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Nursing Satisfaction with Medication Care by Using Neonatal Electronic Medication Management Systems

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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

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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-care-plan section of the system. They also recorded the drugs administered in their shift in the drug-care-documentation section, which finally resulted in a nursing drug care paper as a report. Drug care E-forms were designed in a way to achieve a user-friendly 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 E-form. 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

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).

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

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 serum compatibility with drugs	66.7%	33.3%	0	0	0
3. Satisfaction with the impact of system on the reduction of errors related to 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 drug administration route, such as slow intravenous infusion	77.8%	22.2%	0	0	0
5. Satisfaction with the impact of system on the reduction of errors related to the preparation and dilution of drugs for administration	66.7%	22.2%	11.1%	0	0
6. Satisfaction with the impact of system on the reduction of errors related to drug administration interval, for example every 12 h	66.7%	22.2%	11.1%	0	0
7. Satisfaction with the impact of system on the reduction of errors related to special medication care, such as controlling the pulse	61.1%	38.9%	0	0	0
8. Satisfaction with the impact of system on the reduction of errors related to special monitoring, such as weight control, etc.	66.7%	33.3%	0	0	0
9. Satisfaction with the impact of system on the reduction of the time to access drug information	77.8%	22.2%	0	0	0
10. Satisfaction with the impact of system on the overall enhancement of medication use among nurses	66.7%	22.2%	11.1%	0	0
11. Satisfaction with the impact of system on the overall reduction of medication care errors	66.7%	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 system

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 illegible drug information in nursing documentation	55.6%	44.4%	0	0	0
2. Satisfaction with the impact of system on increasing the accuracy of the medication needed	55.6%	44.4%	0	0	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 medication care	55.6%	33.3%	11.1%	0	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 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 workload	50%	38.9%	11.1%	0	0
10. Satisfaction with the impact of system on the facilitation of the follow-up of previous medication care	22.2%	55.6%	22.2%	0	0
11. Satisfaction with the impact of system on the disease and recovery course identification	22.2%	22.2%	55.6%	0	0
12. Satisfaction with the similarity of the electronic drug forms with paper drug forms	50%	38.9%	11.1%	0	0
13. Overall satisfaction with electronic medication documentation	38.9%	50%	11.1%	0	0

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/
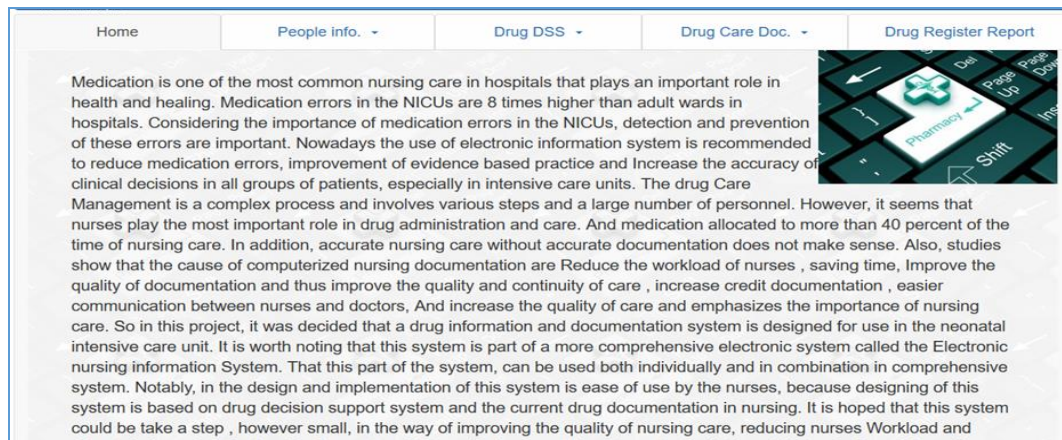

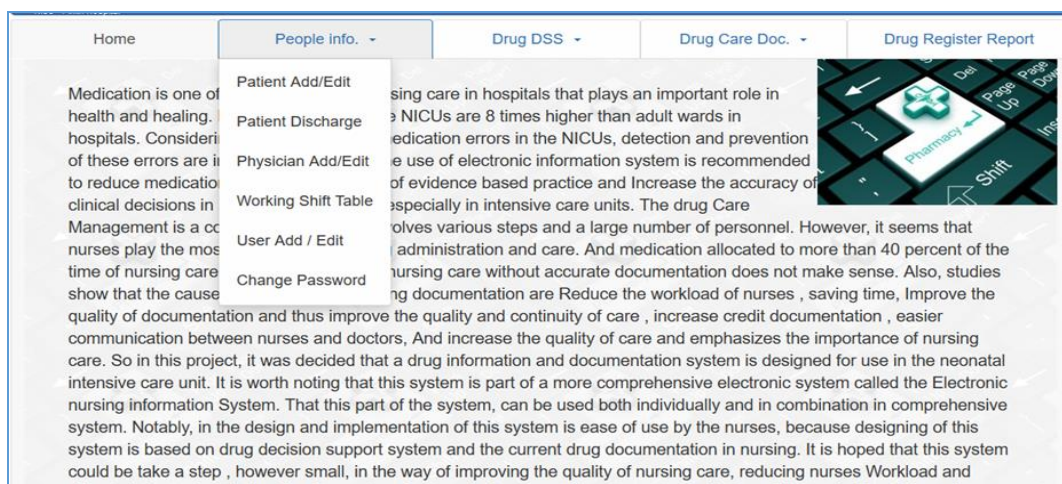**Figure 1.** Login page

Figure 2. Home page

Figure 3. People information page

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

Figure 5. Patient discharge page

Figure 6. Physician add/edit page

Figure 7. User add/edit page
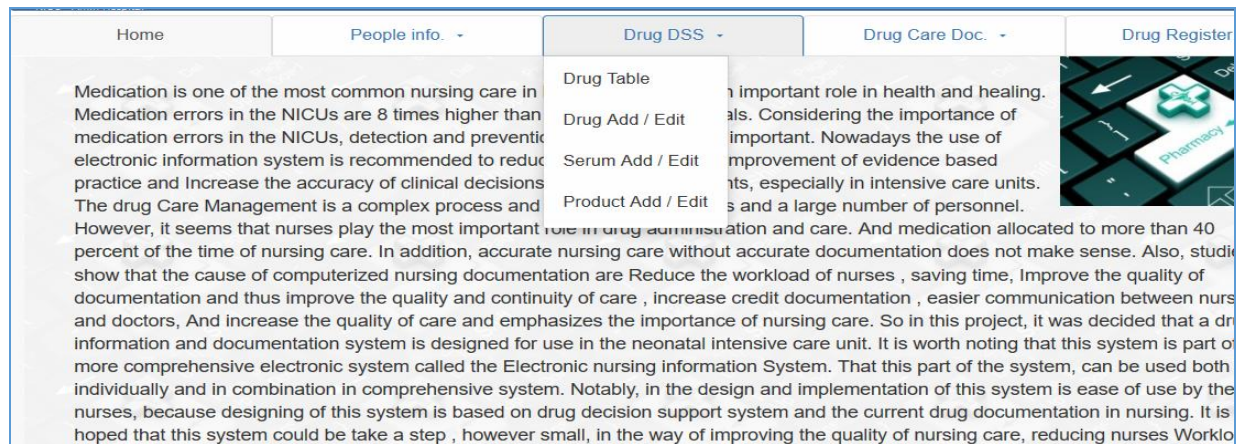

Figure 8. Chang password page
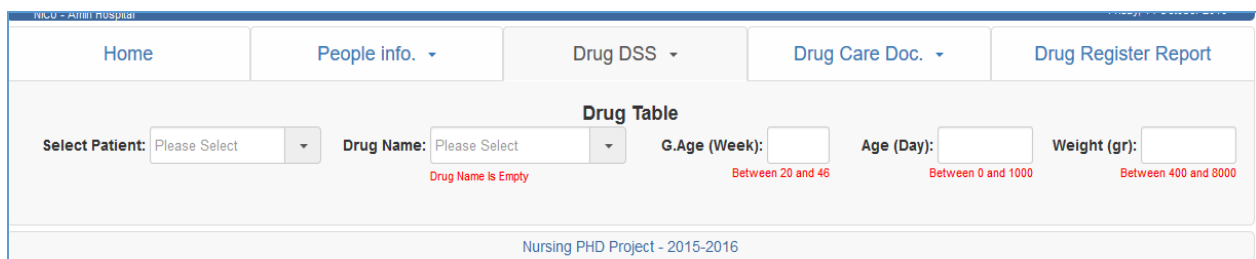
Figure 9. Drug table page
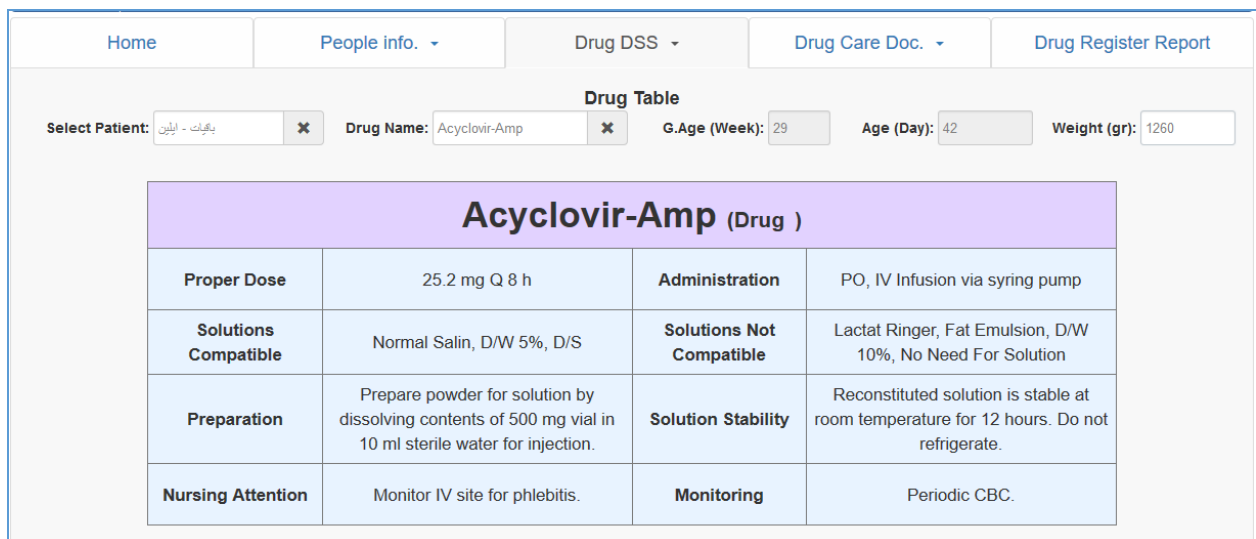

Figure 10. Drug table page

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 non-administration.

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

Figure 12. Drug add/edit page

Figure 13. Serum add/edit page
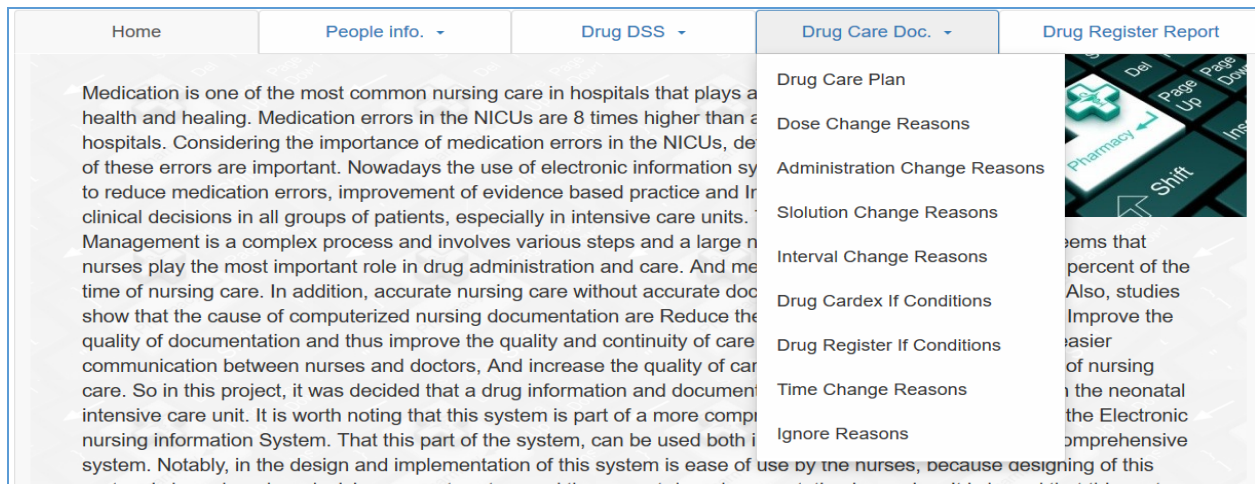

Figure 14. Product add/edit page

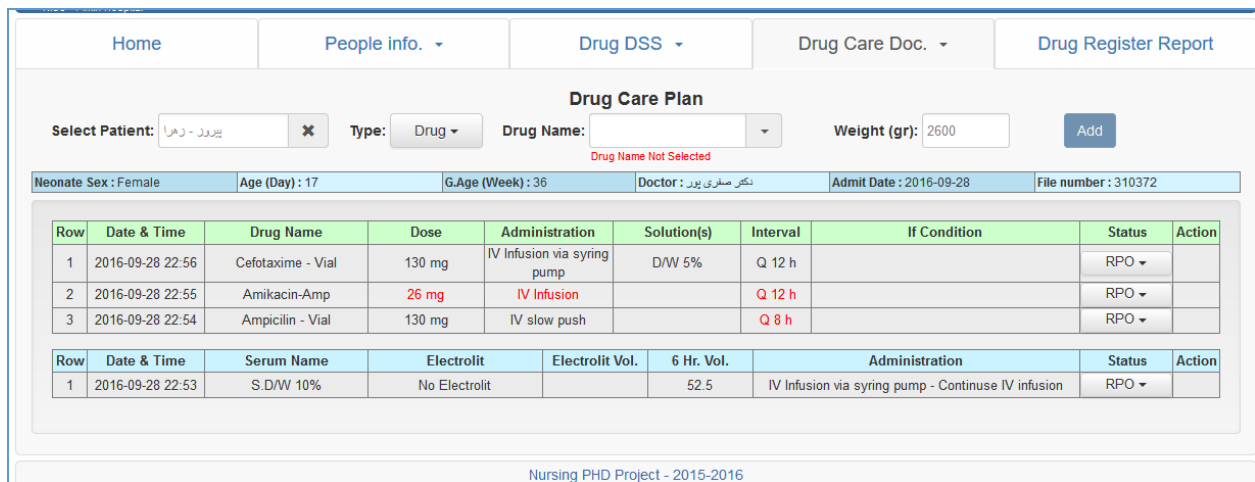**Figure 15.** Drug care documentation page

Figure 16. Drug care plan page

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

Figure 18. Dose change reasons page

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 system (Drug decision support system + Drug documentation)	50%	50%	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 document-tation, 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 study showed that the 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.

In designing the electronic medication 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 implementation 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

Conflicts of interest

None declared.

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