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Review Article

Decision Support Systems and Their Effect on Decreasing Medication Errors and Protecting the Patient Safety

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ABSTRACT

This study intended to explore the development of health information technology and its effect on decreasing the medication errors and protecting the patient's safety. This study which was descriptive-comparative in nature has been conducted in 2013 in order to examine the development process of technology in the healthcare system and its advantages for decreasing the medication errors and maintaining the patient safety. The data were gathered by using different informational resources such as valid articles, books, magazines and web sites. To compare and analyze different technology systems in terms of developing and improving medical services delivered by the respective providers, the varied strategies in use in the selected countries were gathered by studying a large number of articles extracted from numerous scientific magazines and resources so that an appropriate strategy may be proposed for the healthcare system of Iran. As the findings of the study indicated, some information technologies including CPOE, Bar code, AMDS, PDA, etc improved the medication safety decreasing the rate of medication errors remarkably. The obtained rates for such improvement in terms of the type of the error were as follows: 75.47% for prescription errors, 70.34% for the errors due to the prescribed medications listed for the patient use, 87.41% for administration time errors, 93.48% for the errors resulting from the patient's mistakes. Accordingly, to ensure the high performance of

the informational systems, due attention must be paid to their infrastructures. Furthermore, besides strengthening the previous infrastructures, it is necessary to create new ones so as to guarantee the usability of such systems for the hospitals.

Keywords: Health information technology, Medication errors, Patient safety, Medicare.

INTRODUCTION

Patient safety is one of the most important components of medical and healthcare services; however, medical practices are not always safe. To put it differently, a number of risks mostly resulting from medical errors have made the medical and healthcare environments hazardous[1]

Currently, medical errors is one the hotly debated issues in the medical circles. Based on the available statistics, even in the most advanced medical centers worldwide, medical errors annually cause death or harm for a lot of patients[2]. In one report entitled "*The Human is not Infallible"* published in November, 1999, the American Hospital Association called the national attention to the errors within the USA's healthcare system. Medical errors annually cost $5 million for the big teaching hospitals leading to a $17-29 billion cost for the USA's economy per year[3.4]. Based on the estimations, the medical errors have been reported for 4% of the hospitalized patients in the USA hospitals. According to the Institute of Medicine of America's report, annually 44000-98000 of the patients die due to the medical errors[6-3] .The medical errors rank eighth in the list of the mortality causes in USA[7] .In addition, the American Hospitals Institute has announced that 30.5% of the medical errors result from medication errors[3].

In their decision-analysis model, Johnson Bootman (1995)[8] explored a wide range of medication-related complications such as inaccurate dose calculation (overdose or under-dose), the wrong selected medication considering the existing status of the patient, the medication undesirable side effects, drug-drug interactions and using medication lacking any use reason. They estimated the costs of the side effects of the medications and their resulting mortality by $6.76 billion per year[8].

In Canada, in 2003, over $16 billion or $500 per patient has been invested for medication with the investment in this section of health care system increased as much as 10% at the present time[9].

In Australia, medication-related complications account for 2-3% of the causes of hospitalization with 50% of them preventable in nature. Society of Hospital Pharmacists of Australia, Australian Association of Pharmacy Consultants and Society of Hospital Pharmacists of Australia are among the pioneers of the medication administration and resolving medication-related complications[10].

The main reason of these problems is the lack of integrity of the information and its resultant confusion. The lack of integrity of the information forces the health care providers to process the information themselves. The key solution for providing quality and safe care services is redesigning the healthcare system. Although there are many methods, even in the manual systems, for achieving the patient's safety goal, many scholars argue the information technology has the capacity of supporting the high quality services so that we can use it for

delivering safe care and deceasing the risks existing in the care process[1]. Therefore, if used properly, medication prescription as the most common medical method in the modern medical care can be a perfect and cost-effective method[11]. Accordingly, the systems which use information technology are very useful for promoting the quality of the medication use practices. Some of these systems include the computerized physician order entry, the dispensing system of the unit dose of the medication, the bar coded medications monitoring system, the automated prescription systems which form the computerized sections of the prescription control system lead to the safe storage and dispensing of the medications influencing the medication errors at the time of prescription, omission and other activities promoting the optimum medication use in the healthcare system[12]. Health information technology is in fact some sort of strategy used for enhancing the healthcare quality[5] which provides the physicians with the information required for assessment, accountability and matching the data with the treatment events[13] .Technology results in the patient-related data accessibility during the treatment course assisting the physicians in making appropriate decisions[14,15] .

Besides exploring the medication errors, the present research examined the association between the information systems and the rate of medication errors listing the advantages of such systems. Finally, some suggestions were presented regarding the use of information systems for preventing and lowering the medication errors in the healthcare institutions.

MATERIALS AND METHODS

This study which was descriptive-comparative in nature was carried out on the development process of technology in the healthcare system and its benefits in decreasing the medication errors and protecting the patient safety in 2013. The data were collected through informational resources including articles, books, magazines and different scientific resources. We found 200 scientific valid articles on this issue by searching valid websites. This article was written by reviewing 150 articles of this collection. To compare and analysis the various technology systems role in the development and improvement of the medical care delivered by the healthcare services providers, the strategies used by the selected nations were extracted from a large number of articles extracted from magazines and resources so that using them an appropriate strategy may be proposed for the healthcare system of Iran.

RESULTS

- Computerized Physician Order Entry (CPOE)

One of the health information technology tools is the computerized physician order entry (CPOE). Health information management system's society (2004) has defined the computerized healthcare providers order entry system as follows: "an order entry program specifically designed for assisting the service providers in creating and managing the medical orders for servicing and medication therapy of the patients. This program has electronic signature, function framework and specific performance regulations omitting or decreasing the transcription errors. Playing a critical role during the recent years, COPD has acted as a key strategy for remarkable decrease in the medication errors[16]. The present research revealed that the use of computerized healthcare providers order entry system would decrease the rate of medication errors up to 55%. When using the computerized healthcare providers order entry system, it is necessary for the healthcare providers to enter the medication orders electronically (and not manually) decreasing

the errors at the time of the medication orders entry[17].

The use of computerized healthcare providers' medication order entry system must be satisfied by planning and collaboration among the pharmacists. Such orders are a part of the unique and distributed database completely integrated with the pharmacy information system and other main components of information system especially the computerized physician order entry. The use of such computerized system for the entry of the orders will enhance the safety, effectiveness and accuracy of the medication use practices[18]. This system has brought some advantages for the healthcare providers enabling them to check and validate the accuracy of the orders before prescription except the cases when checking the orders will cause a medically unacceptable delay[13].

The potential capabilities of the computerized healthcare providers' medication order entry system included warning about the drug-drug interaction, allergy, overdoze and giving new and accurate information about new medications to be used as a reference by the physicians in their decision-making process. The potential developments in the computerized healthcare providers' medication order entry system stems from following the clinical policies better, stronger link with the information, reduction in the transcription errors due to illegibility and promotion of the collaboration among the personnel. Such developments in turn improve the care quality's results[5].

The computerized healthcare providers' medication order entry system provides the prescriber with some warnings such as drug allergies. The system's drug-specific warnings have been designed for providing some information such as dose regulation or reviewing the requirements during the healthcare orders entry[19]. The application of the healthcare providers' orders entry system and its integration with the laboratory and pharmacy's electronic information systems allowing simultaneous decisions would produce numerous benefits in each domains of medication therapy. Kaushl and Bates (2003) have estimated that the computerized system used for recording the healthcares' orders can lower the rate of drug-related errors as much as 522/000 per year[6].

Some of the capabilities of the computerized healthcare providers' orders entry system were as follows:

- Decreasing the drug errors as much as 55%;
- Decreasing the transcription errors as much as 19%;
- Decreasing the order reading and interpreting errors as much as 84%;
- Decreasing the dispensing errors as much as 68%;
- Decreasing the drug administration errors as much as 59%;
- Decreasing the preventable side effects as much as 17%;
- Decreasing the potential side effects as much as 84[20]%

The decision support system in the computerized physician order entry system is activated based on some factors including the patient's height, weight, age, his/her allergies and other factors influencing the drug selection and use. Although, it does not make the final decision, it assists the physician in his/her decision making and judging the drug selection by its alarms and reminders[21]. In addition, since this system transforms the conventional and paper system into automation entry processes, it acts as a critical and impressive step in developing the health-care organizations. This system change causes the modification and elimination of the problems occurred due to the illegibility of the records, minimization of the transcription errors and lowering the clinical errors on the whole[22].

"CPOE Efficiency in Lowering the Medication-related Errors"

Prolific research has been conducted on exploring the role and effect of CPOE in lowering the rate of medication errors the most important of which are as follows:

- Omitting the prescription and illegible transcription errors;
- Reducing the errors resulting from wrong orders to the pharmacy
- Reducing the wrong order reading risks[16];
- Reducing the delay in implementing the physician's orders
- Providing the possibility for delivering the orders out of the service location;
- Providing the possibility for checking the errors and create warning systems at the time of drug prescription and testing;
- Providing the possibility for checking the drug-drug interactions[23].

- Bar Code-based Medication Administration

The medication bar code mechanism is as follows: when the physician gives an order reviewed and validated by the pharmacist, the nurse scans one bar code on the patient's bracelet and one on the his/her medication. The computer matches the medication with the physician's order immediately. If there is any mismatch in terms of dose, dispensing time or delivering mode, the system sends an audio alarm. The bar code system is a relatively new method; hence, there is little information regarding its effectiveness. However, it enjoys a lot of potentialities since it is considered as the last opportunity for preventing the medication-related errors [24]. Based on one study carried out in the Cancord hospital, bar code has been accompanied by a reduced medication error by 80%. Bar code ensures whether the used medication has been the appropriate or not identifying the medication prescriber and the target patient, as well[25].

The research on the effectiveness of this information system as far as the rate of the medication errors is concerned has provided some evidence on its positive role in lowering the rate of the errors of this type. The most important ones are as follows:

- A reduction in the rate of wrong prescription errors as much as 75.47%;
- A reduction in the rate of errors resulting from the medication prescription listed for the patient's use as much as 70.34%;
- A reduction in the rate of the drug administration time errors as much as 81.41%;
- A reduction in the rate of patients errors as much as 93.48[26]%.

On the average, this information system reduces the drug administration stage errors by 65% -70%. Nearly, as much as 1.3% cases of the clinical problems related to the medications tend to be reported by the patients with 20% of them soluble through dialogue between the patient and the pharmacist. Based on these results, the pharmacists must involve the patients in controlling the drug prescription and medication-related clinical problems administration[27]. The form, dosage, undesirable side effects or the existence of more effective or more accessible, the high costs of safety problems, the conditions not responsive to the treatment or using wrong medication all are among the attribute available in the decision support system advantageous for error decreasing[28,29]. Poon and Cina (2005) showed that the bar code technology decreased the rate of the discharge-time drugs dispensing errors and the preventable side effects errors by 85% and 63%, respectively[30]. The bar code-based prescription validates that the correct drug is given to the correct patient at the correct time. Based on the estimations, this technology will reduce the drug errors up to 3.2% and 500,000 of the side effects and combined errors until the next two decades which saves

up to $93 billion in the costs associated with the patient suffering and wasted workload time[18].

"Automated Medication Dispensing System" (AMDS)

AMDS is a computerized data storage system or drug storing and dispensing cabinets which monitors and controls drug dispensing. As an automated drug dispensing cabinet, this software is also called automated drug dispensing machine. In 2007, automated medication dispensing system was used in more than 80% of hospitals. Presently, the majority of hospitals use this information system which has more applications for outpatients[31]. The main aim of AMDS is eliminating the drug dispensing from the pharmacists' functions plan which is carried out by proper drug dispensing by the nurses during the treatment course. The drug orders must be sent to the ADMS's center server located in the pharmacy to be checked by the pharmacist. Only the drugs validated and checked by the pharmacist along with a profile of the patient appear on the computer monitor screen accessible by the nurse using a password. The physical part of ADMS is equipped with drug containing cabinets or drawers with the cabinets equipped with a pilot guiding the nurse to the correct automatic cabinet containing the desirable drug. Before administering the drug, the nurse will check and validate it. Whenever a drug is taken from the cabinet, the pharmacy department's server system records it. As the inventory of the cabinet goes below the normal level, the server automatically sends the request for new drugs. Besides, the system server is connected to the patient bills system; hence, any drug pickup is automatically followed by issuing a bill for the respective patient[24]. AMDS is used for maintaining the drugs in one place and dispensing them to a specific patient. Linked to a bar code and hospital information system, this system can remarkably decrease the rate of drug errors[25]. In fact, ADMS provides us with a safe and effective method for dispensing the drugs. In addition, dispensing drugs using AMDS system provides the pharmacists with more time to deal with clinical affairs leading to a reduction in the drugs errors[24]. Generally, this system plays a significant role in identifying the potential and real drug problems, resolving the real drug problems and preventing the possible drug-related complications[32,33].

"Personal Digital Assistor" (PDA)

PDA or pocket computer was introduced by the Apple computer company in Las Vegas, Nevada in 7 January, 1992. PDA is a cell phone which functions as a manager of personal information. The current PDA is connectable to the computer. This type of computers has a touch screen; however, some of its modern models have audio capabilities, as well. Many of them have wireless access to the internet, intranet or extranet. Most PDAs are intelligent telephones[34]. PDA makes accessing to, organizing, collecting, storing and processing all types of information possible allowing implementing different types of software currently available[35]. PDA also acts as a drug prescription device as well as a drug information tool.

- The Benefits of PDA

- Providing the possibility of rapid access to the drug information in every stage of the patient care;
- Enhancing the patients safety through improving the accuracy of identification of the patient in the hospital;
- Providing the possibility of rapid access to the information for the diagnosis and care-related decisions purposes;
- Increasing the pharmacists' interventions in the drug prescription stage;

- Decreasing the illegible orders errors from 9.1% to 2.7%;
- Decreasing the rate the illegible prescription or omissions errors significantly[34];
- Providing an efficient method for the safe drug prescription[36].

PDA may decrease the errors existing in the drug orders leading to a remarkable improvement in the results of patient care and reduced costs[23]

DISCUSSION AND CONCLUSION

Information technology is necessary for the efficient and timely communications and supporting the medication use process[37]. In 2007, to explore the health information technology, its required knowledge and existing expectations, the state of Arizona's healthcare professionals held a meeting on the pharmacy performance and electronic prescriptions referring to some expected benefits of this system including the decrease in the transcription errors, the progress of formulary matching, strengthening the links with the prescribers, increasing the efficiency and ensuring the accuracy of the information and some of its disadvantages including insufficient knowledge about the software applications and the patient's expectations as well as the need to training[38]. The pharmacists have enumerated the performance of the pharmacy based on the advanced technology and electronic prescription as the highest priorities of the electronic health system[39,40].

Given the fact that the most common medical errors are medication errors and the medication therapy process includes 5 stages i.e. prescription, transcription, medication dispensing, medication use administration and treatment analysis. Medication errors can occur in any of these stages[21]. Numerous studies have revealed that a number of information technologies may enhance the medication safety among which CPOE, bar code, AMDS and PDA can be named.

- Among these, it appears that CPOE is the most effective one[41] so that given its capabilities, it can prevent a lot of errors occurring in the medication prescription stage[21]
- AMDS provides a safe and efficient method for dispensing the medications decreasing the rate of the medication dispensing stage errors.
- Bar code system ensures that the nurses has properly dispensed the medications for the patients; hence, this system will lead to a reduction in the rate of medication usage administration stage errors.
- PDA will decrease the transcription stage errors, as well[42].

Information technology is necessary for efficient and timely communication and supporting the medication use process. In 2007, to explore the health information technology, knowledge and expectations, the state of Arizona's healthcare professionals held a meeting on the pharmacy performance and electronic prescriptions referring to some expected benefits of this system including the decrease in the script errors, the progress of formulary matching, strengthening the links with the prescribers, increasing the efficiency and ensuring the accuracy of the information and some its disadvantages including insufficient knowledge about the software applications and the patient's expectations as well as the need to training[38]. The pharmacists have enumerated the performance of the pharmacy based on the advanced technology and electronic prescription as the highest priorities of the electronic health system[40].

Hence, an ideal system will be achieved by combining these four technologies. As the final note, despite some possible drawbacks such as the costly and time-consuming installation and maintenance processes, allotting time for training the users and the physicians and nurses' resistance towards using them[23], the foregoing

information systems had a drastic effect in decreasing the rate of medication errors ensuring the patient's safety.

Research suggestions

To ensure the high performance of the information systems, their infrastructures must be taken into account. For instance, the various decision support tools existing in the CPOE require receiving the related information from other information systems available in the hospital. Therefore, to ensure whether the hospitals can use such systems or not depends on creating new infrastructures of course, along with strengthening the previous infrastructures.

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