original article

Prescribing errors among adult patients in a large tertiary care system in Saudi Arabia

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BACKGROUND: Multiple studies have investigated medication errors in hospitals in Saudi Arabia; however, prevalence data on prescribing errors and associated factors remains uncertain.

OBJECTIVES: Assess the prevalence, type, severity, and factors associated with prescribing errors.

DESIGN: Retrospective database review.

SETTING: Large tertiary care setting in Riyadh.

PATIENTS AND METHODS: We described and analyzed data related to prescribing errors in adults (>14 years of age) from the Medication Error Electronic Report Forms database for the two-year period from January 2017 to December 2018.

MAIN OUTCOME MEASURES: The prevalence of prescribing errors and associated factors among adult patients.

SAMPLE SIZE: 315 166 prescriptions screened.

RESULTS: Of the total number of inpatient and outpatient prescriptions screened, 4934 prescribing errors were identified for a prevalence of 1.56%. The most prevalent types of prescribing errors were improper dose (n=1516; 30.7%) and frequency (n=987; 20.0%). Two-thirds of prescribing errors did not cause any harm to patients. Most prescribing errors were made by medical residents (n=2577; 52%) followed by specialists (n=1629; 33%). Prescribing errors were associated with a lack of documenting clinical information (adjusted odds ratio: 14.1; 95% CI 7.7-16.8, *P*<.001) and prescribing anti-infective medications (adjusted odds ratio 2.9; 95% CI 1.3-5.7, *P*<.01).

CONCLUSION: Inadequate documentation in electronic health records and prescribing of anti-infective medications were the most common factors for predicting prescribing errors. Future studies should focus on testing innovative measures to control these factors and their impact on minimizing prescribing errors.

LIMITATIONS: Polypharmacy was not considered; the data are from a single healthcare system.

CONFLICT OF INTEREST: None.

Medications are fundamental for disease management, but errors in medication usage, which are defined as preventable and unintentional drug-induced harm, can be fatal.[1] In the US, medication-related errors have been estimated to cause 140000- deaths annually and carry a financial burden of $76 to $136 billion on healthcare systems.[2] Due to the global threat of medication errors (MEs) on healthcare systems, the World Health Organization has launched the third Global Patient Safety Challenge with the theme of "medication without harm".[3,4] Therefore, understanding and preventing MEs are essential for patient safety across the globe.[5] Prescribing errors (PEs) are the most preventable types of MEs since they occur in the early stages (prescribing/ordering stage);[6,7] MEs are difficult to resolve after this initial stage.[8-12]

Prescribing can be defined as an order written by a qualified prescriber intended for testing, diagnosing, treating, or preventing diseases.[13] Medication prescriptions should include patient information, indication, medicine name, formulation, dose, timing, route of administration, frequency, and duration of therapy. A PE is considered present if any of these items are missing or inappropriately written.[14-16] PEs can be triggered by personal, contextual, and/or knowledge-based factors, which include but are not limited to stress, tiredness, inadequate attention to detail, lack of competence and skills, overloaded schedules, lack of documentation, prolonged work hours, and insufficient pharmaceutical knowledge and experience.[11,17,18]

There is conflicting data on the prevalence of PEs in Saudi Arabia as the reported prevalence ranges between 5% and 77%, with many potential factors contributing to inaccuracies, such as hand-written prescriptions, inconsistent setting and study design, lack of an electronic reporting system and audits, and the use of a wide range of definitions for PEs.[8] Furthermore, what is known about the factors associated with PEs are not thoroughly examined. This study aimed to assess the prevalence, type, and severity of PEs that were reported electronically and verified for completeness. At the same time, the study also aimed to explore factors associated with PEs among adult patients at a large tertiary care system in Saudi Arabia.

PATIENTS AND METHODS

This study was a retrospective review of orders in the Medication Error Electronic Report Forms (MEERF) database reported by healthcare professionals for adult (aged >14 years according to the Saudi Ministry of Health and King Saud Medical City age classification guidelines) inpatient and outpatient prescriptions for the period between January 2017 and December 2018 at a large tertiary care hospital system in Riyadh, Saudi Arabia.[19,20] The healthcare setting is composed of three hospitals with a total bed-capacity of 1269 beds, dental and dialysis centers, and five primary healthcare clinics at which all inpatient and outpatient prescriptions were issued electronically by authorized physicians using the computerized physician order entry (CPOE) system. The healthcare system policy requires every healthcare professional to complete a MEERF for every ME, including PEs. Every MEERF is composed of 18 items that fulfill the medication safety criteria of the Institute for Safe Medication Practices, the Saudi Central Board for Accreditation of Healthcare Institutions, and WHO, which is adopted by the Saudi Ministry of Health.[4,21,22] Medication safety officers were responsible for evaluating and analyzing every MEERF for accuracy and completeness, presenting ME data quarterly to the Pharmacy and Therapeutics Committee, and ensuring preventive measures to avoid reoccurrence. PEs were identified and extracted from the MEERF database based on predetermined criteria (Appendix A). Ethical approval number (H1RI-16-Jul19-01) was obtained from the institutional review board of King Saud Medical City.

Data collection

All MEERFs documented between January 2017 and December 2018 were retrieved. Duplicate records were removed. PEs were identified and extracted from the MEERF database. Data was collected on patient gender, age, medications, drug class, route of administration, and high alert, look-alike and sound-alike medications, prescriber category, PE type, severity, location, time, and factors associated with or contributed to PEs. PE outcomes were classified per the National Coordinating Council for Medication Error Reporting and Prevention.[24] Coded data were exported to an Excel sheet for cleaning, management, and validation.

Medication classification

The Anatomical Therapeutic Chemical (ATC) classification system established by the WHO categorizes medications according to their effect on body organs or their chemical, therapeutic, and pharmacologic properties.[23] High alert medications pose a high risk of causing harm to patients and devastating consequences when they are used incorrectly (e.g., insulin, potassium chloride injection).[23] Look-alike/sound-alike (LASA) medications have similar looking or sounding names, which increases the potential for errors to occur.

Statistical analysis

Categorical variables are presented as frequencies and percentages. The chi-squared test was used to test the association between the exposure factors and outcome variables. All factors associated with PEs, with a *P* value <.1 and at least 20 observations in a univariate analysis were included in the multivariate logistic regression model. Data were analyzed using IBM SPSS (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Statistical significance was set at a *P* value of <.05.

RESULTS

Of 315166 prescriptions screened, 9685 MEERFs were reported; 6953 for adult patients, out of which 4934 errors were identified as PEs, with a prevalence of 1.56% (4934/315166) (**Figure 1**). The 2019 non-PEs were used as the other level of the binary multiple logistic regression. A total of 3358 adult patients were identified for 1.5 PEs per patient record; the majority were males (53.4%). The mean (SD) age of the study cohort was 48.4 (19.3) years. Patients aged 26 to 45 years (35.9%) and those aged 46 to 65 years (34.9%) made up the majority, while older patients represented 18.8% of the total study cohort.

The most frequently detected PE types were improper dose (n=1516; 30.7%) and frequency (n=987; 20.0%) (**Table 1**). Oral and parenteral were the most common routes of administration associated with PEs. Most were PEs without harm (n=3287; 66.7%); 40 prescriptions were PEs with harm (0.8%). A large number of PEs were reported as near misses (46.3%). The majority of the PEs were issued by medical residents (n=2577; 52%), followed by specialists (n=1629; 33%), and most occurred in medical wards (n=1970; 39.9%).

Anti-infectives for systemic use, particularly antibacterials, were the class most often associated with PEs (**Table 2**), among which cefuroxime was the anti-infective drug most often associated with PEs (**Figure 2**). In addition, omeprazole and enoxaparin were the most frequently reported individual medications associated with PEs (**Figure 3**). The high alert medications (enoxaparin, insulin, heparin, potassium chloride, warfarin, noradrenaline, and chemotherapy drugs) accounted for 18.0% of PEs (n=890), while LASA medications (folic acid, insulin, metformin, cholecalciferol, and ceftriaxone) accounted for 8.5% of PEs (n=420). Most of the PEs were reported by pharmacists (92%), followed by nurses (5.0%) and physicians (3.0%).

Multivariate risk factor analysis showed that PEs are significantly associated with anti-infective, antineoplastic and immunomodulating agents, systemic hormonal preparations excluding sex hormones and insulins, alimentary tract and metabolism, cardiovascular system, blood and blood-forming organs, and nervous system medication classes (**Table 3**). Moreover, the lack of documenting clinical information (age, weight, gender, diagnosis, allergy, medication history, etc.) was highly associated with PEs (adjusted OR 14.1, 95% CI 7.7:16.8, *P*<.01).

DISCUSSION

The prevalence of PEs among adult patients (>14 years of age) in a large healthcare system in Riyadh was 1.56 PEs per 100 prescriptions. PEs accounted for 71% of MEERFs. Furthermore, the most significant predictor for PEs was a lack of documenting clinical information. Among medication classes, prescribing anti-infectives, antineoplastic and immunomodulating agents, systemic hormonal preparations, high alert medications, and alimentary tract and metabolism medication classes were highly associated with PEs. Among individual medications, omeprazole, enoxaparin, cefuroxime, and atorvastatin were highly associated with PEs. There was no significant association between any particular prescribing group and PEs.

PE prevalence in our study was lower than that reported by national and international studies;[4,8,9,25] however, out of all MEs detected, PE rates were comparable to that reported in other studies.[26] This inconsistency of PE prevalence with other studies suggests the lack

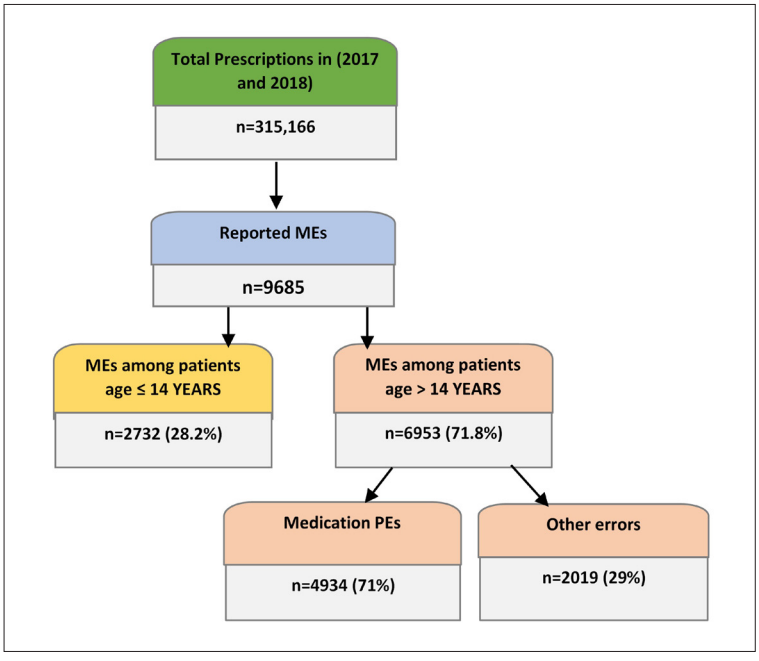

Figure 1. Selection of medication prescriptions for prescribing errors.

Table 1. Characteristics of reported medication prescribing errors (n=4934).

Improper dose (over, under or extra dose)	1516 (30.7)
Wrong frequency	987 (20.0)
Omission error	400 (8.1)
Wrong drug	353 (7.2)
Wrong strength/concentration	278(5.6)
Drug-drug interaction	216 (4.4)
Wrong duration	188 (3.8)
Wrong route	161 (3.3)
duplication therapy	159 (3.2)
Wrong dosage form	109 (2.2)
Medication without indication	100 (2.1)
Use prohibited abbreviation	90 (1.8)
Wrong documentation entry of medications	78 (1.6)
Incomplete information of prescription /order	76 (1.5)
Wrong rate of infusion	68 (1.4)
Wrong time of administration	52 (1.2)
Wrong patient	31 (1.1)
Diagnosis was not related to medications	28 (1.0)
Contraindicated	24 (0.5)
Patient allergic to medication prescribed	20 (0.4)
Route of administration	
Oral	2876 (58.3)
Injectable	1897 (38.4)
Topical	60 (1.2)
Inhalation	56 (1.1)
Other	45 (0.9)
Severity of PEs	
No Error	
A) Circumstances or events that have the capacity to cause error	1607 (32.6)
PEs with no harm	
B) An error occurred, but the error did not reach the patient, "Near Miss."	2283 (46.3)
C) An error occurred that reached the patient but did not cause patient harm	891 (18.1)
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	113 (2.3)
PEs with harm	
E) An error occurred that may have contributed to or resulted in temporary harm and required intervention	26 (0.5)
F) An error occurred that may have contributed to or resulted in temporary harm to the patient and required initial or prolonged hospitalization	12 (0.2)
G) An error occurred that may have contributed to permanent harm	0 (0.0)
H) An error occurred that required intervention necessary to sustain life	2 (0.1)
PEs cause death	
(I) An error occurred that may have contributed to a patient's death	0 (0.0)
Time of PEs occurrence	
Day shift	4562 (92.5)
Evening shift	372 (7.5)
Prescribers' group issued PEs	
Consultant	572 (11.6)
Specialist	1629 (33.0)
Resident	2577 (52.0)
Others	156 (3.2)
Location ward/unit involved	
Medical	1970 (39.9)
Surgical	322 (6.5)
Intensive Care Unit	320 (6.5)
Emergency Department	440 (8.9)
Obstetrics & Gynecology	75 (1.5)
Operation Room	57 (1,2)
Oncology	84 (1.7)
Outpatient Clinical	649 (13.2)
Discharge Lounge	5 (0.1)
AKU Center	149 (3.02)
Dental Center	2 (0.04)

Note: The total does not necessarily make 100% due to missing data.

PEs, Prescribing Errors

Table 2. Classes of medications associated with prescribing errors using the ATC classification system.

Medications by the ATC Classifications	Descriptive Statistics
Alimentary tract and metabolism drugs	1156 (23.4)
Digestives, incl. Enzymes	2 (0.1)
Drugs for acid related disorders	533 (0.1)
Drugs for constipation	47 (1.0)
Vitamins	165 (3.3)
Mineral supplements	120 (2.4)
Blood and Blood forming organs drugs	629 (12.7)
Antianemia preparations	95 (1.9)
Blood substitutes and perfusion solutions	32 (0.6)
Antithrombotic agents	498 (10.1)
Antihemorrhagics	3 (0.1)
Cardiovascular system drugs	871 (17.7)
Agents acting on the renin-angiotensin system	200 (4.1)
Calcium channel blockers	109 (2.2)
Beta blocking agents	120 (2.4)
Antihypertensives	17 (0.3)
Diuretics	36 (0.7)
Cardiac therapy	65 (1.3)
Lipid modifying agents	324 (6.6)
Dermatological drugs	84 (1.7)
Antifungals for dermatological use	12 (0.2)
Corticosteroids, dermatological preparations	64 (1.3)
Antibiotics and chemotherapeutics for dermatological use	5 (0.1)
Other dermatological preparations	3 (0.1)
Genitourinary system and sex hormones drugs	36 (0.7)
Sex hormones and modulators of the genital system	18 (0.4)
Urological	10 (0.2)
Other gynecological	8 (0.2)
Systemic hormonal preparations, excluding sex hormones and insulin	53 (1.1)
Thyroid therapy	39 (0.8)

Table 2 (cont.). Classes of medications associated with prescribing errors using the ATC classification system.

Medications by the ATC Classifications	Descriptive Statistics
Calcium homeostasis	2 (0.1)
Pituitary and hypothalamic hormones and analogs hormones and insulins	12 (0.2)
Anti-infectives for systemic use	1322 (26.8)
Antibacterial for systemic use	1213 (24.6)
Antivirals for systemic use	86 (1.7)
Antimycotics for systemic use	24 (0.5)
Antineoplastic and immunomodulating agents	176 (3.6)
Antineoplastic agents	153 (3.1)
Immunosuppressants	23 (0.5)
Musculoskeletal system drugs	171 (3.5)
Anti-inflammatory and antirheumatic products	148 (3.0)
Muscle relaxants	4 (0.1)
Drugs for treatment of bone diseases	4 (0.1)
Antigout preparations	15 (0.3)
Nervous system drugs	273 (5.5)
Analgesics	143 (2.9)
Psycholeptics	57 (1.2)
Antiepileptics	60 (1.2)
Anti-parkinson	7 (0.1)
Anesthetics	5 (0.1)
Respiratory system drugs	92 (1.9)
Antihistamines for systemic use	35 (0.7)
Drugs for obstructive airway diseases	48 (1.0)
Nasal preparations	2 (0.1)
Cough and cold preparations	7 (0.1)
Antihistamines for systemic use	35 (0.7)
Sensory organs drugs	38 (0.8)
Ophthalmological	38 (0.8)
Various other drugs	33 (0.7)
Diagnostic agents	33 (0.7)

of a systematic method for detecting PEs. Despite the availability of CPOE and electronic medical information databases, these systems appear to be incapable of providing accurate and precise detection of MEs and PEs. More sophisticated software systems such as machine learning and artificial intelligence have been shown to be effective in ME and PE detection.[27] On the other hand, poor documentation was significantly associated with PEs in our study; nevertheless, poor documentation has been minimally addressed in the literature.[28-30] Inappropriate documentation and charting of medical information remains an issue that jeopardizes patient safety and continuity of care. It is not an internal problem, rather it is a matter of malpractice by prescribing physicians and underutilization of available resources.[31] Evidence has shown that proper documentation ensures the safe transition of healthcare, maintains quality assurance, and improves patient safety.[32,33] One of the suggested solutions to improve documentation/charting of medical information in electronic health records is the utilization of bedside and point-of-care systems such as computers on wheels.[34]

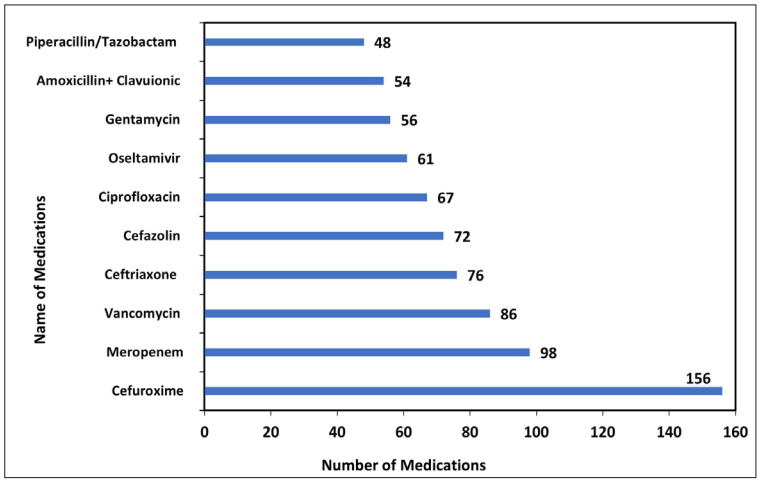

Figure 2. The most common anti-infective medications associated with prescribing errors.

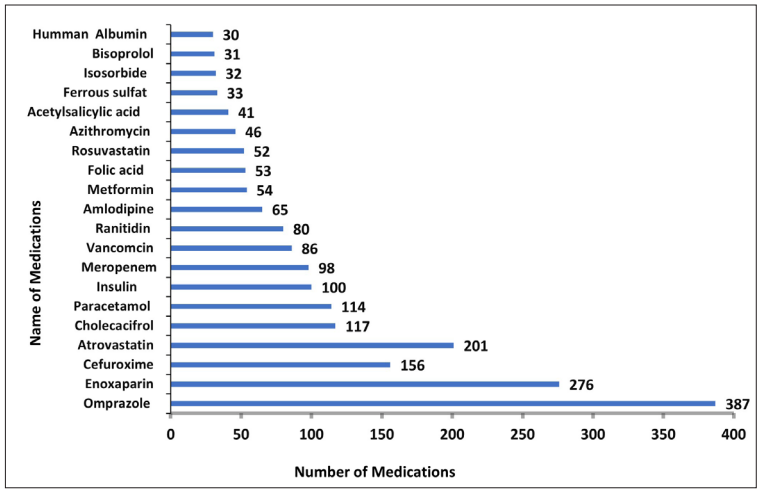

Figure 3. The most common medications involved in prescribing errors.

Improper dose and frequency were the most prevalent types of PEs; prescribing of anti-infective drugs, antibacterial, in particular, was highly associated with PEs, out of which cefuroxime (12.9%), meropenem (8.1%), while vancomycin (7.1%) stood out as the most common antibiotics with PEs. Cefuroxime and vancomycin are considered first-line antibiotics in multiple infectious diseases, which unspecialized physicians can prescribe in some circumstances, justifying their association with PEs. However, meropenem is a reserved antibiotic that should be prescribed by infectious diseases (ID) physicians when no other options are available. This could explain the emergence of antimicrobial resistance observed in hospitals and supports the desperate need to establish antimicrobial stewardship programs and recruit infectious disease clinical pharmacists.[35,36] Omeprazole was the most individual drug associated with PEs, despite its safety profile and controversy over excessive prescription by physicians. Reports have shown that the rate of inappropriate prescribing of proton pump inhibitors for stress ulcer prophylaxis could reach up to 71%, which has been attributed to prescribing physician ignorance of proper indications and its side effects such as Clostridium difficile infections.[37,38]

Inappropriate documentation of medical information is a common problem in hospitals.[31] The issue compromises patient safety and continuity of care, constitutes malpractice by prescribing physicians and underuses available resources. Evidence has shown that proper documentation ensures the safe transition of healthcare, thus maintaining quality assurance and improving patient safety.[32,33] One of the suggested solutions to improve documentation/charting of medical information in electronic health records is the utilization of bedside and point-of-care systems such as computers on wheels.[34]

Our study is the largest retrospective study of PEs in Saudi Arabia. Limitations include not considering the total number of drugs prescribed in each prescription as polypharmacy increases the probability of PEs. This study is exclusively based on the voluntary reporting of MEs, and there is a possibility that other prescribing errors not included could exist. In addition, this includes data from a single healthcare setting;

Table 3. Multiple logistic regression analysis of factors associated with prescribing errors among patients older than 14 years of age (n=4934).

Characteristics	Prescribing errors (n=4934)	Medication errors other than prescribing errors (n=2019)	*P* value	Odds ratio (OR) (95% CI)	Adjusted OR (95% CI)
Mean (SD) age (years)	48.4 (19.23)	49.9 (18.79)	.04	**1.3 (1.1-1.3)**	0.9 (0.7-1.1)
Gender					
Male	2736	1170	<.01	**1.3 (1.1-1.6)**	1.0 (0.9-1.3)
Female	2198	849			
Time					
Day shift (0700-1900)	4562	1480	<.01	**4.5 (3.9-5.2)**	1.1 (0.9-1.9)
Route of administration					
Oral	2876	821	<.01	**2.0 (1.8-2.3)**	0.4 (0.5-1.7)
Injectable	1897	1100	<.01	0.5 (0.5 -0 .6)	0.5 (0.5-0.6)
Inhalation	56	43	.01	0.5 (0.4-.8)	0.5 (0.4-0.8)
Topical	60	33	<.01	0.5 (0.2-2.3)	0.5 (0.2-2.3)
Other (reference level)	45	22	<.01		
Medication class					
Anti-infective for systemic use	1322	815	<.01	**1.8 (1.1-2.4)**	**2.9 (1.3-5.7)**
Alimentary tract and metabolism	1156	289	<.01	**2.7 (1.9-3.5)**	**2.2 (1.8-2.7)**
Cardiovascular system	871	287	<.01	**2.2 (1.6-3.1)**	**1.9 (1.6-2.3)**
Blood and blood forming organs	629	201	<.01	**1.7 (1.2-2.4)**	**1.6 (1.3-1.9)**
Nervous system	273	153	<.01	**2.4 (1.9-4.8)**	**1.5 (1.3-1.9)**
Antineoplastic and immunomodulating agents	176	31	<.01	**2.9 (1.6-5.2)**	**2.6 (1.6-4.3)**
Musculoskeletal system	171	35	<.01	0.9 (0.7-1.4)	0.8 (0.6-1.3)
Respiratory system	92	56	.02	0.8 (0.3-1.9)	0.7 (0.2-1.9)
Dermatological	84	34	.96		
Systemic hormonal preparations excluding sex hormones and insulins	53	30	.02	**2.8 (1.3-5.7)**	**2.3 (1.2-4.7)**
Sensory organs	38	11	.31		
Genitourinary system and sex hormones	36	6	.04	0.9 (0.8-1.9)	0.8 (0.3-1.5)
Various (reference level)	33	71	<.01		
Prescriber made error			<.01		
Consultant	572	59	<.01	0.9 (0.1 -1.0)	0.3 (0.2-0.4)
Specialist	1629	117	<.01	0.9 (0.1-1.0)	1.0 (0.1-2.0)
Resident	2577	202	<.01	1.0 (0.23-1.1)	1.0 (0.1-2.0)
Others (reference level)	156	179	.01		

Table 3 (cont.). Multiple logistic regression analysis of factors associated with prescribing errors among patients older than 14 years of age (n=4934).

Characteristics	Prescribing errors (n=4934)	Medication errors other than prescribing errors (n=2019)	*P* value	Odds ratio (OR) (95% CI)	Adjusted OR (95% CI)
High alert medication					
Yes	890	239	<.01	**1.7 (1.4-2.2)**	**2.3 (1.5-3.2)**
Look-a-like and sound-alike medication			<.01		
Yes	420	244	<.01	**1.8 (1.5-2.3)**	**1.8 (1.4-2.3)**
Other causes[a]			<.01		
Lack of documenting clinical information	1279	83	<.01	**14.1 (8.3-16.7)**	**14.1 (7.7-16.8)**
Drug information missing	1441	1601	<.01	1.3 (0.9-1.7)	1.0 (0.7-1.4)
Miscommunication of drug order	749	166	<.01	0.9 (0.5-1.1)	0.6 (0.4-1.1)
Physicians schedule overload	485	141	<.01	0.9 (0.7-1.4)	0.8 (0.2-1.2)
Physicians outdated medication information	1684	310	<.01	**1.6 (1.3-1.7)**	**1.6 (1.4-1.7)**
Improper medical history retrieval	53	16	.04	**1.5 (1.3-1.6)**	**1.3 (1.2-1.8)**
Improper order verification	221	115	.03	0.9 (0.2-1.3)	0.4 (0.2-1.1)
Inconsistent supply of medications (reference level)	746	929	<.01		

Bolded values included in multiple logistic regression model. [a]Causes listed on the Medication Error Electronic Report Forms.

Model Summary

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
5323.376[a]	.356	.508

[a]Estimation terminated at iteration number 6 because parameter estimates changed by less than .001

however, such a system unifies the method of detection, reporting, and definition of PEs. In conclusion, inadequate documentation in electronic health records and prescribing of anti-infectives were the most common predicting factors for PEs. Future studies should focus on testing innovative measures to control these factors and their impact on minimizing PEs.

Acknowledgments

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