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Design, implementation, and evaluation of a CPOE system in a cancer care setting: A case study on the gastric cancer patients

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Abstract:

BACKGROUND: Chemotherapy is a complex, multi-disciplinary, and error-prone process. Information technology is being increasingly used in different health care settings with complex work procedures such as cancer care to enhance the quality and safety of care. In this study, we aimed to develop a computerized physician order entry (CPOE) for chemotherapy prescribing in patients with gastric cancer and to evaluate the impact of CPOE on medication errors and order problems.

MATERIALS AND METHODS: A multi-disciplinary team consisting of a chemotherapy council group and system design and implementation team was formed for chemotherapy process evaluation, requirement analysis, developing computer-based protocols, and implementation of CPOE. A before and after study was conducted to evaluate the impact of CPOE on the chemotherapy process and medication errors and problem orders. To evaluate the level of end-user satisfaction, an ISO Norm 9241/110 usability questionnaire was chosen for the evaluation.

RESULTS: Before the implementation of the CPOE system, 37 medication errors (46.25%) and 53 problem orders (66.25%) were recorded for 80 paper-based chemotherapy prescriptions. After implementation of the CPOE system, 7 (8.7%) medication errors and 6 (7.5%) problem orders were recorded for 80 CPOE prescriptions. The implementation of CPOE reduced the medication error by 37.55% and the problematic order by 58.75%. The results for usability evaluation indicate that the CPOE was within the first class of the ISONORM level rating; this shows that a CPOE is with very high satisfaction and a very high functionality rate.

CONCLUSION: Developing a CPOE system significantly improved safety and quality of the chemotherapy process in cancer care settings by reducing the medication error, deleting unnecessary steps, improving communication and coordination between providers, and use of updated evidence-based medicine in direct chemotherapy orders. However, the CPOE system does not prevent all medication errors and may cause new errors. These errors can be human-related factors or associated with the design and implementation of the systems.

Keywords:

Chemotherapy, computerized provider order entry, gastric cancer, medication error

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Background

Gastric cancer (also known as cancer of the stomach) is a worldwide health problem.[1] According to Globocan 2020, gastric cancer remains the third lauding cause of cancer-related death and the sixth most common malignant tumor in the world.[2] In 2020, 1,089,103 new gastric cancer and 768,793 new cancer-related deaths occurred globally.[2] Patients with gastric cancer usually receive different treatment plans such as surgery, radiation therapy, immunotherapy, chemotherapy, and target therapy.[3] Although chemotherapy

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is an effective method for the treatment of patients with cancer, it is also a complex, multi-disciplinary, and error-prone process.[4] Chemotherapy medication error might lead to serious consequences because of a narrow therapeutic index, high toxicity, and the health status of patients with cancer.[5] Base on the report "to err is human" from the Institute of Medicine, about 44,000 and 98,000 patients die each year in USA because of medication error, and in this case, chemotherapy agents were the second most common cause of fatal medication error.[4,6] Because of the complexity of chemotherapy regimens, errors can occur anytime and at any stage of the chemotherapy process including prescribing, dispensing, transcribing, monitoring, and administration phases.[7] However, the highest rate of medication error occurs in the prescribing phase.[4,8] In particular, dosing errors, either overdose or underdose, wrong medications, wrong frequency, missing pre-medications, and incorrect volumes of hydration are the most common types of errors that occur at the prescribing phase and can consequently result in catastrophic response or death.[6,9-11]

Chemotherapy medication errors should be addressed in order to enhance patient safety and improve the quality of cancer care. Several distinct strategies are employed to decrease chemotherapy errors and the risk of cancer patient harms, for example, use of pre-printed standard forms, developing policies and procedures for the secure handling of high-risk medications, continuous training of health care providers, computerized physician order entry (also called CPOE), and clinical decision support system (called CDSS).[9,12-16]

Studies show that the implementation of the CPOE system, a tool for electronic entry medications for drug ordering, especially chemotherapy agent ordering, can essentially prevent or significantly reduce the medication errors at any stage of the medication use process, especially at the prescribing phase (a 44% to 88% reduction in prescribing phase errors).[4,13,17-19]

Many previous studies have attempted to use the CPOE system and investigate the impact of CPOE on medication error and adverse drug events in other medical specialties or hospital wards, but to the best of our knowledge, no specific CPOE system has been developed for chemotherapy of patients with gastric cancer and no study which focuses on the evaluation of the impact of such a system on gastric cancer chemotherapy medication errors has been published. In order to reduce the burden of medication errors and safety incidents related to chemotherapy of patients with gastric cancer, the present study was conducted for design and implementation of a CPOE system for chemotherapy of patients with gastric cancer and then to evaluate the impact of the CPOE system on the chemotherapy medication error.

Materials and Methods

Study design and setting

The present study was conducted in the Oncology ward at Baqiyatallah Teaching Hospital in Tehran, Iran. Baqiyatallah Teaching Hospital is one of the largest referral cancer centers in Iran. In 2019, the Oncology Department of Baqiyatallah Hospital prescribed more than 30,956 chemotherapy orders, equivalent to 2,600 chemotherapies per month, at the in-patient and out-patient units, which works 24 hours per day and 7 days of a week. A before and after study was used to evaluate the impact of CPOE on the chemotherapy process and medication errors and problem orders and the level of end-user satisfaction.

Study participants and sampling

A multi-disciplinary team consisting of a chemotherapy council group (two oncologists and fellows, chemotherapy nurse specialist) and system design and implementation council group (two Ph. D. in Medical Informatics and Health Information Management) was formed for chemotherapy process evaluation, requirement analysis, design, and implementation of a guideline-based CPOE system. The team also included patient safety research fellows consisting of patient safety study fellows.

Ethical consideration

This study was approved by the ethical committee board of Baqiyatallah University of Medical Sciences as part of ongoing continuous quality and safety improvement endeavors of cancer patients' candidates for chemotherapy. (Ethic code: IR.BMSU.REC.1399.445).

Data collection tool and technique

Process analysis and protocol development

To analyze the current chemotherapy process and treatment guidelines, a team was composed of oncologists and chemotherapy nurses. The chemotherapy process was divided into four main sections, including the reception unit, chemotherapy prescription by oncologists, prescription verification by clinical pharmacists, and the administration phase by nurses. Figure 1 presents the process of chemotherapy management.

To provide the rules of the chemotherapy ordering system, we require that all available gastric cancer chemotherapy protocols be reviewed and written on an order set that includes a structured prescription. The structured prescription identifies the chemotherapy regimens or protocol, basis doses for automatic patient-specific dose calculation, protocols for the

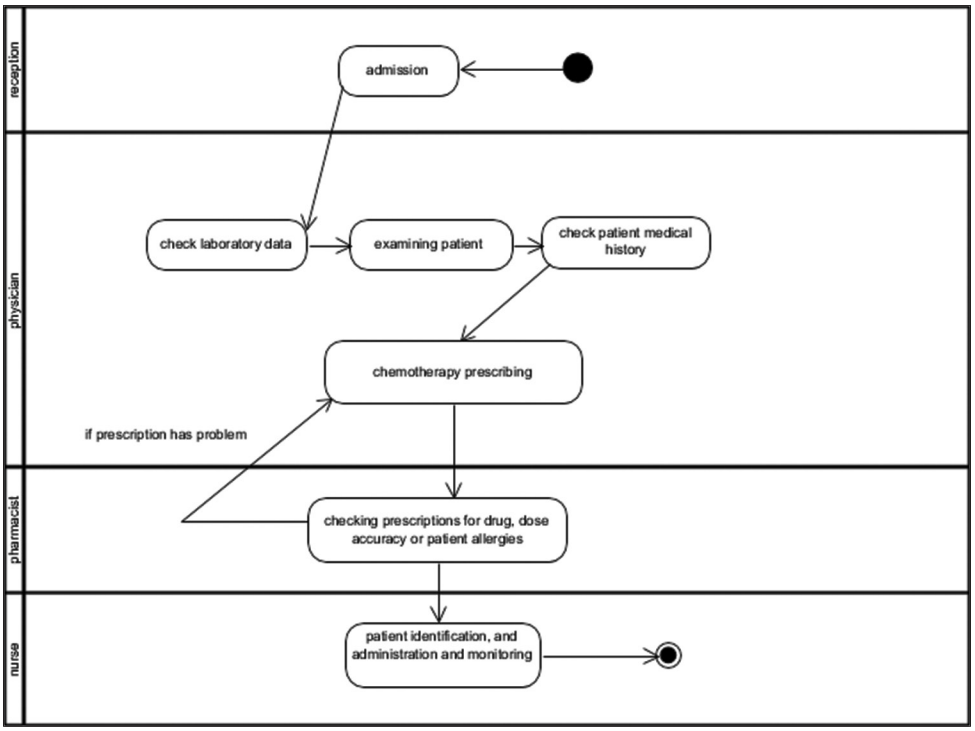

Figure 1: Chemotherapy process in cancer care settings

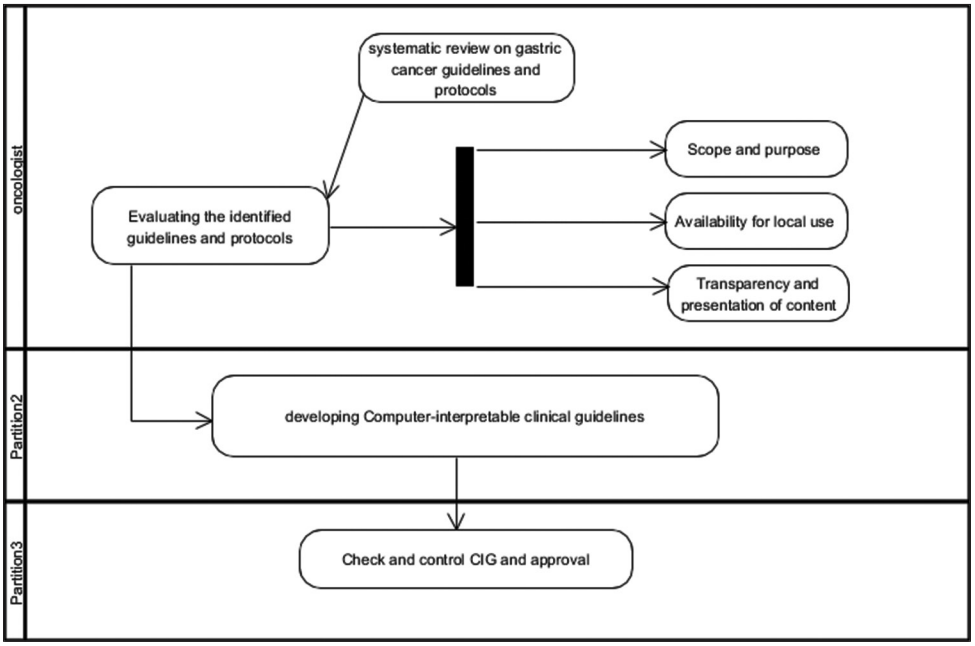

Figure 2: Activity diagram for the prioritization and development of gastric cancer structured protocols

hydration orders and pre-chemotherapy medication, cycle frequency, number of cycles, and criteria to begin treatment. The process for the development of gastric cancer structured protocols is shown in Figure 2. Each of the collected chemotherapy protocols was validated by a chemotherapy council group based on its respective international guidelines such as ASCO, NCCN, Oncology Nursing Society, CCO, COSA, ASHP, literature evidence, and the current local health care product regulatory organization.[20-24] There are also the respective examination forms consisting of clinical, laboratory, and demographic forms, which were developed through developing questionnaires in an iterative multi-disciplinary collaboration. Validation of protocols was performed by five oncologists and 18 fellows from November 1, 2020 to January 1, 2021.

Design and development of conceptual modeling

Recommendations of the PROJECT team based on the requirement analysis findings (essential identified elements for chemotherapy ordering in routine care) and capabilities of CPOE were used for design of the CPOE system to meet the needs of chemotherapy prescribing and to address the identified hazardous modes. For this purpose, the functional and non-functional requirements of the CPOE were identified; then, the design of the CPOE system by providing the conceptual model (use case, activity, class, sequence diagram) through the object-oriented analysis method and using the UML modeling language was completed, and the respective forms consisting of examination forms, patient profile forms, prescription forms, and so on were developed.

Software development

To enhance the safety and ensure optimization of chemotherapy ordering and management abilities, the CPOE software was implemented with a clinical decision support system with capabilities such as automatic prescribing, calculation of drug doses, and alert generation, as well as providing a reminder service. Furthermore, from a view of safety and technology, the content of the CPOE system demands to be easily adapted to new research results as the chemotherapy guidelines for gastric cancer patients are subject to continuous change as is the study on the outcomes. Therefore, an updated protocol/regimen interface was developed. In addition, to access information of patients at the point of ordering, the patient management system (PMS) was developed and added to the CPOE system to further support the prescribing of gastric cancer chemotherapy and treatment plans.

Prescribing medication error and system evaluation

This study consisted of a comparison of error rates in a pre- and post-implementation study design. Paper-based prescriptions over 3 months before implementation and CPOE prescription over 3 months after implementation of CPOE were selected for analysis. Prescribing medication error was defined as "any mistake originating in the prescription process and discovered by clinical pharmacists." This error can occur at clinical decision making, transcription, or prescribing policy. The appropriateness of orders is evaluated by clinical pharmacists with experience based on national/international guidelines, developed protocols, and label information. For analysis, a method of classification of possible problems and errors was used. The error category clearly referred to mistakes that have a potential injury to the patient and problem categories defined as mistakes unlikely to cause patient injury.[25] Table 1 provides lists of problems and error classification methods.

Table 1: Classification of problems and errors in chemotherapy prescription

Categories	Types of mistakes
Problems	Lack of patient identifiers or diagnosis information
	Lack of signatures
	Lack of height, weight, or BSA information
	Missing dose
	Lack of information of treatment or cycle number
	inconformity between name of order set and drugs ordered
	inconformity between chemotherapy and supportive care
Errors	incorrect or illegible patient information
	Illegible medication name
	incorrect dose
	Wrong body surface area calculation
	wrong calculation of creatinine clearance
	incorrect dose units
	incorrect regimen frequency or administration time
	deletion of chemotherapy medication or supportive care
	incorrect diluent

Evaluation of the level of end-user satisfaction took place from May 2021 until June 2021. To evaluate the level of end-user satisfaction, an ISO Norm 9241/110 usability questionnaire was chosen for the evaluation. It considered the seven principles of assessment of the computerized system. The seven principles of ISO Norm 9241/110 are shown in Table 2.

We interviewed nine system end users (oncologists, clinical pharmacists, and nurses). They were given the task to sign up for creating an account, to work with a patient management system (registering, updating, reporting, and searching patient information), to prescribe pre-chemotherapy medications and chemotherapy regimens based on patient-specific data, and to validate and administrate prescriptions. Each ISO norm question is assessed with a score from 1 to 7. Therefore, a maximum score of 147 can be obtained for one questionnaire. The test users were divided into two groups, users using the paper-based prescribing method (handwriting method) and users prescribing chemotherapy order by the CPOE system (post implemented method).

Results

Design

The system design for developing the CPOE system was carried out by four disparate diagrams through the object-oriented analysis method and using the UML modeling language: The structural diagram (class diagram) and behavioral diagram (use case diagram, sequence diagram, and activity diagram) of the system were developed by the system design and implementation council group. Three major actors were involved in the

Table 2: Principle of ISO norm 9241/110

Dialog Principle	Description
Suitability for the task	A dialog is suitable for a task when its support the users in the effective and efficient completion of the task
Selfi-descriptivness	A dialog is self-descriptive when each dialog step is immediately comprehensible through feedback from the system or is explained to the user on request
Controllability	A dialog is controllable when the user ID able to initiate and control the direction and pace of interaction until the point at which the goal has been met.
Conformity with user expectations	A dialog is conformed with the user expectations when it is consistent and correspond to the user characteristics, such as task, knowledge, education to commonly accepted conventions.
Error tolerance	A dialog is error tolerant if despite evident error in input, the intent results may be achieved with either no or minimal corrective action by the users
Suitability for individualization	A dialog is capable of individualization when the interface software can be modified to suit the task needs , individual's preference and skills of the user
Suitability for learning	A dialog is suitable for learning when its support and guides the user in learning to use the system

chemotherapy ordering phase, including an oncologist, a clinical pharmacist, and a nurse. Each of the users has a special role in different parts of the chemotherapy prescribing. Oncologists, nurses, and pharmacists have access on one or several CPOE modules including the patient profile and past treatment history of patients. There was access for updated guideline modules and calculation interfaces and modification or validation of the patient profile.

Figures 3 shows the complete system class diagram for the proposed system.

Prescribing process before/after the implementation of the CPOE system

Before implementation of the CPOE system, treatment blocks were not standardized between guidelines and oncologists. The oncologist's prescription was retrieved from a pre-formatted paper-based document that was transferred to the clinical pharmacy by the nursing staff. Both oncologists and nurses reviewed the order and copied the essential data for each medication on their special working sheets. Identified errors had to be communicated to all other care providers involved and reformed on several documents, with no guarantee for modification in all documents or completeness, and also, out-patient orders need a signature on printed copies. After implementation of the CPOE system, the oncologist logs on into the CPOE system and selects the chemotherapy module. Once the chemotherapy is prescribed, it is automatically sent to the pharmacy system and then the nursing system. Similarly, any correction in the initial (primary) order is immediately transmitted to all health care providers involved. Any development of a new chemotherapy protocol or regimens or any alteration to an existing protocol or regimen has to be reviewed and then validated by the multi-disciplinary group before implementation. The CPOE system also allowed to eliminate some steps in the old chemotherapy workflow and delete potential blocks, for example, persuading providers to make a change.

Implementation of the system

After establishing the design of the system, the team developed the CPOE system. The CPOE system contains a prescribing module permitting patient-specific chemotherapy prescriptions by directly connecting prescriptions to the standardized guidelines database in the CDSS module and automatically proposing drug standard doses based on body surface area (BSA) or creatinine clearance (CR-CL) (based on the Cockcroft–Gault formula). All drug doses can be increased or decreased depending on the specific characteristics of the patients, particularly the performance status of renal or hepatic functions, or patient BSA, and also, all medication doses can be rounded by the oncologist based on patient-specific characteristics or commercially available labels of the drug. The system was developed between January 2021 and April 2021 with the Python Programming Languages as a front-end and SQL as the back end. The CPOE system could include a single chemotherapy medication or a combination of them, given on 1 day or various days. Each ordering drug prescribed is secured by several alarms: Dose error, drug–drug interactions, or repetitive treatment, exceeding the specified maximum dose or cumulative dose, incorrect values for BSA, weight or size, and route or cycle errors. Figure 4 includes screenshots of the developed CPOE system which shows the main feature of the system.

Medication error evaluation

To assess the effect of the CPOE system on safety of chemotherapy (medication errors and problems) and evaluation of user satisfaction (based on the principle of ISO Norm 9241/110) among the system's actors (the oncologist, clinical pharmacist, and nurse), data were collected and reviewed for 80 chemotherapy orders (paper-based orders) before the CPOE implementation and 80 chemotherapy orders after implementation of the CPOE system. The review was conducted by two medical oncology specialists and clinical pharmacists in August 2021 for all 160 orders. The number and type of problem

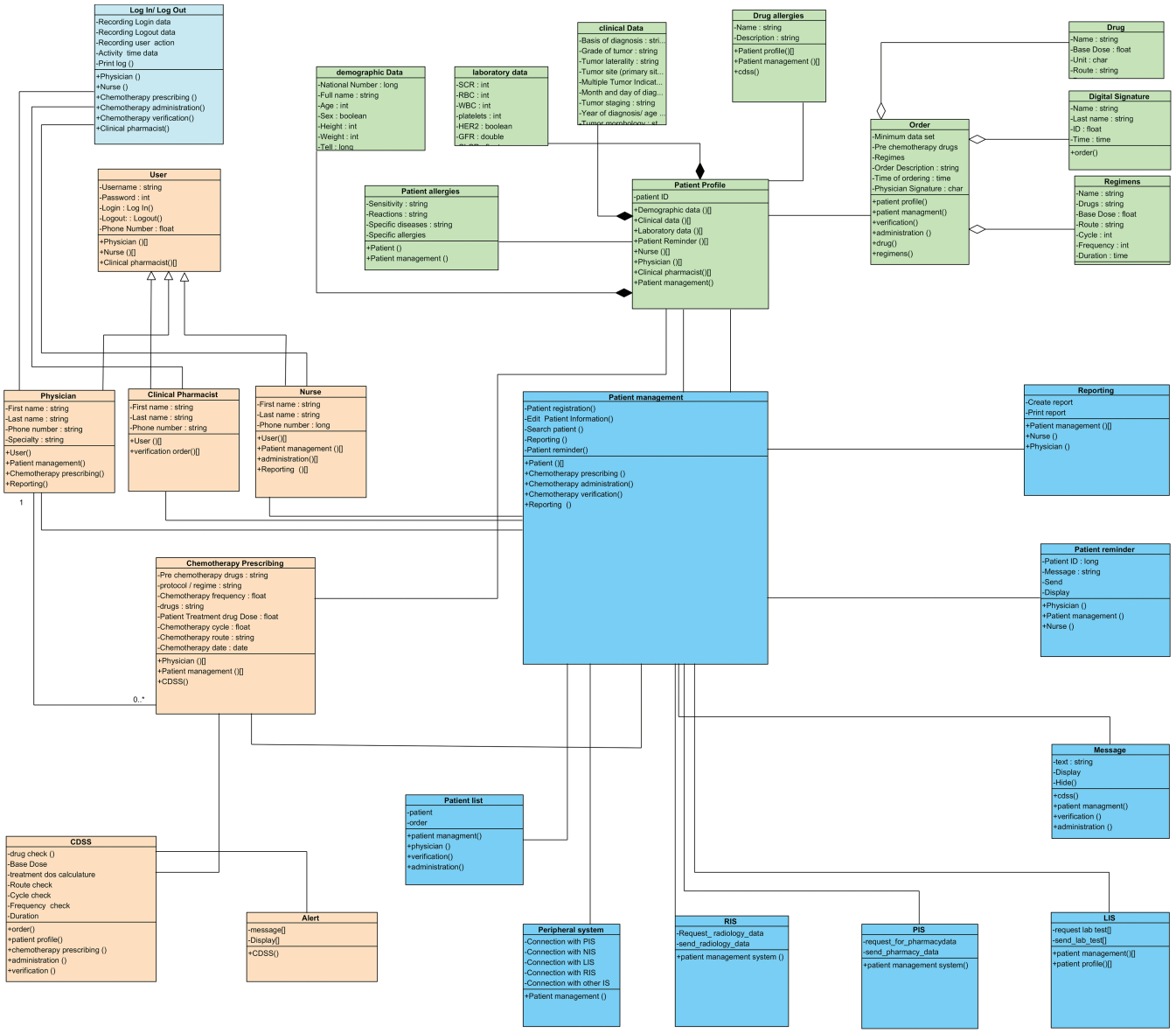

Figure 3: Complete system class diagram

prescriptions and prescriptions with errors for the handwriting prescribing method (before CPOE) and CPOE prescribing method (after CPOE implementation) are listed in Table 3.

At least one medication error or problem was accrued in 100% of the paper-based prescriptions before implementation of the CPOE system and in 7% of the CPOE ones ($p < 0.0084$).

As shown in Table 2, for 80 chemotherapy paper-based orders as prescriptions before the CPOE implementation, a total of 90 medication-related events (both medication errors and order problems) were reported. The most common medication error and problem in paper-based prescriptions were an incorrect dose and the lack of patient identifiers or diagnosis information ($P<.001$). For the 80 electronic orders after implementation of CPOE, 13 chemotherapy medication-related events for both medication errors and problems were reported.

Of these events, the number of medication errors that reached the patient harms decreased by 37.55%, from 37 to 7 after implementation of the CPOE system. Orders with problems declined by 58.75%, from 53 to 6.

Errors and problems in incorrect or illegible patient information (0.007*); illegible medication names (0.002*); wrong body surface area calculation (0.004*); the lack of patient identifiers or diagnosis information (0.000*); the lack of height, weight, or BSA information (0.000*); and the

Table 3: Prescriptions, problems, and medication errors before and after using the CPOE system in the cancer care setting

Number and types of problems and errors	No. (%) of problems and errors		
	Before CPOE (*n*=80)	After CPOE (*n*=80)	*P*
Errors	37	7	
incorrect or illegible patient information	7	0	0.007
Illegible medication name	2	0	0.002
incorrect dose	6	0	0.000
Wrong body surface area calculation	5	0	0.004
wrong calculation of creatinine clearance	5	0	0.023
incorrect dose units	2	0	0.155
incorrect regimen frequency or administration time	3	4	0.699
deletion of chemotherapy medication or supportive care	0	3	0.080
Dangerous abbreviation	2	0	0.155
Problems	53	6	0.037
Lack of patient identifiers or diagnosis information	17	0	<0.001
Lack of signatures	2	3	0.405
Lack of height, weight, or BSA information	15	0	<0.001
Missing dose	1	0	0.316
Lack of information of treatment or cycle number	11	2	<0.005
Inconformity between name of order set and drugs ordered	4	0	0.043
Inconformity between chemotherapy and supportive care	2	1	0.405

P<0.05=Significant differences

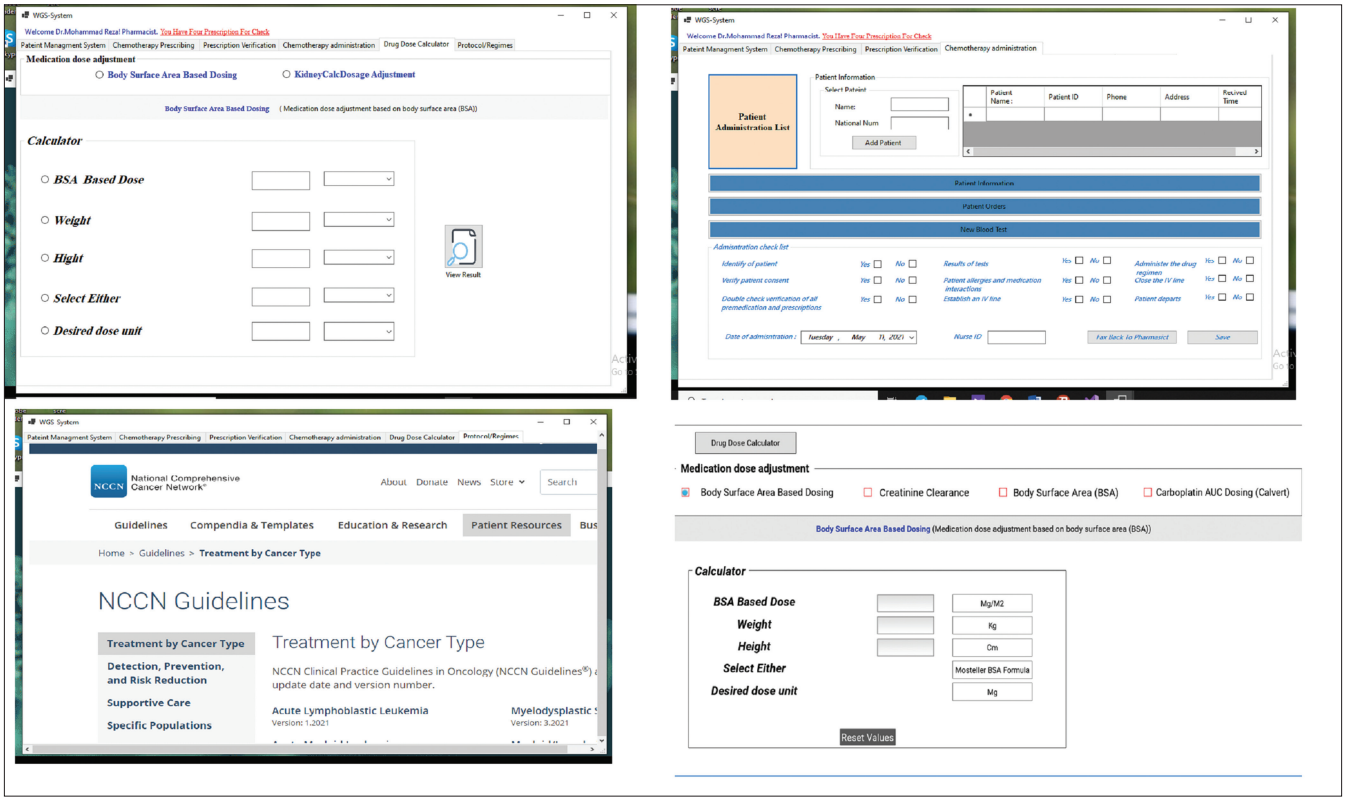

Figure 4: Screenshots of the developed CPOE system

lack of information of treatment or cycle number (0.005*) were frequent in paper-based prescriptions and completely absent after implementation of the CPOE system.

Level of user satisfaction

The assessment outcomes were in a mean total of 114 out of 147 scores. The results indicate that the CPOE system was within the first class of the ISONORM

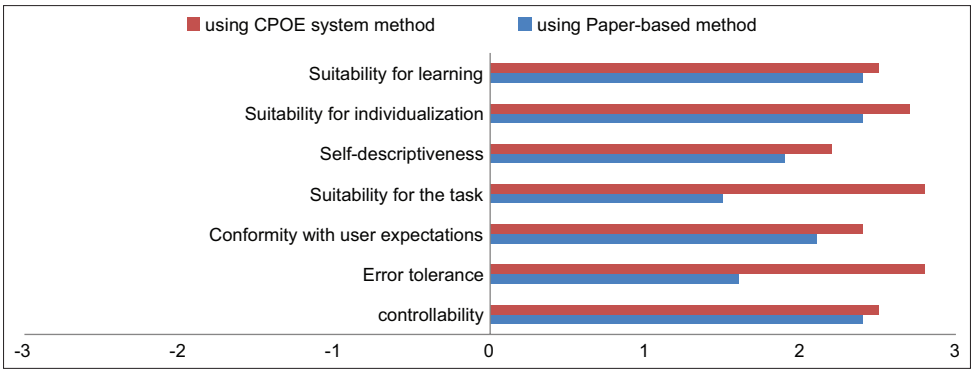

Figure 5: Difference between the paper-based method and CPOE chemotherapy method in the result of ISO-NORM 9241

level rating; this shows that a CPOE system is with very high satisfaction and a very high functionality rate. The bar chart in Figure 5 shows the difference between the CPOE chemotherapy methods before and after implementation in the result of the ISO-NORM 9241 assessment.

Discussion

The study of problem orders and chemotherapy medication error is important to improving and increasing safety measures in the process of chemotherapy prescribing and should be addressed to enhance patient safety and improve the quality of cancer care. In this project, we have successfully developed a CPOE system for chemotherapy prescribing in the cancer care unit. The implementation of the CPOE system provides effective mechanisms for the transformation of paper-based ordering into a computerized-automated ordering method.

The positive impact of our developed CPOE system in this study can be explained by its effect on patient safety and improving the chemotherapy process, enhancing communication and coordination of care between different providers (oncologists, nurses, and pharmacists), electronic ordering, and directing orders based on standardized protocols.

Chemotherapy is a complex process and highly prone to errors for various reasons, such as multiplicity and complexity of chemotherapy regimens, the use of cytotoxic drugs with a narrow therapeutic index, and the need for adjustment of doses and sequences based on a variety of s parameters.[1] Analyzing the results of our study showed a significant reduction in incidence of both the medication error by 37.55% and the problem order by 58.75%. These results suggest that the implementation of the CPOE system can result in problem order and error minimization if the CPOE system is coupled with a clinical decision support system with several capabilities such as automatic calculation of drug dose, the removal of manual data entry by using the drop-down menu, alert generation at times of drug–drug and drug–allergy interactions, and route and frequency of the regimen checking system. Furthermore, a CPOE system resolves the problems of translating illegible order and highly decreases the need for transcription. Published studies also show that the CPOE system, a tool for electronic entry medications for drug prescribing, especially chemotherapy agent ordering, is considered an essential tool for minimizing errors and problem orders at any stage of the medication process, especially at the prescribing phase (a 44% to 88% reduction in prescribing phase errors).[26] In the same report by Aziz *et al*.[27] the chemotherapy medication error decreased from 26% to 2.4% following implementation of the CPOE system (26% vs 2.4%). Voeffray *et al*.[28] in their study demonstrated that the average of chemotherapy medication error reduced 22 times after using the CPOE system. In another study, the researcher reported a 69% decrease in the chemotherapy prescription errors for oral chemotherapy drugs within 6 months post implementation of the CPOE system. Based on the findings of our study and review of published papers, the CPOE system addresses secure prescribing by several established checkpoints including (1) reduction of dose error using an automatic drug dose calculator (dose adjustment based on weight, BSA, or the Calvert/Chatelut formula), (2) checking for drug–drug and drug–allergy interactions and repetitive treatment, (3) exceeding the specific maximum dose or cumulative dose, (4) prevention of error related to inaccurate routes or wrong values of cycles, and (5) standardization of practices.[29] Therefore, transition from the handwriting chemotherapy prescribing method to electronic prescribing by developing the CPOE system which integrated with a clinical decision support system is associated with the reduction of medication errors and problem orders through elimination of prescription, interpretation, and transcription error.

As shown by the results of our study, the overall improvement in the process of chemotherapy ordering was expected because orders were simple to read

compared to paper-based orders. The CPOE system improves the documentation of the care processes; also, the order was more complete because the CPOE system did not allow incomplete orders to be documented. In the study of Harshberger *et al*., the same results were reported. In this study, the completeness of chemotherapy prescriptions and order documentation were improved after using the CPOE systems.[30] The CPOE orders did not include any illegible data or incorrect doses which could cause coordination issues and delay in the chemotherapy workflow. The CPOE system also made the essential information available to involved providers. Orders were directly and immediately delivered to the pharmacy and then the nurse unit. The unessential steps and sub-steps in the chemotherapy process were eliminated. Therefore, our developed CPOE system could delete some repetitive and extra steps in order to coordinate and synchronize and could save time. Similar results have been reported in the study of Pirnejad *et al*.[31] In this study, they reported, with the use of the CPOE system in a cancer care setting, that chemotherapy orders were easier to read compared to paper- based orders and the orders were more complete.

Paper-based guidelines are commonly used in the chemotherapy process; however, they fail to consider the complexity of this process. The use of standard clinical guidelines and protocols guarantees accurate and safe chemotherapy prescribing.[32] Pirnejad *et al*.[31] mentioned in their study, "protocol-based care allows safest and more efficient care for patients in cancer care settings." In this project, we established standardized chemotherapy protocols based on local and international clinical guidelines, and we integrated them into the clinical decision support system in a useful and user-friendly system. Therefore, the implementation of the CPOE system provided a chance for the use of standard protocols in the cancer care unit by directly connecting the prescriptions to the standard guideline database in the CDSS module, automatically proposing drug doses based on BSA or the CR-CL based on the Cockcroft–Gault formula.

We also found that the CPOE system implemented for the chemotherapy process in our study was feasible and acceptable to end users (oncologists, clinical pharmacists, and chemotherapy nurses) and results in high rates of involvement and user satisfaction. Evaluation of user satisfaction was also surveyed in some studies.[19,27,33] In the study conducted by Aziz *et al*.[27] the results showed that three types of users including oncologists, consultants, and clinical pharmacists perceived CPOE to be user-friendly, whereas the other users including nurses perceived it as not user-friendly. High end-user satisfaction scores were stated for all users in the study conducted by Wang *et al*.[33]

Our results in this project are in line with the findings of previous studies on quality of care and safety in the context of using the CPOE system for the chemotherapy process in the cancer care unit. Most of the reviews demonstrated a significant reduction in the rate of chemotherapy errors and generally improvements of safety and quality of care. However, there are studies also indicating the risks of using these systems for chemotherapy. Small *et al*.[34] reported, in their study, more severe and life-threatening errors that occurred after the implementation of the CPOE system. Our experience in this project and review-related study suggests that it seems that several main factors play an important role in the successful implementation of these systems. These include the integration of CPOE systems with patients' electronic records, the involvement of key stakeholders (oncologists, clinical pharmacists, nurses, and the system design and implementation team) from the early stages of system design and development, the training of users, and developing the required skills for appropriate use of the systems.[19,27,35]

Limitations and recommendations

Our study has also limitations. The data used in this study were gathered at only one teaching hospital with a limited number of prescriptions. However, the findings seem to be valid. Another limitation was the focus on medication errors, and we did not measure outcomes related to turn-around time and the potential impact of CPOE on the severity of errors and adverse drug events. A study is highly recommended to measure the impact of the CPOE system on the chemotherapy turn-around time, the severity of errors, and adverse drug events in cancer care settings.

Strengths and novelty

Because of the several reasons including the following: (1) high prevalence of gastric cancer and the increasing trend of this cancer worldwide, (2) the findings from studies show the many complexities and difficulties in the process of chemotherapy for gastric cancer patients, and (3) the high rate of medication errors. Thus, we need strategies to respond to these issues. Considering these, no specific gastric cancer CPOE system has been designed and implemented yet. In the present study, for the first time, we designed and developed the CPOE system based on the existing standard guidelines and protocols. In addition, we evaluated the impact of the CPOE system for chemotherapy prescribing of patients with gastric cancer.

Conclusion

Developing the CPOE system significantly improved safety and quality of the chemotherapy process of patients with gastric cancer in cancer care settings by reducing the medication error, deleting unnecessary

steps, improving communication and coordination between providers, and use of updated evidence-based medicine in direct chemotherapy orders. However, the CPOE system does not prevent all medication errors and may cause new errors. These errors can be human-related factors or associated with the design and implementation of the systems.

Ethics approval

This original study was part of a larger study, approved by Iran National Committee for Ethics in Biomedical Research with Approval ID: IR.BMSU.REC.1399.445.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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