Impact of Implementing Electronic Health Records on Medication Safety at an HIMSS Stage 6 Hospital: The Pharmacist's Perspective

Meshaal Mohammed Eisa Hamad and Sulaiman Bah

Can J Hosp Pharm. 2022;75(4):267-75 https://doi.org/10.4212/cjhp.3223

ABSTRACT

Background: Medication errors can cause severe injuries and may lead to death. Electronic health records (EHRs) that are well designed and implemented could help to reduce medication errors. The medication management process needs close study to understand how medication safety metrics evolve as hospitals mature in terms of their EHR implementation.

Objective: To examine the effect of adopting EHRs on medication errors at the Royal Commission Hospital in Jubail, Saudi Arabia, a Health Information Management System Society (HIMSS) stage 6 hospital.

Methods: This study had a quasi-experimental time-series design. Retrospective data were collected for 1.5-year periods before and after implementation of EHRs. The variables analyzed were obtained from various units in the study setting. Data on medication errors were collected from the risk management section of the quality department. The medication management process was studied qualitatively. The quantitative data were analyzed using descriptive and inferential statistics.

Results: The median number of medication orders per patient showed a significant decrease, from 22.76 before EHR implementation to 18.76 after implementation ($p < 0.001$). The median number of incidents per patient showed a significant increase, from 0.029 before to 0.040 after implementation ($p = 0.004$). The qualitative analysis of processes involved in the medication management process helped to explain these changes.

Conclusion: Contrary to expectations, this study showed that an HIMSS stage 6 hospital could experience an increase in medication errors following implementation of EHRs. Qualitative analysis showed that the increase in medication error reporting rate could be attributed to an increase in detection following improvement in the medication management process. This has implications for interpreting quality metrics as hospitals mature in terms of their EHR implementation.

Keywords: electronic health record, medication errors, medication safety, pharmacist intervention

RÉSUMÉ

Contexte : Les erreurs de médication peuvent causer des blessures graves et entraîner la mort. La bonne conception et la mise en place de dossiers de santé électroniques (DSE) pourraient aider à les réduire. Le processus de gestion des médicaments doit faire l'objet d'un examen attentif pour comprendre comment les paramètres de sécurité relatifs aux médicaments évoluent à mesure que les hôpitaux se modernisent grâce à la mise en place de DSE.

Objectifs : Examiner l'effet de l'adoption des DSE sur les erreurs de médication au Royal Commission Hospital de Jubail, en Arabie saoudite, un hôpital de stade 6 de la Health Information Management System Society (HIMSS).

Méthodes : Cette étude utilisait une méthodologie de série chronologique quasi expérimentale. Des données rétrospectives ont été recueillies pendant des périodes de 1,5 an avant et 1,5 an après la mise en place des DSE. Les variables analysées ont été obtenues à partir de diverses unités dans le cadre de l'étude. Les données sur les erreurs de médication ont été recueillies auprès de la section de gestion des risques du service qualité. Le processus de gestion des médicaments, quant à lui, a été étudié de manière qualitative. Les données quantitatives ont été analysées à l'aide de statistiques descriptives et inférentielles.

Résultats : Le nombre médian d'ordonnances médicales par patient a fortement diminué, passant de 22,76 avant à 18,76 après la mise en place des DSE ($p < 0,001$). Le nombre médian d'incidents par patient a quant à lui augmenté de manière importante et est passé de 0,029 avant à 0,040 après la mise en place des DES ($p = 0,004$). Les résultats de l'analyse qualitative des étapes du processus de gestion des médicaments expliquent en partie ces changements.

Conclusion : Contrairement aux attentes, cette étude a montré qu'un hôpital de stade 6 de la HIMSS pourrait connaître une augmentation des erreurs de médication à la suite de la mise en place de DSE. L'analyse qualitative a montré que l'augmentation du taux de déclaration des erreurs de médication pouvait être attribuée à une augmentation de la détection suivant l'amélioration du processus de gestion des médicaments. Ce constat a des implications pour l'interprétation des indicateurs de la qualité à mesure que les hôpitaux se modernisent en mettant en place des DSE.

Mots-clés : dossier de santé électronique, erreurs de médication, sécurité des médicaments, intervention en pharmacie

INTRODUCTION

Medication safety plays an important role in reducing medication errors. All health care providers (including hospital pharmacists) are collectively responsible for reducing medication errors. In the modern era, health care providers are digitally connected through electronic health records (EHRs). The EHR serves as the information-gathering medium for the patient. As reported by Atasoy and others,[1]

> Ideally, information gathering begins before a patient encounter, retrieving records from other providers or past patient encounters. This, and other information, is then updated at the beginning of the patient's interaction with the physician or nursing staff; additional data—such as lab values, images, and progress notes—are added as the encounter progresses.

At a minimum, the EHR facilitates documentation and communication among health care providers, reduces misunderstanding and miscommunication, and expedites the provision of care. EHR systems can be enhanced to include e-prescribing, as well as testing for drug–drug interactions, testing for drug allergies, testing for dosing errors, and subsequent documentation of the results of testing once completed.[2] In general, the benefits of EHRs far outweigh their drawbacks.[2-5]

Despite the many advantages of EHRs, medication errors continue to occur. From the perspective of the hospital pharmacist, medication errors "may occur in the storage, prescribing, transcription, preparation and dispensing, or administration and monitoring of medications."[6] Hence, for the purpose of enhancing the role of hospital pharmacists in reducing medication errors, the International Pharmaceutical Federation, in its revised "Basel Statements on the Future of Hospital Pharmacy" (approved in 2014), made several pertinent recommendations. Some of these recommendations deal with the interaction of the pharmacist with the EHR for the purposes of documentation and therapeutic decision-making.[7] In this regard, Nelson and others[8] performed a literature review and summarized 3 main ways in which pharmacists use EHRs. The first is documentation, which includes medication reconciliation notes, allergy documentation, and "interventions". The second is medication reconciliation, which includes comparing and contrasting medication lists and "[evaluating] effectiveness and adverse drug events." The third is patient evaluation and monitoring, which includes "identifying potential medication problems, reviewing medication regiments, [and] checking drug-drug interactions".[8]

It is thus important to shed light on the pharmacist's role in medication safety within the EHR environment. However, given that EHR implementation is not uniform in all health care settings, a yardstick is needed to measure the level of implementation in each setting, to better contextualize the pharmacist's role. A good tool for this purpose is the Health Information Management Systems Society (HIMSS) electronic medical record adoption model (EMRAM).[9] This model, developed in 2005, comprises 8 stages, numbered from 0 to 7. At stage 0, none of the 3 ancillaries (laboratory, radiology, and pharmacy) is installed. At stage 1, EHR systems are installed in all 3 ancillaries. Over time, the EHR system matures progressively until, by stage 7, it has become paperless.[9] In this staging process, metrics are developed for monitoring progress from one stage to the next. This model assumes a steady increase in "indicators of good performance" and, correspondingly, a steady decrease in "indicators of poor performance". For example, medication errors are reduced by stage 4 and eliminated by stage 6.[9]

Evidence is now emerging to challenge this narrative. As Bowman[10] has pointed out, it is not merely the design of the EHR system that is important, but also its implementation, or how it is incorporated into clinical processes and how users apply it in routine clinical care. In short, there is a qualitative dimension to the use of EHRs, which is manifested in many ways. One example is found in the early literature on factors leading to the slow adoption of EHRs by physicians, despite availability.[1] The quantification of medication errors can be complemented by a qualitative investigation of process factors involved in the implementation of EHRs.

The study reported here takes a closer look at medication management within an EHR system. Once the EHR system has been implemented, it is expected that the medication management process—including assessing, prescribing, verifying and dispensing orders, administering, and monitoring—will change, either through the addition of new options or the modification of previous options. These new options, such as electronic medication reconciliation and availability of drug guidelines, would directly integrate standard pharmacy functions with the EHR. For such integration, pharmacists should be applying these options and providing the system team with feedback by reporting any medication errors that do occur.

The aims of the study were to compare the incidence of medication errors and the medication error reporting process before and after implementation of EHRs. The specific objectives were to calculate quantitative indicators of medication safety, to describe qualitative indicators of medication safety, to compare qualitative and quantitative indicators of medication safety before and after implementation of EHRs, and to ascertain the effect of EHR implementation on medication safety. It was anticipated that the results would be useful in reviewing the health care quality metrics as EHR systems progress from one HIMSS EMRAM stage to the next.

METHODS

Study Setting

The study was conducted at the Royal Commission Hospital in Jubail, Saudi Arabia, a 200-bed secondary care hospital providing inpatient and outpatient care to the local population. The hospital uses a commercial EHR system (BestCare), which was implemented on October 31, 2017. At the time of the study, the hospital was ranked at HIMSS stage 6; more recently, in November 2021, it was elevated to HIMSS stage 7.

Ethics Approval

The study received ethics approval from Imam Abdulrahman Bin Faisal University (IRB-PGS-2020-03-003) and the study setting where the research was conducted.

Study Design

The study had a quasi-experimental time-series design and was based on retrospective data for a 1.5-year period before the implementation of EHRs (February 1, 2016, to July 30, 2017) and a 1.5-year period after implementation (December 1, 2018, to May 31, 2019). Included in the study were incident reports and pharmacist interventions related to medication errors. A pharmacist intervention refers to action taken from the pharmacist to the prescriber intended to prevent a medication error. Before EHR implementation, medical staff submitted incident reports manually to the risk management unit; after EHR implementation, incidents were reported electronically to the same unit. Incident reports and pharmacist interventions not related to medication errors during the study period were excluded (e.g., adverse drug reactions and patients' refusal of medication therapy).

The study was a full population study (not a sample), because all medication errors satisfying the inclusion criteria were considered. The data (for all inpatients) for different units in the study setting were based on monthly reports obtained from the risk management department (incident reports) or the pharmacy department (pharmacist interventions). The medication errors were classified by staff members in the study setting (i.e., the Royal Commission Hospital) as wrong dose, wrong drug, drug–drug interaction, missed dose, wrong patient, wrong route, wrong dilution, wrong time, wrong frequency, wrong unit, wrong formula, expired medication, and contraindicated drug.

Statistical Analysis

For the analysis, 2 sets of data were collected, quantitative (based on the monthly reports) and qualitative. The monthly reports on medication-related incidents and medication orders (before and after EHR implementation) were normalized by patient data for comparability. The z-test for difference in proportion was used to compare proportions, and the Mann-Whitney *U* test was used to compare medians. Statistical significance was defined as $p < 0.05$. The analyses were done using PAST software.[11] The qualitative variables refer to medication management process functions before and after EHR implementation. Using a qualitative approach, the medication management process was broken down into steps, and the risks of medication error before and after EHR implementation were identified and analyzed.

RESULTS

Depending on the number of patients seen, monthly medication orders at a hospital can run into the hundreds or thousands. Table 1 shows the monthly numbers of medication orders in relation to the number of patients at the study site before and after EHR implementation. The median medication order per patient was 22.76 before EHR implementation and 18.76 after implementation. According to the Mann-Whitney *U* test, the difference between the medians was statistically significant ($p < 0.001$). Similarly, Table 2 shows the monthly incident reports in relation to the number of patients at the study site before and after EHR implementation. The median incidents per patient was 0.029 before EHR implementation and 0.040 after implementation. According to the Mann-Whitney *U* test, the difference between the medians was statistically significant ($p = 0.004$).

The breakdown of medication errors by type is shown in Table 3 for the period before implementation and in Table 4 for the period after implementation. The most frequent type of error before EHR implementation was wrong-dose errors (42 reports), followed by wrong-drug errors (33 reports), whereas errors involving expired medication were least frequent (3 reports) (Table 3). After EHR implementation, the pattern for most and least frequent error types was similar: wrong-dose errors remained most frequent (121 reports), followed by wrong-drug errors (95 reports), with errors involving expired medication being least frequent (3 reports) (Table 4).

Before implementation of the EHR system, pharmacist interventions were performed but not recorded (Table 3). After implementation, pharmacist interventions were documented automatically in the EHR system (Table 4). The total number of pharmacist interventions in the post-implementation period was 5329, with the highest monthly total ($n = 445$) in January 2019. In addition, the highest monthly number of reported errors after implementation ($n = 26$ in August 2018) did not correspond to the highest monthly number of orders, but rather to the lowest number of pharmacist interventions (165).

To complement this quantitative analysis, a qualitative description of pharmacist interventions and the medication management process was carried out and is summarized in Table 5. The overall process was subdivided as follows: assessing, prescribing, verifying and dispensing the order,

TABLE 1. Medication Orders per Patient before and after Implementation of Electronic Health Records[a]

Month and Year	No. of Medication Orders	No. of Patients	Orders/ Patient
Before implementation			
2016			
February	8 419	436	19.31
March	8 504	430	19.78
April	8 398	415	20.24
May	8 615	416	20.71
June	8 065	325	24.82
July	8 171	293	27.89
August	8 713	338	25.78
September	8 935	349	25.60
October	8 809	454	19.40
November	9 674	393	24.62
December	9 802	483	20.29
2017			
January	9 764	480	20.34
February	10 049	429	23.42
March	9 837	443	22.20
April	10 122	458	22.10
May	9 957	427	23.32
June	10 254	360	28.48
July	9 825	375	26.20
Total	165 913	7 304	
Mean			22.72
Median			22.76
After implementation			
2017			
December	6 859	366	18.74
2018			
January	7 802	375	20.81
February	7 516	395	19.03
March	8 148	434	18.77
April	8 977	531	16.91
May	9 437	571	16.53
June	6 618	358	18.49
July	8 363	452	18.50
August	7 596	432	17.58
September	8 113	472	17.19
October	9 664	545	17.73
November	9 627	502	19.18
December	10 167	539	18.86
2019			
January	10 160	569	17.86
February	9 606	449	21.39
March	10 447	535	19.53
April	11 065	568	19.48
May	9 285	447	20.77
Total	159 450	8 540	
Mean			18.67
Median			18.76

[a]For comparison between the 2 periods, $U = 25$, $z = 4.32$, $p < 0.001$.

TABLE 2. Incidents per Patient before and after Implementation of Electronic Health Records[a]

Month and Year	No. of Incident Reports	No. of Patients	Incidents/ Patient
Before implementation			
2016			
February	10	436	0.023
March	13	430	0.030
April	10	415	0.024
May	9	416	0.022
June	11	325	0.034
July	12	293	0.041
August	10	338	0.030
September	14	349	0.040
October	12	454	0.026
November	11	393	0.028
December	12	483	0.025
2017			
January	13	480	0.027
February	11	429	0.026
March	16	443	0.036
April	20	458	0.044
May	17	427	0.040
June	16	360	0.044
July	10	375	0.027
Total	227	7304	
Mean			0.033
Median			0.029
After implementation			
2017			
December	15	366	0.041
2018			
January	20	375	0.053
February	16	395	0.041
March	23	434	0.053
April	18	531	0.034
May	16	571	0.028
June	21	358	0.059
July	15	452	0.033
August	26	432	0.060
September	18	472	0.038
October	16	545	0.029
November	22	502	0.044
December	21	539	0.039
2019			
January	23	569	0.040
February	19	449	0.042
March	17	535	0.032
April	21	568	0.037
May	17	447	0.038
Total	344	8540	
Mean			0.040
Median			0.040

[a]For comparison between the 2 periods, $U = 71$, $z = 2.87$, $p = 0.004$.

administering the drug, and monitoring. The pharmacist's role changed considerably during EHR implementation. For example, in terms of preparation of a discharge medication summary, such summaries were not available before EHR implementation but could be generated by the system after implementation. Similarly, 9 of the 10 steps in the prescribing process were not done before EHR implementation, but these were all feasible after implementation. For the verifying and dispensing process, 5 of the 9 steps were not available before EHR implementation, but could be added afterward. For the administering process, 2 of the 3 steps were not done before EHR implementation, but could be done afterward. Finally, for the monitoring process, 6 of the 8 steps were not done before EHR, but could be done afterward. Some of the steps (e.g., in the prescribing, verifying and dispensing, and monitoring processes) became easier and clearer after EHR implementation. Finally, some steps that were formerly completed manually could be completed electronically after EHR implementation (in the prescribing, verifying and dispensing, and monitoring processes).

Table 5 shows that various pharmacist interventions are important aspects of the medication management process that help to increase error detection. For example, during the verifying process, if the pharmacist has any concerns during review of medication orders, they will advise the prescriber by means of an intervention. This process is added to the medication management process, which helps the pharmacist to write notes immediately. In addition, such interventions are automatically documented in the patient's file.

DISCUSSION

With the introduction of EHR systems in hospitals, it is expected that medication errors will decline. In addition, with EHR systems that include a pharmacy module and

TABLE 3. Types of Errors before Implementation of Electronic Health Records, February 2016 to July 2017

Month-Year	Wrong Dose	Wrong Drug	Drug–Drug Interaction	Missed Dose	Wrong Patient	Wrong Route	Wrong Dilution	Wrong Time	Wrong Frequency	Wrong Unit	Wrong Formula	Expired Medication	Contraindicated Drug	Total	Pharmacist Interventions
Feb-16	1	1	1	1	2	1	0	2	0	0	1	0	0	10	NR
Mar-16	3	1	2	2	1	0	1	1	0	2	0	0	0	13	NR
Apr-16	2	1	1	0	2	1	0	1	0	0	1	1	0	10	NR
May-16	1	2	2	1	0	0	0	1	0	1	0	0	1	9	NR
Jun-16	3	1	3	0	1	0	1	1	0	0	1	0	0	11	NR
Jul-16	2	1	2	2	0	1	0	1	0	1	1	0	1	12	NR
Aug-16	1	1	1	3	1	0	1	1	0	1	0	0	0	10	NR
Sep-16	1	2	2	1	3	1	1	1	1	0	0	0	1	14	NR
Oct-16	2	1	1	2	1	1	2	1	1	0	0	0	0	12	NR
Nov-16	2	1	1	1	1	1	1	2	0	0	1	0	0	11	NR
Dec-16	1	1	2	1	1	1	1	1	1	1	0	1	0	12	NR
Jan-17	2	3	1	1	2	2	0	1	1	0	0	0	0	13	NR
Feb-17	1	2	1	1	2	1	1	1	1	0	0	0	0	11	NR
Mar-17	2	4	2	1	1	1	1	1	0	1	1	0	1	16	NR
Apr-17	6	5	3	2	1	1	0	1	1	0	0	0	0	20	NR
May-17	7	4	1	1	1	1	0	1	1	0	0	0	0	17	NR
Jun-17	3	2	2	2	1	2	0	1	1	1	0	1	0	16	NR
Jul-17	2	0	2	1	1	1	1	1	1	0	0	0	0	10	NR
Total	42	33	30	23	22	16	11	20	9	8	6	3	4	227	NR

NR = pharmacist interventions not recorded.

clinical decision support features, further reductions in medication errors are expected.[4] These were our expectations for the current study. In addition, for the particular study setting, we expected that the total number of medication orders would increase over time, following the addition of new medical services, such as hyperbaric medicine, plastic surgery, and extended care. However, the findings were opposite to both expectations. More specifically, the number of medication orders declined and the number of medication errors increased after implementation of the EHR system. This counterintuitive finding could only be explained by a qualitative study of the system from the pharmacist's perspective.

In our qualitative study, we found several reasons for the reduction in medication orders. First, the new options available in the EHR system solved some previously existing problems. For example, the new system does not continue processing an order if the requested medication is not included in the hospital's drug formulary. Second, for medications with different dose strengths, prescribers sometimes had to enter more than 1 order for the same medication to obtain the desired amount; however, the EHR system allows automatic selection of the most suitable dosage with a single medication order, which has thus reduced the overall number of medication orders. Third, in the new system, use of the "order setting" decreases the number of medication orders because prescriptions for several medications can be combined in a single order, especially for orders with more than 2 components; previously, a separate order would have been required for each component.

We identified several reasons for the unexpected increase in the number of incident reports related to medication errors after EHR implementation. First, pharmacists on the EHR team played a role in guiding the design of the system, by determining their needs and desired changes from the existing system and how they could integrate the new system into their workflow. This higher level of awareness contributed to a higher error detection rate than before EHR implementation. This finding aligns with a study

TABLE 4. Types of Errors after Implementation of Electronic Health Records, December 2017 to May 2019

Month-Year	Wrong Dose	Wrong Drug	Drug–Drug Interaction	Missed Dose	Wrong Patient	Wrong Route	Wrong Dilution	Wrong Time	Wrong Frequency	Wrong Unit	Wrong Formula	Expired Medication	Contraindicated Drug	Total	Pharmacist Interventions
Dec-17	4	3	1	1	1	0	1	1	1	0	1	1	0	15	213
Jan-18	6	4	2	1	2	0	1	1	1	1	1	0	0	20	267
Feb-18	5	4	1	2	1	1	0	1	0	1	0	0	0	16	263
Mar-18	8	5	3	1	2	0	1	0	1	1	0	0	1	23	235
Apr-18	5	5	2	1	1	0	1	1	1	0	0	1	0	18	252
May-18	5	4	1	1	1	1	0	0	1	0	1	0	1	16	307
Jun-18	8	7	3	0	1	1	0	0	0	0	0	0	1	21	205
Jul-18	6	3	2	0	1	1	0	1	0	1	0	0	0	15	226
Aug-18	9	7	3	1	2	1	0	0	1	0	0	1	1	26	165
Sep-18	8	3	2	1	0	1	1	0	0	1	0	0	1	18	218
Oct-18	5	7	1	0	1	0	0	1	0	0	0	0	1	16	302
Nov-18	7	7	3	0	0	1	0	0	1	0	1	0	2	22	357
Dec-18	8	6	2	1	1	0	1	0	0	0	0	0	2	21	433
Jan-19	8	7	3	1	0	1	0	1	0	1	0	0	1	23	445
Feb-19	7	6	3	1	0	0	1	0	0	0	0	0	1	19	443
Mar-19	6	5	3	0	0	1	0	0	1	0	1	0	0	17	376
Apr-19	9	7	2	1	0	0	0	0	0	0	0	0	2	21	375
May-19	7	5	3	1	1	0	0	0	0	0	0	0	0	17	247
Total	121	95	40	14	15	9	7	7	8	6	5	3	14	344	5329

TABLE 5 (Part 1 of 2). Steps of Medication Management Process before and after Implementation of Electronic Health Records

Process and Steps	Description	Before[a]	After[a]
Assessing			
Patient identification	Information for the particular patient, including name, address, birth date, gender	Yes	More data available
Medication history	Complete list of previous and current medications used by patient	From dispensed list	From different sources
Diagnosis	Accurate diagnosis of patient's problem	Sometimes missed or unclear	Differentiation between current and previous diagnoses
Electronic medication reconciliation	Request from physician to pharmacist to review patients' medications	No	Yes
Discharge summary	Document outlining details of the patient's hospital stay	No	Yes
Prescribing			
Medication selection	Selection (by clinician) of optimal medication for the patient	No	Yes
Clinical decision support system (safety check)	Safety check to ensure selected medication does not interfere with patient's allergies, other drugs, or medical conditions, taking into account patient's body size and pharmacokinetics for proper dose	No	Yes
Formulary and benefits check	List of prescription drugs used by practitioners in a given setting to identify drugs offering the greatest overall value	No	Yes
Drug guideline	Document providing guidance for decision-making and criteria regarding medicines, management, and treatment in specific areas of health care	No	Limited for specific medications
Medication ordered	Seamless transmission of medication order from clinician to dispenser	Yes	Easier and with greater clarity
Documentation of ordered medication	Documentation of the order in a location where health care provider can access the information	No	Yes
Illegible handwriting	Although prescriber usually knows what is written, pharmacist may have problems reading and interpreting information	No	No (paperless)
Prescriber instructions	Specific notes from prescriber to dispenser	Entered manually	Listed as options
Dose calculation	Dosage adjustment calculations based on clinical features such as weight or renal function	No	Yes
Knowledge update	Updates to ensure the prescriber has the latest drug information	No	Limited
Verifying and dispensing order			
Evaluate/approve order	Review of medication order and approval for dispensing	No	Yes
Clinical decision support system (safety check)	Safety check to ensure selected medication does not interfere with patient's allergies, other drugs, or medical conditions, taking into account patient's body size and pharmacokinetics for proper dose	No	Yes
Double-check procedures	Additional safety check, by another pharmacist	Manual	Electronic
Medication distribution	Delivery of medication to dispensing location	Yes	Yes
Patient and medication identification	Identification and verification of patient and medication order by health care professional	No	Yes
Medication preparation and labelling	Identification, preparation, labelling, and packaging of medication order for delivery to dispensing location	Yes	Easier and clearer
Education	Education of the clinician on medication use, storage, toxicity, and contraindications	No	Yes
Use of a colour alert	System to alert dispenser to the need for care with certain drugs	No	Yes
Use of a look-alike/ sound-alike alert	System to prevent mixup between medications with names that look or sound similar	Physical	Electronic
Administering			
Medication information identification	Identification of correct medication by review of drug name, dose, time of day, and route	Yes	More data available
Dispensing of individual dose	Accurate individual medication dose properly dispensed to clinicians	No	Yes
Time when dose was taken	Administration of proper dose to the patient at the right time	No	Yes

TABLE 5 (Part 2 of 2). Steps of Medication Management Process before and after Implementation of Electronic Health Records

Process and Steps	Description	Before[a]	After[a]
Monitoring			
Routine dosing and tracking	Routine administration of proper medication dose and recording of time when medication is taken or not taken	No	Yes
Reporting and trending	Receipt by clinician of overview and trending data from medication log and outcomes	No	Yes
Integrated plan of care	Automated notes for health care professional relating to specific points	No	Yes
Recall of medication	Removal of medication from the market because it is found to be either defective or potentially harmful	No	Yes
Restricted medication	Closed formulary, which may limit drugs for use by specific physicians, in specific patient care areas, or for specific diseases	No	Yes
Admission medication reconciliation	Review of patients' home medications at the time of admission	Manual	Electronic
Access to laboratory results	Check for appropriate baseline laboratory results	Yes	Easier and clearer
Documentation of all details	Process of providing required data for patients' medications (written by health care provider)	No	Yes

[a]In the "Before" and "After" columns, the entry "No" means that this function was not performed before implementation of electronic health records, and the entry "Yes" means that this function was being performed after implementation of electronic health records.

that observed cognitive workload changes among nurses during the transition from a manual system to an EHR system.[12] Second, the new system allowed pharmacists to see more details of individual prescriptions, including information about the prescriber (consultant or specialist), specific instructions, and the patient's medication history. Third, the pharmacy supervisor could monitor workflow through the new system, which helped in managing the medication-use process, identifying particular users (prescribers or dispensers), tracking the time of ordering and dispensing, and even determining the particular medication given to an individual patient; pharmacists are expected to be more alert to medication errors with this level of supervision. Fourth, the new system facilitated communication among health care providers in case of order changes or the addition of instructions from the prescriber. This option allowed pharmacists to see deleted or cancelled orders and the person who made the change; it also allowed pharmacists to write notes for the prescriber, whenever errors involving double entries, wrong patient, or wrong dose were detected. Fifth, after EHR implementation, pharmacists had easy access to many services that helped them check laboratory results to verify whether a medication dispensed from the pharmacy had been given to a patient or not. Sixth, the quality department modified the incident report window, making it easier to access. This facilitated the documentation of incidents and automatic reporting to the risk unit, which again helped in increasing the reporting of medication errors.

One of the main limitations of this study was the manual documentation of pharmacist interventions before EHR implementation; as such, data were not available for comparison with interventions after EHR implementation (which were recorded in the system). Another limitation was the small number of errors analyzed, given that pharmacists reported only 344 errors out of 5329 interventions (less than 7%). Finally, another limitation of this study is that the risk unit in the quality department modified the incident report window at the study setting, with the result that staff members understood well how to use it. This may have helped staff members to report medication errors better than before.

CONCLUSION

The EHR system introduced at the study site significantly changed the medication management process. Changes were manifested at all stages of the medication management process, including assessing, prescribing, verifying and dispensing of orders, administering medications, and monitoring. Collectively, these changes led to decrease in the number of medication orders per patient and an increase in the error detection rate. Notably, this study showed that an HIMSS stage 6 hospital could experience an increase in errors with implementation of an EHR system. This might also happen if a hospital facility were to "leapfrog" from a manual system to a high stage in the HIMSS EMRAM.

The results of this study suggest that the information technology unit in the study setting could consider including pharmacist interventions for the purposes of incident reporting and could create an option for such interventions within the EHR system. This might improve clarity and avoid duplication of work. Finally, health care providers are urged to report any medication errors to the risk management unit to improve medication safety and other clinical care services.

References

1. Atasoy H, Greenwood BN, McCullough JS. The digitization of patient care: a review of the effects of electronic health records on health care quality and utilization. *Annu Rev Public Health*. 2019;40:487-500.
2. Menachemi N, Collum TH. Benefits and drawbacks of electronic health record systems. *Risk Manag Healthc Policy*. 2011;4:47-55.
3. Manca D. Do electronic medical records improve quality of care? Yes. *Can Family Physician*. 2015;61(10):846-7.
4. Griever M. Do electronic medical records improve quality of care? No. *Can Family Physician*. 2015;61(10):847-9.
5. Radley DC, Wasserman MR, Olsho LE, Shoemaker SJ, Spranca MD, Bradshaw B. Reduction in medication errors in hospitals due to adoption of computerized provider order entry systems. *J Am Med Inform Assoc*. 2013;20(3):470-6.
6. Mansur JM. Medication safety systems and the important role of pharmacists. *Drugs Aging*. 2016;33(3):213-21.
7. *Revised FIP Basel statements on the future of hospital pharmacy*. International Pharmaceutical Federation, Hospital Pharmacy Section; 2014 [cited 2021 Dec 20]. Available from: https://www.fip.org/files/fip/FIP_BASEL_STATEMENTS_ON_THE_FUTURE_OF_HOSPITAL_PHARMACY_2015.pdf
8. Nelson SD, Poikonen J, Reese T, El Halta D, Weir C. The pharmacist and the EHR. *J Am Med Inform Assoc*. 2017;24(1):193-7.
9. Rayner J, Chinwadzimba P. *Five things you need to know about HIMSS EMRAM attainment*. Oracle; 2019 Nov 29 [cited 2021 Dec 20]. Available from: https://www.cerner.com/gb/en/blog/five-things-you-need-to-know-about-himss-emram-attainment
10. Bowman S. Impact of electronic health record systems on information integrity: quality and safety implications. *Perspect Health Inf Manag*. 2013;10(Fall):1c.
11. Hammer Ø, Harper DAT, Ryan PD. PAST: paleontological statistics software package for education and data analysis. *Palaeontol Electr*. 2001 [cited 2021 Dec 20];4:9 p. Available from: http://palaeo-electronica.org/2001_1/past/issue1_01.htm
12. Colligan L, Potts HWW, Finn CT, Sinkin RA. Cognitive workload changes for nurses transitioning from a legacy system with paper documentation to a commercial electronic health record. *Int J Med Inform*. 2015;84(7):469-76.

Meshaal Mohammed Eisa Hamad, PharmD, MPH, is with the Pharmacy Department of Royal Commission Hospital, Jubail, Saudi Arabia

Sulaiman Bah, PhD, is with the Department of Public Health, College of Public Health, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia.

Competing interests: None declared.

Address correspondence to:
Dr Sulaiman Bah
Department of Public Health
Imam Abdulrahman Bin Faisal University
PO Box 1982
Dammam 31441
Saudi Arabia

email: sbah@iau.edu.sa

Funding: None received.