IJN Iranian Journal of Neonatology



OpenOriginal ArticleNursing Satisfaction with Medication Care by Using
Neonatal Electronic Medication Management Systems

Mahboobeh Namnabati¹, Fariba Taleghani¹, Maryam Varzeshnejad^{2*}

1. Nursing and Midwifery Care Research Center, Faculty of Nursing and Midwifery, Isfahan University of Medical Sciences, Isfahan, Iran 2. Faculty of Nursing and Midwifery, Isfahan University of Medical Sciences, Isfahan, Iran

ABSTRACT

Background: Medication management is a complex process with multiple stages that involves different health care teams. Based on the evidence, an electronic medication management system offers significant benefits, such as reduced medication errors, improved conformity, enhanced time and cost efficiency, and increased patient safety. This study aimed to design and implement an electronic medication management system and measure the nurse's satisfaction regarding the application of this system.

Methods: In this technical action research, the nurses' satisfaction with the use of the designed system was evaluated. The electronic medication system development and data collection were conducted in two phases. The first phase included the design and development of an electronic nursing medication management system to be used in the neonatal intensive care unit. The second phase involved the evaluation of the nurses' satisfaction with the use of the electronic system by applying a five-point Likert scale questionnaire.

Results: The findings were divided into two categories, including results related to the design of the electronic systems and those regarding the evaluation of nurses' satisfaction with the use of the electronic systems. The design of the electronic system was successful as the nurse's satisfaction evaluation revealed a high level of satisfaction with the use of the system.

Conclusion: Electronic medication management system has more practical advantages than other similar systems. This system helps the nurses to identify and prevent many medication errors and save time in drug care documentation. Therefore, this system is a big step towards satisfaction with nursing medication care.

Keywords: Electronic medication management systems, Medication care, Neonatal, Nursing satisfaction

Introduction

Medication management is a complex process with multiple stages that involves different health care teams (1). However, it seems that nurses are the major responsible staffs in drug administration. Medication care consumes more than 40% of the nurses' time. Inadequate human resources and long working hours, leave the nurses prone to medication errors (2). Since the 1960s, there has been a dramatic increase in drug information.

Therefore, the clinical staff, especially nurses, face with significant growth of drug types and their related issues, such as safety, efficiency, and side effects (3). Today, medication errors are the second most common type of clinical errors (4). Medication care management is defined as the responsibility to deliver medication with the aim of improving the quality of patients' life (3). Neonates, as a high-risk group of patients in the hospital, are exposed to more medication errors and unintended side effects (1). The unique features and complexity of the Neonatal Intensive Care Unit (NICU) environment, along with the excessive vulnerability of this group of patients, increase the risk of medication errors (5). These issues have forced the nurses to look for better methods for providing safe care, improving care quality, and minimizing the length of hospital stay with minimum damage caused by medication errors (4).

Furthermore, medication safety can be enhanced by technology (6). Health information technology is not only a necessary foundation for improving health care delivery (7), but also offers an opportunity to transform healthcare to a safer practice (8). In addition, clinical information systems in the hospitals have led to the enhancement of care

* Corresponding author: Maryam Varzeshnejad, Faculty of Nursing and Midwifery, Isfahan University of Medical Sciences, Isfahan, Iran. Tel: +989126388957; Email: m_varzeshnejad@yahoo.com

Please cite this paper as:

Namnabati M, Taleghani F, Varzeshnejad M. Nursing Satisfaction with Medication Care by Using Neonatal Electronic Medication Management Systems. Iranian Journal of Neonatology. 2017 Dec: 8(4). DOI: 10.22038/ijn.2016.20213.1226

quality and reduction of medical errors (9).

Electronic medication management systems offer significant benefits, such as reduced medical errors, improved conformity, enhanced time and cost efficiency, and increased drug safety (6). According to the literature, clinical decision support systems integrated with electronic medical record system have a high potential to reduce medication errors (10). It is widely recognized that the features of an electronic medication administration system must be accepted by nurses in order to support them in their daily processes (11).

In addition, some studies have emphasized the importance of contextual design of such systems. Contextual design is a structured methodology for investigating the user's workplace for the purpose of designing a software, which addresses the needs of the user (12). Care satisfaction can affect patient safety and nurses' productivity, performance, and quality of care (13). If nurses are satisfied with the functions provided by a system of this nature, they are much more likely to make their efforts to focus on the professional aspects of medication administration (11).

With this background in mind, the present study aimed to design and develop an electronic nursing medication management system to be used in the NICU, and then evaluate the impact of this system on nursing satisfaction with medication care and documentation.

Methods

The main method of this study was technical action research, which facilitates the integration of research and practice (14). Action research is known as a partnership approach for researching in the healthcare environment that improves the services and the people involved in the healthcare, including care recipients and caregivers (15). Furthermore, technical action research is a kind of action research that starts with a special intervention and continues by monitoring the results of the given intervention (16).

This study was conducted in two phases. First, we designed and developed an electronic nursing medication management system to be used in the NICU (including three steps). In the second phase, the nurses' satisfaction with the electronic system was evaluated by applying a five-point Likert scale questionnaire. Each phase included some steps that are described below.

First phase: Step 1

The drug decision support system was

designed and developed with the preparation of a list of common medication errors based on the previous studies conducted in the NICUs. Then, a list of the commonly used drugs in the NICU and the related drug information was prepared. The classified drug information was entered into an Excel file in Persian and English to prepare the software. Finally, a web-based drug decision support system was developed in collaboration with a software development team.

Additionally, the related literature was investigated, and the most common causes of medication errors by made by the nurses in the NICU were identified and classified. These medication errors included dose calculation errors, zero and decimal point errors (17, 18), time frequency of drug use (19), similarity between the names of the drugs (20), wrong setting of the infusion rate and devices (21), use of an incompatible solution during the drug dilution (4), incorrect route of drug administration (22), and inattention to the nursing precautions and drug considerations (23).

At this phase, depending on the type of the required information, the drug information was extracted from the neonatal pharmacology reference and the pharmaceutical information sheet in the drug packages. The data were classified in an Excel file as a bilingual source (i.e., Persian and English). The information about the drug was divided into eight categories, including the calculation of drug dose based on neonate's weight, gestational and postnatal age, administration route, monitoring, drug preparation, nursing attention, compatibility/incompatibility of the solution, and stability of the solution. Then, the Excel file was converted to a web-based drug decision support system by the software development team.

First phase: Step 2

In the second step, the drug care documentation system was designed and developed. The nurses entered all drug orders in the nursing-drug-careplan section of the system. They also recorded the drugs administered in their shift in the drug-caredocumentation section, which finally resulted in a nursing drug care paper as a report. Drug care Eforms were designed in a way to achieve a userfriendly and context-based system similar to paper forms that are currently used in the NICU.

The difference here was that the documentation was performed only by clicking the existing options with no need to type in the Eform. Furthermore, the electronic form was designed to be a smart one. In this regard, the system alarms the user automatically to recheck the information if the user wants to record any drug information that does not match with the information in the drug decision support system.

First phase: Step 3

The third step involved the integration of the two mentioned systems. Accordingly, at this phase, an electronic nursing medication management system was designed and developed to be used in the NICU.

Second phase

In this phase, we started to use the electronic system in a 10-bed NICU with 18 nurses. To this

Table 1. Nurses' satisfaction with the drug decision support system

13. Overall satisfaction with electronic medication documentation

aim, the nurses were informed about the objectives of the study, and their written informed consent was obtained. At this phase, one of the researchers trained the nurses to use the system. The training sessions were held in the hospital in a practical and individualized manner. After the training phase, the nurses started to use the electronic system for real patients. Subsequently, a satisfaction questionnaire was designed in cooperation with the nurses using the principles of an action research study. This questionnaire included two sections and 26 items rated on a five-point Likert scale. At the end, the satisfaction rate (in percent) of each item and the overall rate of nurses' satisfaction were calculated (tables 1 and 2).

Nurses' satisfaction with drug decision support system	Too much	Much	Normal	Little	Too little
1. Satisfaction with the impact of system on the reduction of medication errors	66.7%	33.3%	0	0	0
2. Satisfaction with the impact of system on the reduction of errors related to	66 704	22 204	0	0	0
serum compatibility with drugs	00.7%	33.3%	0	0	0
3. Satisfaction with the impact of system on the reduction of errors related to	66 704	22 20/	0	0	0
serum incompatibility with drugs	66.7%	33.3%	0	0	0
4. Satisfaction with the impact of system on the reduction of errors related to	77 00/	22 204	0	0	0
drug administration route, such as slow intravenous infusion	77.0%	22.290	0	0	0
5. Satisfaction with the impact of system on the reduction of errors related to the	66 704	22 204	11 104	0	0
preparation and dilution of drugs for administration	00.7%	22.290	11.1%	0	0
6. Satisfaction with the impact of system on the reduction of errors related to	66 70%	22 20%	11 104	0	0
drug administration interval, for example every 12 h	00.7 70	22.270	11.170	0	0
7. Satisfaction with the impact of system on the reduction of errors related to	61 106	28 00%	0	0	0
special medication care, such as controlling the pulse	01.170	30.970	0	0	0
8. Satisfaction with the impact of system on the reduction of errors related to	66 704	22 20/	0	0	0
special monitoring, such as weight control, etc.	00.7%	33.3%	0	0	0
9. Satisfaction with the impact of system on the reduction of the time to access	77 00/	22 204	0	0	0
drug information	77.070	22.270	0	0	0
10. Satisfaction with the impact of system on the overall enhancement of	66 70%	22 20%	11 104	0	0
medication use among nurses	00.7 70	22.270	11.170	0	0
11. Satisfaction with the impact of system on the overall reduction of medication	66 70%	22 20%	٥	0	0
care errors	00.7%	33.3%	0	0	0
12. Overall satisfaction with electronic drug decision support system	66.7%	33.3%	0	0	0
Table 2. Nurses' Satisfaction with the electronic medication documentation syste	m				
Nurses' satisfaction with the electronic medication documentation system	Too much	Much	Normal	Little	Too little
1. Satisfaction with the impact of system on the reduction of errors related to	55.6%	44 4%	0	0	0
illegible drug information in nursing documentation	55.670	11.170	0	Ū	0
2. Satisfaction with the impact of system on increasing the accuracy of the	55.6%	44 4%	0	0	0
medication needed	33.070	11.170	0	Ū	0
3. Satisfaction with the impact of system on rapid decision-making in medication care	55.6%	22.2%	22.2%	0	0
4. Satisfaction with the impact of system on the accuracy of decision making in	55.6%	33.3%	111%	0	0
medication care	55.670	00.070	11.170	Ū	0
5. Satisfaction with the impact of system on the ease of medication care records	33.3%	44.4%	11.1%	11.1%	0
6. Satisfaction with the impact of system on the reduction of medication care	22.20/		11 10/	11 10/	0
record time	22.2%	55.6%	11.1%	11.1%	0
7. Satisfaction with the impact of system on the ease of medication care report	22.2%	44.4%	33.3%	0	0
8. Satisfaction with the impact of system on the required access time to					
medication care documentation	11.1%	55.6%	33.3%	0	0
9. Satisfaction with the impact of systems on the reduction of nurses' medication	50%	38.9%	11.1%	0	0
10. Satisfaction with the impact of system on the facilitation of the follow-up of	22.2%	55.6%	22.2%	0	0
previous medication care					
11. Saustaction with the impact of system on the disease and recovery course identification	22.2%	22.2%	55.6%	0	0
12 Setiefaction with the similarity of the electronic drug forms with some line					
12. Sausiaction with the similarity of the electronic urug forms with paper drug	50%	38.9%	11.1%	0	0
1011115					

0

11.1%

38.9%

50%

The face validity of the questionnaire was determined by the participating nurses who were supposed to use the system. In addition, the content validity was confirmed by 10 nursing faculty members. The reliability of this instrument was also calculated, rendering a Cronbach's alpha of 0.86.

After using the system by the nurses for the documentation of nursing drug care for real patients, the nurses filled out the satisfaction questionnaire. Satisfaction about each submenu of the system was measured with different items. In addition, the questionnaire included one general item about the overall satisfaction with drug decision support system, medication document-tation system, and integrated system.

Results

The results of this study led to the design and development of an electronic nursing medication management system for the NICU that allowed the nurses to carry out medication care and documentation with minimal error and resulted in high level of nursing satisfaction. The results were presented in two parts. In the first part, we described the components of the designed program, and in the second part, the results of the satisfaction questionnaire were presented.

Part 1 - System description

This system includes a login page and four main menus that are as follows:

• *Login page:* On this page, the users are required to enter their own username and password to log in. It should be noted that three levels of user access are defined in the system by using a

special username and password. These three levels include highest level of access for the system administrator, mid-level access for the supervisor who can edit, add, or remove information, and low-level access for general users (i.e., nurses) who can only read, register, and document the patient drug information in the system (Figure 1).

The four main menus:

- 1. Home: This page provides general information about the system for the users. The information includes system information, source of drugs, guidelines for using the system, and guidelines to get access to the support team and system designers (Figure 2).
- 2. Individuals information: This menu consists of six sub-menus (Figure 3), including patient add/edit (Figure 4), patient discharge (Figure 5), physician add/edit (Figure 6), user add/edit (Figure 7), working shift table (Figure 8), and change password (Figure 9). This menu generally includes adding and editing information about the people in the system.
- 3. Drug decision support: This page contains four sub-menus (Figure 10), namely drug information table, drug add/edit, serum add/edit, and blood product add/edit.
- In the drug information table, eight cells are displayed to the user by selecting the drug name. The three items necessary for the calculation of drug dose in the NICU, namely "birth weight", "gestational age", and "postnatal age, were also considered in this part. In the first cell of the drug information table, the system shows calculated drug dose and frequency of administration. In addition, other necessary information, such as solution compatibility/

Username:	user
Password:	••••
 Drug Decision Support S Nursing Process Decision 	System O Drug Care Documentation System
⊚ Nurs	sing Information Solution System
(NICU -
	Login

Figure 1. Login page

Home	People info	Drug DSS -	Drug Care Doc	Drug Register Repo
a constant	de la cont			/ X ON XON
Medication is one	of the most common nursing o	care in hospitals that plays	an important role in	2 PUP
health and healing	J. Medication errors in the NIC	Us are 8 times higher than	adult wards in	
nospitais. Conside	aring the importance of medica	ation errors in the NICUs, d	letection and prevention	- marrier
of these errors are	important. Nowadays the use	e of electronic information s	system is recommended	Chill
to reduce medicat	ion errors, improvement of evi	dence based practice and	Increase the accuracy of	
clinical decisions i	n all groups of patients, espec	ally in intensive care units	. The drug Care	
Management is a	complex process and involves	various steps and a large	number of personnel. Howe	ever, it seems that
nurses play the m	ost important role in drug adm	inistration and care. And m	redication allocated to more	than 40 percent of the
time of nursing ca	re. In addition, accurate nursin	ng care without accurate do	ocumentation does not make	e sense. Also, studies
snow that the cau	se of computerized nursing do	cumentation are Reduce to	ne workload of hurses , savi	ng time, improve the
quality of docume	hation and thus improve the q	luality and continuity of car	e, increase credit documen	tation, easier
communication be	siveen nuises and doctors, An	in increase the quality of ca	ate and emphasizes the imp	ionance of nursing
intensive sere unit	bject, it was decided that a dru	ig information and docume	probability electropic system	or use in the neonatal
intensive care unit	. It is worun noung that this sys	stern is part of a more com	prenensive electronic system	I called the Electronic
sustem Netably in	n System That this part of the	system can be used both	individually and in combina	tion in comprohensive
system. Notably, I	n System. That this part of the	e system, can be used both	individually and in combination	tion in comprehensive
evetom is based o	n System. That this part of the n the design and implementati	e system, can be used both on of this system is ease o	individually and in combination in dividually and in combination in pursing this is pursing this is the pursing this is the pursing the second se	tion in comprehensive e designing of this
system is based o	n System. That this part of the n the design and implementati n drug decision support system	e system, can be used both on of this system is ease o m and the current drug doo	n individually and in combina of use by the nurses, becaus cumentation in nursing. It is l	tion in comprehensive e designing of this hoped that this system

Drug Register Report Home People info. -Drug DSS -Drug Care Doc. -Patient Add/Edit Medication is one of sing care in hospitals that plays an important role in health and healing. > NICUs are 8 times higher than adult wards in Patient Discharge edication errors in the NICUs, detection and prevention hospitals. Consideri of these errors are in Physician Add/Edit e use of electronic information system is recommended to reduce medicatio of evidence based practice and Increase the accuracy of Working Shift Table clinical decisions in specially in intensive care units. The drug Care Management is a cc olves various steps and a large number of personnel. However, it seems that User Add / Edit nurses play the mos administration and care. And medication allocated to more than 40 percent of the time of nursing care jursing care without accurate documentation does not make sense. Also, studies Change Password show that the cause ng documentation are Reduce the workload of nurses , saving time, Improve the quality of documentation and thus improve the quality and continuity of care , increase credit documentation , easier communication between nurses and doctors, And increase the quality of care and emphasizes the importance of nursing care. So in this project, it was decided that a drug information and documentation system is designed for use in the neonatal intensive care unit. It is worth noting that this system is part of a more comprehensive electronic system called the Electronic nursing information System. That this part of the system, can be used both individually and in combination in comprehensive system. Notably, in the design and implementation of this system is ease of use by the nurses, because designing of this system is based on drug decision support system and the current drug documentation in nursing. It is hoped that this system could be take a step , however small, in the way of improving the quality of nursing care, reducing nurses Workload and



Ho	me	F	People info. 👻	Drug D	oss 🗸	Drug Care Doc. 👻	Drug Register Report		
	Patient Add/Edit								
Select Patient:	New Patient	•	• Doctor: Selec	ct Doctor 🔹	•Birth Weigł (gr	Mother Con	dition: Nothing Selected -		
First Name:			*Last Name:		*Head C (cm): Neonate Blood (Group: N/A +		
Father Name:			• File number:		Chest C (cm): Mother Blood C	Group: N/A +		
*Birth Date:		©	Insurance: Ple	ease Select -	Length (cm): •Neonat	e Sex: Male -		
•Admit Date:	=	©	Bed No: Plea	ease Select -	•G.Age (Week): Child Birth	n Type: N.V.D		
			Apgar 1:	Apgar 2:	*Admit Weigł (gr	Diag	nosis:		
				Clear	Save				

Figure 4. Patient add/edit page

incompatibility, administration route, monitoring, precautions, preparations, and special nursing considerations, is shown in other cells (figures 10 and 11). . Drug/serum and blood product add/edit information: This part is accessible only to those who are allowed to edit this information. Compared to other similar systems, it is the

Home	People info	Drug DSS 👻	Drug DSS + Drug Care Doc. +					
		Patient Discharge						
Select Please Select Patient:	Select Please Select - Patient:							
Nursing PHD Project - 2015-2016								

Figure 5. Patient discharge page

Home	People info	Drug DSS 👻	Drug Care Doc. 👻	Drug Register Report					
Physician Add/Edit									
s	Select Physician: Select Doctor								
		Physician Inactive							
Save									
Nursing PHD Project - 2015-2016									

Figure 6. Physician add/edit page

Home	People info. •	Drug DSS 🕞	Drug Care Doc. •	Drug Register
		User Add / Edit		
* Select User: Add New User	- *User Na	me:	*Access Level:	Administrator -
•Password:	•Password Rep	eat:	*Nursing Code:	
First Name:	Last Na	me:	• Full Name:	
Shift Sort:		Use In Shift Table	Active	
		Save		
		Nursing PHD Project - 2015-2016		

Figure 7. User add/edit page

Home	People info	Drug DSS 🕞	Drug Care Doc	Drug Register
		Change Password		
	•Old Passw	ord:		
	•New Password Rep	eat:		
	• Password Rep	eat:		
		Save		
		Nursing PHD Project - 2015-2016		

Figure 8. Chang password page

Home People info		Drug DSS +		Drug Care Doc	Drug Register
Medication is one of th	e most common nursing care in	Drug Table	n important ro	ble in health and healing.	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Medication errors in the NICUs are 8 times higher than		Drug Add / Edit	als. Consider	ing the importance of	
medication errors in th	e NICUS, detection and prevention		important. No	owadays the use of	1 marman
electronic information	system is recommended to reduc	Serum Add / Edit	mprovement	of evidence based	
practice and Increase	the accuracy of clinical decisions		nts, especially	y in intensive care units.	$(\cdot, \mathbf{Y}_{\Box})$
The drug Care Manag	ement is a complex process and	Product Add / Edit	s and a large	number of personnel.	
However, it seems that	t nurses play the most important		uation and car	e And medication allocate	d to more than 40

show that the cause of computerized nursing date. In addition, accurate nursing care without accurate documentation does not make sense. Also, studie show that the cause of computerized nursing documentation are Reduce the workload of nurses, saving time, Improve the quality of documentation and thus improve the quality and continuity of care , increase credit documentation , easier communication between nurs and doctors, And increase the quality of care and emphasizes the importance of nursing care. So in this project, it was decided that a dr information and documentation system is designed for use in the neonatal intensive care unit. It is worth noting that this system is part or more comprehensive electronic system called the Electronic nursing information System. That this part of the system, can be used both individually and in combination in comprehensive system. Notably, in the design and implementation of this system is ease of use by the nurses, because designing of this system is based on drug decision support system and the current drug documentation in nursing. It is hoped that this system could be take a step , however small, in the way of improving the quality of nursing care, reducing nurses Worklo

Figure 9. Drug table page

NICO - Amin nospitar						
Home	People info	Drug DSS 👻	Drug Care Doc. 👻	Drug Register Report		
Select Patient: Please Select	Drug Name: Please Sel Drug Name is	Drug Table ect - G.Age (Weel Empty Bet	k): Age (Day): tween 20 and 46 Between 0	Weight (gr): and 1000 Between 400 and 8000		
Nursing PHD Project - 2015-2016						

Figure 10. Drug table page

Hom	e	People info Drug E	DSS -	Drug Care Doc. 👻	Drug Register Report			
Select Patient	باقبات - البلين :	Drug Name: Acyclovir-Amp	Table G.Age (Week): 29	Age (Day): 42	Weight (gr): 1260			
Acyclovir-Amp (Drug)								
	Proper Dose	25.2 mg Q 8 h	Administration	PO, IV Infusion via	syring pump			
	Solutions Compatible	Normal Salin, D/W 5%, D/S	Solutions Not Compatible	Lactat Ringer, Fat Er 10%, No Need Fo	nulsion, D/W or Solution			
	Preparation	Prepare powder for solution by dissolving contents of 500 mg vial in 10 ml sterile water for injection.	Solution Stability	Reconstituted solution room temperature for 1 refrigerate	n is stable at 2 hours. Do not e.			
	Nursing Attention	Monitor IV site for phlebitis.	Monitoring Periodic		3C.			

Figure 11. Drug table page

most important advantage of this system. By entering this page, the user can change, add, and edit all drug/serum and blood product information. This option was predicted and added in the system because of the significant changes required in drug/serum and blood product information over time (figures 12, 13, and 14).

1. Drug care documentation: This page contains 10 sub-menus (Figure 15) that include drug care

plan, drug care report, dose change reason, reason to change the administration route, reason to change the compatible solution, reason to change the frequency of drug administration, drug care plan if condition, drug care report if condition, reason to change administration time, and reason for nonadministration.

• Drug care plan: Physician's drug order is displayed with a table in this menu (Figure 16).

Но	Home People info Drug DSS -		People info		Drug Care Doc. 👻		,	Drug Register Report	
Drug Add / Edit									
Drug Name:	Amikacin-Amp		*	lew: Amikacin-A	Amp	*Administra	tion: 2 Selecte	ed 🕶	Sol. 3 Selected -
Preparation:	For IV use dilute	with a compatible soluti	on to a concent	ration of 5 mg/m	Monitoring:	Measure ser	rum concentration	when tre	eating for more than 48 hours
Notice	در میلی لیٹر رقیق شود	به میزان ۵ میلی گرم			Notice	یک بعد از درمان	رى سطح سرمى 48 ساد	اندازه گی	
Sol. Stability:	Refer to drug ma	nufacturer			Nursing	Daily weight	control for dosage	e adjustr	nent
🗌 Notice	وں کارخانہ سازندہ داری	يت. مراجعه به دستم ا				رای تلظیم دوزاژ	کتئرل وزن روزانه ب		
				Dosing	g Interval Table				
		G.Age (Week)	Ag	e (Day)	Dosage	•	Interval	Action	
		24 To 29	() To 7	18 mg		Q 2 day	× 🗹	
		24 To 29	8	To 28	15 mg		Q 36 h	× 🗹	
		24 To 29	29	To 1000	15 mg		Q 1 day	× 🗹	
		30 To 34	() To 7	18 mg		Q 36 h	ר	
		30 To 34	8	То 1000	15 mg Q 1 day 🗶 🗹				
		35 To 46		All	15 mg	g Q1 day 🗶 🗹		× 🗹	
		20 To 46 🛃		1000 🗹 All	15 To 15	m	On Order -	+	
		High	1	Clea	ar Save				

Figure 12. Drug add/edit page

Home People info		Drug DSS 🕞			Drug Care Doc. 👻	Drug Register Report				
					Serum A	dd / Edit				
Serum Name:	Please Select	-	New:			Administra	tion:	Nothing Selecte	Sol. Comp.:	Nothing Selecte
Preparation:						Monitoring:				
Notice						□ Notice				
Sol. Stability:						Nursing				
Notice						Attn.:				
Clear Save										

Figure 13. Serum add/edit page

Hc	Home People info			•	Drug DSS 👻			Drug Care Doc. 👻	Drug Regist	Drug Register Report	
						Produc	t Add / Edit				
Product Name:	Pack Cell	×	New:	Pack Cell				Administratior	1 Selected -		
Injection Duration:	ln 4 h ◄		Volume:	200	То	300	cc	Sol. Comp.:	1 Selected -		
Preparation:	Blood bag is read	dy for injection	1				Monitoring:	Precise control of vital signs before	ore, during and after injection	on j	
Notice	ماده تزريق موجود است	کیسه خون آه					Notice	ل دقیق علائم حیامی قبل، حین و بعد از انزریق	كتتر		
Prod.	.Blood bag conta	ining the red t	blood cell stora	age time for	35 day	/s at a	Nursing	Blood transfusions must be mate	ched for ABO and Rh		
Stability:	دمای 1 تا 6 درجه می	مدے 35 روز در ا	گلبول های قرمز به	بسه خون حاوى ا	لهداری کر	مدت زمان نگ	Attn.:	کنترل از نظر سازگاری گروه خون و ارهاش			
	Clear Save										
					Nur	sing PHD	Project - 2015-2016	3			

Figure 14. Product add/edit page

Home	People info	Drug DSS 👻	Drug Care Doc. 👻	Drug Register Report
Medication is one of	the most common nursing	care in hospitals that plays a	Drug Care Plan	2 0 ² 0 ² 0 ²
health and healing. I hospitals. Considerir	Medication errors in the NIC ng the importance of medica	CUs are 8 times higher than a ation errors in the NICUs, de	Dose Change Reasons	The state of the
of these errors are in	mportant. Nowadays the use	e of electronic information sy	Administration Change Rea	sons ener with
to reduce medication clinical decisions in a	n errors, improvement of ev all groups of patients, espec	idence based practice and Ir cially in intensive care units.	Slolution Change Reasons	
Management is a co nurses play the mos	mplex process and involves t important role in drug adm	s various steps and a large n ninistration and care. And me	Interval Change Reasons	ems that percent of the
time of nursing care. show that the cause	In addition, accurate nursin of computerized nursing do	ng care without accurate doo ocumentation are Reduce the	Drug Cardex If Conditions	Also, studies Improve the
quality of documenta	ation and thus improve the o	quality and continuity of care	Drug Register If Conditions	asier
communication betw	een nurses and doctors, Ar	nd increase the quality of car		of nursing
care. So in this proje	ect, it was decided that a dru	ug information and documen	Time Change Reasons	the neonatal
intensive care unit. I	t is worth noting that this sy	stem is part of a more comp		the Electronic
nursing information	System. That this part of the	e system, can be used both i	Ignore Reasons	omprehensive
system Notably in t	he design and implementat	ion of this system is ease of	use by the nurses pecause	designing of this

system. Notably, in the design and implementation of this system is ease of use by the nurses, because designing of this Figure 15. Drug care documentation page

Home People info. -Drug DSS -Drug Care Doc. -**Drug Register Report** Drug Care Plan × Type: Drug -یورد - دهرا Select Patient: یررد - دهرا Weight (gr): 2600 Drug Name: ne Not Sele Admit Date : 2016-09-28 Neonate Sex : Female Age (Day) : 17 G.Age (Week): 36 ىكەر مىفرى يور : Doctor File number : 310372 Row Date & Time Drug Name Dose Administration Solution(s) Interval If Condition Status Action IV Infusion via syring 2016-09-28 22:56 Cefotaxime - Vial 130 mg D/W 5% Q 12 h RPO -1 pump 2 2016-09-28 22:55 Q 12 h RPO -Amikacin-Amp 26 mg IV Infusion 2016-09-28 22:54 3 Ampicilin - Vial 130 mg Q 8 h RPO -IV slow push Date & Time Serum Name Electrolit Electrolit Vol. 6 Hr. Vol. Status Action Row Administration 1 2016-09-28 22:53 S.D/W 10% No Electrolit 52.5 IV Infusion via syring pump - Continuse IV infusion RPO -Nursing PHD Project - 2015-2016

Figure 16. Drug care plan page

						Drug	Register Re	port				
Selec	t Patient:	یروز - زم	×			and g	it given it.	port				
onate :	Sex : Female	Age (D	ay): 17		G.Age (Week) : 36		Doctor :	نگٹر منفری پرز	Admi	t Date : 2016-09-28	File number : 3103	372
Row	Time	Drug Na	ame	Dose	Administration		Solution(s)	Serum	If Co	ndition	Not Apply	Actio
1	2016-10-14 10:56	Cefotaxime	e - Vial	130 mg	IV Infusion via syring pump		D/W 5%					•
2	2016-10-14 10:55	Amikacin	-Amp	26 mg	IV Infusion							(†)
Row	Time	Serum N	lame	6 Hr. Vol	. In Shift	g.t.t	Administra	ition	Electrolit	Electrolit Vol.	Not Apply	Actio
1	2016-09-28 22:53	S.D/W 1	10%	52.5		2	IV Infusion via syring pump - Continuse IV infusion		No Electrolit			•

Figure 17. Drug register report page

• Drug care report: Nurse's drug care and documentation are also displayed in this part

(Figure 17).

• Another part of this menu is just accessible by

Home	People info. •	Drug DSS 👻	Drug Care Doc. 👻	Drug Register Report						
Select: A	naphylaxis Response -									
Text (EN): And	aphylaxis Response									
Text (FA): محمد	واکهن انقرار کسی (Faxt (FA):									
		Litem Inactive								
Add/Update										
		Nursing PHD Project - 2015-2016								

Figure 18. Dose change reasons page

Home	Home People info			Drug DSS 👻 Drug Care Doc. 👻						
Select:										
Text (EN):	Text (EN): In case of difficulty breathing									
Text (FA):										
	□ Item Inactive									
	Add/Update									
			Nursing PHD Project - 2015-2016							

Figure 19. Drug care plan if condition

the supervisor and administrator of the system, and they can add/edit drug information to keep the system up to date (figures 18 and 19).

Part 2- Satisfaction evaluation

In this part, we evaluated the satisfaction of the nurses who used the system. Satisfaction evaluation forms were administered to the nurses after they used the system for the real patients for several times. The nurses were asked about their satisfaction with each item and submenu through separate items. Reduced medication errors and overall satisfaction with the system were the issues enquired about with two general items in the questionnaire.

The satisfaction questionnaire consisted of three parts. Part one included items related to electronic drug decision support system (12 items), part two entailed items concerning electronic medication documentation system (13 items), and part three involved one item about the overall satisfaction with the electronic medication management system (i.e., the integrated system).

In the first part of the questionnaire, the first

eight items were about the information presented in the eight cells of the drug table. The next four items in this section were related to the decrease in the access time to drug information, enhancement of medication, reduction of overall medication error, and overall satisfaction with the drug decision support system. Data analysis showed that 66.7% of the nurses chose "Too Much" option regarding the overall satisfaction with the drug decision support system. Therefore, we concluded that the use of the system was associated with a high satisfaction rate. Therefore, this electronic system can be used as a guide to make the best decisions in clinical nursing practices.

In addition, the highest satisfaction level among different parts of the drug decision support system was related to the impact of the system on the reduction of errors related to drug administration route (77.8%) and the time required to access the drug information (77.8%). Accordingly, the results revealed that this system could help the nurses save time and improve direct nursing care.
 Table 3. Overall satisfaction with the electronic medication management system

Overall satisfaction with electronic medication management system	Too much	Much	Normal	Little	Too little
1. Overall satisfaction with the electronic medication management	50%	50%	0	0	0
system (Drug decision support system + Drug documentation)	5070	5070	0	0	0

In the second part of the questionnaire, the nurses were asked about the electronic medication documentation system (13 items). The impact of system on different aspects of nursing medication care documentation was evaluated through 12 items. The last item was about the overall satisfaction with the electronic medication documentation system. Among the different parts of the drug care documentation system, the greatest satisfaction was related to the impact of the system on the reduction of errors related to illegible drug information in nursing documenttation, accuracy of the required medication, rapid decision-making, and accuracy of nursing decisions. The 13th item of this part showed that 50% of the nurses selected "Much" option to show their overall satisfaction with the system (Table 3).

At the end, 100% of the nurses selected "Much" and "Too much" option in response to the ending question about the overall satisfaction with using the system.

Discussion

In this study, we tried to design an electronic medication management system that can reduce all types of medication errors. In this regard, Jani et al. (2008) conducted a study to assess the effect of an electronic prescribing system on the incidence and types of medication errors (18). The mentioned system is similar to our system due to the coverage of medication errors associated with dose calculation and route of administration. However, it seems that our system is more comprehensive due to its focus on all kinds of medication errors and the incorporation of medication care documentation forms.

In the present study, all factors affecting the neonatal drug calculations, including birth weight, gestational age, and postnatal age, were considered in designing the system. In a study conducted by Kadmon et al. (2009), a computerized order entry system integrated with clinical decision support system was designed for the physicians as the target group. The findings of the mentioned study demonstrated that the implementation of the computerized physician order entry system resulted in a slight reduction in the medication errors. However, the integration of the clinical decision support system led to a significant reduction in this regard (24). The results of the mentioned study highlighted the major effect of weight-based drug calculation errors in pediatric and neonatal patients. Therefore, it is necessary to use a drug information system to reduce the medication errors not only for drug care, but also for drug care documentation.

In our study, the medication management system was designed in a way to display the compatibility and incompatibility of the solutions to dilute and inject drugs. Similarly, Bertche et al. (2010) focused on preventing adverse drug interactions and their side effects in the intensive care units by means of an electronic clinical decision support system. Their results showed that the number of the patients with at least one case of drug interaction decreased by 18% at the end of the study (23). Therefore, it can be concluded that the present system can effectively prevent this type of medication errors by considering the compatible and incompatible solutions for drug injection and dilution.

The management of the large number of drugs entered into the system and the ability to add and edit the drug information are among the important issues in the present study (ability to keep the system up to date). In this regard, Kazemi et al. (2011) conducted a study for assessing the effect of a computerized physician order entry integrated with decision support system on medication errors in the neonatal ward. Their designed system included only anticonvulsants and antibiotics while other drugs were not considered. However, the present system covered all types of drugs. The findings of the mentioned the study showed that application of computerized physician order entry system without using decision support system made no significant change. However, the integration of the two systems resulted in a significant decrease in the errors (19).

In a study conducted in Germany, Pruszydlo et al. (2012) focused on the development and evaluation of a computerized clinical decision support system for switching the drugs if necessary (25). This system was similar to our web-based system and that of Kazemi et al. in terms of integration with physician order entry system. The findings of the mentioned study revealed a reduction in medication errors after implementing the system.

The studies by Pruszydlo and Kazemi showed that the integration of decision support systems with other electronic systems were more effective. Therefore, in the present study, the integration of the drug decision support system with the drug care documentation system led to the development of a comprehensive system of nursing medication management, which reduced not only the medication errors, but also the medication care and documentation time.

designing the electronic medication In management system in the current study, a special attention was given to the frequency of drug administration based on the neonatal age and weight as sources of medication errors. Similarly, You et al. (2012) designed and implemented an administration decision support system in Switzerland. Their purpose was to only determine the exact dosage and frequency of drug administration based on the determination of drug concentration in the patient's blood (26). Nonetheless, this system could not be widely used due to the structural and application complexity of certain drugs. Therefore, efforts were made to consider the easy and fast application of the designed system as important features.

Based on the overall comparison of the present designed system with other drug information systems, it can be concluded that the advantages of the this system include:

- Being designed and developed based on the common causes of medication errors in the NICU
- Integration of two systems with a potential to cover medication care and documentation
- Use of the reliable sources of pharmaceutical information
- A web-based design of application (an independent platform that does not require any further installation)
- Fast accessibility to the information
- Simultaneous access by multiple users
- Use of short and rational phrases for quick and easy access to the information in decision support system
- Reduction of care decision making time
- Reduction of nurses' stress during decision making
- Evidence-based decision making
- Reduction of documentation time
- Bilingual system (i.e., Persian-English)
- Possibility of being used in different countries
- Potential for long-term storage of medication

care documentation

- Potential to conduct research and statistical studies for hospital policy making and future planning
- Similarity of the electronic forms with paper forms regarding simplicity of application
- Possibility of keeping the system updated by users free with no necessity for the presence of the system designer (one of the most important advantages of the present system, which is not present in any other systems)
- Potential of enhancing the pharmaceutical information among the nurses
- Potential for to be used in the in-service trainings and education of nursing students
- Ability to use each system separately or use the hybrid system
- Three user access levels to prevent any possible abuse or errors
- Intelligent design based on the work shift of the nurses in order to prevent possible errors
- Easy documentation design by one click, which reduces the documentation time

Three factors that should be considered in designing and developing a useful and successful electronic system include the context-based and user-friendly design as well as incorporation of user needs in designing and monitoring the system.

The limitations of this study included the need for making structural changes in some routine structural nursing work and training the staff for using the system. Making any change, although positive, is usually associated with some challenges. However, given the unique advantages of the system, researchers hope to overcome the limitations by the correct implementation of the system.

Due to the nature of this study (i.e., action research), the following steps were taken with the active participation of all nurses in the study:

- 1. When designing the system, nurses' suggestions were considered, based on which changes were incorporated.
- 2. The titles and information of the eight cells of the drug table were determined using a checklist that was filled out by the participation of all nurses in the study.
- 3.A total of 120 nursing diagnoses related to the NICU were selected and entered into the system by the participation of all nurses in the study.
- 4. Medication satisfaction questionnaires were prepared in collaboration with three volunteer nurses.

5. Results of the study were analyzed in collaboration with three volunteer nurses participant in the study.

Conclusion

This study led to the design and implementtation of a medication management system with unique and beneficial features. This system has advantages over other similar systems that made it more functional. This system allows the nurses to identify and prevent medication errors, save care and documentation time, and take major steps towards promoting neonatal safety. Another important advantage of this system is the high levels of nurse's satisfaction (i.e., user) regarding its application. We believe that if nurses (i.e., users) are satisfied with the new system, it will be more useful and effective.

Acknowledgments

The present study is a part of a Ph.D. dissertation in nursing titled "Development and implementation of nursing information system in NICU". Hereby, the researchers of this study appreciate the attempts and collaboration of all those who contributed to this research, including the software developer team and the staff nurses in the NICU of Amin Hospital of Isfahan, Iran.

Conflicts of interest

None declared.

References

- 1. Clifton-Koeppel R. What nurses can do right now to reduce medication errors in the neonatal intensive care unit. Newborn and Infant Nursing Reviews. 2008;8(2):72-82.
- Rahimi F, Rezaei SA, Baghaei R, Feizi A. Factors influencing medication errors according to nurses' decisions to do self-report. International Journal of Basic & Clinical Pharmacology. 2015;4(1):130-3.
- Shah P, Ghori V, Pandy H, Vaghela P. Drug Information System. International Journal of Pharmaceutical & Health Science. 2010;1(2):56-61.
- 4. Noorian M, Rassouli M, Kavousi A. Nurses' perspectives on factors related to medication errors in neonatal and neonatal intensive care units. Iran Journal of Nursing. 2013;25(80):65-74.
- 5. Samra HA, McGrath JM, Rollins W. Patient safety in the NICU: a comprehensive review. The Journal of perinatal & neonatal nursing. 2011;25(2):123-32.
- Ammenwerth E, Schnell-Inderst P, Machan C, Siebert U. The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. Journal of the American Medical Informatics Association. 2008;15(5):585-600.
- 7. Fiks AG. Designing computerized decision support

that works for clinicians and families. Current problems in pediatric and adolescent health care. 2011;41(3):60-88.

- 8. Jao CS, Hier DB. Clinical decision support systems: An effective pathway to reduce medical errors and improve patient safety: INTECH Open Access Publisher; 2010.
- 9. Varzeshnejad M, Rassouli M, Zagheri Tafreshi M , Kashrf R, Moss J. Transcultural Mapping and Usability Testing of the Clinical Care Classification System for an Iranian Neonatal ICU Population. Comput Inform Nurs. 2014 32(4):182-8.
- Polen HH, Clauson KA, Thomson W, Zapantis A, Lou JQ. Evaluation of nursing-specific drug information PDA databases used as clinical decision support tools. International journal of medical informatics. 2009;78(10):679-87.
- 11. Hozak MA, Nelson J, Gregory D. Relationship of Hospital Architecture to Nursing Staff Caring for Self, Caring for Patients, and Job Satisfaction. Interdisciplinary Journal of Partnership Studies. 2016;3(1):5.
- 12. McCoy AB, Waitman LR, Lewis JB, Wright JA, Choma DP, Miller RA, et al. A framework for evaluating the appropriateness of clinical decision support alerts and responses. Journal of the American Medical Informatics Association. 2012;19(3):346-52.
- Murrells T, Robinson S, Griffiths P. Job satisfaction trends during nurses' early career. BMC nursing. 2008;7(1):1.
- 14. Castelo Branco FMF, de Medeiros JM, Monteiro CFdS. The action research in construction of knowledge of the academic in nursing on the phenomenon of drugs. Journal of Nursing UFPE on line [JNUOL/DOI: 105205/01012007/Impact factor: RIC: 0, 9220]. 2013;7(3):985-9.
- 15. Crow J, Smith L, Keenan I. Sustainability in an action research project: 5 years of a Dignity and Respect action group in a hospital setting. Journal of Research in Nursing. 2009.
- 16. Hiltunen L. Enhancing web course design using action research. 2010.
- 17. Thursky KA, Mahemoff M. User-centered design techniques for a computerised antibiotic decision support system in an intensive care unit. International journal of medical informatics. 2007;76(10):760-8.
- Jani YH, Ghaleb MA, Marks SD, Cope J, Barber N, Wong ICK. Electronic prescribing reduced prescribing errors in a pediatric renal outpatient clinic. The Journal of pediatrics. 2008;152(2):214-8.
- 19. Kazemi A, Ellenius J, Pourasghar F, Tofighi S, Salehi A, Amanati A, et al. The effect of Computerized Physician Order Entry and decision support system on medication errors in the neonatal ward: experiences from an Iranian teaching hospital. Journal of medical systems. 2011;35(1):25-37.
- 20. Yuan MJ, Finley GM, Long J, Mills C, Johnson RK. Evaluation of user interface and workflow design of a bedside nursing clinical decision support system. Interactive journal of medical research. 2013;2(1).

- 21. Cheraghi MA, Nikbakhat Nasabadi A, Mohammad Nejad E, Salari A, Ehsani Kouhi Kheyli S. Medication errors among nurses in intensive care units (ICU). J Mazand Univ Med Sci. 2012;21:115-9.
- 22. Fossum M, Ehnfors M, Fruhling A, Ehrenberg A. An evaluation of the usability of a computerized decision support system for nursing homes. Appl Clin Inform. 2011;2(4):420-36.
- 23. Bertsche T, Pfaff J, Schiller P, Kaltschmidt J, Pruszydlo MG, Stremmel W, et al. Prevention of adverse drug reactions in intensive care patients by personal intervention based on an electronic clinical decision support system. Intensive care medicine. 2010;36(4):665-72.
- 24. Kadmon G, Bron-Harlev E, Nahum E, Schiller O,

Haski G, Shonfeld T. Computerized order entry with limited decision support to prevent prescription errors in a PICU. Pediatrics. 2009;124(3):935-40.

- 25. Pruszydlo MG, Walk-Fritz SU, Hoppe-Tichy T, Kaltschmidt J, Haefeli WE. Development and evaluation of a computerised clinical decision support system for switching drugs at the interface between primary and tertiary care. BMC medical informatics and decision making. 2012;12(1):137.
- 26. You W, Simalatsar A, Widmer N, De Micheli G, editors. A drug administration decision support system. Bioinformatics and Biomedicine Workshops (BIBMW), 2012 IEEE International Conference on; 2012: IEEE.