 2005 [30].Two items of the scale are responded number of medication administration errors and 12 items of scale are responded of type of medication administration errors in a five-choice Likert scale, with options ranging from '1 = Not at all' to '5 = very much'. It has been used in several Iranian and foreign studies on a population of nurses [21] which has showed an accepted validity and reliability (internal consistency reliability: α = 0.84) and content validity index (CVI = 75%-100%). The tool was translated into Persian by Taheri et al and its content validity was evaluated and approved by 10 experts. The Cronbach's Alpha of the third part of the tool about injectable drugs and non-injectable drugs was 0.82 and 0.71, respectively [21].

In this study, after obtaining approval from the ethics committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1396.263V), and obtaining appropriate licenses and submitting the sampling permits to the Qazvin University of Medical Sciences and the hospitals with NICUs, the research objectives were explained to the participants and their informed written consent was obtained. They were given the necessary explanations regarding the anonymity of questionnaires and their choice in participating in the study as volunteers. The demographic characteristics questionnaires were then completed by nurses in both wards. The third section of the questionnaire (medication administration errors) was given to all nurses in all three shifts anonymously. After completion, the nurses put the questionnaires in the boxes embedded in the ward for reporting errors. In the next step, the use of drug calculation cards was taught to the nurses through face-to-face training during four separate training sessions. The questions of nurses about how to use the cards were answered. The cards were available in the treatment room for all nurses in the two wards. The intervention lasted three months. In addition to coordinate with the supervisors and hospital nurses' management, researchers randomly attended different shifts in order to ensure the correct application of cards. After three months of using the drug calculation card, the "medication administration errors reporting" questionnaire was given to the nurses again and data was analyzed using descriptive and inferential statistics software.

In this study, 21 drug calculation cards were prepared based on the children's immune system called Brose low-lutein color-coded system that helps the nurses to have the correct and rapid pre-calculated information about the dose [31], for the most widely used inter Venus (IV) drugs (cartridge-type). In order to determine the most widely used drugs, after coordination with the pharmacy technical officer, the requested medication list of December, January, and February were obtained from the pharmacy, from which the drugs whose doses were prescribed in cc were excluded. The epinephrine injections dose was prescribed as 0.1 to 0.3 cc per kg of body weight of one in ten thousand ampules, and it was excluded since the ampule available in both hospitals was one in ten thousand. Pancuronium was not on the pharmacy drug list, but because of the importance of the drug, its history of use in both wards, and it is very important side-effects was included in the list of drugs with the calculation card.

Each card had similar information at the same place for standardization, and the name of the drug and the dose of the drug in the volume of solvent was written at the top of the card. The proportion table of drug calculation was provided beside the available doses for the nurses. All doses were calculated in the smallest possible amount that could be drawn into the insulin syringes (0.1 ccs). The exceptions were the drugs whose calculated dose at 1.0 cc was a decimal numerical value (e.g. Co-trimoxazole) for which the 0.5 cc amount was used. Dilution was performed in two, three, or four steps depending on the type of the ampule. A brief explanation of each step is provided beside the shapes. The proper dilution solutions were provided at the bottom of the cards. Only in relation to the calculation card of the phenytoin ampule, the incompatible solutions were also inserted in addition to the diluting solution in another color due to its high sensitivity. The back of the cards included the incompatible drugs with the intended drug on the card at a three-way. After the initial preparation of drug calculating, the cards were controlled by two ICU nurses with 10 and 2 years of experience, a specialist, and an accountant for the calculations. Some boxes were prepared for easy access to the cards.

The medication administration errors questionnaire was given to all nurses in all three shifts anonymously. After completion, the nurses put the questionnaires in the boxes embedded in the ward for reporting errors. In the next step, the use of drug calculation card was thought to the nurses through face-to-face training during 4 separate training sessions.

The questions of nurses about how to use the cards were answered. The cards were available in the drug room for all nurses in two wards. The intervention lasted three months. In addition to coordination with the supervisors and hospital nursing management, researchers randomly attended different shifts in order to ensure the correct use of cards. After three months

of using drug calculation cards, the "medication administration errors reporting" questionnaire [22] was given to the nurses. Then data was entered into the SPSS 14 software and was analyzed using descriptive statistics.

RESULTS

The results showed that the average age of the nurses was 29.13, 75.8% of them were married, and most of them (97%) had a bachelor's degree, and their mean work experience was 3.46 years. Most medication errors (69.7) had occurred in the night shift. A large percentage of nurses (60.6%) have received no education about medication errors. Most of them stated that there was a shortage of nurses (99%) and there was no control or monitoring over medication errors (57.6). The findings also showed that each of the two wards had significantly fewer errors after the intervention (Table 1). In general, the Wilcoxon test showed that a reduction in the errors occurred after the intervention (P = 0.004) (Table 2).

In terms of the types of medication errors, results showed that the medication errors of administration of the drug to the wrong patient (P = 0.044), mistakes in medication calculations (P = 0.000), giving medicine to infants with known hypersensitivity (P = 0.020), and the use of inappropriate solutions for drug dilution (P = 0.004) after the three-month intervention showed significant differences compared to the three months before the intervention (Tables 3 and 4).

Table 1: Study of the Correlation between before and after Using New Drug Calculation Cards on the Amount of Medication Errors in NICUs

Hospital	Errors in Pre-Using Drug Calculation Cards	Errors in Post- Using Drug Calculation Cards	Paired t-Test		P value
Qods	17.4 ± 16.57	13.97 ± 144.76	df=19	t=420.2	0.026
Kowsar	4.72 ± 4.36	2.93 ± 2.64	df=12	t=2.463	0.030

Data in table are presented as Mean ± SD.

Table 2: Distribution of Frequency of Medication Errors before and after Using New Drug Calculation Cards in NICUs

Errors number	Errors number in Pre-Using Drug Calculation Cards	Errors number in Post- Using Drug Calculation Cards
0	7(12.2)	4(12.1)
1-2	4(12.1)	5(15.2)
3-5	5(15.5)	11(33.3)
6-8	0(0)	1(3)
9-11	6(18.2)	5(15.2)
12-14	1(3)	0(0)
15-17	0(0)	0(0)
18-20	2(6.1)	1(3)
21-30	1(3)	2(6.1)
31-40	2(6.1)	0(0)
≥40	5(15.15)	4(12.1)
Total	33(100)	33(100)
Mean	12.41 ± 14.48	9.62 ± 12.72

Data in table are presented as Mean ± SD or No.(%).

Table 3: Study of the Correlation between before and after Using Drug Calculation Cards on the Type of Medication Errors in NICUs

Type of Error	Qods			Kowsar		
	Wilcoxon Test		Test Result	Wilcoxon Test		Test Result
	Z	P		Z	P	
Wrong Method in Medication Administration	0.575	0.565	NS	- 0.264	0.792	NS
Error in Time of Medication Administration	- 0.250	0.803	NS	- 0.333	0.739	NS
Wrong Patient	- 2.217	0.027	NS	0.000	1.000	NS
Wrong Medication	- 0.833	0.405	NS	- 1.633	0.102	NS
Error in Medication Dose	- 1.051	0.293	NS	- 0.690	0.490	NS
Error in Pharmaceutical Calculations	- 2.887	0.004	S	- 2.236	0.025	S
Medication Administration without the Physician's Prescription	- 2.000	0.046	S	- 0.333	0.739	NS
Medication Administration after the Physician's Ceasing Order	- 2.324	0.020	S	- 1.100	0.273	NS
Medication Administration to a Newborn with a Recognized Allergy	- 2.530	0.011	S	0.000	1.000	NS
Use of an Unsuitable Solution for the Drug Dilution	- 2.121	0.034	S	- 2.000	0.046	S
Error in Speed of Drug Injection	- 1.141	0.254	NS	- 1.38	0.254	NS
Neglecting the drug interaction in simultaneous prescription of drugs	- 1.134	0.275	NS	- 1.134	0.275	NS

DISCUSSION

The results of this study on the effects of using the drug calculation card on the amount and type of medication errors showed that most medication errors occur at night shifts which were consistent with other studies [21]. However, Panjavini and Lerner showed that the errors occurred during the day were more [32].In some other studies, the nurses considered evening shifts ineffective in errors [31] or reported a higher probability of errors in the evening shifts than morning shifts [28]. On the other hand, the results of some studies have also shown that errors do not occur in connection with certain working shifts [33].

It appears that the different circumstances of the wards could be the reason for the contradictory results. The factors of a shortage of manpower, high working pressure, and drug administration on several occasions in the night shift in NICU could be effective in the results of the present study. Various studies have reported such factors as affecting the errors. A study by Taheri Habib Abadi et al. introduced a lack of human resources, physical and mental fatigue of nurses, and high volumes of work as factors affecting the occurrence of medication errors [21].

Bizhani et al. reported nurses' carelessness, mental problems of the nurses, lack of knowledge of medications, physical conditions of the workplace (noise, insufficient light), high volumes of work in the ward, nominal similarity of patients, and few number of nurses in relation to the patients as factors affecting the medication error [34]. Heidari et al. investigated the nurses' perceptions of the causes of medication errors in a qualitative study and introduced managerial factors and its subcategories of inefficiency in recruiting, poor physical condition and high workload as affecting factors [34]. The results of Morris et al were inconsistent with this study regarding the rate of medication administration errors, during a prospective cohort study, they showed that although medication barcode system reduced the risk of drug complications up to 47%, the intervention has increased the incidence of medication errors from 69.5 per 100 doses to 79.9 per 1000 doses [35].

Table 4: Distribution of Frequency of different Types of Medication Errors in NICUs

Pre-Using Drug Calculation Cards n (%)					Post- Using Drug Calculation Cards n (%)					Test		
Too Low	Low	Moderate	High	Very High	Too Low	Low	Moderate	High	Very High	Wilcoxon Test		Test Result
Wrong Method in Medication Administration												
13 (39.4%)	14 (42.4%)	5 (15.2%)	1 (3.0%)	0 (0%)	13 (93.4%)	11 (33.3%)	8 (24.3%)	1 (3.0%)	0 (0%)	P=0.740	Z= 0.331	NS
Error in Time of Medication Administration												
13 (39.4%)	5 (15.2%)	12 (36.3%)	2 (6.1%)	1 (3.0%)	11 (33.3%)	11 (33.3%)	7 (21.2%)	4 (12.1%)	0 (0%)	P=0.717	Z= -0.363	NS
Wrong Patient												
9 (27.3%)	15 (45.5%)	8 (24.2%)	0 (0%)	1 (3.0%)	12 (36.4%)	19 (57.5%)	2 (6.1%)	0 (0%)	0 (0%)	P=0.044	Z= - 2.010	S
Wrong Medication												
8 (24.2%)	15 (45.5%)	10 (30.3%)	0 (0%)	0 (0%)	9 (27.3%)	20 (60.6%)	3 (9.1%)	1 (3.0%)	0 (0%)	P=0.108	Z= - 1.606	NS
Error in Medication Dose												
3 (9.1%)	4 (12.1%)	17 (51. 5%)	7 (21.2%)	2 (6.1%)	4 (12.1%)	5 (15.1%)	15 (45.5%)	6 (18.2%)	3 (9.1%)	P=0.711	Z= - 0.371	NS
Error in Pharmaceutical Calculations												
4 (12.1%)	4 (12.1%)	15 (45.5%)	9 (27.3%)	1 (3.0%)	5 (15.2%)	15 (45.5%)	12 (36.3%)	0 (0%)	1 (3.0%)	P=0.000	Z= - 3.501	S
Medication Administration without the Physician's Prescription												
18 (54.5%)	9 (27.3%)	6 (18.2%)	0 (0%)	0 (0%)	0 (0%)	20 (60.6%)	12 (36.4%)	1 (3.0%)	0 (0%)	P=0.165	Z= - 1.388	NS
Medication Administration after the Physician's Ceasing Order												
15 (45.5%)	14 (42.4%)	4 (12.1%)	0 (0%)	0 (0%)	19 (57.6%)	11 (33.3%)	3 (9.1%)	0 (0%)	0 (0%)	P=0.365	Z= - 0.906	NS
Medication Administration to a Newborn with a Recognized Allergy												
18 (54.5%)	12 (36.4%)	2 (6.1%)	1 (3.0%)	0 (0%)	24 (27.7%)	7 (21.2%)	2 (6.1%)	0 (0%)	0 (0%)	P=0.020	Z= - 2.324	S
Use of an Unsuitable Solution for the Drug Dilution												
16 (48.5%)	12 (36.4%)	5 (15.2%)	0 (0%)	0 (0%)	23 (69.7%)	8 (24.2%)	2 (6.1%)	0 (0%)	0 (0%)	P=0.004	Z= - 2.887	S
Error in Speed of Drug Injection												
5 (15.2%)	7 (21.2%)	13 (39.4%)	7 (21.2%)	1 (3.0%)	7 (21.2%)	11 (33.4%)	13 (39.4%)	1 (3.0%)	1 (3.0%)	P=0.101	Z= - 1.640	NS
Neglecting the drug interaction in simultaneous prescription of drugs												
5 (15.2%)	2 (6.1%)	13 (39.4%)	11 (33.3%)	2 (6.1%)	2 (3.0%)	7 (21.2%)	14 (42.4%)	9 (27.3%)	1 (3.0%)	P=0.366	Z= - 0.905	NS

Although conducting the study only in the NICU can shed doubt on the results generalization, it appears that inconsistency in results could be related to the nature of the intervention and also the structured audit of medical reports to determine the error, which has led to the more precise identification of the errors after the intervention in the above study. The results of this study showed that the drug calculation cards can reduce the medication errors rate and help the nurses to simply calculate the smallest dose of the drug and then reach the required dose by dilution. Using the cards helps the nurse with proper calculation and selection of the appropriate solution for drug dilution. The results of this study indicated a significant reduction in errors of drug calculation and using improper solutions for dilution of medication after the intervention. These cards were not specifically designed to reduce other types of medication errors. However, since usually, the nurses that have a type error more are more likely to have other types of errors, too, the intervention reduced other types of errors, although the reduction was only significant in the drug administration to the wrong patient and administration of drugs to children with known hypersensitivity.

The findings of this study regarding the type and amount of medication errors were not in line with the results of Schimmel et al. In that study, the intervention of completing drug card was nominal and after the intervention the rate of errors in 740 times of medication administration increased to 23% from 19.4% before the intervention. In that study, medication errors were forgetting the drug and administration of the drug which after intervention increased from 18.3% to 36% and 20% to 39.4%, respectively. Those results were different from this study as the intervention increased errors and increased some types of medication errors in that study which can be due to the type of intervention, and on the other hand, the shortness of the intervention period (10 days) have surely affected the results [36]. Simpson et al identified 105 medication errors in ICU during a year in Scotland. Their intervention was a daily review of medication orders by clinical pharmacologists and error correction and training about correct dosage calculations. After the four months of intervention, medication errors decreased in line with the results of

this study so that the error rate reduced from 24.1 errors per 1000 days of performance to 5.1 errors (>0.001) [37]. Flanigen et al showed a decrease in the number of medication errors. Their intervention was using administration charts for implementation and monitoring of gentamicin in the neonatal wards. The mean annual medication errors related to gentamicin reduced from 4.75 to 4, which was not statistically significant [38]. Sharifi et al showed that training significantly decreased the amount of injectable medication errors in "checking before injecting" (60.5% vs. 6.6%), "checking the site of injection" (25.3% vs. 3.4%), "injection duration" (50.1% vs. 27.6%), "checking during injection (42.7% vs. 16.7%) and "checking at the end of injection" (42.3% vs. 2.17%) (0.05) [39].

CONCLUSIONS

Consistent with this study, the results of the above study showed that the intervention resulted in a significant reduction of different investigated errors. However, their investigated errors were not the same as this study, the error rate was not examined in that study. The findings of this study on the reduction of drug calculation errors in NICU were consistent with Ligi, too. The quality improvement team in that study presented some solutions for error prevention. In that study, after the study period, the prevalence of severe iatrogenic events reduced significantly from 7.6 to 4.8 cases per 1000 days, and medicine calculation errors (decimal errors) decreased significantly (0.022) [40]. Therefore using the drug calculation cards by nurses in NICUs had a positive effect on the reduction of medication administration errors.

LIMITATIONS

Since the direct observation approach can increase the number of errors by the presence of the observer, the present study used voluntary reporting (self-report questionnaire) for error reporting, and under-reporting of errors was a limitation of this study. Therefore, it is necessary to be cautious in generalizing the results.

IMPLICATIONS FOR PRACTICE

According to the results, using the drug calculation card significantly reduced the rate of medication administration errors after the intervention. The errors of administration of the drug to the wrong patient, mistakes in medication calculations, giving medicine to infants with known hypersensitivity, and the use of inappropriate solutions for drug dilution after three months of intervention was significantly less than before the intervention indicating that the use of drug calculation card have effectively reduced these types of medication errors.

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ETHICAL CONSIDERATIONS

The research objectives were explained to the participants and their informed written consent was obtained. They were given the necessary explanations regarding design the study. Permission for study was through the Ethical Committee of Shahid Beheshti University of Medical Sciences.

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AUTHORS' CONTRIBUTION

MK and MN designed the study. MR and MN drafted the manuscript and revision of it. ST and MF coordinated the study and participated in gathering data. FS performed Statistical analysis.

CONFLICT OF INTEREST

None declared.

REFERENCES

1. Boldrini A, Scaramuzzo RT, Cuttano A. Errors in neonatology. Journal of Pediatric and Neonatal Individualized Medicine (JPNIM). 2013;2(2):e020230.
2. Adelman JS, Aschner JL, Schechter CB, Angert RM, Weiss JM, Rai A, et al. Evaluating Serial Strategies for Preventing Wrong-Patient Orders in the NICU. Pediatrics. 2017;139(5):e20162863. doi: 10.1542/peds.2016-2863 pmid: 28557730
3. Kale PL, Mello-Jorge MHPd, Silva KSd, Fonseca SC. Neonatal near miss and mortality: factors associated with life-threatening conditions in newborns at six public maternity hospitals in Southeast Brazil. Cadernos Saude Publica. 2017;33.
4. Brener P, Ballardo M, Mariani G, Ceriani Cernadas JM. Medication error in an extremely low birth weight infant: paracetamol overdose. Arch Argent Pediatr. 2013;111(1):53-5. doi: 10.5546/aap.2013.53 pmid: 23381705
5. Dadgari A, Kasaeian A, Dadvar L, Kalatejari M, Rezaee M, Mirzaee M. Effects of Education On Nurses'knowledge And Skill In Drug Dosage Calculation. Knowledge Health. 2012;7(1):20-6.
6. Bifftu BB, Dachew BA, Tiruneh BT, Beshah DT. Medication administration error reporting and associated factors among nurses working at the University of Gondar referral hospital, Northwest Ethiopia, 2015. BMC Nurs. 2016;15(1):43. doi: 10.1186/s12912-016-0165-3 pmid: 27436991
7. Keers RN, Williams SD, Cooke J, Ashcroft DM. Understanding the causes of intravenous medication administration errors in hospitals: a qualitative critical incident

study. BMJ Open. 2015;5(3):e005948. doi: 10.1136/bmjopen-2014-005948 pmid: 25770226
8. Parry AM, Barriball KL, While AE. Factors contributing to registered nurse medication administration error: a narrative review. Int J Nurs Stud. 2015;52(1):403-20. doi: 10.1016/j.ijnurstu.2014.07.003 pmid: 25443300
9. Schmidt CE, Bottoni T. Improving medication safety and patient care in the emergency department. J Emerg Nurs. 2003;29(1):12-6. doi: 10.1067/men.2003.19 pmid: 12556823
10. Ahmadizar F, Soleymani F, Abdollahi M. Study of drug-drug interactions in prescriptions of general practitioners and specialists in iran 2007-2009. Iran J Pharm Res. 2011;10(4):921-31. pmid: 24250431
11. Jones JH, Treiber L. When the 5 rights go wrong: medication errors from the nursing perspective. J Nurs Care Qual. 2010;25(3):240-7. doi: 10.1097/NCQ.0b013e3181d5b948 pmid: 20164807
12. Leufer T, Cleary-Holdforth J. Let's do no harm: medication errors in nursing: part 1. Nurse Educ Pract. 2013;13(3):213-6. doi: 10.1016/j.nepr.2013.01.013 pmid: 23474430
13. Mrayyan MT, Shishani K, Al-Faouri I. Rate, causes and reporting of medication errors in Jordan: nurses' perspectives. J Nurs Manag. 2007;15(6):659-70. doi: 10.1111/j.1365-2834.2007.00724.x pmid: 17688572
14. Friedman AL, Geoghegan SR, Sowers NM, Kulkarni S, Formica RN, Jr. Medication errors in the outpatient setting: classification and root cause analysis. Arch Surg. 2007;142(3):278-83; discussion 84. doi: 10.1001/archsurg.142.3.278 pmid: 17372053
15. Stratton KM, Blegen MA, Pepper G, Vaughn T. Reporting of medication errors by pediatric nurses. J Pediatr Nurs. 2004;19(6):385-92. doi: 10.1016/j.pedn.2004.11.007 pmid: 15637579
16. Samra HA, McGrath JM, Rollins W. Patient safety in the NICU: a comprehensive review. J Perinat Neonatal Nurs. 2011;25(2):123-32. doi: 10.1097/JPN.0b013e31821693b2 pmid: 21540686
17. Dabliz R, Levine S. Medication safety in neonates. Am J Perinatol. 2012;29(1):49-56. doi: 10.1055/s-0031-1285831 pmid: 21861251
18. Chedoe I, Molendijk HA, Dittrich ST, Jansman FG, Harting JW, Brouwers JR, et al. Incidence and nature of medication errors in neonatal intensive care with strategies to improve safety: a review of the current literature. Drug Saf. 2007;30(6):503-13. doi: 10.2165/00002018-200730060-00004 pmid: 17536876
19. Fathi A, Hajizadeh M, Moradi K, Zandian H, Dezhkameh M, Kazemzadeh S, et al. Medication errors among nurses in teaching hospitals in the west of Iran: what we need to know about prevalence, types, and barriers to reporting. Epidemiol Health. 2017;39:e2017022. doi: 10.4178/epih.e2017022 pmid: 28774169
20. Taheri E, Nourian M, Rasouli M, Kavousi A. The study of type and amount of medication errors in neonatal intensive care units and neonatal units. Iran J Crit Care Nurs. 2013;6(1):21-8.
21. Kruer RM, Jarrell AS, Latif A. Reducing medication errors in critical care: a multimodal approach. Clin Pharmacol. 2014;6:117-26. doi: 10.2147/CPAA.S48530 pmid: 25210478
22. Nawwar F, Mohsen L, Aly H, Salah M. Medication Errors in Neonatal Care Units. Public Health Res. 2015;5(5):153-8.
23. Ebrahimpour F, Shahrokhi A, Ghodousi A. Patients' safety and nurses' medication administration errors. Iranian J Forensic Med. 2014;20(1):401-8.
24. Miller K, Haddad L, Phillips KD. Educational strategies for reducing medication errors committed by student nurses: a literature review. Int J Health Sci Educ. 2016;3(1):2.
25. Gray JE, Goldmann DA. Medication errors in the neonatal intensive care unit: special patients, unique issues. Arch Dis Child Fetal Neonatal Ed. 2004;89(6):F472-3. doi: 10.1136/adc.2003.046060 pmid: 15499131
26. You MA, Choe MH, Park GO, Kim SH, Son YJ. Perceptions regarding medication administration errors among hospital staff nurses of South Korea. Int J Qual Health Care. 2015;27(4):276-83. doi: 10.1093/intqhc/mzv036 pmid: 26054575
27. Pelliciotti Jda S, Kimura M. Medications errors and health-related quality of life of nursing professionals in intensive care units. Rev Lat Am Enfermagem. 2010;18(6):1062-9. doi: 10.1590/s0104-11692010000600004 pmid: 21340269
28. Wilkins K, Shields M. Correlates of medication error in hospitals. Health Rep. 2008;19(2):7-18. pmid: 18642515
29. Tavakoli-Ardakani M, Omidi S, Eshraghi A, Salamzadeh J. Medication errors in administration of chemotherapeutic agents: an observational study. Iranian J Pharm Sci. 2013;9(2):1-11.
30. Wakefield BJ, Uden-Holman T, Wakefield DS. Development and validation of the medication administration error reporting survey. Agency For Healthcare Research And Quality Rockville Md, 2005.
31. Heidari M, Yadollahi S, Rafiee Z, Karimifard M, Lalehgani H. A Survey of Nursing Staff's Perspective Regarding Reasons for Medication Errors. J Crit Care Nurs. 2017;10(2).
32. Lerner RB, Carvalho M, Vieira AA, Lopes JM, Moreira ME. Medication errors in a neonatal intensive care unit. J Pediatr (Rio J). 2008;84(2):166-70. doi: 10.2223/JPED.1757 pmid: 18372936
33. Jain S, Basu S, Parmar VR. Medication errors in neonates admitted in intensive care unit and emergency department. Indian J Med Sci. 2009;63(4):145-51. doi: 10.4103/0019-5359.50763 pmid: 19414984
34. Heydari H, Kamran A, Novinmehr N. Nurses' perceptions about causes of medication errors: A qualitative study. J Hayat. 2015;20(4):19-34.
35. Morriss FH, Jr., Abramowitz PW, Nelson SP, Milavetz G, Michael SL, Gordon SN, et al. Effectiveness of a barcode medication administration system in reducing preventable adverse drug events in a neonatal intensive care unit: a prospective cohort study. J Pediatr. 2009;154(3):363-8, 8 e1. doi: 10.1016/j.jpeds.2008.08.025 pmid: 18823912
36. Schimmel AM, Becker ML, van den Bout T, Taxis K, van den Bemt PM. The impact of type of manual medication cart filling method on the frequency of medication administration errors: a prospective before and after study. Int J Nurs Stud. 2011;48(7):791-7. doi: 10.1016/j.ijnurstu.2010.12.007 pmid: 21247578
37. Simpson JH, Lynch R, Grant J, Alroomi L. Reducing medication errors in the neonatal intensive care unit. Arch Dis Child Fetal Neonatal Ed. 2004;89(6):F480-2. doi: 10.1136/adc.2003.044438 pmid: 15499135
38. Flannigan C, Kilpatrick S, Redpath J, Hogan M. 481 Can a Gentamicin Specific Chart Reduce Neonatal Medication Errors? Pediatr Res. 2010;68(S1):245.
39. Sharifi N, Alipour A. The effect of modern educational strategies in reducing intravenous drug administration error: a non-randomized clinical trial. Iranian J Med Educ. 2012;11(6):590-9.
40. Ligi I, Millet V, Sartor C, Jouve E, Tardieu S, Sambuc R, et al. Iatrogenic events in neonates: beneficial effects of prevention strategies and continuous monitoring. Pediatrics. 2010;126(6):e1461-8. doi: 10.1542/peds.2009-2872 pmid: 21078738