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Establishment and Evaluation of Information System for Chemotherapy Care

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***Abstract*—**In order to improve the overall safety of chemotherapy, safety-protecting net was established for the whole process from prescribing by physicians, transcribing by nurses, dispensing by pharmacists to administering by nurses. The information system was used to check and monitor whole process of administration and related sheets were computerized to simplify the paperwork.

***Keywords*—**Chemotherapy, Bar Code Medication Administration (BCMA), Medication Safety.

I. Introduction

CHEMOTHERAPY is a high-risk, high-cost and important nursing care treatment with no error of allowing. Proper execution of chemotherapy is one of the quality indicators of safety for patients. The prescribing error rate of chemotherapy reached 0.34% in 2012 in a local community teaching hospital in northern Taiwan, which was mainly due to an inconsistency between medication instructions and compliance. On the other hand, medication administration error rate of chemotherapy was 0.05, categorized as patient identification error, administering sequence error, and infusion drop dose error. In order to improve administration safety of chemotherapy, a security network for the whole administration process from prescribing, dispensing and administering was built. A prevention strategy of chemotherapy errors was proposed by referring to the literature, which includes physician order entry system, barcode system, etc. It reviews and monitors the medication safety [1] via information systems and simplifies nurse paperwork in accordance with E-application of national policy.

II. Literature Reviews

Serious injury and death in patients have been reported by chemotherapy administration errors and inappropriate treatments [2]. Common administration errors occurring in chemotherapy including prescribing, dispensing, and administering lead to incorrect dosages, transcriptions, administration time, medications, infusion rates, modes and routes of administration, etc. [3]. Chemotherapy negligence can directly harm to patients, which should not be ignored. Researchers believed that the processes from prescribing, through dispensing, to administering are linked and inseparable in relation to risk reduction of chemotherapy [4].

Medication safety involves multidisciplinary fields of health care, from physicians (prescribing), through nurses (transcribing), to pharmacists (dispensing), and eventually nurses again (administering). A medication process is a complicated task involved multidisciplinary health care practitioners. Any mistakes from any parts of them can cause a medication error. Many study results regarding to medication administration errors have showed interrupted administration, exhausted nurses, illegible handwriting of prescription, confused names or appearances between two drugs, and without complying with the three-read and five-right principle [5], which indicated there is often presence of human errors during nursing care processes. In order to reduce human errors in medication safety, healthcare institutions are implementing various types of information systems in clinical nursing care, and many studies have demonstrated that the use of computerized physician order entry (CPOE), bar-code-assisted medication administration (BCMA), electronic medication administration records(eMAR), automated dispensing system, smart pump, and other clinical information systems can effectively reduce errors from different medication processes [6]-[9].

Researchers have also indicated that most of the administration errors resulted from systemic negligence. Therefore, merely excluding the individual who made mistakes cannot promote medication safety. To reduce exposure to unsafe working environment for healthcare workers is the only way to establish a healthcare loop without making mistakes easily [10]. Thus the safe environment of administration should be constructed through the way of system, and personnel education, information technology intervention; system reengineering (simplification and standardization) should be strengthened to establish an error-proofing barrier [11], which is intended to reduce chemotherapy administration error for promotion of medication safety by systemic improvement [12].

III. Study Methods

This study was based on reengineering approaches to analyze the chemotherapy processes, achieve simplification and standardization, identify the key processes, establish the safety system design relevant to error-prevention interface and review the contents of all prescriptions, chemotherapy assessment forms and nursing care records, reset standards and format all records through information system.

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IV. Study Results

A. Analysis of Information System Requirements for Chemotherapy Care

During the healthcare processes, errors often result from poor system design, operating procedures or working conditions. For chemotherapy, the potential failure mode easily occurring in every single step and possible effect analysis were determined through systemically reviewing and analyzing every checkpoint and checking proper functions and requirements of subsystems.

Chemotherapy processes can be divided into four stages, from medication prescribed by a doctor (prescribing), through prescriptions transcribed by a nurse (transcribing), to drugs dispensed by a pharmacist (dispensing), and eventually administration by a nurse again (administering). There are four ideal checkpoints with the corresponding prescription. For the first checkpoint, the comprehensive and correct information needed for chemotherapy regimen prescription should show at the stage of prescribing. The information for prescription needed to be computed and audited includes drug dosage, infusion rate, body surface area, drug interactions, diluted strength, and check of appropriate values of hematological and biochemical tests. In this way, the completeness of administration order of chemotherapy can be assured and the treatment regimen can be complied properly.

For the second checkpoint, the transcribing information should be comprehensive and correct based on the prescription, including drug name, start and due dates of administration, administration sequence, total dose and drops of drugs. For the third checkpoint, sufficient information such as expiry date, the diluted concentration and volume should be specified at the stage of dispensing. Finally, for the administering checkpoint, two nurses must check and confirm the identity of the patient, the stability of the chemotherapy drugs after dispensing (the expiry date), the name of the chemotherapy drugs, the total dose and drops of the chemotherapy drugs consistent with the medication instructions of the prescription prior to administration. Each link should be reduced errors by reviewing record.

B. Planning and Designing of Information System for Chemotherapy Care

Chemotherapy Care Information Systems is a kind of system development for multidisciplinary monitoring. According to the whole system, a physician prescribes orders by computerized physician order entry (CPOE) system, then the information is communicated to the chemotherapeutic drug dispensing room for dispensing and packaging with barcodes, further the drugs are distributed to the nursing station where the patient stays. Prior to administration, nurses open a computerized physician prescription through a network, follow the electronic medication administration record (eMAR), and scan the barcodes of drugs and the barcode on the patient's hand ring to perform the five-right confirmation (i.e. the right patient, the right drug, the right dose, the right route, and the right time) at bedside by using the bar-code-assisted medication administration (BCMA) on the drug and the patient's hand ring, the bar-code scanner, and wireless-mobile nursing car. If an error occurs, an alarm will ring to remind the nurse to re-check. Moreover, the computer system will also automatically complete electronic medication administration records. The system ensures the chemotherapy care safety via the auditing rules of checkpoint established by the processes above. To summary planning and designing of information system for chemotherapy car as follows:

1. To Establish the Standardized Chemotherapy Prescription by Information Systems:

According to the 122 models of anti-cancer regimens for 18 types of cancer, which were established by a local community teaching hospital in northern Taiwan, prescriptions based on the models and in the formatted form can reduce potential errors, such as to improve the integrity and accuracy of the prescription, to avoid dispensing errors. Nurses may clearly interpret prescription information and follow the planned treatment.

2. The Use of Bar-Code-Assisted Medication Administration to Improve the Accuracy of Administration:

Chemotherapy drugs are shown in accordance with the prescription order and color-coded in the screen of computer to help identification by nurse. Bar-code-assisted medication administration is used for auditing patient identification, chemotherapy administration sequence, any missing administration, accuracy of administration time, and double-checking mechanism.

3. Enhance Dispensing Accuracy:

The use of bar-code systems is to enhance dispensing accuracy of chemotherapy drugs and to monitor drug stability (drug expiration date).

4. Related Observation Records Link to Nursing Records:

Infusion observation record and side effect assessment of chemotherapy sheet will be computerized and linked to electronic nursing records, which reduces nurse repeated writing and recording time. If an abnormal condition occurs in the observed item, treatment options and health education leaflets are provided based on evidence-based nursing, which may enhance nurse to check on patient's safety education.

C. Building and Testing of Information Systems for Chemotherapy Care

Since October 2012, we began to review the reasons for the processes of chemotherapy care which easily to cause errors and to develop countermeasures against their checkpoints. In January 2013, we began to plan and build information systems of chemotherapy care with related system requirements discussed by the cross-team group, and in May 2013 this system have been fully implemented. In the beginning of the implementation, the dual mode was used for testing operation, the primary purpose of which is to confirm the accuracy of the system rules. During testing, questions which users respond have to be collected, verified, and clarified, and further to revise and debug the systems for achieving the smooth and accurate

operation of the information systems. The systems were evaluated after implementation for six months.

V. Results and Discussion

In the study, the checkpoints which occurred commonly during the processes of chemotherapy care were controlled by the information systems, which achieved the purpose to audit the subsequent stages of dispensing and administering by using the alarm of the prescription system and the settings of the standardized regimens. The analysis of before and after implement system refers to Table I.

Experts have recommended how to evaluate the effectiveness of clinical information systems, which is based on actual observation, time measurement, questionnaire surveys and feedbacks during the implementation period of each stage [13]. In this study, the evaluation results of the effectiveness for the system after the beginning of the implementation for six months are as follows:

A. Usage of the Bar-Code-Assisted Medication Administration (BCMA) System

The system was formally launched in May 2013.After implementation for about six months the usage rate for BCMA was checked at 73.6% during November 13 to 20, 2013 because the majority did not follow the standard operating procedures. We should strengthen education and training for nurse and build the auditing system for the standard operating procedures of the BCMA.

B. Simplification of Nursing Work

According to the investigation on working time, it revealed that BCMA did not increase the nursing administration time. After computerizing observation record and linking to nursing records during chemotherapy for patients, transcription time of related records was shortened averagely 8 minutes and 50 seconds per patient. Nurse paperwork time was shortened averagely 39 hours 27 minutes and 20 seconds based on the assessment of 268 hospitalized patients undergoing chemotherapy monthly (Table II), and nurse thus can spend more time on direct care and concern of patients.

TABLE I
Analysis of Before and After Implement System

Procedure	Before (Paperwork)	After (Computerized)
	Computerized physician order entry; CPOE	
Prescribe	To enter manually cause the dose inconsistent with the prescription No sequence control of chemotherapy administration Body surface area and dose check are not be audited No patient's test data link No formatted prescription	Chemotherapy model is set up, which reduces errors of the dose inconsistent with the instructions and diluted strength and lifetime accumulated dose prompts Dose adjustment of chemotherapy drugs according to renal function is set up, the system will remind recommend dose Blocking in place of maximum dose alarm Alarms of drug adverse reaction and allergy
Transcribe	Handwriting MAR Increased transcription error rate Information is missing in transcription	Automatic eMAR generation To reduce manual transcription time and errors or missing rate
Dispense	Double check dispense Pharmacists cannot view the treatment plan Errors occur easily during dispensing Stability of chemotherapy dispensing cannot audited	Barcode assisted dispensing Queries of Electronic medical records and cancer treatment plan Dispensing with bar-code confirmation
Administration	Double check administration Check the prescription and transcribe the administration record sheet on paper Bring the paper and chemotherapy drugs to the patient site Conduct patient identification by double checking	Barcode assisted administration Audit of dispensing stability for chemotherapy drug (signing / administering) The total drug volume and drops are brought into automatically by the infusion card To audit the administration sequence of chemotherapy To audit the double-checking administration of chemotherapy Confirmation of infusion safety for chemotherapy and the link between side effect assessment and nursing records

TABLE II
THE MEAN DEVIATIONS OF WORKING TIME FOR NURSING RECORDING BETWEEN BEFORE AND AFTER THE INFORMATION SYSTEM SET UP

Task	Before (Paperwork)	After(Computerized)	Mean Deviations
Chemotherapy administration	32 secs	36 secs	+4 secs
Administration record sheet	7 mins and 42 secs	12 secs	-7 mins and 30 secs
Observation records of infusion safety measures	1 mins and 8 secs	25 secs	-43 secs
Assessment record of side-effect symptoms	1 mins and 20 secs	43 secs	-37 secs
Total			-8 mins and 46 secs

C. Analysis of User Satisfaction

After using the systems for six months, the survey of satisfaction of nurse using the system was reached about 85% of satisfied and very satisfied with the integrity, the accuracy, and the effectiveness of the system, however, the system stability of satisfied and very satisfied was only 48.3% (Fig. 1), which was caused by the slow or even crashing system under normal working condition. The problems were responded to the information department to enhance the signal strength for the areas where the wireless signal was not good and to budget for quality improvement of wireless LAN.

The survey results of using bar-code-assisted medication administration system for chemotherapy in nursing department.

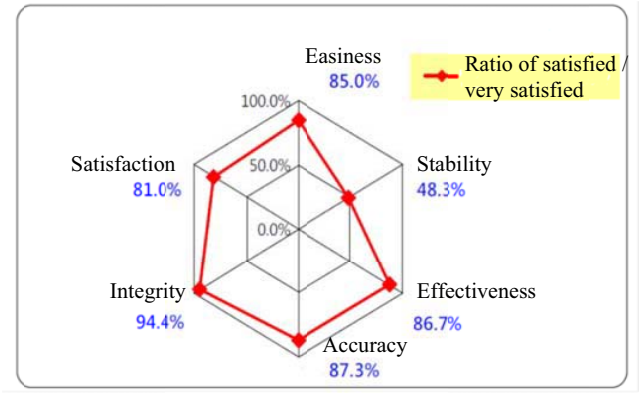

Fig. 1 Radar chart of satisfaction survey results

VI. CONCLUSION

After the implement of information system, the overall reengineering of chemotherapy processes and the implementation of standardized processes can be monitored by the management mechanism of the information systems. Well-standardized processes can reduce potential interpretation errors powerfully by providing clear treatment information, so that it can ensure the integrity and accuracy of the prescription, and related staff to follow the planned treatment properly. Furthermore, the audit of a number of checkpoints by using bar codes can also reduce medication errors. In addition, computerizing relevant forms can reduce to duplication of written records.

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