



## **Analysis of Reported E-prescribing Medication Administration Errors at King Saud Medical City, Riyadh: A Cross-Sectional, Retrospective Study**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author DSAD designed the study and performed the statistical analysis. Author NAQ wrote the protocol and wrote the first draft of the manuscript. Authors DSAD and MIA managed the analyses of the study. All authors managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

**Background:** Drug prescription error is a medication error that most frequently happens in healthcare organizations and adversely affects the healthcare consumers. Most medication errors (MEs) but not all are captured and corrected before reaching the patient by designed system controls. Medication administration errors (MAEs) mostly are made by nurses but frequently reported by clinical pharmacists in hospitals in Saudi Arabia.

**Objective:** This study aimed to analyze exclusively the voluntarily reported drug administration errors in a tertiary care hospital in Riyadh city.

**Methods:** This cross-sectional, retrospective study evaluated consecutively collected medication administration report forms over a period of one year from January 1, 2015 to December 31, 2015.

**Results:** The number of MAEs occurring during stage of drug administration constituted 7.1% (n=971) of total medication errors (n=13677). The maximum number of MEs (n=6838, 50%) and

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MAEs (n=455, 46.9%) occurred during the 4th quarter of the year 2015. The most common MAE happened to be category C (n=888, 91.5%) which means error occurred, reached the patient but without causing any harm. Concerning MAE types, the most common error included wrong frequency (40%) followed by wrong drug (17%), wrong time of administration (16%) and wrong rate of infusion (10%). Nurses made the most of the errors (92.2%) while the clinical pharmacists reported the most MAEs (75.5%). High alert medications (HAM) errors constituted 32.3% (n=314) of MAEs (n=971) and most common HAM errors included the wrong route of administration of Lanus Insulin (15%) followed by Insulin Aspart (15%), Enoxaparin (13%) and Insulin Protamine-Nvomix (12%). Look-alike and sound-alike (LASA) errors constituted 55.2% of MAEs (971/536) and most common LASA drugs identified were Gentamycin (13%), Insulin Mixtard (11%), NPH Insulin (8%) Intralipid vial (8%) and Insulin regular (6%).

**Conclusion:** This retrospective study provides some important tentative pharmacovigilance insights into MAEs, which are partially comparable with current international trends in drug administration errors. Further studies on MAEs are warranted not only in the Kingdom of Saudi Arabia but also other Gulf countries.

*Keywords: Medication errors; medication administration errors; electronic prescribing system; Saudi Arabia.*

## 1. INTRODUCTION

Medication errors (MEs) defined as preventable events that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient or consumer are major problems in healthcare settings. Handwritten prescriptions often contribute largely to the pool of preventable diverse MEs including medication administration errors (MAEs). MEs are multifactorial, present in different forms and severity, and are observed in all age groups of patient population. The etiologies of MEs include unsafe management of medications, wrongly written prescriptions and dispensing of incorrect medications, non-existence of medication safety and quality assurance programs, and lack of health information technology (HIT) integration into the healthcare system [1-10]. The electronic prescribing system (EPS) reduces such errors by 50%, also results in improved patient satisfaction, decreased morbidity and mortality, considerable minimization in cost, positive impact on ambulatory care workflow, and overall patient safety with good quality of life [6]. The EPS empowers all stakeholders including prescribers, pharmacists and managers to efficiently deliver high-quality pharmaceutical services to health consumers across the board [7-10]. On negative side, the EPS may also facilitate risks of e-prescribing medication errors occurrence [11,12]. EPSs have many advantages over handwritten prescriptions; well-articulated principles, operational mechanisms, and standards that help healthcare providers for efficient EP e-refill, prescription history across multiple providers,

eligibility and formulary data flow, authorization, and interoperability [13-16]. Arguably, there is increasing literature on EP and electronic health/medical records (EH/MR) in the Eastern world over the past one decade. The electronic health records [17] and perceptions of clinicians (n=43) about the computerized physician order entry (CPOE) in the intensive care unit [18] have been explored in the Kingdom of Saudi Arabia (KSA). In a survey, clinicians top-rated critical success factors were as follows; the before-go-live training, the availability of adequate clinical resources during implementation, the ordering time, a reduced rate of MEs and improved quality care of health users [18]. Further, Qureshi has reviewed the EP literature and made a strong case for implementing an EPS in all public and private healthcare settings, not only in KSA but also across the Eastern world [19]. An electronic prescribing system was implemented at King Saud Medical City (KSMC) in 2006 and since then few studies have been carried out by our research team and others on medical incidents (near misses and medication errors) [6-10,17-19].

To our knowledge, only a few studies have so far explored exclusively EP medication administration errors (MAE) in KSA. However, various perspectives such as why nurses do not report MAEs, their perceptions of MAEs and pharmacists ME reporting and monitoring in Saudi healthcare settings are studied and nurses related barriers reported were fear, their perceptions of errors or ill-defined concept of error, all errors need reporting, and apprehension of legal consequences [20,21]. As regards

medication errors and their reporting, recently a dozens of studies have been conducted on MEs in different healthcare settings and age groups in Saudi Arabia with variable results [22-31]. Pharmacists especially clinical pharmacists tend to most commonly report MAEs or MEs in general in Saudi Arabia [25,26]. Comparatively, huge literature on MEs and MAEs is available in other countries of the world [32-41]. Therefore, our team designed this study for analyzing different aspects primarily of reported MAEs in Tertiary Care Hospital, Riyadh city, and this research is first of its kind from KSMC. Identification of possible facilitating and impeding factors associated with MAEs may help guide healthcare providers including physicians, pharmacists and nurses and policy makers to develop an action plan to prevent electronic MAEs in the hospitals across Saudi Arabia.

### **1.1 Aim**

The aim of this study is to explore several perspectives of voluntarily reported electronic prescribing medication administration errors (MAEs), an avenue possibly yet to be investigated in details in the Kingdom of Saudi Arabia. The relevance of this study is that it will explore comprehensively MAEs and its results will be provided as feedback to healthcare providers who can take precautions in future for preventing MEs and MAEs. The significance of this study is that it will be the first study of MAEs conducted in the KSMC Riyadh. Based on our previous experience of medical incidents, we presume that voluntary reported MAEs will be small in number in KSMC.

## **2. METHODS**

### **2.1 Study Design and Timeline**

This cross-sectional, retrospective study was conducted over a 12-month period in 2015.

### **2.2 The Setting**

The setting for this study was KSMC, which is a major tertiary care hospital with a 1500-bed capacity in Riyadh region. An average of 2,500 electronic prescriptions is written daily. These prescriptions cover only electronic prescriptions and do not include paper prescriptions or medication orders written on prescription charts. In 2006, KSMC became the first Ministry of Health hospital to implement an electronic

prescribing system. Since then, many hospitals have adopted the electronic prescribing system. The KSMC operates five hospitals including general, paediatric, dental, obstetrics and gynaecology and rehabilitation and serves a wide range of patients drawn from a large population, many of whom present with complex medical comorbidities and are referred from different regions of KSA. The hospital's MEDI system (electronic health record system) has been upgraded regularly since 2006. The EPS is connected to the MEDI system. Medical incidents (medication errors and near misses) from all divisions and hospitals of the medical city are reported voluntarily to the medication safety unit of KSMC. All health care providers and consumers can report medication errors to this unit. Three pharmacists work on electronic medication error data collection, its entry into the computer, and statistical analysis. They also produce a medication error report. Notably, all medication error reporters are required to complete a medication error reporting form. The completed medication error forms are screened and reviewed by the pharmacy designee in the medication safety unit for deciding whether or not the reported medication error is an electronic MAE. Thereafter, this medication error form is further cross-checked and reviewed by a pharmacist and statistical analysis of entered data in computer is performed.

### **2.3 Data Collection**

All medication error report forms were evaluated by the pharmacist. The relevant data were abstracted from these forms. The variables examined in this study were age, gender, medication-related variables (such as drug type, dose, frequency of administration, route of administration, dosage form, concentration, and duration), details on reporters and interveners, types of errors, causes of errors, stages of MAEs made, setting where MAEs made, actions taken against MAEs, and suggested recommendations for preventing their occurrence in the future.

### **2.4 Data Analysis**

The data were entered into the computer and analyzed using Statistical Package for Social Sciences version 21 software (IBM Corporation, Armonk, NY, USA). Descriptive statistics were used to calculate frequencies and percentages.

**3. RESULTS**

Concerning MEs data of 2015, a total number of MEs were 13677 and numbers of MAEs were 971 (7.1%). Total numbers of e-prescriptions dispensed during 2015 were 912,500. The number of MAEs identified in MEs was 971 (7.1%). The maximum number of MEs (n=6838, 50%) and MAEs (n=455, 46.9%) occurred during the 4th quarter of the year. (Table1).

The medication administration errors were classified in accordance to National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP). Notably, categories B to D were classified as no harm whereas categories E to I were classified as preventable adverse drug events. Most of the MAEs (91.5%) reported were of the following type; error occurred, reached the patient but did not result in harm (C type). The second most common MAE (7.3%) was of type D followed by type E (0.8%) and F (0.4%) (Table 2).

There are four main stages of MEs (Fig. 1). From the total MEs in year 2015 (n=13677), most of the MEs occurred at the stage of transcribing and entering (n=5783, 42.3%) followed by prescribing and ordering (n=3765, 27.5%), preparation and dispensing (n=3158, 23.1%) and administration (n=971, 7.1%).

Concerning MAE types, the most common error included wrong frequency (40%) followed by wrong drug (17%), wrong time of administration (16%), wrong rate of infusion (10%), wrong dosage form (5%), wrong documentation (5%), wrong route (3%) and others (3%) (Table 3).

Concerning makers and reporters of MAEs, nurses made the most of the errors (92.2%) followed by clinical pharmacists (2.4%) and others (3.8%) while the clinical pharmacists reported the most errors (75.5%) followed by pharmacists (11.2%), nurses (7.2%) and assistant pharmacists (5.3%) (Table 4).

**Table 1. Number of ME (n=13677) and MAEs (n=971) per quarter**

Quarters	MEs	%	MAEs	%
1 <sup>st</sup> quarter	424	3.1	91	9.3
2 <sup>nd</sup> quarter	2763	20.2	170	17.5
3 <sup>rd</sup> quarter	3652	26.7	255	26.3
4 <sup>th</sup> quarter	6838	50.0	455	46.9
Total	13677	100	971	100

**Table 2. Percentage of MAEs classified by degree of patient harm in accordance to NCCMERP**

Classification	Definition	No.	%
No Error A	Circumstances or events that have the capacity to cause error.	Nil	-
Error, no harm B	An error occurred, but the error did not reach the patient (near miss)	Nil	-
C	An error occurred that reached the patient but did not cause harm to the patient.	888	91.5
D	An error occurred that reached the patient and required monitoring to confirm that it resulted in no harm to the patient and/or required intervention in order to cause no harm.	71	7.3
Error, harm E	An error occurred that may have contributed to or resulted in temporary harm to the patient and required intervention.	08	0.8
F	An error occurred that may have contributed to or resulted in temporary harm to the patient and required initial or prolonged hospitalization.	04	0.4
G	An error occurred that may have contributed to or resulted in permanent patient harm.	Nil	-
H	An error occurred that required intervention necessary to sustain life.	Nil	-
Error death I	An error occurred that may have contributed to or resulted in the patient's death.	Nil	-
Unknown U	Unknown outcome	Nil	-
Total		971	100

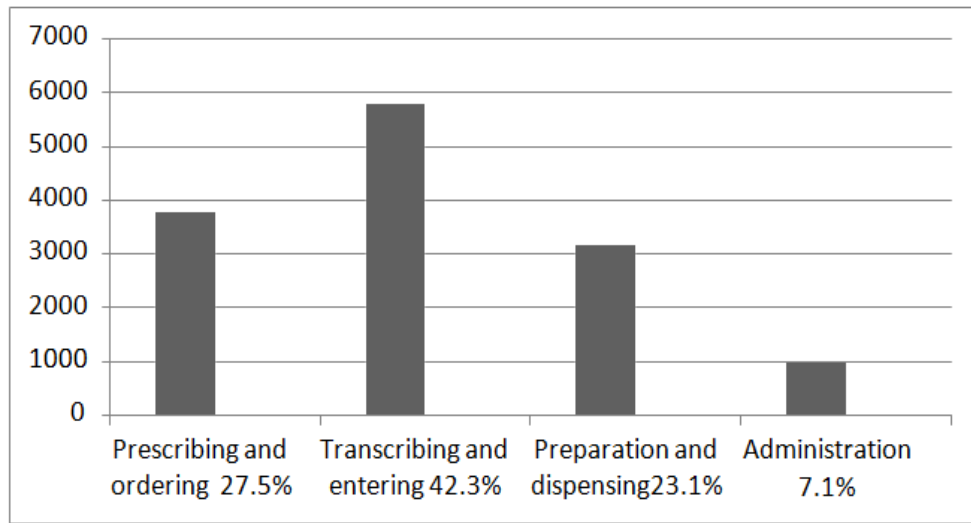


Fig. 1. Column chart showing stages of total medication errors (n=13677)

Table 3. Medication administration error types

Types of MAEs	No.	%
Wrong Frequency	388	40.0
Wrong Drug	169	17.4
Wrong time of Administration	156	16.1
Wrong rate of Infusion	100	10.2
Wrong Dosage form	51	5.3
Wrong Documentation	49	5.1
Wrong Route	25	2.6
Wrong Duration	15	1.5
Dose Omission	13	1.3
Wrong Patient	5	0.5
Total	971	100

Table 4. Administrative medication errors- makers and reporters, 2015

Error makers	No.	%	Errors reporters	No.	%
Physicians	1	0.1	Physicians	5	0.5
Pharmacists (clinical)	23	2.4	Pharmacists (clinical)	733	75.5
Assistant pharmacist	15	1.5	Assistant pharmacist	51	5.3
-----	---	---	Pharmacists	109	11.2
Nurses	895	92.2	Nurses	70	7.2
Others*	37	3.8	Others**	3	0.3
Total	971	100	Total	971	100

\*Patient & Radiology assistant;

\*\*Patient

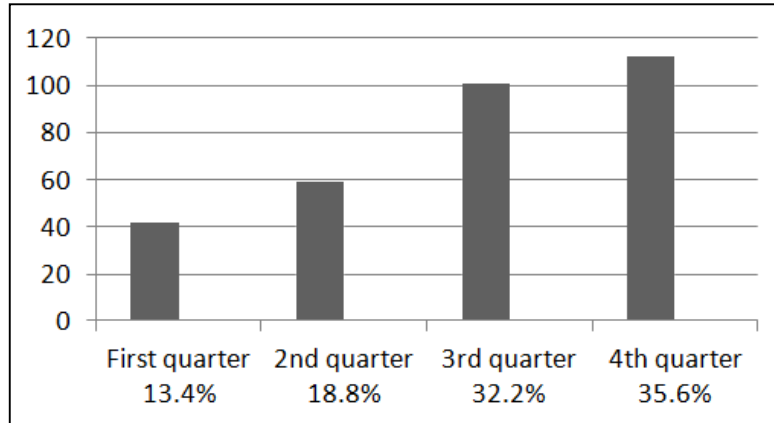
High alert medications (HAM) are often handled carefully in pharmacy care practice, and these errors constituted about 314 (32.3%) of MAEs (n=971). Most common HAM errors occurred with the wrong route of administration of Lanus

Insulin (15.3%) followed by Insulin Aspart (14.7%), Enoxaparin (12.7%), Insulin Protamine-Nvomix (12.4%), Regular Insulin (6.4%), Insulin Glulisine (5.4%), Epinephrine (5.4%), Heparin (4.8%), Warfarin (3.8%), Dopamine (3.2%) and

other medications (14.3%) (Table 5 and Fig. 2). Any of these HAM errors caused no harm to the patients.

From the total MAEs, LASA medication errors constituted 55.2% of MAEs (971/536) and most

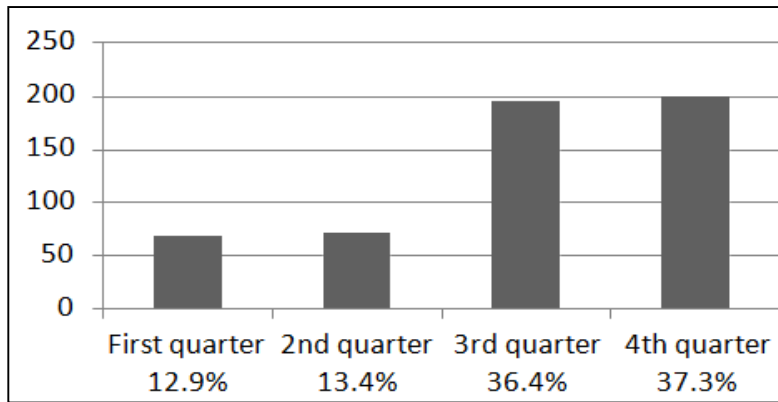
common LASA drugs identified were Gentamycin (13%), Insulin Mixtard (11%), NPH Insulin (8%), Intralipid vial (8%), Insulin regular (6%) and others (Table 6 and Fig. 3). MAEs other than HAM (n=314) and LASA (n=536) constituted 12.5% (n=1210).



**Fig. 2. Column chart showing first to 4<sup>th</sup> quarter of high alert medication (HAM)errors happened during MAEs (971/314, 32.3%)**

**Table 5. Data showing HAM errors (n=314) linked with MAEs**

High alert medications (n=24)	No.	%
Lantus Insulin	48	15.3
Insulin Aspart	46	14.7
Enoxaparin 20-40 mg	40	12.7
Insulin Protamine –Nvomix	39	12.4
Regular Insulin	20	6.4
Insulin Glutuzine	17	5.4
Epinephrine 0.1 mg	17	5.4
Heparin 5000 unit/ml	15	4.8
Warfarin 2 mg-5 mg	12	3.8
Dopamine 400 mcg	10	3.2
Liposomal Amphotericin	8	2.6
NPH Insulin	7	2.2
Rocuronium 50 mg	5	1.6
Amiodarone 150 mg/3 ml	5	1.6
Digoxin 0.125 mg/tab	5	1.6
Potassium Acetate vial	5	1.6
Dabigatran 150 mg/tab	3	1.0
Ketamine 20 mg	3	1.0
Chloral hydrate 200 mg/ml	2	0.6
Sodium Chloride 14.6%	2	0.6
Potassium Chloride 1%	2	0.6
Vincristine 1 mg/ml	1	0.3
Argatroban Amp.	1	0.3
Methotrexate 2.5 mg/tab	1	0.3
<b>Total</b>	<b>314</b>	<b>100</b>



**Fig. 3. Chart showing first to 4<sup>th</sup> quarter of look-alike and sound-alike (LASA) errors happened during MAEs (971/536, 55.2%)**

**Table 6. LASA medication related to AMEs (971/536), 2015**

Name of LASA drugs	No.	%
Gentamycin 80 mg/Amp	71	13.3
Insulin Mixtard	59	11.1
NPH Insulin	44	8.2
Intralipid vial	42	7.8
Insulin regular	34	6.3
Sodium Bicarbonate 8.4%	31	5.8
Succinylcholine Amp	29	5.4
Atracurium 25 mg	22	4.1
Dexamethasone 4 mg/Amp	20	3.7
Rosuvastatin 20 mg	17	3.2
Perindopril 5 mg	17	3.2
Acyclovir 800 mg/tab	16	3.0
Potassium Phosphate 3 mmol/ml	16	3.0
Benzathine Penicillin 1,200,000	15	2.8
Sodium Phosphate 40 mEq/ml	10	1.9
Chropropyramine 25 mg	10	1.9
Calcitonin 100 u/ml	10	1.9
PPD Skin test	9	1.7
Cyclophosphamide 500 mg /vial	6	1.1
Trazodone 50 mg	5	0.9
Sandostatin 0.1 mg/ml	5	0.9
Methotrexate 50 mg/ml	5	1.0
Lidocaine HCl 1%	4	0.8
One alpha 0.25 mcg	4	0.8
Hydralazine 25%	3	0.6
Lorazepam 1 mg	3	0.6
Benztropine 2 mg/tab	3	0.6
Tamoxifen 10 mg	3	0.6
Potassium Acetate 2 mEq/ml	3	1.0
Cyclophosphamide 200 mg /vial	2	0.4
Letrozole 10 mg/tab	2	0.4
Olanzapine 5 mg	2	0.4
Valacyclovir	2	0.4

Name of LASA drugs	No.	%
Sodium Acetate 2 mEq/ml	2	0.4
Amiloride	2	0.4
Risperidone	2	0.4
Hydroxychloroquine 200 mg	2	0.4
Citalopram 20 mg	2	0.4
Vincristine 10 mg/10 ml	2	0.4
Total	536	100

#### 4. DISCUSSION

This cross-sectional, retrospective study explored important aspects of medication administration errors (MAEs) in a tertiary care hospital in Riyadh City. Unlike in medication errors-near misses [7], females in mid-30s (57% versus 43%) were overrepresented in this study because females tend to utilize more healthcare services than their counterparts in ambulatory care. Hence females who utilize more healthcare services are probably at risk to have MAEs as found in this study. This finding is indeed consistent with other reports [24,42,43]. Other factors that also impact healthcare utilization include reproductive biology and age-related mortality [43]. Conventional wisdom would suggest that overutilization of healthcare services by females should increase their risk of having more MAEs. In the last quarter of the year, pressure on physicians to utilize medication stock before the end of the year may have also contributed to the occurrence of more MAEs and MEs [7,8]. Notably, the overall number of prescriptions (n=912,500) and ME rate (0.11) in year 2015 decreased considerably compared to 2012 (N=1036082 & 0.72) [8] and this might presumably be attributed to the better knowledge of healthcare professionals and dispersion of healthcare services to newly established hospitals, primary healthcare centres and private hospitals and clinics in Riyadh city. This study found the occurrence of MAEs was 7.1% from the total MEs. Notably, in pediatric inpatients, the observed rate of MAEs' occurrence was 62.7% and wrong dose being the most common type of MAE with an occurrence rate of 53.7% which are very high figures compared to our study [35]. Both the higher MAEs and wrong dose rate might be due to methodological differences together with pediatric patients, among other causative factors, at very high risk of developing MAEs [35,44,45].

According to this study, the most common MEs classified in line with NCCMERP (Nine error categories A to I of variable severity and

seriousness) were category C (91.5%); potential error occurred, reached the patient but caused no harm and requiring no necessary measures. The MAE occurs during administration stage of MEs and is defined as any difference between what the patient received or was supposed to receive and what the prescriber intended in the original order [46,47]. According to American Society of Health- System Pharmacists (ASHP), MEs are classified into 13 types and the most common MAEs found in the present study were wrong frequency trailed by wrong drug, wrong time of administration, wrong rate of infusion, wrong dosage form, wrong documentation, wrong route and others, and these findings are consistent partially with other studies [22,26,35]. In a review, Masmali et al. reported that frequent types of MEs were prescribing and improper dose/quantity (MAE), and medications commonly involved were antibiotics, antihypertensive, and oral hypoglycemic drugs. The main reasons underlying MEs were three; insufficient performance and knowledge and illegible handwriting [26]. In few studies involving MAEs, additional findings in terms of causes of MAEs reported were as follows; look-alike medications and interruptions in nurse's work performance linked with procedural failures. The reported barriers against not reporting MAEs were related to organizational, personal, administration, and professional issues [22,29,39].

In our retrospective study, most MEs occurred at the stage of transcribing and entering (42.3%) and prescribing and ordering (27.5%) and HAM and LASA medications largely contributed to the pool of MAEs which substantiated partially the findings of other studies (22,26). According to this study, nurses made most of the MAEs (92.2%) while the clinical pharmacists reported the most errors (75.5%), and notably nurses reported only 7.2% of MAEs, findings consistent with other studies that explored other MEs such as near misses [2,7,8]. It is paradox that those who tend to make the greater number of MAEs report the least attributable to a variety of reasons including fear and adverse



consequences [20,22,29]. Furthermore, expatriate nurses with bachelor degree were found to show significant perceptual barriers against reporting MAE [29]. A variety of approaches such as non-punitive anonymous reporting, capturing digitally MAEs prior to reaching patients, computerized physicians' order entry system, integrated clinical decision support system, following guidelines for medication safety practices, supporting clinical pharmacists intervention, correct labeling of medications, closed-loop medication administration, Tall Man lettering, home medication review, minimizing interruptions to nurses, use of smart infusion pumps, barcode medication administration, retaining experienced nurses and lastly targeted training programs for enhancing health literacy of healthcare providers including nurses and users have been reported globally to certainly facilitate reporting and capturing of MEs together with impeding significantly their occurrence, though some of these approaches such as smart infusion pumps may cause potentially dangerous MEs [2,4,5,7-9,20,22,26,29,36,41,44,48,49]. Our team has previously described comprehensively the medication safety programs and guidelines for preventing medication errors in Saudi hospitals [9]. Overall, like other MEs medication administration errors posit a complex conundrum and compromise the patient's safety with considerable increase in morbidity and mortality and cost and, hence, each stakeholder including healthcare users must exercise pharmacovigilance for preventing MAEs in all healthcare settings in Saudi Arabia.

According to this study, there were 24 HAM and the most common HAM errors occurred with the administration of different types of Insulin, anticoagulants, epinephrine, and dopamine, which are used in diabetic patients, deep vein thrombosis and cardio-and cerebro-vascular diseases including myocardial infarction and stroke, shock due to hypotension and sepsis, respectively and these results partially congruous with other research studies [9,22,26,48] and other HAM included narcotics, opiates and sedatives causing MAEs [48]. Although HAM did not result in injury to the patients in our study, their incorrect administration by nurses is known to cause serious consequences, and tailored educational training of nurses strengthen their knowledge of HAMS [9,50].

Besides HAM, LASA medications are frequently involved in the causation of MEs and MAEs, which are frequently reported by healthcare

professionals especially clinical pharmacists and to a lesser extent patient [32,34,37]. Like HAM, LASA medications also tend to potentially harm the healthcare users; however, no injuries were caused to patients as a result of LASA administration of medication in the present study. This might be attributed to regular updates of EHR (or EMR) system and computerized physician order entry systems including e-prescribing system integrated with clinical decision support system and automated capturing of MAEs, application of medication safety unit guidelines and programs and policies, continuous targeted training of healthcare professionals including nurses and patients in MEs and provision of providing MEs feedback to physicians, nurses and pharmacists in Riyadh KSM City [6-16,18,19]. Overall, unlike outpatients, MAEs that mostly included HAM and LASA errors tend to cause potentially dangerous harm to the inpatients in hospital settings.

This study is associated with some limitations as it has retrospective design and these include inferior level of evidence and moderate quality along with selection, recall and misclassification biases and inadequate data. Conversely, its advantages included less expensive, minimal ethical problem and short study timeline with findings partially matching international and national trends in electronic prescribing medication administration errors.

## 5. CONCLUSION

This cross-sectional, retrospective study provides important pharmacovigilance insights into electronic prescribing medication administration errors. The findings and recommendations emanating from this research are comparable with the current international landscape regarding electronic prescribing MAEs and also MEs. Based on our brief literature review and the opinions of MAE reporters and identifiers, this study has made several recommendations for further mitigating electronic prescribing MAEs in King Saud Medical City hospitals, which may be implemented in similar hospitals across the nation. Medication administration error is an unplanned event that tends to result in injury to the patient. However, electronic prescribing systems connected to the MED1 system need to be upgraded regularly for automatic capturing and correcting MAEs in order to prevent the occurrence of real medication errors including MAEs that compromise patient safety, increased

economic cost and increased morbidity and mortality.

### ETHICAL APPROVAL AND CONSENT

From an ethical perspective, the research team submitted the required documents including research protocol to the academic department of KSMC that gave permission to analyze and publish the reported MAEs. As the data were collected from e-prescribing medication errors reported forms written electronically by physicians, this study naturally did not cause any harm to the patients. This study will provide a narrow window concerning harms might have done or not to some patients based on degree of harm in accordance to the classification of NCCMERP. The data was anonymized and its confidentiality was maintained and no third party was allowed to have access to the data.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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