**REVIEW**

# Medication errors and strategies for their prevention

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**Abstract**: Medication errors occur every day causing injury to the patients and even deaths. The health care professionals are not fully aware of the damages done by medication errors in terms of patients' discomfort and economic burden. There is a need to provide information about medication errors to health care providers. This article reviews research done on the various aspects of medication errors. The research work done on prescribing errors, transcribing errors, dispensing errors, administration errors and discharged summaries errors have been examined. Eight strategies to reduce the occurrence of medication errors have been reviewed: (1) Electronic prescribing and computerized physician order entry (CPOE) with clinical decision support systems (CDSSs), (2) Bar Code, (3) Interventions to reduce medication errors, (4) Medication Error Reporting Systems (MERSs), (5) Alerts about medication errors, (6) Prevention of harm from high-alert drugs, (7) Smart Infusion Pumps and (8) Telemedicine or Telehealth or Telepharmacy. Statistical tests used in medication error studies have also been stated.

**Keywords**: Medication errors, medication error reporting system, computerized physician order entry, bar code, telepharmacy, smart infusion pumps.

## INTRODUCTION

Medication errors (MEs) occur every day, which may lead to severe effects including deaths. Public attention was drawn to the issue when the Institute of Medicine (IOM) submitted a report in 1999 entitled 'To Err Is Human: Building a Safer Health System'. It was evaluated that about 0.1million people die in hospitals every year due to medical errors which were preventable and these deaths exceed the combined deaths caused by AIDS, road accidents and breast cancer (IOM). Leape and Berwick in their report in 2005 said that the groundwork for improving safety has been done, but the progress is slow (Leape and Berwick, 2005). In another report by IOM in 2006 entitled 'Preventing Medication Errors', it was found that MEs harm at least 1.5 million people and cost 3.5 billion annually (National Academies organization). Since then the progress on the elimination of medication errors has been made, but the problem still exists and many people become ill due to errors related to inappropriate use of drugs particularly children (Rinke *et al.*, 2014) and elderly people (Fialova and Onder, 2009). In a review published in 2013, it was found that the cost of hospital admissions which were drug related was about 1 billion dollar (Australian Commission on Safety and Quality in HealthCare).

Due to the importance of medication safety, this review article has been written. The aim of this review article was to report research work done about various types of medication errors and the strategies to prevent these errors. The information will hopefully be useful to increase patient safety and improve quality in the health care system.

### *Definitions of medication errors*

Variation existed in the definitions of ME (Wilmer *et al*., 2010). It was suggested that a clear-cut definition of ME has the potential to improve the quality and consistency of medication error reporting (Lisby *et al*., 2010)**.** The European Medicines Agency (EMA) in a workshop on tackling medication errors (28th February to 1st March, 2013) held in London, UK has expressed the need to propose a common working definition of ME (Medication Errors Workshop).

The definitions of ME can be found in the published research work (ASHP; Bates *et al*., 1995; www.ccalac .org; Consumer Safety Organization; www.drugs.com; ISMP; Jennane *et al*., 2011; www.lexis-us; Medication Errors Workshop; NCCMERP; Riaz *et al*., 2014; VA Center). The types of medical errors and medication errors are given in table 1.

### *Medication errors*

These take place during all steps of the medication process (generally 4 steps: ordering, transcribing, dispensing and administration) particularly during the prescribing stage. Near misses or a potential adverse drug events are MEs that are stopped before harm can occur (VA Center).

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***(a) Prescribing Errors***

These errors are due to errors in prescription writing process. The American Society of Hospital Pharmacist in 1993 issued guidelines on preventing MEs (ASHP).

The prescribing errors in two government hospitals were investigated. The total prescribing errors in outpatient departments and emergency wards were 39-44% and 60-73.5% respectively. The drug overdose was found in about 8-19% prescriptions. The age group 21-30 years received the most treatment (21-24% in emergency wards) in both hospitals. The omission of diagnosis and patient addresses was found in most of the prescriptions. Legibility issue was present in manual prescriptions and was absent in prescriptions written by electronic prescribing (Riaz *et al*., 2014). In another study, a total of about 43% MEs (1065/2467 errors) was detected. The investigated MEs were ordering, transcribing, dispensing, administration and discharge summaries (Lisby *et al*., 20005). The prescribing errors in 3 NHS hospitals in the UK were investigated. The errors found included inappropriate dose and incorrect formulation (Franklin *et al*., 2011).

The occurrence of prescribing errors was studied in15 inpatient cases randomly selected from the psychiatry department of a public sector hospital. The percentage of prescribing errors was 39.3% and the mean medication prescribed per case was 5.6 (Shawahna and Rahman, 2008). The prevalence of prescribing errors was 52.5% (209/398) in a study carried in Ethiopia. The prescribing errors were 25.7%, 15.5% and 15.1% for wrong drug combinations, wrong frequency, and wrong dose respectively. The major part (32.5%) of the MEs was errors associated with antibiotics (Agalu *et al*., 2011). A study was conducted to compare the prevalence of prescribing errors made during first twenty four hours of admission in four public care hospitals. A relationship between the number of prescribed drugs and the number of prescribing errors was found to be linear (r=0.6) (Barton *et al*., 2012).

A harm (injury) caused by the use of drugs is called as an Adverse Drug Event (ADE). If ADE is due to an error is called as preventable ADE (pADEs) and if injury occurs due to no error (such as allergy) is called non preventable ADE. ADE also includes adverse drug reaction (ADR), which is defined as adverse effects produced by a drug at normal dose. ADR also includes adverse reaction produced by an allergy which is an ADR mediated by the immune system (VA Center; Jennane *et al*., 2011). In a study, five of 530 MEs (about 1%) resulted in ADEs, but most MEs were preventable through the use physician computer order entry (Bates *et al*., 1995). In another study, it was found that 1.4% of all medication orders led to pADEs. The total number of pADEs was 103. Two cases were life threatening and one case was fatal (Doormaal *et al.* 2009). The incidence of medication errors in a care unit was investigated. There were 113 pADEs and 8 ADEs. Two ADEs led to death (Jennane *et al*., 2011). A systematic study was performed on the occurrence of MEs and ADEs. The authors found that variation existed in the reported rates and definitions of MEs and ADEs (Wilmer *et al*., 2010). Further, the risk factors related to an ADE should be examined (Oladimeiji *et al*., 2007).

***(b) Transcribing Errors***

These errors occur due to a wrong or incomplete transfer of the information from the prescription. The occurrence of transcription errors was studied in a public hospital in Pakistan. The errors were 16.9% and 13.8% for inpatients and discharged patients respectively. Further errors regarding labels were 6.1%. Transcription errors were reduced: by the use of Tall Man letters, metric units and avoiding trailing zeros after the decimal point. These errors increased with the increase in the duty hours of nurses (Shawahna *et al*., 2013). In a study carried in an intensive care unit in Morocco found that MEs (which occurred in transcribing stage) were present in 60% cases (Jennane *et al*., 2011).

Transcription errors were investigated in a hospital in Tehran. The highest transcription error (52%) was omission (Fahimi *et al.*, 2009). The risks of misinterpretation of telephone orders are recognized. The factors responsible for such errors include poor signal-to-noise ratio, inability to recognize spoken drug names and sound–alike names (Lambert *et al*., 2010). A deadly cost of medication transcription error was reported in which instead of 8 units (according to the prescription), 80 units of insulin were transcribed. The patient received 10 times more insulin and this resulted in the death of the patient. The jury gave 140 million dollars verdict in favour of the plaintiff's family (http://waywithwordsblog.com/).

***(c) Dispensing Errors***

These errors are due to a disagreement between the medicine(s) dispensed and the prescription. In a study, a dispensing error was reported. The child (11 month weighing 8kg) with fever and running nose was prescribed a 5ml of a formulation of acetaminophen containing 125mg drug/5ml, but was dispensed a syrup containing 250mg acetaminophen/5ml. The child's father read the label on the next day. He talked with the paediatrician and came to know about this error. If the error had not been found, acetaminophen dose given to the child might be fatal (Goel and Gupta, 2011).

In a review article, the published literature for dispensing errors from 1966 to February 2008 was searched and 60 relevant research articles were identified. The common dispensing errors were the wrong drug or strength or labels with wrong instructions. The factors contributing to

dispensing errors were inadequate staff, high workload, interruptions, inadequate lighting and look-alike / sound-alike drugs (James *et al*., 2009).

In a study it was found that the content errors were identified in about 2% of the dispensed items and these dispensing errors could be prevented if the systems were linked to either patient medication records (PMR) or electronic transfer of prescriptions (ETP) (Franklin and O'Grady, 2007). In another study, it was shown that the content errors were 262 (87.3%) out of the 300 identified prescribing errors (Costa *et al*., 2008).

***(d) Administration errors***

These take place during the administration of the drugs. It was described that errors due to nurses are administration errors and such errors negatively affect nurses such as they may feel guilty and can experience a loss of confidence in their abilities (Gladstone, 1995). The factors responsible for the nurses' failure in reporting medication errors were investigated in Taiwan (Chiang *et al*., 2010). In a study on liquid medication administration, parents were observed for dosing accuracy (5-mL dose) using dosing cups. Dosing errors made by parents using the cup with marked printing and with etched marking were 26% and 24% respectively (Shonna *et al*., 2010). It has been suggested that sticking to the 'Five Rights' of medication safety can prevent administration MEs (AHRQ and Quality Patient Safety Network).

***(e) Discharge summaries errors***

These errors occur due to a discrepancy between discharged summaries and medical records. The discrepancy was investigated in drug omission, drug name, administration route, dose of drug and the drug regimen (Lisby *et al*., 2005). In other studies, the discrepancy between medical records and discharge summaries was shown to be from 16 to 36% (Morrrill and Bareuther, 1988, Wilkin *et al*., 1978 and Wilson *et al*., 2001).

***(f) Monitoring errors***

Little research work has been done on monitoring errors. The monitoring of renal function is important in the case of the patients with impaired kidneys and patients taking drugs which are mainly excreted via kidneys. The types of medical errors and medication errors are given in table 1.

## STRATEGIES TO REDUCE THE OCCURENCE OF MEDICATION ERRORS

***1. Electronic prescribing and computerized physician order entry (CPOE) with clinical decision support systems (CDSSs)***

Electronic prescribing (computer-aided prescribing**)** and CPOE is a technology framework that permits physicians to write and send prescriptions electronically to the concerned pharmacy. A sophisticated e-prescribing system can create and refill prescriptions, view patient history and may also be integrated with an electronic medical record (EMR) (American College of Rheumatology; http://searchhealthit.techtarget.com).

A CPOE system provides clear, readable and complete orders. The system has the ability to decrease the prescribing and transcribing errors. CPOE systems can be integrated with CDSS. A CDSS can suggest drug doses, administration routes, etc. and may also offer drug safety features such as checking for allergies due to drugs or interactions between drugs (Jasperien *et al*., 2009). In a recent review article it was found that CPOE with CDSS resulted in 36% to 87% reduction in prescribing errors (Rinke *et al*., 2014). In another review, it was observed that electronic prescribing and CDSS reduce improper use of drugs and poly pharmacy (Clyne *et al*., 2012).

The unwanted consequences of CPOE include new types of work, errors and over dependence on the technology (Cambell *et al*., 2006). The use of the electronic prescribing incident reporting tool revealed a variety of problems related to prescribing (Hincape *et al*., 2014). The patient pictures can be used to reduce CPOE errors (Hayman *et al*., *2012)*.

***2. Bar code***

Bar coding of drug labels can reduce MEs and improve patient safety. Barcodes may include the identification number of a drug, brand name, packaging size, expiry date of a drug and batch number. The FDA recommended the use of bar coding in 2003 which came in to effect in 2006. Barcode Medication Administration (BCMA) is an inventory control system used in hospitals. The goal of BCMA is to ensure that patients are receiving the correct medications at the right time (http://searchhealthit.techtarget.com).

Three different bar code processes using bar code medication administration (BCMA) technology were investigated. Two included scanning all the doses and the third involved scanning only one dose. All unit doses contained a bar code. The implementation of BCMA showed a saving of more than 2 million dollars annually (Kaufmann, 2008).

***3. Interventions to reduce medication errors***

The interventions were made for reducing medication errors. In an educational intervention made in a Malaysian public hospital, error-free prescriptions increased by 3.5% (Ng and Ibraheim, 2011). It was found that the pharmacist intervention decreased the risk of ADEs and MEs in outpatients (Murray *et al*., 2009). It was shown that the presence of a pharmacist as a member of the patient care team in an intensive care unit substantially lowered ADEs caused by prescribing errors. Further almost all changes

**Table 1**: Types of Medical Errors and Medication Errors

| Medical Errors (Preventable Human Errors) | | | | | | |
|---|---|---|---|---|---|---|
| Medication Errors | Diagnostic Errors | Surgery Errors | Medical equipment use Errors | Hospital acquired infections | Damage during normal use of approved drugs | Wrong laboratory reports |
| Medication Errors (Preventable Medication Errors) | | | | | | |
| Prescribing /Ordering Errors | Transcribing Errors | Dispensing Errors | Administration Errors | Discharge Summaries Errors | | Monitoring Errors |

**Table 2**: Statistical tests used in medication error studies

| Test | Aim |
|---|---|
| Chi-square test or Fisher's exact test<br>Student's *t*-test<br>Mann–Whitney test | The frequencies between medical and surgical wards were compared.<br>Parametric data were compared.<br>Non-parametric data were compared. (Lisby *et al*., 2009) |
| Chi-square test | To compare data obtained from two out-patient departments or two emergency wards of two different hospitals (Riaz *et al*., 2014). |
| Chi-square test | To find association between two years (2010-2011) written reports on medication errors (Dalmolin *et al*., 2013). |
| Chi-square test | To find significant difference for those prescription orders having more than 5 drugs and beta-blockers (Nesar *et al*., 2014). |
| Multivariate regression analysis | To find association between type of medication error and preventable adverse events (Oladimeiji *et al*., 2007). |

were accepted by the physicians (Leape *et al*., 2003). The most common interventions made by pharmacists were: change of dose, patient education, substitute or clarify Rx (Rx means to take; the superscription or heading part of the prescription) and order laboratory test (www.ccalac.org).

***4. Medication error reporting systems (MERSs)***

An effective medication error reporting system provides an opportunity to find the causes of MEs. In the absence of such a system, the majority of MEs goes unnoticed. MERSs (the local and national) were present in sixteen countries (Anna-Riia *et al*., 2012).

The Institute for Safe Medication Practice (ISMP) was established under the guidance of Michael R Cohen. ISMP Medication Errors Reporting Program (MERP) receives the error reports from healthcare professionals each year. ISMP's program 'Med-ERRS (Medical Error Recognition and Revision Strategies)' works with the pharmaceutical industry to prevent errors which are based on confusing naming, labelling, packaging and device design. The institute also publishes five safety alert newsletters (ISMP).

The US Food and Drug Administration (FDA) tracks MEs through its 'MedWatch' programme (MedWatch). The National Coordinating Council for Medication Error Reporting and Prevention (NCC-MERP) works under the United States Pharmacopeia to promote the unharmed use of drugs (NCCMERP). MEDMARX is a MEs reporting voluntary programme in the USA designed for hospitals. It works under the US Pharmacopeia and has the largest registry of adverse drug events (Kane-Gill, 2013; Santell *et al*., 2003).

***5. Alerts about medication errors***

The alerts are issued to provide the information about drug safety and MEs**.**

The Institute for Safe Medication Practice issues 5 alerts (ISMP).

***5.1 Safe Medicine*:** is a monthly newsletter which focuses on the prevention of medication errors.

***5.2 The NAN Alert*:** is sent by email and contains information on medication and device errors. The alert warns health care providers about the medication errors that have recently caused serious harm or death.

***5.3 Ambulatory Care Edition***: is a newsletter (monthly) which provides information about drug -related errors.

***5.4 Long-Term Care Advise-ERR*:** is a newsletter (monthly) which *describes MEs and their causes.*

***5*.5 Nurse Advise-ERR**: is a newsletter (monthly) for nurses to provide the medication safety information.

NHS England and another agency jointly published two alerts on MEs and medical devices (NHS England).

***6. Prevention of harm due to high alert drugs***

These drugs should be used with extreme care. High alert drugs when misused can produce significant patient harm and even deaths. These drugs included insulins (39%), heparin (27%), warfarin (22%), digoxin (6%) and promethazine (1%) (Santell *et al*., 2003). These

medications should be packaged differently than others (ISMP). The alerts for warfarin were detected in prescriptions by bar code system (FitzHenry *et al*., 2011).

***7. Smart infusion pumps***

Medication administration errors also include errors due to IV pumps. The newly developed "smart infusion pumps" reduce errors because these pumps contain software that alert the user to the potential errors. These smart pumps have drug libraries. It was concluded that intravenous medication errors could be detected using smart pumps (National Academies Organization, Rothschild *et al*., 2005 and Smart Pumps). A report of technology adoption for improved medication safety in 2006 documented that 37% of hospitals were using smart infusion pumps (Pedersen, 2006). The adoption rate of smart IV pumps in 2012 was 70% (Vanderveen, 2012).

These pumps can reduce errors associated with miscalculated doses (ISMP). Further, the failure to use these pumps correctly places the patient at increased risk (Harding, 2013). In a database search from January 2003 to July 2008 showed that a planned research related to the efficacy of such pumps in preventing MEs is still required (Herztel and Sousa, 2009). The details about smart pumps can be found in a recent book published in 2011 (Phelps, 2011).

***8. Telemedicine or telehealth or telepharmacy***

By the use of online technology such as video conference or video phone, a physician examines a far off patient i.e. thousands of kilometers away and can write a prescription. Further a distant pharmacist can dispense the prescription. The patient counseling can be done remotely by the pharmacist. The health professionals can continuously monitor a patient from a distance in a real time (Arya and Alam, 2013)**.** Telepharmacy can reduce cost of health care. When patients don't take their medications properly (medication administration errors), there is a bad impact on their health. The impact on health care spending due to poor medication adherence was estimated to be over 105 billion dollars (Andros, 2013). In a study it was shown that the adherence to medication improved by the use of telepharmacy (Arya and Alam, 2013)**.**

A study reported a slight difference in dispensing error rates between telepharmacies and standard pharmacies and both rates can be compared with nationally reported errors (about 2% error rate) (Friesner *et al*., 2003). Telepharmacy is working in North Dakota, the USA. There were eighty-one pharmacies involved in the North Dakota telepharmacy project uptill March 2014. The project has provided the services to remote areas of the state. It has added approximately 26.5 million dollars in the local rural economy (North Dakota Telepharmacy Project). The impact of telepharmacy was evaluated in three community hospitals in California, the USA. After implementation of the telepharmacy, the number of times that nurses obtained and administered medications without pharmacist review declined by 35.3%. There was a reduction in the percentage of high-risk medications obtained without a pharmacist review. The survey showed the increased comfort of nurses with the medication-use system. The estimated cost savings resulting from resolving medication-related problems were 261,109 dollars per hospital (Schneider, 2013). Telepharmacy practices were investigated in country side hospitals in various states in the USA. Some states reported that error rates have improved due to telepharmacy. It was found that many states have no described regulations for telepharmacy (Casey *et al*., 2010).

A nationwide telepharmacy chat-service was launched in Denmark in 2012 for free counseling of the citizens. The enquiries found were: 36% drug-related enquiries, 26% technical in nature, 19% related to symptoms and 19% other enquiries. Eighty nine percent customers were satisfied with the counseling (Ho *et al*., 2014).

## USE OF STATISTICS IN MEDICATION ERROR STUDIES

The results in medication error studies are given as frequency or number or % or mean ± SD. Statistical tests have also been used in ME studies (table 2).

## CONCLUSION

Medication errors occur at all stages of the medication use process. Medication errors harm the patients as well as produces economic burden on health care system. Various strategies to prevent medication errors have been successful but more research work is still needed to completely prevent these errors.

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