The effect of a well-designed computerized physician order entry on medication error reduction

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ABSTRACT

Introduction: Paper-based prescription orders, commonly having numerous medication errors, can increase adverse drug events (ADEs) and threaten the patient's safety. Computerized physician order entry (CPOE), as an appropriate alternative, can significantly reduce medication errors. This study aimed to investigate the effects of well-designed CPOE in reducing medication errors and ADEs.
Method: Electronic databases including EBSCO Host, Web of Science, PubMed, SID, Google Scholar, Iranmedex, Irandoc were used to conduct the literature review. We reviewed all the papers published about CPOE and its impacts on medication errors from 1998 until 2015. Thus 56 articles were found. Considering the relevance of their title and abstract with the objectives of the study, and deleting repetitive cases, 32 articles were selected, among which 10 articles were directly related to the objectives of the study.
Results: A number of studies indicate that CPOE can reduce the incidence of serious medication errors and ADEs. Nonetheless, there is evidence indicating that CPOE could negatively affect the patient's health if the system is not well-designed.
Conclusion: The replacement of conventional, paper-based prescription orders with well-designed CPOEs in hospitals could play a key role in minimizing medication errors and improving the patients' safety. To this end, the CPOEs have to be designed according to recent standards and needs.

Keywords: Paper-based Prescriptions, Well-Designed CPOE, Medication Errors.

Introduction

Patient safety is of special significance in health care delivery. However, medical mistakes, in general, and medication errors, in particular, are among the most common factors threatening the patient's safety, thereby making the health care a dangerous environment for the patients (1, 2). Medication errors commonly occur in hospitals (2, 3). More than one million serious medication errors occur in the USA hospitals each year. Although most of these errors are harmless, or could be prevented on time, some do result in an adverse drug event (ADE) (4). ADEs are injuries that result from taking a medication (5, 6). According to a report by the Institute of Medicine (IOM) over 770,000 people are injured or die in the USA from ADEs annually (7, 8).

In Iran, like other countries, medication errors and ADEs occur in health care centers, causing problems for patients and the centers (8, 9). The results of a study conducted in a hospital in Tehran indicated that 16.8% of a total of 370 patients under study experienced at least one ADE. The severity of 9.8% of the ADEs was identified as mild, 86.3% as moderate, 1% as severe, and 2.9% as lethal. The results also showed that almost 59% of the ADEs were identified as preventable ADEs (10). Another study carried out in Iran reported that 51.8% of the reviewed prescriptions contained errors. Prescribing errors and omissions were rated as the highest (52%), and dosing amount to 18% of the total errors (11).

Paper-based prescription system is known as the main source of most medication errors and ADEs. In this type of ordering system, physicians use hand-written orders for patients, which are then rewritten by various care providers, like the nurses (7). In hand-written prescriptions, problems such as illegibility, errors through rewriting prescriptions, use of unapproved or non-standard names and abbreviations or incomplete orders are likely to happen a lot. Such problems could result in improper access to patient information (such as drug sensitivity) (2, 12, 13). The use of computerized physician order entry (CPOE) is suggested as a solution to reduce paper-based medication errors (2, 12, 14, 15).

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CPOE, in its most basic level, is a computer application that accepts physician orders electronically; it serves as a substitute for physicians' handwritten orders and prescriptions (6, 7, 16, 17). CPOE has numerous advantages over paper-based prescription orders, in terms of standardization, legibility, use of approved terms and specification of key data fields, like route of administration (13). In addition, CPOE system is a key component of a clinical information system and not simply a stand-alone application (6, 14, 17). CPOE is integrated with other systems (e.g. pharmacy information system) to provide the needed patient information and to facilitate the delivery of the ordered interventions (7). Besides automating the ordering process, CPOE systems can mostly benefit from Clinical Decision Support Systems (CDSSs) which may include suggestions or default values for drug doses, routes, and frequencies. More complicated CDSSs can be used to check drug sensitivity, drug-laboratory value, and drugs interaction; they can additionally provide reminders about corollary orders (e.g. glucose checks after ordering insulin) or guidelines to the physician when ordering prescriptions (6, 7, 17).

The first CPOE was implemented in early 1970s at El Camino Hospital in California. Although the system was implemented primarily for cost savings, it proved to be effective in improving the patient's safety by minimizing medication errors. After the initial successful development of CPOE, some hospitals in different countries, especially the USA, have attempted to implement it (18, 19). In these hospitals, a number of studies have been conducted to investigate the effects of CPOE on patient safety, while comparing it with paper-based prescription orders. In these studies, researchers have evaluated CPOE from different aspects (19). Bearing in mind the capabilities of CPOE in improving the quality of patients care and its advantages over paper-based prescription orders, the researchers, in this study, aimed to examine the effects of well-designed CPOEs on reduction of medication errors and adverse drug events.

Method

This study is a review article. We reviewed all the papers published about CPOE and its impacts on medication errors from 1998 until 2015. The international and domestic electronic databases including EBSCO Host, Web of Science, PubMed, SID, Google Scholar, Iranmedex, Irandoc and relevant journals were used to conduct the literature review. To increase the accuracy of search the titles of all papers were manually checked in the archives of journals. The criteria for initial exclusion and selection included investigating the titles and abstracts in terms of relation to objectives of the study and deleting the repetitive cases. In this regard, 32 articles were investigated and among them, 10 papers were directly related to the objectives of the study. These papers were included in the process of qualitative evaluation. The selection criteria were as follows: studies which were directly related to CPOE and its impacts on medication errors; studies investigating the consequences of well-designed CPOE; and studies investigating the factors

influencing the successful implementation of CPOE; Since there are insufficient Farsi references regarding the research subject, or the Farsi references were irrelevant to the research objectives, only English references were used.

Results

In most of CPOE studies, the impact of CPOE on reducing medication errors has been investigated (Table 1). In 1998, Bates et al. conducted a study in 4 general care units and 2 intensive care units (ICUs) of a 726-bed Boston Hospital. According to their results, the implementation of CPOE led to 55% reduction in non-intercepted serious medication errors, and 84% reduction in mild medication errors (20). In another study, medication errors reduced by 81.5% after CPOE implementation in 6 American hospitals (21).

In some studies, in addition to the effect of CPOE on a high number of medication errors, the type of errors (i.e. illegibility, incomplete prescriptions, drug sensitivity, and drugs interaction, etc.) was also investigated. According to the results, the implementation of CPOE resulted in a significant decrease in error types (1, 20, 21). In a study carried out in a hospital in Sweden, for example, there was 90% decrease in the types of errors, particularly in illegibility errors, following the implementation of CPOE system (22).

A fall in medication errors and ADEs, due to CPOE implementation, has brought about a fall in the length of stay and hospital costs (23-25). According to a report by the First Consulting Group in 2003, the positive impact of CPOE on reducing preventable ADEs would approach a large sum of money per year if CPOE were adopted (25)

There are studies referring to the negative impact of CPOE on the patient's safety (26-34). Koppel et al. (2005), for example, found that a widely used CPOE system led to 22 new types of medication error risks (35). In a study by Han et al. (2005), the mortality rate in a pediatric hospital increased from 2.80% to 6.57% after CPOE implementation (31).

Discussion

The results of the studies have shown that implementing a well-designed CPOE results in reduction of medication errors and increases the patient's safety. The other aspects that researchers have investigated in some studies are the effect of CPOE on ordering process and length of stay. Since CPOE decreases the length of stay of patients and improves the ordering process, it will reduce the hospital costs. The connection between CPOE and CDSS in the design stage is really essential because it prevents some medication side effects such as drug interaction and allergies.

CPOE communication with other subsystems of HIS such as Pharmacy Information System is one of the most important characteristics of a well-designed CPOE which facilitates and accelerates the ordering process, allows the exchange of information, and creates effective coordination among health care providers. Therefore, it leads to validated treatment plans and optimal use of

resources such as time, equipments, and medication. The results of the study conducted by Mykhjian et al. (2002) showed that CPOE communication with other subsystems improved the ordering process and average ordering time was declined by 67% (23). On the other hand, the results of some other studies show that lack of CPOE communication with other sub-systems causes some problems such as the lack of coordination among health care providers, disruptive process of care, lack of access to all of the required information, and increasing workloads (30, 35).

Considering a comprehensive controlling operation is another feature of a well-designed CPOE creating its intelligence. It leads to some advantages such as reduced medication errors, improved patient safety, facilitated and accelerated ordering process, and reduced costs. Controlling patient profile, for example, is one of the controlling operations to determine the patient's drug allergies which can markedly reduce such medication errors. Ash et al. (2006) showed that lack of such facilities in CPOE can cause serious problems and damage to patient (27). Inappropriate alerting time and too many warnings by CPOE are other problems, leading to physicians' dissatisfaction. It also leads to increased medication errors, increased costs, and longer ordering process. The results of study show that physicians ignored 88% of CPOE warnings concerning drug interaction due to inappropriate alerting.

Such ignorance causes some drug interaction errors which might cause serious harms to the patient.

Timely and appropriate warning and reminders by a well-designed CPOE can dramatically help the physicians for effective decision, reduced medication errors, and increased patient safety.

Security problems were reported as other CPOE unintended and negative consequences pointed out in some studies (35). Such problems are caused due to lack of security safeguards and standards in CPOE. It increases possible violations of individual privacy and the confidentiality of information, thereby leading to reduced patient safety and increased costs. User-friendly and system flexibility are other characteristics of a well-designed CPOE which lead to increased user satisfaction, facilitated ordering process, and reduced medication errors.

Poor design is claimed to be the reason for the negative effects of CPOE use (31, 35, 36). Precise and proper designing of CPOE is extremely important in achieving the desired outcome (25). As such, a rise in medication errors, with grave consequences for patients, is inevitable if CPOE system is not designed well. Medication errors, due to improper use of the system, could additionally serve as a barrier against successful adoption of CPOE in hospitals (37).

Conclusion

Implementation of efficient CPOE in hospitals and its use instead of paper based ordering system has an effective role in reducing medication errors and increasing patient safety. Appropriate design is one of the most important factors in CPOE's efficiency.

Table 1. Results on CPOE implementation from the studies selected, indicating a positive impact on patient safety

Study	Settings	Results
Bates et al. 1998 (20)	Adult inpatients on medical, surgical, and intensive care wards at BWH	55% decrease in non-intercepted serious medication errors 17% decrease in preventable ADEs
Potts et al. 2004 (29)	20-bed pediatric critical care unit in a tertiary-care children's hospital	40.9% decrease in preventable ADEs 99.4% decrease in minor medication errors
Upperman et al. 2005 (30)	Tertiary care pediatric hospital	40% decrease in harmful ADEs
Colpaert et al. 2006 (4)	22-bed intensive care unit at tertiary care hospital	96% decrease in minor prescription errors 58% decrease in non-intercepted potential ADE 84% decrease in preventable ADE
Walsh et al. 2008 (31)	Pediatric hospital	7% decrease in non-intercepted serious medication errors
Doormaal et al. 2009 (14)	Two medical wards of the 1300-bed University Medical Center and two medical wards of the 600-bed teaching hospital	69% decrease in medication errors
Mir et al. 2009 (23)	The department of internal medicine in two hospitals	90% decrease in medication errors
Hug et al. 2009 (21)	Six Massachusetts community hospitals with 100 to 300 beds	81.5% decrease in preventable ADEs
Roberts et al. 2013(27)	Mayo Clinic Hospital, a 232-bed teaching hospital	CPOE implementation was associated with a reduced rate of insulinorders containing errors. There was a significant decrease in preventable ADEs after implementation.
Hernandez et al. 2015(28)	A before-after observatio nal study was conducted in the 66-bed orthopedic surgery unit of a teaching hospital (700 beds) in Paris France.	The use of CPOE led to a significant 92%decrease in prescribing errors

Thus, CPOE should be designed according to efficient CPOE's standards and requirements. The connection between CPOE and CDSS and facilities like drug interactions control, drug allergies control, dose control, and integration of CPOE with other information systems, such as pharmacy information system, are necessary for an efficient or well-designed CPOE. So, these cases should be taken into account in CPOE analysis and design. At the end, a well-designed CPOE is an intelligent application that by having interoperability with the relevant subsystems of Health Information System (HIS) facilitates entering care and study plans of health care providers, especially attending physician. It also prevents harmful medication errors and contraindication orders, and as a result, it saves money for health care organizations.

Finally, the following guidelines can be adopted to improve the design of CPOEs which, in turn, could prevent problems caused by these systems:

• The CPOE system should be designed and implemented according to the standards and requirements set up by internationally approved institutes, which help to prevent the occurrence of problems discussed above (38-40).

• According to the software engineering standards, the data elicitation and analysis, as a key step in information system development, should only focus on the users' points of view. This way, the researchers would have a better understanding of the users' views and needs that have to be properly dealt with if there is to be less user resistance (17).

• After CPOE implementation, some problems are likely to happen due to the lack of, or poor integration between CPOE and other information systems. Suitable integration of CPOE with other systems should, therefore, be taken into consideration in the design phase.

• The appropriate design of the user interface and the ease of use are other important factors that can be effective in reducing the physician's resistance. The design of the CPOEs, hence, should be based upon usability standards (41).

• A well-designed CPOE has to cover the entire process of physicians ordering process. Thus, the developing CPOE project team should have a comprehensive literature review, and analyze the system in a way that they can find its strengths and weaknesses (42).

Conflict of Interest

There are no conflicts of interest.

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