

Nrupal Patel, Mira Desai¹,
Samdih Shah¹, Prakruti Patel¹,
Anuradha Gandhi¹

Department of Pharmacology,
Government Medical College, Surat,
¹Department of Pharmacology,
B. J. Medical College, Ahmedabad,
Gujarat, India

Address for correspondence:

Dr. Mira Desai,
Department of Pharmacology,
B. J. Medical College,
Ahmedabad - 380 016, Gujarat, India.
E-mail: desaimirak@yahoo.co.in

Abstract

A study of medication errors in a tertiary care hospital

Objective: To determine the nature and types of medication errors (MEs), to evaluate occurrence of drug-drug interactions (DDIs), and assess rationality of prescription orders in a tertiary care teaching hospital. **Materials and Methods:** A prospective, observational study was conducted in General Medicine and Pediatric ward of Civil Hospital, Ahmedabad during October 2012 to January 2014. MEs were categorized as prescription error, dispensing error, and administration error (AE). The case records and treatment charts were reviewed. The investigator also accompanied the staff nurse during the ward rounds and interviewed patients or care taker to gather information, if necessary. DDIs were assessed by Medscape Drug Interaction Checker software (version 4.4). Rationality of prescriptions was assessed using Phadke's criteria. **Results:** A total of 1109 patients (511 in Medicine and 598 in Pediatric ward) were included during the study period. Total number of MEs was 403 (36%) of which, 195 (38%) were in Medicine and 208 (35%) were in Pediatric wards. The most common ME was PEs 262 (65%) followed by AEs 126 (31%). A potential significant DDIs were observed in 191 (17%) and serious DDIs in 48 (4%) prescriptions. Majority of prescriptions were semirational 555 (53%) followed by irrational 317 (30%), while 170 (17%) prescriptions were rational. **Conclusion:** There is a need to establish ME reporting system to reduce its incidence and improve patient care and safety.

Key words: Medication errors, medicine, Medscape Drug Interaction Checker, pediatric, Phadke's criteria

INTRODUCTION

The National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) has defined medication errors (MEs) as, "Any preventable event that may cause or lead to inappropriate medication use

or patient harm, while the medication is in the control of the health care professional, patient, or consumer."^[1] American Society of Hospital Pharmacists guidelines for MEs stated that incidence of MEs is not exactly known because of variations in different definitions

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of ME, different methods, or subject populations.^[2] In India, studies done in Uttarakhand and Karnataka have documented ME rate to be as high as 25.7% and 15.34%, respectively, in hospitalized patients.^[3,4] Unfortunately, most of the MEs remain undetected, if clinical significance or outcome does not adversely affect the patient. While some of the MEs also result into serious morbidity or mortality and have a significant economic impact on the patient and health care system. The Institute of Medicine estimated costs due to medical errors in the US of was approximately \$37.6 billion/year. About \$17 billion of it are associated with preventable errors.^[5] Overall, MEs increase morbidity, mortality, and economic burden to health care system.

Drug-drug interactions (DDIs) are defined as combining two or more drugs in such a way that the potency or efficiency of one drug is significantly modified by the presence of another.^[6] DDIs account 6–30% of all adverse drug events and can increase occurrences of ME. Furthermore, self-medication, poor communications between the prescriber and the patient, and even demand of the patient for medicine for each symptom, unethical drug promotion and inducements increases irrational prescribing.^[7] This increase the number of drugs per prescription which may lead to ME and DDIs. Hence, monitoring of DDIs and rationality plus ME would be an essential element of high quality of medical care. The data about these are lacking in our hospital, hence the present study was carried out with the objectives to determine demography about MEs, DDIs, and rationality of prescriptions.

MATERIALS AND METHODS

An observational, prospective study was conducted in a unit of General Medicine and Pediatric Ward at Civil Hospital, Ahmedabad from October 2012 to January 2014. The study was approved by Institutional Ethics Committee (approval number - 20/13). All patients admitted to one specific unit of General Medicine and Pediatric ward were included while patients shifted to other wards were excluded. Chart review and direct observation method were used to detect MEs. The NCCMERP guidelines 2010 definitions were used for MEs.^[1] Direct observation was also carried out by investigator, who accompanied the staff nurse during medication administration round. If necessary, investigator also interviewed patients or care taker to gather information. For MEs patients were followed up till discharge. DDIs were assessed by Medscape Drug Interaction Checker software (version - 4.4 available on: <http://www.reference.medscape.com/drug-interactionchecker>. Developed by Medscape). According to software, DDIs were classified as minor (non-significant) that do not require patient monitoring, major (significant) which require monitoring,

and serious DDIs in which a medical intervention is required. Rationality of prescription orders was assessed using Phadke's criteria.^[8] And, standard text books of Medicine and Pharmacology. Based on these criteria, each prescription was allocated 30 points. Out of which, prescription scoring between 0 and 14 were categorized as irrational, 15–24 semi-rational, while prescriptions scoring between 25 and 30 were categorized as rational.

RESULTS

A total number of 1147 (529 in Medicine and 618 in Pediatric) patients were enrolled during study period. Among them, 38 were not included due to discharged against medical advice (15), death (11), transferred to other wards (9), and absconded (3). Hence, a total of 1109 patients were included in the study, of which, 511 were from Medicine and 598 from Pediatric ward. Total 403 (36%) MEs were detected, among which 195 (48%) were in Medicine and 208 (52%) were in Pediatric wards.

Demographic details

Mean Age of the patient including in study was 42.28 ± 0.82 years in Medicine and 4.5 ± 0.67 years in Pediatric ward. Age group between 12–32 years (71, 36%) and <1 year had the highest number of MEs (67, 32%). Majority of MEs were observed with intravenous (IV) route (368, 91%) followed by oral (26, 6%). In addition majority of MEs were observed with male (123, 67%) in Medicine ward and boys (111, 53%) in Pediatric ward. Most common drug group all MEs was antibacterial in both wards [Table 1].

Medication errors

A total of 403 MEs occurred during the study period [Table 2]. Out of 403, 262 were prescription errors (PEs). Majority of them (260, 99%) were inappropriate selection of medicine. Antibacterial (181, 70%) was the most common inappropriately prescribed drug group followed by gastrointestinal (GI) (79, 30%). Ceftriaxone (89), co-amoxiclav (41), metronidazole (40), chloroquine (6),

Table 1: Common drug groups involved in medication errors

Drug group	Medicine ward (n=195)	Paediatric ward (n=208)
Antibacterial drugs	105	106
Drugs used in cardiovascular diseases	9	16
Drugs used in Gastrointestinal diseases	70	14
Vitamins	1	31
Intravenous Fluids	5	32
Others	5*	9**

*Atropine, antiplatelets, β_2 agonist, insulin. ** β_2 agonist, NSAIDs, antiepileptic

and gentamicin (5) were among antibacterial group, while ondansetron (54) and ranitidine (25) from GI group, which were inappropriately prescribed.

Out of 403 MEs, dispensing errors (DEs) were seen in 15 patients. The prescribed medicines were not dispensed and thus had consequences of omission. Out of 15 omissions, there was one death due to missed dose of atropine in organophosphates poisoning.

A total of 126 (31%) medicine administration errors (AEs) were observed during the study period. Of these, 72 were incorrect dose administration (either lower or higher than the prescribed), 38 were inaccurate dosing interval (not as per specified time interval), and wrong route of administration (oral instead of IV) was detected in 15 and medicine administration to the wrong patient was observed in one patient [Table 3].

Table 2: Types of medication errors (n=403)

Type of error	No. of error (%)
Prescription errors	262 (65)
Inappropriate selection of medicine	260
Incomplete medical history of patient	02
Dispensing errors	15 (4)
Omission	15
Administration errors	126 (31)
Inaccurate dose	72
Error in dosing interval	38
Wrong route of administration	15
Wrong patient	01
Total number of medication errors	403 (100)

Out of 1109 prescriptions, 508 (46%) had the presence of potential DDIs. Majority of DDIs were nonsignificant (269, 53%) followed by significant (191, 38%). While 48 (9%) of DDIs were serious [Figure 1]. In potential significant DDIs, cardiovascular (CVS) drugs were most commonly involved (108) followed by antibacterial (30) hypolipidemics (26) antiepileptic (20) and anticoagulants (7) [Table 4].

Rationality of each prescription was assessed using Phadke's criteria. Out of 1109 prescriptions, 1042 were assessed for Rationality as. In (67) prescription diagnosis was not mentioned was excluded from rationality assessment. The mean rationality score was 21.4 ± 5.2 (mean \pm standard deviation). Majority of prescriptions (555, 53%) scored between 15 and 24 points and were categorized as semi-rational. While 317 (31%) scored between 0 and 14 points, thus categorized as irrational. However, 170 (16%) prescriptions scored between 25 and 30 points and thus were rational [Figure 2].

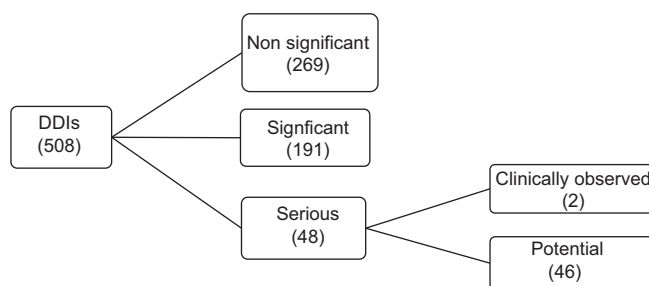


Figure 1: Categorization of Drug-Drug Interactions

Table 3: Type of medicine administration errors (n=126)

Type of error	Medicines	Number of medicines		
		Extra or high dose	Low dose	
Inaccurate dose (n=72)	IV fluid (24)	13	11	
	Multivitamins (18)	7	11	
	Furosemide (17)	10	7	
	Co amoxiclav (8)	4	4	
	Salbutamol (3)	1	2	
	Enalapril (2)	2	0	
	Errors in dose interval (n=38)		Early	Late
IV Fluid (12)		4	8	
Ceftriaxone (10)		2	8	
Co-amoxiclav (5)		2	3	
Metronidazole (3)		0	3	
Mannitol (3)		1	2	
Vitamin-D3 (2)		1	1	
Insulin (2)		1	1	
Wrong route of administration (n=15)		Oral to IV	IV to oral	Tablet to syrup
	Zinc (9)	0	0	9
	Ranitidine (4)	1	3	0
	Paracetamol (2)	0	2	0
Wrong patient (n=1)	Diagnosis	Wrongly administered		
	Pneumonia	Calcium		

IV=Intravenous

DISCUSSION

The goal of medication use is to achieve defined therapeutic outcomes with improvement of quality of life and minimize patient risk.^[9] ME can occur at any phase of medication use cycle from prescribing, dispensing, and administration of a drug to the patient. It increases morbidity and mortality of the population along with increase in the cost of the treatment. Further, it also affects patient's confidence in medical care.^[10,11]

MEs are common in hospitalized patients at a rate of 5 per 100 medication prescriptions or 1.4 per admission.^[12] Pediatric population is vulnerable with the risk of 6 MEs per 100 admissions.^[13] Our study observed 36% of ME while a study in France reported 27.6% of MEs.^[14] Our observations are comparable to a study done at Indore.^[15] Present study showed that 12–32 years of age group was

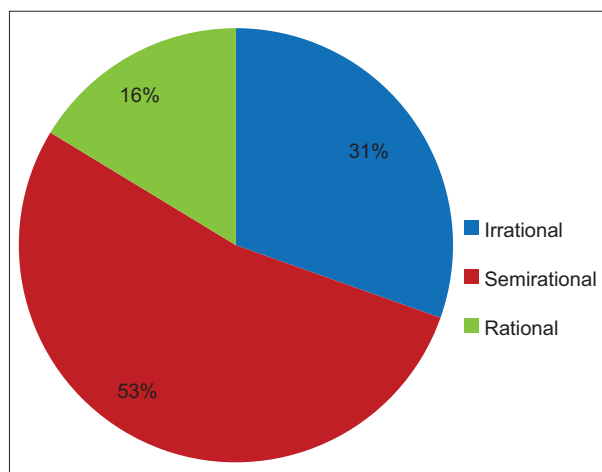


Figure 2: Rationality of prescription

more affected in MEs in medicine ward, while a study done in Delhi reported that 28–38 years of age group was commonly involved.^[16] On the contrary, Pote *et al.* reported that more than 60 years had high number of MEs.^[17] While in case of pediatric ward, <1 year of age group had high number of MEs, which is comparable to a study done in Saudi Arabia.^[18] This is alarming as infants (<1 year) are vulnerable population for medicine AEs such as wrong dose, wrong route of administration, or use of off-label drugs. In addition, pharmacokinetic or pharmacodynamic of drugs also differ in this patient population. This calls for a need to monitor ME in pediatric wards and educate the stakeholders. In our study, males were more affected from MEs which is comparable to an Indian study conducted in Karnataka in Medicine and surgery wards and Al-Jeraisy *et al.* in Pediatric ward in Saudi Arabia.^[4,18] In present study, IV route of administration was involved with MEs which is supported by a study in Karnataka in Medicine and Surgery departments and also by Ross *et al.* in Pediatric department.^[4,19] This suggests that MEs are commonly associated with IV route.

The most common drug group involved in MEs in Medicine ward was antibacterial followed by GI group, CVS group and IV fluids. This could be because a significant number of patients were hospitalized due to infectious diseases and CVS diseases. While GI drugs such as ranitidine and ondansetron have been prescribed inappropriately, anticipating gastritis and vomiting in these patients. Our finding have been supported by a study done in medical wards of tertiary care teaching hospital where ME with anti-bacterials is highest.^[17,18]

Inappropriate selection of medicines is one of the most common prescribing errors. According to standard text

Table 4: Drugs responsible for DDI

Significant DDIs	Effect	Type of interaction (PK/PD)	No. of DDIs (n=126)
Atenolol + Amlodipine	Increased antihypertensive effect	PD	15
Heparin + Clopidogrel	Increased anticoagulant effect	PD	12
Spirolactone + Furosemide	Fluctuations in potassium level	PD	12
Aspirin + Atenolol	Hyperkalemia	PD	12
Enalapril + Aspirin	Increased renal toxicity	PD	11
Furosemide + Digoxin	Increases antihypertensive effect	PD	10
Atorvastatin + Digoxin	Statin increases level of digoxin	PK	10
Aspirin + Clopidogrel	Increased anticoagulant effect	PD	8
Aspirin + Spirolactone	Hyperkalemia	PD	7
Aspirin + Digoxin	Hyperkalemia	PD	4
Spirolactone + Digoxin	Hyperkalemia	PD	5
Dexamethasone + Ondansetron	Steroid decreases effect of ondansetron	PK	5
Atenolol + Digoxin	Hyperkalemia	PD	4
Propranolol + Spirolactone	Fluctuations in potassium level	PD	4
Enalapril + Furosemide	Increased antihypertensive effect	PD	3
Enalapril + Digoxin	Enalapril increases level of digoxin	PK	2
Atorvastatin + Spirolactone	Spirolactone increases level of Atorvastatin	PK	2

PK=Pharmacokinetic, PD=Pharmacodynamic

and reference books, we differentiated between appropriate and inappropriate medicines. Based on that, we found that antibacterial was the most commonly inappropriately prescribed drug group. That may increase chance of antibacterial resistance and also cost of the treatment. DEs, especially omission was detected in both the wards. The consequences of missed drug dose are difficult to predict as it varies with clinical disease, condition of the patients, and pharmacokinetics of drug. A wide variation in DEs from 4.7% to 33% has been observed by Gaur *et al.* and Kumar *et al.*, respectively. Both the studies had similar dispensing system as our study.^[3,4] However, 1–1.7% of DEs have been observed in hospitals following unit dose dispensing system.^[20,21] This system reduces the chances of dose errors.

Our study showed that the most common medication AEs were inaccurate dose followed by inaccurate dosing interval. Studies done by Kumar *et al.* reported 17.4%, while Agarwal and Joshi reported 45.5% dose errors.^[4,16] A study in Saudi Arabia showed 47.3% overdose errors.^[19] It has been documented in a study done by Parihar and Passi *et al.* that IV fluid administration is involved with wrong rates worldwide.^[15] The reason for inaccurate dose administration is due to poor communication between health care professional team, missed labeling of IV fluid, and improper use of instruments. An inaccurate dosing interval error was observed in our study which is higher than the reported by Kumar *et al.*^[4] Busy schedule, urge to complete work as early as possible, and missing double check/cross checking of prescription orders can lead to wrong route of administration. These reasons not only increase the patient risk, but also increase the cost of treatment.

Our study showed the presence of potential significant and serious DDIs in the prescriptions from Medicine and Pediatric ward. Potential significant DDIs were more common with CVS drugs such as atenolol, enalapril, digoxin, and furosemide. The risk of DDI was significant due to multiple drug therapy along with co-morbidities in patients more than 40 years of age. Similar observations have been reported by Patel *et al.* and Sepehri *et al.*^[22,23] Surprisingly, nine serious reactions were observed with ondansetron. However, their potential to cause serious DDI has been neglected by prescribers. This calls for educating prescribers regarding DDI and undertaking prescription audit on regular basis.

Prescribing of medications outside the accepted medical standards is known as an inappropriate prescribing.^[24] In present study, PEs were evaluated using Phadke's criteria. To our satisfaction, majority of the prescriptions were semi-rational in both Medicine and Pediatric wards. This suggests that majority of the prescriptions had appropriate

drugs with correct dosage instructions. However, there were few irrational prescriptions (31%) with unnecessary drugs such as ondansetron, ranitidine, multivitamins, folic acid, ceftriaxone, and metronidazole. A study done by Shah *et al.* observed 28.3% irrational prescriptions which is less as compared to our findings.^[8]

Our study had few limitations such as we were not able to record MEs on public holidays and Sundays. Furthermore, we could not assess the actual impact of DDIs and while assessing the rationality and DDIs, the clinicians' viewpoint was not taken into account, which could have been different than ours.

CONCLUSION

Our study shows the occurrence of MEs at each phase of medication use cycle. Along with potential DDIs and semi-rational prescriptions. Probably, computerizing the medication process system in hospital settings and pharmacological education of prescribers and nurses could help to reduce ME. In addition, drug use policy should be implemented and maintained to reduce inappropriate use of drugs.

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Conflicts of interest

There are no conflicts of interest.

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