Title: A Comparative Analysis of Electronic Prescribing Near Misses in King Saud Medical City, Riyadh, Saudi Arabia

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Background:

A "near miss" or close call is a medication error that happened but did not result in injury or damage to the patient. These medication errors (MEs) are captured and corrected before affecting the patient either fortuitously or purposefully by designed system controls imbedded in electronic health record (EHR) as well as electronic prescribing systems (EPS).

Objective: This study analyzed the reported electronic prescribing near misses (NMs) in King Saud Medical City (KSMC) in Riyadh city.

Methods: The ME report forms were consecutively collected over a period of one year, from 1 January to 31 December, 2012. These forms were evaluated for data abstraction and a comparative analysis of NMs/NM report forms of first 6-month (n=1025, timeline 1) versus second 6-month (n=2398, timeline 2) was carried out. No systematic intervention prior to timeline 2 was used in this study.

Results: The total number of MEs/NMs report forms was 3423 and total number of reported NMs was 7415, as each form could contain more than one NM. Drug prescription items, medication dispensing stages, NM makers and identifiers, underlying causes, sites of errors, prescribed drugs and suggested actions to avoid NM errors all differed significantly between the two timelines, which could be attributed to natural, real world practices in KSMC.

Conclusion: This prospective study found significant differences in factors related to NMs between two six month periods in a single year. Reasons for these differences between two timeframes remain poorly understood. NMs comparative studies using systematic interventions are warranted in the Kingdom of Saudi Arabia.

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1. INTRODUCTION

A near miss is a medication error that happened but did not reach the patient. Near miss may also be defined as an error that reached the patient but did not result in harm [1]. According to the Agency for Healthcare Research and Quality (AHRQ), a near miss is an event or situation that did not produce patient injury only because of chance [2]. However, the Institute for Safe Medication Practices (ISMP) has criticized this definition [1]. ISMP considers a near miss as a close call, which is an event, situation, or error that took place but was captured before reaching the patient. European researchers extensively reviewed the literature on the definition of NM and defined three near miss incidents (Type 1-3) [3]. These were based on a combination of "patient reached" and "patient harmed", and focused on error handling processes in terms of detection, explanation, countermeasures and their combinations. As a result, they developed a near miss incident matrix. Near misses and medication errors are considered medical incidents (MIs) [4]. Electronic health records (EHRs) embedded with electronic prescribing system (EPS) considerably reduces medication incidents [3-13].

There is much less literature on electronic prescribing (EP), and medical incidents in the Eastern world [14-15]. Recently, one descriptive study has explored electronic prescribing near misses (NMs) in King Saud Medical City (KSMC), Riyadh, Saudi Arabia [16]. However, this paper comparatively examines electronic prescribing near misses voluntarily reported over one year and attempts to elucidate factors that impact electronic prescribing NMs in KSMC, Riyadh, Kingdom of Saudi Arabia (KSA).

2. OBJECTIVE AND SCOPE

This study seeks to estimate the monthly rate of NMs during the year 2012 in KSMC, Riyadh, and compare factors influencing NMs between the first and second [T1 and T2] six months of the year, building on our previous work [16]. This study attempts to discuss the personal, ecological and system influences, i.e., real world practice factors at KSMC that might have affected the occurrence of NMs during the two timeframes. The main assessment involves electronic prescribing NMs recorded in ME report forms during the year 2012. In addition, monthly NMs were also gathered from e-prescribing data available in pharmaceutical care department. The scope of this study is larger as it explores the rate and possible real world practice determinants of NMs over a period of one year and the findings of this study may help medical city planners to develop medication safety plan, further

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organize medical services especially during second half of the year, tailor targeted training courses and prevention strategies to reduce near misses in different hospitals and ambulatory care services in KSMC and by extension patient safety will improve.

3. MATERIAL AND METHODS

The study was conducted from 1 January to 31 December 2012 at KSMC, which is a major 1400-bed tertiary care hospital. In 2006, KSMC became the first Ministry of Health (MOH) hospital to implement an electronic prescribing system (EPS). This tertiary care hospital serves a wide range of patients drawn from a large population in and around Riyadh, many of whom present with complex medical problems and are referred from different regions of KSA. The hospital's MEDI system, i.e., electronic health record system, has been upgraded regularly since 2006. The EPS is connected to the MEDI system. The number of daily e-prescriptions at KSMC varies and does not include paper prescription or medication orders written on patients' charts.

Medical incidents (MIs) are reported voluntarily to the medication safety unit of KSMC. All healthcare providers and consumers can report medication errors (MEs) to this unit. Two coordinators, one from pharmacy and the other from Drug Poisoning Information Center (DPIC) work on electronic MEs data collection, its entry into the computer, and statistical analysis. They also produce quarterly ME reports. All MEs reporters are required to complete an ME reporting form. The completed ME forms are screened and reviewed by the pharmacy designee in the medication safety unit for deciding whether or not the reported ME is a near miss. Thereafter, this ME form is sent to DPIC for further review and statistical analysis. Sentinel errors are investigated by a committee using root cause analysis (to be reported in a forthcoming paper). Two other methods for reporting electronic prescribing NMs not used in this study are web and telephone.

NMs in the present report were examined during the two consecutive six-month timeframes [T1 & T2]. No systematic intervention, such as a randomized clinical trial, was implemented between T1 and T2 to influence NMs in this study. We examine here the role of real world practice factors that might have affected NMs between the two arbitrary time periods. These real world practice factors are not measured in this study. KSMC setting factors that may have had an influence included the implementation of a medication safety unit in mid-year 2012; organization of a medication safety committee; design and distribution of a medication error flow chart in all KSMC departments; assigning an ME pharmacist to all departments of KSMC; implementation of twice-monthly educational and awareness sessions on MEs for all nurses, pharmacists, and physicians, including newly employed staff; adoption of a blame-

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free culture in reporting and documenting MEs; distribution of posters and brochures on MEs throughout KSMC; and an annual evaluation and competency report of activities to motivate and engage employees in reporting and documenting MEs. Finally, annual vacations taken by staff and time off for Ramadan (fasting) and Hajj (pilgrimage) that occurred especially during T2 may have influenced near misses occurrence, identification and reporting during that period. An arbitrary division of year 2012 into two timelines -T1 and T2 were also impacted by these factors and unstructured programs.

3.1 DATA COLLECTION

All medication error report forms were evaluated by the pharmacist and Drug Poisoning Information Center staff. The relevant data were abstracted from these forms. The variables examined were gender, medication-related variables such as drug types, 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 electronic prescribing NMs made, settings where NMs were made, actions taken to avoid the occurrence of NMs, and suggested recommendations for preventing electronic prescribing NM errors in the future. In addition, real practice MEs safety/prevention programs at KSMC were also identified. For this purpose, key pharmaceutical care managers of KSMC were consulted. This study was approved by the Academic Department of KSMC that gave permission to analyze and publish our findings regarding electronic prescribing NMs.

3.2 DATA ANALYSIS

Data were analyzed using the Statistical Package for Social Sciences version 17 software (IBM Corporation, Armonk, NY, USA). Descriptive statistics were used to calculate frequencies and percentages. We also calculated rate of NMs for each month during the year 2012. The NM rate was equal to the number of NMs for a particular month X 100 divided by the number of prescriptions made during the month. The NMs data for T1 and T2 were compared using z-test. This test is used to compare two proportions created by two random samples or two subgroups of one random sample. Exact p values are reported in various tables and value equal or less than .05 was considered significant. Most of p values are .001. Bar graph for NMs/ME report forms of the year 2012 was plotted.

4. RESULTS

A total of 3,423 NM report forms were collected between January 1, 2012 and December 31, 2012. Although the total number of electronic prescribing NM report forms was 3,423, each

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form could contain more than one near miss. The number of NM report forms that contained more than one NM error was 1163 (34%). The number of NMs was 7415 for the year 2012 [Table 1, during T1=2,716 and T2=4699] and reporters' and interveners responses as shown in various tables [T2-10 and T1 and T2] differ across individual items listed in the NM report forms. This is possibly attributed to missing values in NM report forms. The numbers of NM report forms in first and second half of the year were 1,025 (29.9%) and 2,398 (70.1%), respectively. The distribution of ME/NM report forms by month (Figure 1-Bar graph) showed that they ranged from 55 to 898 per month.

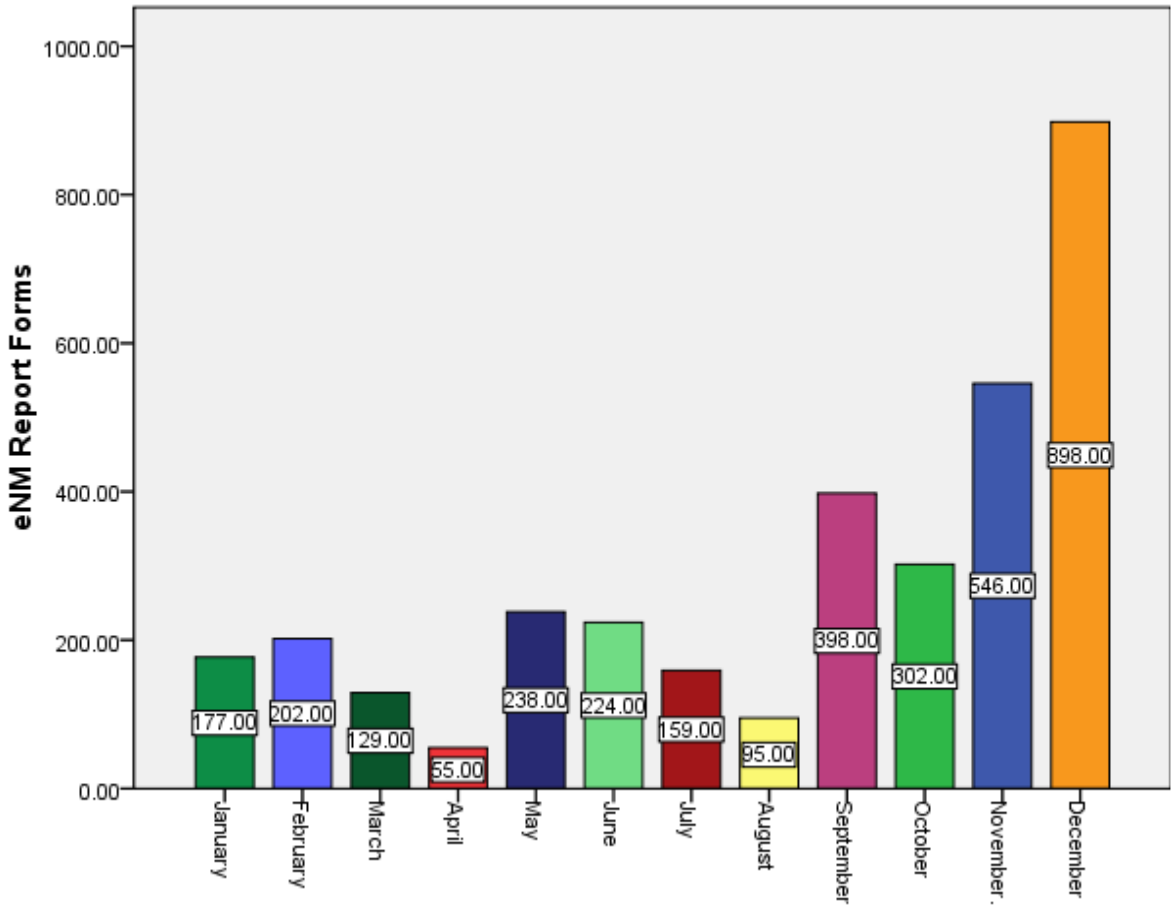

Figure 1: eNM Report Forms by Months

The Table 1 presents the monthly distribution of electronic prescriptions, frequency of NMs and their rates.

Table 1. NMs by month in 2012

Month / Variable	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total

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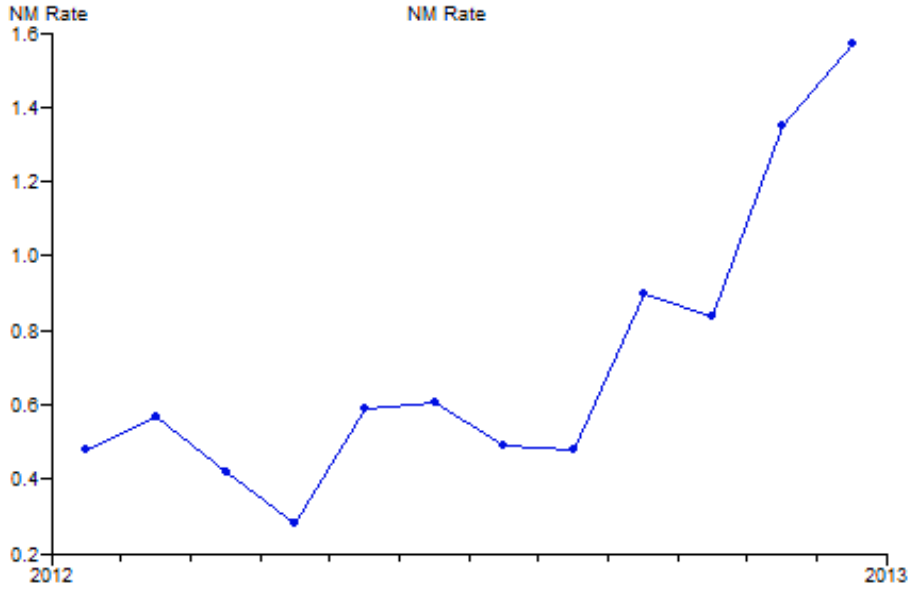
No. of prescription	96321	92000	86012	88829	97548	88821	83644	65163	86819	78053	77154	95718	1036082
No. of NMs	459	527	361	252	572	545	406	315	785	657	1038	1498	7415
Rate of NMs%	0.48	0.57	0.42	0.28	0.59	0.61	0.49	0.48	0.90	0.84	1.35	1.57	0.72

The number of NM report forms during T2 (n=2,398, 70.1%) was more than double those in T1 (n=1025, 29.9%). Males comprised 58.7% (n=602) of NMs during the first 6-months compared to 48.8% (n=1170) during the second 6-months. Time-series graph (Figures 2) of NMs shows the different rates (in percentages) of NMs between T1 and T2 during 2012.

Figure 2. Time-series graph of month-wise NMs rate for the year 2012.



Compared to T1, there was significant decrease in incorrect doses, wrong dosage forms, drug-drug monitoring, wrong quantity, and wrong patient during T2, whereas there was a significant increase in wrong strength/concentration and wrong route. Other drug related variables did not differ between the two timelines (Table 2).

Table 2. Distribution of drug-related variables in NMs medication errors*

Medication variables in NMs	First 6-months		Second 6-months		Z value	P value
	No. of Cases	%	No. of Cases	%		
Wrong Frequency	266	25.95	633	26.27	0.42	.67
Incorrect Dose	250	24.39	415	16.57	5.39	.007
Wrong Drug	126	12.29	343	13.69	1.11	.26
Wrong Duration	97	9.46	242	9.66	0.18	.85

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Wrong Strength/ Concentration	92	8.98	529	21.12	8.60	.001
Wrong Dosage Form	57	5.56	94	3.75	2.41	.01
Monitoring Error-Drug-Drug	53	5.17	70	2.79	3.49	.005
Wrong Quantity	28	2.73	9	0.36	6.28	.001
Wrong Patient	21	2.05	22	0.88	2.87	.004
Omission Error	14	1.37	21	0.84	1.43	.15
Wrong Documentation	12	1.18	28	1.12	0.13	.89
Wrong Route	4	0.39	74	2.95	4.70	.003
Wrong Rate	3	0.29	14	0.56	1.03	.29
Wrong Time of Administration	2	0.19	11	0.44	1.08	.27
Total	1025	100%	2505	100%		

Reporters' responses related to drug-variable items listed in NM report forms

NMs significantly decreased during transcription and entering, monitoring and administration stages of medication processing during T2 compared to T1. However, NMs related to physician orders significantly increased during T2 compared to T1. There was no difference in NMs between T1 and T2 for the dispensing and delivery stages (Table 3).

Table 3. Stages during which near miss medication errors were discovered*

Stages Involved	First 6-months		Second 6-months		Z value	P value
	No. of Cases	%	No. of Cases	%		
Transcription & Entering	676	55.32	1074	43.93	6.51	.001
Physician Ordering	397	32.49	1150	47.03	8.40	.001
Dispensing & Delivery	115	9.41	210	8.59	0.82	.41
Monitoring	24	1.96	8	0.33	5.02	.005
Administration	10	0.82	3	0.12	3.34	.008
Total	1222	100%	2445	100%		

Reporters' responses to listed drug processing stages during which NMs were identified.

Physicians and pharmacists made significantly fewer NMs during T2 compared to T1 and nurses and assistant pharmacists made significantly more NMs during T2 compared to T1 (Table 4).

Table 4. Health professionals who committed near miss medication errors

Health professionals	First 6-months		Second 6-months		Z value	P value
	No. of Cases	%	No. of Cases	%		
Physicians	493	47.27	282	10.42	24.96	.001
Nurses	436	41.80	2197	81.18	23.63	.001
Pharmacists	66	6.33	29	1.07	9.1	.001

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Asst. Pharmacists	48	4.60	198	7.33	3.0	.002
Total	1043	100%	2706	100%		

Furthermore, pharmacists were more likely to identify NMs during T1 compared to T2. A significant reverse trend was observed for assistant pharmacists who identified more NMs during T2 compared to T1. There were no significant differences in NM identification between nurses, physicians and clinical pharmacists between two time periods, although the latter group does not usually engage in medication dispensing (Table 5).

Table 5. Health professionals who identified near miss medication errors

Error Identifiers	First 6-months		Second 6-months		Z value	P value
	No. of Cases	%	No. of Cases	%		
Pharmacist	1002	97.28	2251	93.83	4.19	.003
Nurse	14	1.36	24	1.00	0.92	.35
Asst. Pharmacist	10	0.97	119	4.96	5.62	.002
Clinical Pharmacist	2	0.19	1	0.04	1.38	.166
Physicians	2	0.19	4	0.17	0.17	.86
Total	1030	100%	2399	100%		

Corrective actions by health professionals in response to NM medication errors significantly decreased between T1 and T2 with regard to dose corrections, calls for clarification, cancelled drugs, forwarding orders to health providers, discontinuation of drugs, and occurrence of variance report (OVR). Conversely, actions taken by professionals significantly increased from T1 to T2 with regard to pharmacist noting NM and waiting for response and no drug dispensing (Table 6).

Table 6. Actions taken by pharmaceutical staff in response to near miss medication errors*

Action	First 6-months		Second 6-months		Z value	P value
	No. of Cases	%	No. of Cases	%		
Change to correct dose/ drug/duration/ frequency/rate/ route/dosage form/patient/strength/quantity	710	34.97	1025	19.03	14.45	.001
Pharmacist note & wait for response	358	17.64	1880	34.91	14.45	.001
Call reporter for clarification	471	23.20	322	5.98	21.39	.001
No Dispensing	331	16.31	1900	35.28	15.88	.001
Educational Session	48	2.36	156	2.89	1.24	.21
Cancelled drug	28	1.38	16	0.29	5.41	.006
Forward order to nurse/physician/pharmacist	28	1.38	27	0.79	3.92	.009
D/C Drug	24	1.18	17	0.32	4.48	.007

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Informed Nurse/Physician to change the order	12	059	22	0.41	1.03	.29
OVAR	11	0.54	8	0.15	2.98	.003
Supervise the Asst. Pharmacist/Pharmacist during dispensing	9	0.44	12	0.22	1.59	.111
Total	2030	100%	5385	100%		

Pharmacy staff took appropriate actions in response to reported NMs identified in NM report forms/e-prescriptions.

According to the perceptions of NM reporters, the main causes for NMs were wide-ranging (Table 7). Notably, lack of education and miscommunication regarding the drug order as causes for NMs increased significantly between T1 and T2. On the other hand, environmental, staffing, or workflow problems, drug information missing, drug name/label/package problems, lack of quality control or independent check system, clinical information missing, drug delivery device problems and drug storage or delivery problems significantly decreased between T1 and T2. However, patient education problems as a cause for NMs did not differ significantly between the two time periods (Table 7).

Table 7. Causes of near miss medication errors*

Cause of Error	First 6-months		Second 6-months		Z value	P value
	No. of Case	%	No. of Case	%		
Lack of Staff Education	419	34.12	2127	49.95	9.80	.001
Miscommunication of Drug Order	387	31.51	1865	43.79	7.71	.001
Environmental, Staffing, or Workflow Problem	199	16.21	89	2.09	19.53	.001
Drug Information Missing	121	9.85	99	2.33	11.84	.001
Drug Name, Label, Package Problem	40	3.26	50	1.17	5.06	.004
Lack of Quality Control or Independent Check System	39	3.18	11	0.26	9.47	.001
Clinical Information Missing	15	1.22	12	0.28	4.14	.003
Drug Delivery Device Problem	4	0.33	2	0.04	2.60	.009
Drug Storage or Delivery Problem	3	0.24	1	0.02	2.52	.011
Patient Education Problem	1	0.08	2	0.04	0.45	.64
Total	1228	100%	4258	100%		

*Reporters' responses to listed causes in NM report forms when they report one or more NMs

Regarding locations where NM medication errors were reported and made, NMs significantly decreased between T1 and T2 for the inpatient-pharmacy and other settings. Conversely, NMs increased significantly between T1 and T2 at the OR-pediatric hospital, possibly because the training programs in this setting did not highlight and emphasize pediatric ME problems (Table 8).

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Table 8. Locations where near miss medication errors were made*

Site of Errors	First 6-months		Second 6-months		Z value	P value
	No. of Case	%	No. of Case	%		
OPD-General Hospital	453	44.67	841	34.88	5.39	.007
ER-General Hospital	237	23.37	767	31.81	4.95	.007
OPD Maternity Hospital	203	20.02	326	13.52	4.80	.002
In-Patient Pharmacy	53	5.23	33	1.37	6.58	.001
OPD-Pediatric Hospital	23	2.27	136	5.64	4.28	.002
Out-Patient Pharmacy	22	2.17	42	1.74	0.84	.39
ER-Pediatric Hospital	12	1.18	169	7.01	6.95	.001
OR-Pediatric Hospital	7	0.69	47	1.95	2.70	.006
Others	4	0.39	50	2.07	3.8	.001
Total	1014	100%	2411	100%		

*Location will remain the same but reporters may identify more than one NM there and its documentation in NM report forms.

The NMs decreased significantly between T1 and T2 in relation to cardiovascular agents, metabolic agents, and miscellaneous drugs. However, NMs significantly increased between T1 and T2 in relation to coagulation modifiers, respiratory agents, psychotherapeutic agents (Table 9).

Table 9. Medications involved in near miss medication errors*

Medications	First 6-months		Second 6-months		Z value	P value
	No. of Cases	%	No. of Case	%		
Anti-infective	239	22.61	512	20.61	1.33	.18
Cardiovascular agents	207	19.58	354	14.25	3.97	.007
CNS Agents	154	14.57	367	14.77	0.15	.87
Nutritional products	69	6.53	130	5.23	1.53	.12
Gastrointestinal Agents	67	6.34	145	5.84	0.57	.56
Coagulation modifiers	64	6.05	837	33.69	17.28	.001
Metabolic agents	46	4.35	76	3.06	1.92	.05
Hormones	39	3.69	79	3,18	0.77	.43
Respiratory agents	37	3.50	412	16.59	10.71	.001
Topical agents	29	2.74	56	2.25	0.87	.38
Genitourinary Tract Agents	19	1.81	36	1.45	0.76	.44
Psychotherapeutic Agents	17	0.95	92	3.70	3.30	.001
Antineoplastics	13	1.23	21	0.85	1.07	.28
Miscellaneous agents	57	5.39	98	3.95	1.92	.05
Total	1057	100%	2484	100%		

*Reporters' responses to listed medications involved in NMs

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Recommendations by NM reporters decreased significantly between T1 and T2 with regard to double checks and patients counseled, whereas CME, stop nurse drug entry, medication reconciliation, and system upgrade all significantly increased from T1 to T2 (Table 10).

Table 10. Recommendations to avoid near miss medication errors*

Recommendation	First 6-months		Second 6-months		Z value	P value
	No. of Cases	%	No. of Cases	%		
Double Check	822	50.09	426	12.59	28.84	.001
CME	511	31.14	1276	37.72	4.56	.005
Physician Entry/stop nurse medication entry	303	18.46	1484	43.87	17.63	.001
Medication Reconciliation	3	0.18	96	2.84	6.35	.002
Patient Counseling	2	0.12	--	--	2.03	.042
System Upgrade	--	--	101	2.98	7.07	.001
Total	1641	100%	3383	100%		

*Reporters' responses to listed recommendations in NMs report forms when they report NMs

5. DISCUSSION

This study estimated the NM rate and compared important aspects of electronic prescribing NMs across two timelines in a tertiary care hospital in Riyadh City. Unlike the female predominance in MEs, males were slightly overrepresented (1772 males versus 1651 females from e-prescriptions) in this and our previous study [16] despite the fact that in ambulatory care females tend to utilize more healthcare services. However, the number of females increased during T2 matching the universal trend [17]. Other factors that also impact healthcare utilization include reproductive biology and age-related mortality [17]. Conventional wisdom would suggest that overutilization of healthcare services by females should increase their risk of having more NMs; however, the reverse was the case in this study, at least during T1. In the second half of the year, pressure on prescribers to utilize medication stock before the end of the year may have also contributed to this finding. Our finding that females who utilize more healthcare services paradoxically tend to have fewer NMs diverges from other reports [22] and, therefore, needs replication in future studies.

For some outpatient departments and the inpatient pharmacy at KSMC, there was significant drop in NMs between T1 and T2 possibly due to the implementation of a medication safety plan, regular training of staff especially pharmacy personnel, and rigorous quality monitoring. Other important sites for NMs were pediatric and adults emergency and maternal ambulatory care services, which is consistent with other studies [5-6,12,16,18]. In these settings, except for the maternity hospital, the proportion of NMs increased significantly between T1 and T2, possibly due to staff shortages and less rigorous quality monitoring in emergency settings

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during the Hajj season, when healthcare providers' services are diverted to the two holy sites and the training programs not targeting pediatric and emergency ME problems. While other factors [19] also influence the occurrence of medical incidences (MIs) and reporting, how they affect the occurrence of MIs throughout the year are unknown.

In general, factors such as patient's age, weight, diagnosis, prescribed medications, experience of health care providers, practice setting, and the presence or absence of EPS have a strong impact on the prevalence of MEs [19]. Interestingly, similar factors predict the occurrence of NMs [20], an important aspect of medication errors. Myers and associates substantiated that the causes of and contributing factors to MEs are similar to those involved in NMs [8]. Addressing the same issue, a study from Japan examined predictors of NMs and adverse events and found that those for NMs and adverse events are quite similar. Years of experience, frequency of night shifts, ward location, and time pressure were all significantly related to both NMs and adverse events. According to this study, there was little difference between the causes of NMs and those of adverse events [20].

According to the present study, the rates of near misses/close calls varied throughout the year and were significantly higher during T2 (n=4699 vs.2716). This finding is consistent with other studies, which also report variable prevalence of electronic prescribing MEs and NMs [9,16,21-25]. Variations in the prevalence rate of medication errors have been attributed to different factors including methodology, definitions of MEs, study settings, classifications of MEs, and sample size [23-24], which may also help to explain the differences reported regarding electronic prescribing NMs. In a systematic review of medication errors, researchers reported prevalence of MEs ranged from 2% to 75%, with no association found between how MEs were defined and their prevalence. However, the majority of studies reported prevalence rates below 10% [24]. Approximately 35% of MEs are potentially preventable adverse events/near misses [25]. Arguably, NMs that are not checked and corrected will lead to a significant rise in MEs with consequences that range from mild to serious to fatal. Therefore, the primary reason for identifying and correcting NMs is to improve the management of health care systems so that health risks are reduced and patient safety is further improved. However, both MEs and NMs are frequently underreported [4,12,26] as we found in the present study. The monthly NM rate here ranged from 0.48 % to 1.57%, with an overall annual rate of 0.72%.

A variety of clinical factors related to NMs decreased significantly between T1 and T2, whereas others increased. However, some factors, including the wrong time of drug administration, did not change between T1 and T2. Though no straightforward explanations can be offered, medication safety programs and related training courses on medical incidents may have contributed. However, these variables have been reported as causes for

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medical incidents in previous studies [16,27-29]. These findings argue for the presence of electronic checks in the process of prescribing and dispensing medications throughout the year in order to prevent these medical incidents and the adverse health consequences and economic losses involved [30-31]. The correct and complete documentation of medication-related variables in e-prescriptions is mandatory and strongly recommended in clinical and pharmaceutical practice worldwide. Only when this is accomplished will patient safety, quality care, cost reductions and decreased morbidity and mortality be ensured across the healthcare system [19]. This has been substantiated in at least one study of NM events on labor and delivery, in which medication and patient identification errors were the most common near miss events [5]. In another study of perceptions of perioperative nurses, personal factors reflecting “communication between team”, “inconsistent information,” and “incorrect monitoring” were the most frequently identified causes of near misses [7].

Medical incidents (MIs) can occur at any one of the five stages of medication administration, including medication prescribing [16,26]. To address this issue further, a study found that the phase affected by the most medication errors in all three models was transcription and the least affected phase was administration, but prescription errors were the worst in single-dose systems [32]. In another study, nurses reported that medication administration and transcription errors were the most frequent types of NMs caused by personal factors rather than by institutional factors. This study emphasized that education to avoid personal errors, including STAR, i.e., stop, think, act, review, and verification of proper procedures, was imperative for nurses to avoid NMs [10]. In mental health settings, medication administration errors are the most common errors, and distraction, poor communication and being unfamiliar with the ward are common contributory factors [11]. These results underscore the importance of double checking, training of health professionals, and focusing on physician entry in reducing near misses [10-11,16]. The present study found that NMs significantly decreased between T1 and T2 during transcription and entering, monitoring and administration stages of medication processing. However, NMs related to physician ordering significantly increased from T1 to T2, possibly due to an overall shortage of staff. The fact that annual vacations of most physicians and the pilgrimage season falls during T2 may explain this increase in near misses related to physician ordering. During the second six months of the year, hospitals in KSA are usually short of physicians and those who remain tend to overwork and develop fatigue, which is associated with more medication errors and near misses [33].

Physicians and nurses tend to make the most near misses, whereas pharmacists and nurses are those most likely to identify and report NMs. Furthermore, pharmacists are most likely to intervene in order to prevent medication errors [16,27–29]. Pharmacist interventions

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result in the prevention of up to 89% of medication errors [28,29,34]. We found that physicians and pharmacists but not nurses made significantly fewer NMs during T2. While pharmacists identified significantly more NMs during T1 than during T2, this finding was reversed for assistant pharmacists who identified more NMs during T2 than during T1. Making, identifying, reporting and intervening in NMs are closely shared by a triad that is comprised of physicians, nurses and pharmacists. In light of the Eindhoven model, investigators proposed that nurses manage medical errors by identifying and correcting them [35]. Evidently, health professionals often do not report near misses for many reasons including fear and blame [36]. Other investigators have reported unique approaches for capturing electronic prescribing near misses in order to develop a patient safety culture [25].

According to our previous study [16] antibiotics, cardiovascular drugs, CNS agents, nutritional products, GIT agents and coagulator modifiers were the most frequent medications involved in NMs. Globally, antibiotics are prescribed most frequently and are the most common source of adverse drug events [37-38]. Several issues related to prescribing such medications including route of administration and associated near misses have been reported [9,16,39-42]. IV medications from multiple drug groups have been associated with up to 54% of potential adverse drug events/near misses and 56% of medication errors [39]. In one survey, near misses were identified most frequently (90.3%) by emergency department pharmacists [37]. According to the present study, NMs associated with some drugs either significantly decreased or significantly increased from T1 to T2. We feel that near misses associated with medications should ideally decrease not only during T2 but also throughout the year.

It has been emphasized that the counseling of patients regarding medication use and the documenting of details in e-prescriptions by physicians are key to preventing medication errors [43] including near misses. The advantages and techniques of patient counseling have been discussed [16,44-45]. Furthermore, patients and their family members are important source of identifying medical incidents affecting their health care [46]. Besides counseling of patients and caregivers, their appropriate training and engagement in identification of medication errors in emergency departments may further boost health care safety [46]. We found that NM medication error reporters recommended significantly less double checking and patient counseling during T2. Patient counseling is clearly underused in this tertiary care setting. Counseling of patients regarding medication use needs to be mandatory as it tends to reduce medical incidents and facilitates patient safety and improves quality of life.

A number of limitations affect the generalizability of this study's results. Although several variables related to NMs were influenced by natural real world practice factors in KSMC, this

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study was not designed to fully explain the time trends in near misses discovered here. However, factors related to healthcare providers and healthcare consumers (personal), the healthcare institution (institutional), and healthcare informatics (EP system) clearly influence the occurrence, identification, reporting, and prevention of NMs. Missing values need to be highlighted, which is an obvious limitation of this study. However, given values in various tables will guide about the missing data and its overall quality. Finally, the results of this study are preliminary in nature and therefore further researches on NM are needed especially to determine what factors impact the occurrence of near misses/close calls.

6. CONCLUSION

We report here the rate of NMs and other important insights into electronic prescribing near misses between two consecutive six-month periods during 2012, with findings that are consistent with results from other investigators internationally. Based on our brief literature review, our research findings, opinions of near miss reporters, and the recent initiation of several real practice operational programs, we make several recommendations for further mitigating NMs at KSMC and other similar tertiary care hospitals. NM prevention interventions such as double checking, rigorous quality monitoring, and regular training of staff in prescribing, providing incentives for reporting NMs, ensuring system updates, and patient counseling should be implemented in all tertiary care hospitals across the nation. Although electronic prescribing NMs do not result in injury or damage to the patient, they need to be identified and corrected. Otherwise MEs will increase significantly with a range of adverse consequences. Electronic prescribing systems/electronic health record systems need to be updated for capturing and correcting NMs, which will help to prevent real MEs associated with increased economic costs, poor health outcomes and compromised quality of life.

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COMPETING INTERESTS

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All authors except AMAB and NAQ are affiliated to the tertiary care hospital where this study was conducted. Abdullah Mohammed Al-Bedah and Naseem Akhtar Qureshi have no conflicts of interest in this work.

AUTHORS' CONTRIBUTIONS

Dalal Salem Al-Dossari designed the study, reviewed all NMs report forms, and helped in performing the statistical analysis. Ibrahim Abdulaziz Al-Zaagi also helped in designing this study, managed the analyses of the study and reviewed the first draft. Siham Dawood Al-Saud also contributed to the concept development of this paper, and searched and reviewed the selected relevant literature. Dr. Abdullah M. Al-Bedah also helped in the development of concept of this study and reviewed the first draft. Dr. Naseem Akhtar Qureshi wrote the protocol, and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

ETHICAL APPROVAL

This study was approved by the Academic Department of KSMC that gave permission to analyze and publish our findings regarding electronic prescribing NMs.

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