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AVOIDING MEDICATION ERRORS-WHAT IS THE BEST EVIDENCED BASED PRACTICE

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ABSTRACT

Introduction: Medication errors are costly and a threat to patient safety. This article aims to review practices, with a special emphasis on technological interventions employed to reduce medication errors and to discuss the value of these different applications.

Materials and methods: A literature review was conducted using PubMed to find articles whose title and abstract indicated that the articles' content addressed technological interventions to minimize medication errors. Bibliographies of resulting articles were also reviewed and selected for discussion.

Results and discussion: After a qualitative analysis by two reviewers, 70 articles were selected for review and discussion. Computerized physician order entry, is widely used and is useful in minimizing many errors in the 'Medication Use Process'. Clinical decision support systems, personal digital assistants and mobile clinical assistants have shown to be very effective in minimizing prescribing errors. Using machines instead of man as in automated dispensing machines, bar coding, robotic dispensing and 'Smart' devices have been tried experimentally to contain drug dispensing and drug administration errors.

Conclusions: There is evidence that technological interventions have contributed to minimize medication errors, but their usability, cost benefits and safety need to be further evaluated.

KEY WORDS: Medication errors, computerized physician order entry, Prescribing errors, Dispensing errors, Drug administration errors.

INTRODUCTION

Medication errors are adverse drug events which are preventable[1]. They are very common and diverse. Some summarize medication errors as the five wrongs; the wrong drug, wrong dose, wrong route, wrong patient and wrong time[2]. They can also be more broadly classified using the 'Medication Use Process' as prescribing errors, transcribing errors, dispensing errors, administration errors and monitoring errors.

Bates et al showed that 49% of medication errors in hospitalized patients are due to physician ordering, followed by 26% nursing administration, 11% transcription errors and 14% pharmacy dispensing[3]. Another study demonstrated commonest errors as, wrong strength with a 36.5% error rate followed by wrong drug, wrong frequency, wrong formulation, wrong patient and wrong instructions errors with 16.7%, 7.7%, 7.0%, 6.9% and 3.1% error rates respectively (Figure 1)[4]. The "Proximal Causes" of these medication errors were described by Leap et al in 1995 (Table 1) [5].

Figure-1: Occurrence of common medication errors [4].

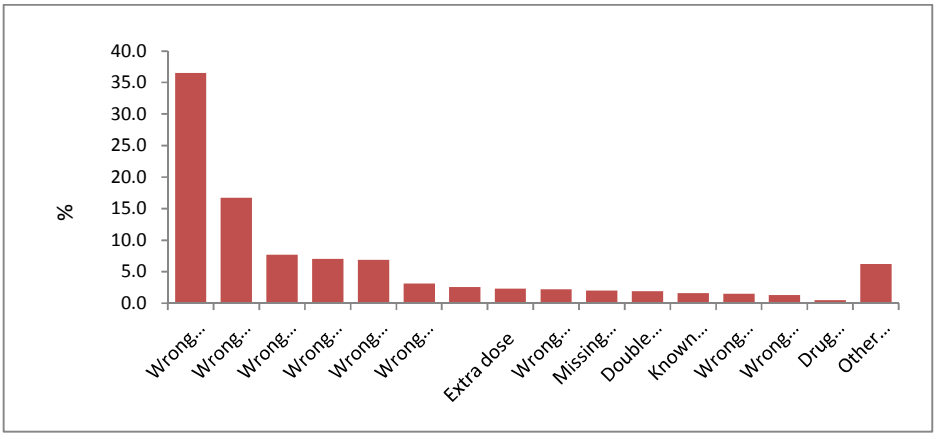


Table-1: "Proximal Causes" of medication errors [5].

"Proximal Causes" of Medication Errors
1. Lack of knowledge about the drug
2. Lack of information about the patient
3. Rule violations
4. Slips and memory lapses
5. Transcription errors
6. Faulty drug identification
7. Faulty interaction with other services
8. Dosing errors
9. Infusion pump/parenteral delivery error
10. Inadequate monitoring
11. Drug stocking or delivery problem
12. Preparation error
13. Lack of standardization

Medication errors account for more than 80,000 hospitalizations and about 7000 deaths in the inpatient setting, 32-69% of which were preventable. The annual hospital cost of preventable medication errors was estimated to be approximately $2 billion[6].

Hence, this article aims to review practices, with a special emphasis on technological interventions employed to reduce medication errors and to discuss the value of these different applications.

MATERIALS AND METHODS

A literature review was conducted using PubMed to find articles whose title and abstract indicated that the articles' content addressed technological interventions to minimize medication errors. Only studies with full text articles, in English language, published during the past 10 years (2000 – 2010) were included. Bibliographies of resulting articles were also reviewed and selected for discussion. All articles were independently reviewed by to investigators before inclusion. Disagreement was resolved by consensus. Articles selected for inclusion were categorized using two characteristics: Type of medication error and type of intervention.

RESULTS

53, 233 and 328 articles resulted when 'Technology AND reducing medication errors', 'Bar code OR automated dispensing machines OR robotic dispensing OR smart devices AND medication error' and 'Computerized physician order entry OR personal digital assistants OR clinical decision support system OR mobile clinical assistants AND medication errors' were used as search terms respectively. After a qualitative analysis by the two reviewers 36 articles were selected for review and discussion. Bibliographic review resulted in including an additional 34 articles. Non-English articles, review articles, articles not related to minimizing medication errors and articles with outdated findings were excluded. Among the articles included, 45 were related to electronic prescribing, 8 to bar-code technology in drug administration, 2 to bar-code technology in drug dispensing, 2 to automated drug dispensing, 1 to use of robots in drug dispensing, 2 to use of "Smart" pump in drug administration, 1 to drug monitoring and 9 to non technological interventions in reducing medication errors. The following is a discussion of the findings..

DISCUSSION

Practices adopted in preventing medication errors

Medication errors happen due to system failures and human errors. The good news is that most are aware of the severity of this issue and various applications have been tried in order to error proof healthcare systems. Most importantly, practices adopted in reducing errors need to be effective, uncomplicated and economical. Sophisticated applications may increase medication errors. Some applications, though effective in minimizing errors, has a very high installation and maintenance cost. Therefore it is crucial that these different applications are carefully evaluated before implementation.

1. Preventing prescribing errors

Computerized Physician Order Entry (CPOE)

Many errors can happen during prescribing, especially when junior medical practitioners are involved. Prescribing error rate was shown to be significantly higher when preregistration house officers (43.1%) and medical officers (33.4%) were involved in prescribing[4]. In addition, environment, team, task and individual factors have also been found to contribute to prescribing errors[7]. CPOE is extensively employed in order to reduce the occurrence of prescribing errors. Prescribing electronically and linking it directly to the pharmacy have been shown to be effective in minimizing such errors, minimizing verbal orders, standardizing the order and improving the legibility of prescriptions[8-10]. CPOE has demonstrated to be useful in reducing non intercepted serious medication errors[11, 12]. Song et al reported a reduction in medication incident reports in three consecutive years, as a result of using CPOE [4]. Additionally, the rate of adverse drug event (ADE) reporting was also shown to have improved with the implementation of CPOE; a practice that is essential in improving patient safety[13, 14].

Clinical Decision Support System (CDSS)

CDSS is another intervention that has been employed for the reduction of medication errors. Most CDSSs are integrated with CPOE for synergistic reduction of prescribing errors[15-18]. CDSSs are used to alert and aid prescriber decisions with regard to therapeutic management, dose, frequency, duration of drug therapy, allergy and side effects, drug and food interactions, laboratory check values and related decisions[19-21]. Performing background checks on patients, providing timely information, feed back on cost and appropriateness of

medication, are some of the other features of a CDSS[22]. A study showed a 70% reduction in ADEs caused by anti-infective agents through the use of a computer based anti-infective drug management programme [23]. Use of CDSSs to reduce toxic doses of thoephylline in patients, has shown an error reduction of 37.8% to 18.9% in control vs interventional patients [24]. In contrast, another study on achieving a goal serum theophylline level had not shown a significant difference [25]. Detection of warfarin toxic levels and heparin toxic levels aided by CDSS, have shown positive trends in reducing errors but without statistical significance[19].

A drug dosing support system called 'quicklist' showed a reduction of prescribing errors from 18.3 to 1.9 per 100 orders, even when quicklist was used only 30% of the time[26].

The Prescribing Information and Communications Systems (PICS) is an evolving system developed in Birmingham, England (F:\birmingham_pics_cse_as_partner.htm). It combines electronic prescribing facilities together with patient history and reports, and contains algorithms to prompt the prescriber. It is hoped that this will improve the quality of prescribing.

Drawbacks of using CPOE and CDSSs

Although CPOE and CDSSs have shown to be effective in minimizing medication errors they are not without limitations. Koppel et al revealed 22 types of error risks introduced by CPOE, of which the more significant ones are shown in table 2 [27]. Increased number of errors with electronic prescribing in comparison to hand written prescriptions, especially dosing errors, duration errors and 'drugs not required on discharge', have been reported[28, 29].

Table-2: Risks facilitated by Computerized Physician Order Entry (CPOE) [28].

Risks facilitated by CPOE
1. Fragmented CPOE displays that prevent a coherent view of patients' medications.
2. Pharmacy inventory displays mistaken for dosage guidelines.
3. Ignored antibiotic renewal notices placed on paper charts rather than in the CPOE system.
4. Separation of functions that facilitate double dosing and incompatible orders.
5. Inflexible ordering formats generating wrong orders.

If CPOE systems are not linked to the pharmacy, pharmacist need to re-enter the prescription manually which could result in errors. Studies show that 25.7% of surveyed hospitals with electronic prescribing lacked information system links to their pharmacy[30].

Constant alerting of medication errors, regardless of the severity of the error, may create alarm fatigue among the prescribers causing them to ignore alerts all together. The reliability of these systems to alert prescribers on contraindicated drugs and hazardous drug interactions, have shown weaknesses[31-33]. Other studies on physician response to alerts showed that 30 to 90% of the alerts were ignored by physicians[34-37] or were handled inappropriately[38, 39].

Other drawbacks of CPOE are increased prescribing time[40] and increased pharmacists' time spent on checking prescriptions and solving related problems[41]. Surprisingly some physicians have reported that electronic prescribing is not more time consuming than handwritten prescriptions, and preferred to continue with CPOE[42]. Studies have also shown that the usage of CPOE varies; while it was minimal with some prescribers (approx 2.8%), some generated the bulk (approx 90%) of their prescriptions using a computer system[42-47]. Different features of the CPOE were shown to affect the usability rates and medication errors[48].

Barriers in implementing CPOE and CDSSs

There are many barriers in implementing CPOE and CDSSs in a healthcare setting; staff resistance for change and innovation[49-51] and large capital investments are among them. Nevertheless, once the system is in place, cost advantages have been achieved due to improved procedures[19]. Use of CPOE has shown cost saving of $5 to $10 million per year [52]. CPOE and CDSSs prevent ADEs and thereby add to cost savings. A study showed that an estimated cost of $2.8 million, due to preventable ADEs, could have been saved annually by implementing a CPOE system[53]. A computer assisted antibiotic dosing program has been shown to save $100,000 per year due to reduced antibiotic dosing as well as reduced ADEs.

Difficulties in evaluating the effectiveness of CPOE and CDSS

Effectiveness of CPOE and CDSSs are difficult to assess due to reasons such as incomparability of studies and small sample size[19]. Assessment of standard CPOE and CDSSs in multicentre studies is clearly needed. As a step forward, the Leapfrog inpatient CPOE standard was developed. It included a requirement for all

organizations operating CPOE to demonstrate on testing that their inpatient CPOE system can alert physicians to at least 50% of common serious prescribing errors[54].

Personal Digital Assistants (PDAs)

Many medication errors are due to lack of knowledge or information by prescribers and pharmacists. PDA or Palm Pilot links prescribers and pharmacists with a medication information database that provides information needed for prescribing, dispensing and counselling. It also provides access to patient specific medication profiles and options to print out patient discharge medication records, which is useful in reducing prescribing and transcribing errors[55]. A drop from 22% to 8% transcribing errors was shown with the use of PDAs [56].

Modified prescriptions and medication charts

Simple methods such as, use of modified prescriptions with prompts for medication name, form, strength, dose, route, frequency, refills, quantity, indication, and additional directions have shown trends of improving prescribing errors, especially omission errors. In a study, modified prescriptions recorded one error out of 150 prescriptions while the standard form recorded nine out of 293[57].

Using "one write" non-carbon prescription forms that generate an instant copy has helped in improving prescription documentation and reducing errors that occur due to transfer of data from prescription to medication chart. An 82% increase in prescription documentation was shown after using "one write" non-carbon prescription forms[58].

Modifying medication charts have been studied for its effect on reducing medication errors. The redesigned medication chart included patient identifiers and ADR details in all the pages where drugs were prescribed. It prompts for entering dosing times for regular medicines to minimize misinterpretation of medical abbreviations by nursing staff and a special section for entering the warfarin INR for monitoring purposes. In this study, the percentage of errors per order per patient decreased significantly from 20% before the intervention to 15.8 % after the intervention with an absolute error reduction of 4.2% [59].

Mobile Clinical Assistants (MCAs) in improving prescribing errors: The introduction of MCAs integrated with PICSs has enabled prescribers to perform e-prescribing at the patient's bedside. It has been reported that

MCAs help to avoid 400 to 450 errors per week, save approximately 10% of the drug budget and reduce duplication of drug charts (F:\birmingham, mobile clinical assistants 2.htm).

2. Preventing dispensing errors

Reducing dispensing errors is also an important element in the prevention of medication errors. Although not as many interventions have been attempted as in prescribing errors, the following are some of the measures taken towards achieving these goals.

Minimizing illegibility of prescriptions

Illegible prescriptions account for many dispensing errors. If CPOE is linked to the pharmacy network, dispensing errors caused by illegible handwriting of the prescriber may be reduced.

The readability of prescriptions, when written as block letters, as opposed to freehand style was also assessed among pharmacists and patients. There was improved readability when prescriptions were written in block letters among both groups[60].

Automated dispensing machines

Automated dispensing machines can minimize dispensing errors[61]. These machines may have drugs stored according to the drug type or patient profile, and access to medication is only upon the correct provision of information by the pharmacist or nurse. Use of automated dispensers has also shown to reduce drug administration errors such as omission errors and wrong time errors[62].

Bar-coding

Bar-coding of medications is useful in reducing mistakes with regard to drug names, doses and administration times[11, 63]. A study on the use of bar-coding showed improved accuracy and timing of inpatient dispensing[64].

Robots in dispensing:

Use of robots in dispensing can minimize dispensing errors. A study demonstrated that dispensing errors decreased from 2.9% to 0.6% when using robots for dispensing[65]. However, setting up a robotic system involves a large initial outlay, and may not be feasible in a small pharmacy.

3. Preventing administration errors: As discussed earlier, administration errors record the second highest error frequency out of all medication errors. Preventive measures have been attempted to minimize such errors.

Intravenous administration is a very high error prone route of administration. Use of "Smart" devices in intravenous administration, have shown to be effective in dose calculations, especially in reducing ten fold dosing errors[22, 66]. Nevertheless, as in electronic prescribing, error alerting by "Smart" pumps are also associated with weaknesses[67, 68]. Linking CPOE with drug administration, where electronic dose calculations and dose checks are possible, would help to minimize harmful administration errors, especially for critical drugs such as narcotic drugs and chemotherapeutic agents[22, 69]. Use of bar-coding systems has shown a significant reduction in drug administration errors[22, 70, 71], even though, majority of the errors detected by this technology were shown to have minimal risks to patients[72]. The VA Bar-Code Administration Project has prevented 378,000 drug administration errors since it was established in 1999 [2].

Use of bar-code verification technology with an electronic medication-administration system (bar-code eMAR) has shown to reduce non-timing errors from 11.5% to 6.8%, the rate of related potential ADEs from 3.1% to 1.6% and total elimination of transcribing errors[70]. However, the adoption of bar-code technology in drug administration is associated with many issues. Poor user acceptance, technical barriers, complication of routine workflow leading to work-arounds by users are some of the major concerns that have been reported by studies[73-77].

Additionally, use of colour coded syringes have also been used to minimize wrong route errors[78].

3. Preventing Drug Monitoring Errors

Preventing monitoring errors is equally important in minimizing medication errors. The use of computer controlled telephone systems for monitoring patients was tested in patients on antihypertensive drugs. Antihypertensive medication adherence improved by 17.7% for patients monitored by telephone as opposed to 11.7% in the control group. Their mean diastolic pressure also reduced more than the controlled group[79].

Medication containers with counting devices to count opening and closing times have shown to be ineffective in improving patient compliance[80].

4. Clinical Pharmacist Intervention

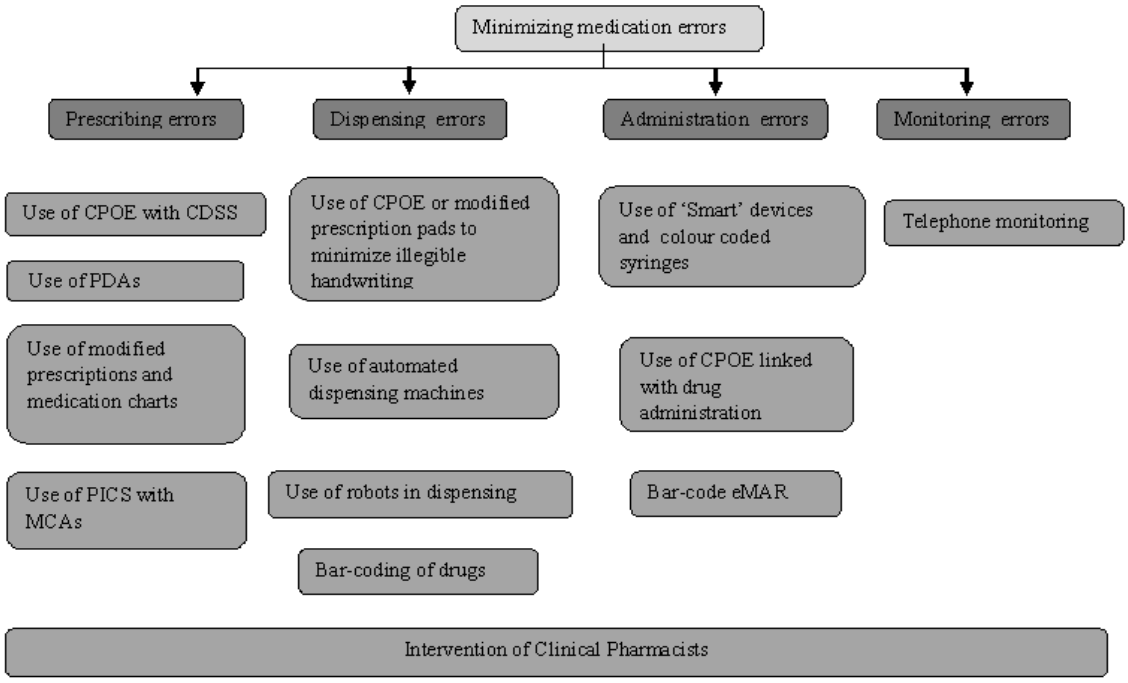
Medication errors can occur despite the use of technological interventions[81]. The inclusion of a clinical pharmacist in the healthcare team to assist, prescribers with drug information, counseling patients and

therapeutic drug monitoring can greatly help to minimize medication errors in all areas. Clinical pharmacist intervention has been successful in reducing preventable adverse drug events by 66% and has shown a potential to save over $270,000 annually, by preventing medication errors[82]

CONCLUSIONS

Medication errors can happen due to system errors or human mistakes. It costs many lives and millions of dollars but the important thing is that they are preventable and need not happen. Many studies have been conducted and many strategies have been implemented (Figure 2) to minimize medication errors. More standardized procedures need to be developed in reducing medication errors; hence the need for more systematic and broader studies is evident.

Figure-2: Strategies adopted to minimize medication errors.



CPOE, computerized physician order entry; CDSS, clinical decision support system; PDA, personal digital assistant; PICS, prescribing information and communications system; MCA, mobile clinical assistants; Bar-code eMAR, bar-code verification technology with an electronic medication-administration system.

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