

Assessment of Pharmacy Information System Performance in Three Hospitals in Eastern Province, Saudi Arabia

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Abstract

The pharmacy information system is one of the central pillars of a hospital information system. This research evaluated a pharmacy information system according to six aspects of the medication process in three hospitals in Eastern Province, Saudi Arabia. System administrators were interviewed to determine availability of functionalities. Then, system users within the hospital were targeted to evaluate their level of usage of these functionalities. The study was cross-sectional. Two structured surveys were designed. The overall response rate of hospital users was 31.7 percent. In all three hospitals studied, the electronic health record is hybrid, implementation has been completed and the system is running, and the systems have computerized provider order entry and clinical decision support. Also, the pharmacy information systems are integrated with the electronic health record, and computerized provider order entry and almost all prescribing and transcription functionalities are available; however, drug dispensing is a mostly manual process. However, the study hospitals do not use barcode-assisted medication administration systems to verify patient identity and electronically check dose administration, and none of them have computerized adverse drug event monitoring that uses the electronic health record. The numbers of users who used different functionalities most or all of the time was generally low. The highest frequency of utilization was for patient administration records (56.8 percent), and the lowest was for linkage of the pharmacy information system to pharmacy stock (9.1 percent). Encouraging users to use different functionalities was highly recommended.

Keywords: pharmacy information system; usage; hospital users; system administrators

Introduction

A pharmacy information system (PIS) must have several core functions, including inpatient and outpatient order entry, dispensing, and inventory and purchasing management.¹ A PIS makes practitioners aware of the unsafe measurement of drugs, prescribed overdoses, and potential drug interactions.² In addition, a PIS can help pharmacists “reduce clinical errors with intelligent warnings, messages, and rejection notices; gain immediate access to clinical information from throughout the enterprise; access all relevant data from a single centralized processing screen; and minimize lost revenue with the option to charge on administration.”³

Assessing hospital pharmacy practice is very important to identify strengths and weaknesses. The American Society of Health-System Pharmacists (ASHP) national survey of pharmacy practice in hospital settings in the United States focuses on practices and technologies for managing and improving the medication use system and the role that pharmacists play in this effort. The national surveys are organized according to six aspects of the medication-use system: prescribing, transcribing, dispensing, administration, monitoring, and patient education.⁴⁻⁶ These surveys therefore represent a composite picture of the ways hospitals and health systems are managing and improving the entire medication-use system and the role that pharmacists play in medication-use system management.⁷ Assessment of prescribing and transcribing practices includes the process of formulary system management; the use of drug policy tools by the pharmacy and therapeutics committee to improve medication use; the extent of pharmacist consultations; the provision of drug information to prescribers; the process of medication order receiving, evaluation, and transcription; and the use of computerized provider order entry (CPOE) systems, electronic medical records, and other medication safety technologies.⁸ Assessment of monitoring and patient education practices is used to evaluate pharmacists’ medication therapy monitoring activities and inpatient therapeutic drug monitoring activities, the methods used to monitor adverse drug events, patient education and counseling activities, transition of-care services, processes of medication reconciliation, medication order review and entry, implementation of medication-use system

technologies, outpatient dispensing pharmacy operations, and pharmacist involvement in ambulatory clinics.⁹ Assessment of dispensing and administration practices examines the inpatient medication distribution system, the use of technology in medication distribution, the methods for medication preparation and dispensing, the use of closed-system transfer devices, the process of medication administration, the use of smart infusion pumps, the use of barcode technology, the use of medication administration records (MARs), the outsourcing of preparation activities, and the process of medication order review. This aspect also includes human-resource commitments and turnover, estimated vacancy rates of hospital pharmacist and pharmacy technician positions, and acquisition costs of pharmaceuticals.¹⁰

Throughout the last two decades, researchers have identified many barriers to the adoption and use of computer applications in healthcare.¹¹ Assessment of information technology systems is important to identify barriers and suggest solutions. Nanji et al.¹² identified that process issues (training requirements and process flow issues), technology issues (hardware, software, and the role of vendors), and resistance (communication issues, changing roles, and negative perceptions about technology) are the main barriers to implementation of a pharmacy barcode scanning system. The recommended strategies to overcome these barriers were adequate training, continuous improvement, and adaptation of workflow.

As reported in the literature, the main barriers to the use of CPOE include change in workflow, lack of standardization of medical terminology and different technologies, and lack of financial incentives. One study proposed a comprehensive model of four pillars to increase the adoption of CPOE and ensure that its use leads to improvement in quality and cost: (1) incentives to promote adoption, (2) further research into the benefits and factors associated with successful implementation, (3) development of guidelines for implementation, and (4) development of common measures to assess its impact.¹³ Barron et al.¹⁴ identified that a major barrier to the adoption of CPOE is cost, which is largely related to the purchase and implementation of a new information system. However, Poon et al.¹⁵ suggested that to address the obstacles to implementing CPOE, “hospitals could mitigate the cost barrier by refocusing their priorities on patient safety.”

In Saudi Arabia, published studies assessing hospital pharmacy practice are limited. Recently, Alsultan et al.¹⁶⁻¹⁸ designed a project in collaboration with the King Saud University College of Pharmacy, the Saudi Pharmaceutical Society, and the ASHP. The project surveyed the current state of pharmacy practices in the hospitals in the Riyadh region.

To the best of the researchers’ knowledge, no published research has been done to assess PIS use in Eastern Province, Saudi Arabia. Measuring the adoption rate of this technology is crucial for decision making at the central level.

Objectives

This research evaluated the PIS in three hospitals in Eastern Province, Saudi Arabia, from two points of view:

- The first part assessed the availability of the PIS functionalities in three study settings using the six steps in the medication process (prescribing, transcribing, dispensing, administration, monitoring, and patient education).
- The second part evaluated the usage level of the PIS in each of the six steps in the medication process.

Material and Methods

This study examined the PIS at each of three hospitals: King Fahd Hospital of the University–University of Dammam (KFHU), which used the QuadraMed electronic health record (EHR); Dammam Central Hospital (DCH), which used the MedicaPlus EHR; and King Fahd Specialist Hospital in Dammam (KFSH-D), which used the MedicaPlus EHR with customization according to users’ needs.

The study design was a cross-sectional, paper-based survey. The research team was asked by the Saudi Ministry of Health to undergo the United States National Institutes of Health web-based training course “Protecting Human Research Participants” before starting the research project. All team members were successfully completed the course. Two members of the research team who are involved in teaching health information systems to university students and had previously completed research projects on information and communication technology and information systems interviewed the system administrators to determine availability of different PIS functionalities.

A convenience sample of PIS users—those who were available at the time of data collection—was included. PIS users were physicians, pharmacists, and nurses. Respondents totaled 208 of 500 potential respondents at KFHu for a response rate of 41.6 percent, 156 of 500 at DCH for a response rate of 31.2 percent, and 111 of 500 at KFSH-D for a response rate of 22.2 percent. The total number of respondents was 475. The overall response rate was 31.7 percent.

Then, a structured survey for the PIS users was designed as a checklist to test adoption rates of these functionalities. (See [Appendix B](#)). The response scale for usage was as follows: I do not use; I use some of the time; I use most or all of the time; not available/not active; and not applicable to my specialty. Data collection tools were not tested for validity or reliability. The PIS users' data collection tool was self-administered. Data were collected after approval was received from the committee of research ethics at the University of Dammam and the Ministry of Health in Saudi Arabia.

Data were statistically analyzed using SPSS version 20.0. Results were displayed as frequency tables. Chi-square tests were used to test significant differences between hospitals at $p \leq .05$. The Kruskal-Wallis test was used to test the difference between mean ranks of the use of PIS functionalities among physicians, nurses, and pharmacists.

Results

[Table 1](#) illustrates some common features at the three hospitals: The EHR system was hybrid (part paper and part electronic). Implementation was completed and the system was running. The system had CPOE. The PIS was integrated with the EHR and CPOE. The EHR had a clinical decision-support (CDS) system that supported CPOE and the PIS. All prescribing and transcription functionalities were available at DCH and KFSH-D. However, some functionalities were not available at KFHU. Prescription orders were received in the pharmacy through CPOE in all study settings. Dispensing in inpatient departments was almost entirely manual with the exception of KFSH-D, where robotic and barcode technology was used in inpatient departments. None of the hospitals had barcode-assisted medication administration (BCMA) systems to verify patient identity and electronically check dose administration. In addition, none of the hospitals had smart infusion pumps or adverse drug event (ADE) monitoring using the EHR system.

Table 1: Results of On-Site Interviews with Information Technology Administrators at Three Hospitals in Eastern Province, Saudi Arabia (2014)

Characteristics	King Fahd Hospital of the University (KFHU)	Dammam Central Hospital (DCH)	King Fahd Specialist Hospital in Dammam (KFSH-D)
Hospital type	University	General	Specialist
Bed size	>300	>300	100-300
Size of information technology department	Fewer than 5 full-time staff	Fewer than 5 full-time staff	More than 10 full-time staff
Size of medical record department	More than 10 full-time staff	More than 10 full-time staff	More than 10 full-time staff
Type of electronic health record (EHR)	Hybrid	Hybrid	Hybrid

Stage of EHR system implementation	Implementation completed and the system is running	Implementation completed and the system is running	Implementation completed and the system is running
Brand name of EHR system implemented	QuadraMed	MedicaPlus	MedicaPlus customized for users' needs
Does your EHR system meet certification standards?	✓	✓	✓
Does your EHR system have computerized provider order entry (CPOE)?	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	✓
System integration:			
Is your pharmacy information system (PIS) integrated with your EHR system?	✓	✓	✓
Is your PIS integrated with your CPOE?	✓	✓	✓
Do you have a clinical decision-support (CDS) system?	✓	✓	✓
If yes, does your CPOE support use of the CDS system?	✓	✓	✓
Does your PIS support use of the CDS system?	✓	✓	✓
Prescribing and transcription:			
Does your PIS/CPOE have access to patient demographics?	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
Does your PIS/CPOE have access to patient problem lists?	✓	✓	<input type="checkbox"/> <input type="checkbox"/>
Does your PIS/CPOE have access to patient allergy lists	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
Does your PIS/CPOE have access to patient medical histories?	✓	✓	✓
Does your PIS/CPOE have access to patient administration records?	✓	✓	✓
Does your PIS/CPOE have access to drug formularies?	✓	✓	✓
Does your PIS/CPOE have drug-drug interaction/contraindication alerts?	✓	✓	✓
Does your PIS/CPOE have drug-allergy alerts?	✓	✓	✓
Does your PIS/CPOE have inappropriate dosage alerts?	✓	✓	✓
Does your PIS/CPOE have drug-disease/condition alerts?	x	✓	✓
Does your PIS/CPOE check for maximum dosage?	✓	✓	✓
Does your PIS/CPOE support pediatric dosage?	✓	✓	✓
Does your PIS/CPOE support drug-to-indication linkage?	x	✓	✓

Does your PIS/CPOE support linkage to other drug information?	x	✓	✓
Does your PIS/CPOE support age precautions?	x	✓	✓
Does your PIS/CPOE recommend therapeutic drug monitoring or lab tests?	✓	✓	✓
Is your PIS linked to the pharmacy stock?	<input type="checkbox"/> x	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
How are prescription orders are received in the pharmacy?	CPOE	CPOE	CPOE
Dispensing and administration:			
How are drugs dispensed in inpatient departments?	Manual dispensing	Manual dispensing	Robotic and manual dispensing
Does the robotic system use barcode technology?	Not applicable	Not applicable	<input type="checkbox"/> <input type="checkbox"/>
Does your PIS use medication administration records (MARs)?	✓	✓	✓
Does the hospital use barcode-assisted medication administration (BCMA) systems to verify patient identity and electronically check dose administration?	<input type="checkbox"/> x	x	x
Does your hospital use smart infusion pumps?	<input type="checkbox"/> x	<input type="checkbox"/> x	<input type="checkbox"/> x
How do you document medication administration?	Handwritten	Handwritten and electronic	Computer-generated paper and electronic
Technology used in pharmacy drug distribution system	Manual and carousel	Manual	Automated dispensing cabinets
Monitoring and patient education:			
Does your hospital have computerized adverse drug event (ADE) monitoring using the EHR system?	x	x	x
Does your hospital have any computerized system for patient education about drugs' uses and precautions?	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> x	<input type="checkbox"/> <input type="checkbox"/>

[Table 2](#) shows that 78.7 percent of participants were nurses, 82.5 percent were female, and 44.2 percent were under 30 years of age. The majority had 5 to 10 years of work experience (37.5 percent) and 2 to 5 years of experience in PIS/CPOE use (43.6 percent).

Table 2: Profile of Pharmacy Information System Users in Three Hospitals in Eastern Province, Saudi Arabia (2014)

Characteristics	King Fahd Hospital of the University (KFHU) (n = 208)		Dammam Central Hospital (DCH) (n = 156)		King Fahd Specialist Hospital in Dammam (n = 111)		Total (n = 475)		Chi-square	p
	No.	%	No.	%	No.	%	No.	%		
Profession										
Physician	9	4.3	21	13.5	17	15.3	47	9.9	32.21	.000
Nurse	177	85.1	127	81.4	70	63.1	374	78.7		
Pharmacist	22	10.6	8	5.1	24	21.6	54	11.4		

Gender										
Male	25	12	34	21.8	24	21.6	83	17.5	7.63	.022
Female	183	88	122	78.2	87	78.4	392	82.5		
Age										
<30	97	46.6	74	47.4	39	35.1	210	44.2	18.68	.017
30+	49	23.6	52	33.3	41	36.9	142	29.9		
40+	40	19.2	19	12.2	27	24.3	86	18.1		
50+	19	9.1	10	6.4	4	3.6	33	6.9		
60+	3	1.4	1	0.6	0	0	4	0.8		
Years of work experience										
<5	70	33.7	55	35.3	33	29.7	158	33.3	9.26	.159
5+	80	38.5	54	34.6	44	39.6	178	37.5		
10+	28	13.5	24	15.4	26	23.4	78	16.4		
15+	30	14.4	23	14.7	8	7.2	61	12.8		
Years of experience with pharmacy information system/computerized provider order entry										
<3 months	19	9.1	22	14.1	6	5.4	47	9.9	31.82	.000
3 to <12 months	28	13.5	10	6.4	14	12.6	52	10.9		
1 to <2 years	17	8.2	19	12.2	15	13.5	51	10.7		
2 to 5 years	80	38.5	85	54.5	42	37.8	207	43.6		
>5 years	64	30.8	20	12.8	34	30.6	118	24.8		

Table 3 reveals that the numbers of participants who used the patient data functionalities of the system most or all of the time were generally low. The highest adoption rate was for the patient administration record (56.8 percent), and the lowest was for the patient problem list (29.5 percent). The numbers of participants who used the PIS prescription functionalities most or all of the time were low. The highest frequency was for prescription orders sent electronically to the pharmacy (51.6 percent). The lowest frequencies were for drug-to- indication linkage (19.2 percent) and linkage to other drug information (18.5 percent). The numbers of participants who used decision-support system functionalities most or all of the time were very low. The highest frequency was for drug-allergy alerts (38.5 percent), and the lowest frequencies were for drug–disease/condition alerts (12 percent) and age precaution dosage support (10.3 percent).

Table 3: Utilization of Pharmacy Information System Prescribing and Transcribing Functionalities in Three Hospitals in Eastern Province, Saudi Arabia (2014)

Questions	Do Not Use		Use Some of the Time		Use Most or All of the Time		Not Active/ Not Available		Not Applicable		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Patient data												
Patient demographics	112	23.6	101	21.3	239	50.3	0	0	23	4.8	475	100
Patient problem list	127	26.7	162	34.1	140	29.5	0	0	46	9.7	475	100
Patient allergies list	78	16.4	100	21.1	268	56.4	0	0	29	6.1	475	100
Patient medical history	90	18.9	96	20.2	258	54.3	0	0	31	6.5	475	100
Patient administration record	54	11.4	124	26.1	270	56.8	0	0	27	5.7	475	100
Prescription												

Do you use the system to order prescriptions?	94	19.8	38	8.0	245	51.6	0	0	98	20.6	475	100
If yes, are orders sent electronically to the pharmacy?	94	19.8	38	8.0	245	51.6	0	0	98	20.6	475	100
Drug formulary	93	19.6	83	17.5	208	43.8	0	0	91	19.2	475	100
Drug-to-indication linkage	73	15.4	54	11.4	91	19.2	208	43.8	49	10.3	475	100
Linkage to other drug information	75	15.8	56	11.8	88	18.5	208	43.8	48	10.1	475	100
Recommendations for therapeutic drug monitoring or lab tests	142	29.9	91	19.2	176	37.1	0	0	66	13.9	475	100
Decision-support system												
Drug–drug interaction or contraindication alerts	151	31.8	104	21.9	170	35.8	0	0	50	10.5	475	100
Drug-allergy alerts	141	29.7	102	21.5	183	38.5	0	0	49	10.3	475	100
Check for maximum dosage	152	32	98	20.6	170	35.8	0	0	55	11.6	475	100
Pediatric dosage support	122	25.7	85	17.9	129	27.2	0	0	139	29.3	475	100
Age precaution dosage support	127	26.7	49	10.3	49	10.3	208	43.8	42	8.8	475	100
Drug–disease/condition alerts	125	26.3	51	10.7	57	12	208	43.8	34	7.2	475	100

[Table 4](#) reveals that among the dispensing and administration functionalities, the highest adoption rate was for the use of the system to print drug labels (47.6 percent), and the lowest was for use of linkage of the PIS to the pharmacy stock (9.1 percent).

Table 4: Utilization of Pharmacy Information System Prescription Dispensing and Administration Functionalities in Three Hospitals in Eastern Province, Saudi Arabia (2014)

Questions	Do Not Use		Use Some of the Time		Use Most or All of the Time		Not Active/ Not Available		Not Applicable		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Use of linkage of the pharmacy information system to the pharmacy stock	119	25.1	51	10.7	43	9.1	221	46.5	41	8.6	475	100
Use of the system to check for drugs' expiration date	167	35.2	58	12.2	116	24.4	49	10.3	85	17.9	475	100
Use of the system to print drug labels	95	20	37	7.8	226	47.6	24	5.1	93	19.6	475	100
Use barcode technology for outpatient prescriptions	197	41.5	37	7.8	69	14.5	54	11.4	118	24.8	475	100

[Table 5](#) illustrates that the frequency of use of the PIS for patient education about drugs' uses and precautions was 14.7 percent, and the frequency of use to monitor patients' response/progress with certain medications was 14.5 percent.

Table 5: Utilization of Pharmacy Information System Monitoring and Patient Education Functionalities in Three Hospitals in Eastern Province, Saudi Arabia (2014)

Questions	Do Not Use	Use Some of the Time	Use Most or All of the Time	Not Active/ Not Available	Not Applicable	Total
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	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Do you use system features to monitor patients' response/progress with certain medications?	254	53.5	100	21.1	69	14.5	0	0	52	10.9	475	100
Do you use system features for patient education about drugs' uses and precautions?	257	54.1	94	19.8	70	14.7	0	0	54	11.4	475	100

[Table 6](#) demonstrates that among the different professions, pharmacists had the lowest adoption rank for the patient data (106.76) and prescription (46.88) functionalities. Differences between the different professions were significant (.000 for each). Pharmacists had the lowest utilization rank for the decision-support system (164.71). Physicians had the lowest adoption rank for the prescription dispensing and administration (143.09) and monitoring and patient education (154.19) functionalities.

Table 6: Utilization of Pharmacy Information System Functionalities by Professions in Three Hospitals in Eastern Province, Saudi Arabia (2014)

Pharmacy Information System Functionalities	Physicians' Mean Rank	Nurses' Mean Rank	Pharmacists' Mean Rank	Kruskal-Wallis Test	
				Chi-square	p
Patient data	113.03	213.48	106.76	66.447	.000
Prescription	158.09	105.15	46.88	51.781	.000
Decision-support system	182.15	188.17	164.71	2.254	.324
Prescription dispensing and administration	143.09	167.55	152.23	3.828	.147
Monitoring and patient education	154.19	183.40	172.16	4.286	.117

Discussion

Although most PIS features were available in the study settings, the frequency of users who used different functionalities most or all of the time was generally low.

In a study done in Shiraz, Iran, to evaluate PIS use and identify its strengths and weaknesses in the teaching hospitals affiliated with Shiraz University of Medical Sciences, results revealed that the data entry mechanism and presentation of reports had complete conformity to the standards of the American College of Physicians.¹⁹ In contrast, the current study demonstrated that the frequency of use of the system for patients' data was approximately 50 percent. Moreover, the frequency of use of the patient problem list was only 29.5 percent.

In a study done by Isfahani et al.²⁰ for evaluation of the role of a PIS in the management of medication-related clinical complications, researchers studied the standards related to the registration of drug-related information, drug use condition, drug allergies and drug interactions, and patients' nutrition condition and body performance. Their findings (with maximum mean scores of 44.75, 10, and 31.25 percent for teaching, private, and social-service hospitals, respectively) revealed that the hospitals examined in the study were remarkably far from the desirable state in their drug errors, drug side effects, drug interactions, and drug usage-related challenges. Moreover, the study done in Shiraz, Iran, found that drug interactions showed no conformity with the standards of the American College of Physicians.²¹ This finding is parallel to those of the current study, in which the participants' use of the decision-support system most or all of the time was generally very low. The use of drug-allergy alerts was only 38.5 percent, the use of drug-drug interaction or contraindication alerts was only 35.8 percent, and the use of drug-disease/condition alerts was very low (12 percent). In addition, the frequency of use of the PIS features most or all of the time to monitor patients' response/progress with certain medications was very low (14.5 percent).

In a study by Hines et al.,²² researchers conducted on-site interviews with pharmacists throughout the state of Arizona to document pharmacists' awareness of drug–drug interaction and other medication-related CDS features available within a PIS. All respondents indicated that their pharmacy system provided drug–allergy and drug–drug interaction alerts. Approximately 60 percent of the pharmacists reported that their drug–drug interaction decision-support systems included recommendations for managing drug interactions. This goes hand in hand with the findings of the current study, in which system administrators reported that the PIS/CPOE had drug interaction and contraindication alerts and drug–allergy alert features.

Pedersen et al.²³ studied the process of medication order receiving, evaluation, and transcription and the use of CPOE systems, EHRs, and other medication safety technologies. They found that EHR systems are the cornerstone of the process and have partially or completely replaced paper in nearly 60 percent of hospitals. The use of CPOE systems with decision support to assist prescribers is increasing. The authors of that study concluded that the increased use of enterprise systems that include various patient-safety technologies or that integrate CPOE and a PIS has nearly eliminated the need for the pharmacy staff to reenter medication orders from CPOE systems. Findings of the current study, however, indicated that the use of the system to order prescription and send orders electronically to the pharmacy was only 51.6 percent for each. The interviews with the system administrators of the study settings revealed that the three hospitals were using hybrid medical records (part paper and part electronic). Moreover, the use of other prescription functionalities that improve patient safety was low. Participants' use of the drug formulary most or all of the time was only 43.8 percent, and use of the recommendations for therapeutic drug monitoring or lab tests was only 37.1 percent. In addition, linkage to drug indications (19.2 percent) and linkage to other drug information (18.5 percent) accounted for the lowest rates of use most or all of the time.

Isfahani et al.²⁴ explored the role that the PIS may play in the management of medication-related complications. They claimed that the hospitals in question did not pay sufficient attention to standards established by pharmaceutical associations regarding medication therapy, including registration of drug usage status, drug interactions, and drug side effects in the PIS. Maximum mean score percent of 44.75, 10, and 31.25 were obtained for teaching, private and social services hospitals, respectively. These findings are comparable to those of the current study, in which system administrators reported that the hospitals in the study had no computerized ADE monitoring using the EHR system.

Pedersen et al. revealed that automated dispensing cabinets were used by 89 percent of hospitals, robots were used by 11 percent, carousels were used in 18 percent, and machine-readable coding was used in 34 percent of hospitals to verify doses before dispensing. MARs have become increasingly computerized, with 67 percent of hospitals using electronic MARs. BCMA was used in 50 percent of hospitals, and 68 percent of hospitals had smart infusion pumps.²⁵ In contrast, the hospitals in the current study had no BCMA systems to verify patient identity and electronically check dose administration. Moreover, they had no smart infusion pumps. Drugs were dispensed in inpatient departments almost entirely manually, although one hospital used robotic technology. Automated dispensing cabinets were used in one hospital, and carousels were used in another hospital. However, MARs were available in all study settings.

Hospitals use many methods to identify patients in need of medication therapy monitoring, such as using a list of medications to identify patients who require daily monitoring by pharmacists or using abnormal laboratory test values to prompt dosage adjustments.²⁶ Other methods include targeting patients as directed by a hospital committee (50.1 percent), by specific medical or surgical services (41.1 percent), by high-cost medications (30.7 percent), and by disease state (30.7 percent). The use of these methods has been stable during the last six years.^{27,28} These findings contradict those of the present study, in which system administrators reported that study hospitals had no computerized ADE monitoring using the EHR system. Moreover, the frequency of PIS users' utilization of system features to monitor patients' response/progress with certain medications most or all the time was very low (14.5 percent).

Pedersen et al. reported that 21.5 percent of hospitals have pharmacists routinely conduct discharge medication counseling for at-risk patient groups. Furthermore, 9.4 percent of hospitals routinely have pharmacists follow up with selected high-risk patient groups (e.g., through phone calls) regarding appropriate postdischarge medication use.²⁹ These findings are comparable to those of the current study, in which the mean rank of utilizing monitoring and patient education by pharmacists was 172.16. Moreover, the frequency of PIS users' utilization of system features for patient education about drugs' usage and precautions most or all the time was very low (14.7 percent). However, system administrators in the hospitals studied mentioned that KFHU and KFSH-D had computerized systems for patient education about drugs' uses and precautions. However, DCH did not have this feature.

Conclusions and Recommendations

Most PIS features were available in the study settings. However, adoption rates of different functionalities most or all of the time were generally low. Top problem areas were as follows: among data functionalities of the system, the patient problem list; among PIS prescription functionalities, the drug-to-indication linkage and linkage to other drug information; among decision-support system functionalities, the drug–disease/condition alerts and age precaution dosage support; among dispensing and administration functionalities, the use of linkage of the PIS to the pharmacy stock; and among monitoring and patient education, the monitoring of patients' response/progress with certain medications and the use of the PIS for patient education about drugs' uses and precautions. Furthermore, pharmacists and physicians should be targeted first.

The following actions are recommended:

1. Involve healthcare professionals in the process of system choice and implementation.
2. Provide effective training for users on the use of the system.
3. Ensure availability of system administrators or a help desk for help at any time.
4. Allow time for use of the system (i.e., do not make usage of the system an added burden for the users).
5. Have a system administrator track the usage level of different functionalities and communicate this information with users.
6. Study problem areas experienced by users and fix them.
7. Customize the PIS functionalities according to users' needs; for example, add computerized ADE monitoring using the EHR system to monitor ADEs in all study settings, and add a computerized system for patient education about drugs' usage and precautions at DCH.
8. To measure the extent of PIS adoption over time, repeat the survey nationally at regular intervals (every two years, three years, etc.).

This research is applicable to other regions. Specifically, the kingdom of Saudi Arabia is divided into many provinces, and this study could be conducted in other provinces, such as the central province, which includes the capital (Riyadh) and other surrounding cities, and the western provinces, which include Makkah, Madinah, Jeddah, and other surrounding cities. This additional research should help us better understand the level of adoption among other provinces and the factors affecting such adoption.

Source of Funding

The Deanship of Scientific Research at University of Dammam in SA (project code 2014290) funded this study. The source of funding has no role in data collection, data analysis, or writing of the final report.

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Appendix A: System Administrator Interview Questionnaire

University of Dammam

Applied Medical Sciences College

Health Information Management and Technology Department

Hospital Characteristics:

1. Which type of hospital do you work in?
 - ☐ General hospital
 - ☐ Specialist hospital
 - ☐ University hospital
2. Where is your hospital located? ☐ Urban area
 - ☐ Semi-urban area
 - ☐ Rural area
3. What is the size of your hospital?
 - ☐ Under 100 beds
 - ☐ 100-300 beds
 - ☐ Above 300 beds
4. What is the size of your information technology department?
 - ☐ Fewer than 5 full-time staff
 - ☐ 5-10 full-time staff
 - ☐ More than 10 full-time staff
5. What is the size of your medical record department?
 - ☐ Fewer than 5 full-time staff
 - ☐ 5-10 full-time staff
 - ☐ More than 10 full-time staff

I. EHR System:

6. Does your hospital use electronic health records (EHRs)?
- ☐ Yes, all electronic
 - ☐ Yes, part paper, part electronic
 - ☐ No
7. At which state is the implementation of your EHR system?
- ☐ Implementation completed and the system is running
 - ☐ Implementation completed but the system is not running
 - ☐ Implementation in progress
 - ☐ Planning to acquire an EHR system in the next 12 months
 - ☐ Planning to acquire an EHR system in the next 13-24 months
 - ☐ No plans to acquire an EHR system
8. what is the brand name of the EHR system that has been implemented?
9. Does your EHR system meet certification standards?
- ☐ Yes
 - ☐ No
 - ☐ Not applicable
10. Does your EHR system have computerized provider order entry (CPOE)? ☐ Yes
- ☐ No
 - ☐ Not applicable

II. Prescription and Transcribing**System Integration:**

11. Is your pharmacy information system (PIS) integrated with your EHR system?
- ☐ Yes
 - ☐ No
 - ☐ Not applicable
12. Is your PIS integrated with your CPOE?
- ☐ Yes
 - ☐ No
 - ☐ Not applicable
13. Do you have a clinical decision-support (CDS) system? ☐ Yes
- ☐ No

If Yes,

14. Does your CPOE support use of the CDS system?
- ☐ Yes
 - ☐ No
15. Does your PIS support use of the CDS system?
- ☐ Yes
 - ☐ No

System features

16. Does your PIS/CPOE have access to patient demographics?
- ☐ Yes
 - ☐ No
17. Does your PIS/CPOE have access to patient problem lists?
- ☐ Yes

- ☐ No
18. Does your PIS/CPOE have access to patient allergy lists?
- ☐ Yes
☐ No
19. Does your PIS/CPOE have access to patient medical histories?
- ☐ Yes
☐ No
20. Does your PIS/CPOE have access to patient administration records?
- ☐ Yes
☐ No
21. Does your PIS/CPOE have access to drug formularies?
- ☐ Yes
☐ No
22. Does your PIS/CPOE have drug–drug interaction/contraindication alerts?
- ☐ Yes
☐ No
23. Does your PIS/CPOE have drug-allergy alerts?
- ☐ Yes
☐ No
24. Does your PIS/CPOE have inappropriate dosage alerts?
- ☐ Yes
☐ No
25. Does your PIS/CPOE have drug–disease/condition alerts?
- ☐ Yes
☐ No
26. Does your PIS/CPOE check for maximum dosage?
- ☐ Yes
☐ No
27. Does your PIS/CPOE support pediatric dosage?
- ☐ Yes
☐ No
28. Does your PIS/CPOE support drug-to-indications linkage?
- ☐ Yes
☐ No
29. Does your PIS/CPOE support linkage to other drug information?
- ☐ Yes
☐ No
30. Does your PIS/CPOE support age precautions?
- ☐ Yes
☐ No
31. Does your PIS/CPOE recommend therapeutic drug monitoring or lab tests?
- ☐ Yes
☐ No
32. Is your PIS linked to the pharmacy stock?
- ☐ Yes
☐ No
33. How are prescriptions orders received in the pharmacy?
- ☐ Electronically through CPOE
☐ Copy of handwritten order
☐ Original handwritten order (copy stays in chart)
☐ Fax
☐ Digital image capture (e.g. Pyrix Connect)
☐ Other, please specify _____

III: Dispensing and administration:

34. Does the inpatient department use traditional manual unit dose systems or robotic systems that automate the drug dispensing process?
- ☐ Manual unit dose system
 - ☐ Robotic systems
 - ☐ Both
35. Does the robotic system use barcode technology?
- ☐ Yes
 - ☐ No
 - ☐ Not applicable
36. Does your PIS use medication administration records (MARs)?
- ☐ Yes
 - ☐ No
37. Does the hospital use barcode-assisted medication administration (BCMA) systems to verify patient identity and electronically check dose administration?
- ☐ Yes
 - ☐ No
38. Does your hospital use smart infusion pumps?
- ☐ Yes
 - ☐ No
39. How do you document medication administration?
- ☐ Handwritten MAR
 - ☐ Electronic MAR
 - ☐ Using BCMA
40. Technology used in pharmacy drug distribution system:
- ☐ Robot
 - ☐ Automated dispensing cabinets (ADCs)
 - ☐ Carousel
 - ☐ Manual distribution

IV. Monitoring and Patient Education:

41. Does your hospital have a computerized adverse drug event (ADE) monitor using the electronic medical records?
- ☐ Yes
 - ☐ No
42. Does your hospital have any computerized system for patient education about drugs' uses and precautions?
- ☐ Yes
 - ☐ No
43. Does your system generate any of the reports below:
- a. Daily reports to control the dispensing of medication based on dispensing location. Yes/No
 - b. Reports related to the required medication to be purchased. Yes/No
 - c. Reports related to medication inventory. Yes/No
 - d. Reports related to medication prices. Yes/No
 - e. Reports related to annual performance of the pharmacy. Yes/No
 - f. Reports related to the financial status of the pharmacy. Yes/No
 - g. Reports related to the medication inventory at the end of the year. Yes/No
 - h. Other reports, please specify:
-
-
-

Appendix B: Pharmacy Information System (PIS) Users' Questionnaire

University of Dammam

Applied Medical Sciences College

Health Information Management and Technology Department

Section 1: Personal information

1. What is your professional role?

- ☐ Physician
☐ Nurse
☐ Pharmacist
☐ Other, please specify _____

2. Sex:

- ☐ Male
☐ Female

3. Age in years:

- ☐ <30
☐ 30+
☐ 40+
☐ 50+
☐ 60+

4. Years of experience:

- ☐ <5 ☐ 5+
☐ 10+
☐ 15+

5. How long have you been using PIS/computerized provider order entry (CPOE) for prescription?

- ☐ <3 months
☐ 3 to <12 months
☐ 1 to <2 years
☐ 2 to 5 years
☐ >5 years

Section 2: Prescription and Transcribing

Does your hospital use PIS/CPOE for any of the following? Please indicate the extent to which you use them.

Questions	Usage Level				
	I do <i>not</i> use	I use <i>some</i> of the time	I use <i>most</i> or <i>all</i> of the time	Not active/ not available	Not applicable to my practice or specialty
Patient data					
6. Patient demographics					
7. Patient problem list					
8. Patient allergies list					
9. Patient medical history					
10. Patient administration record					
Prescription					
11. Do you use the system to order prescriptions?					
12. If yes, are orders sent electronically to the pharmacy?					
13. Drug formulary					

14. Drug indications linkage					
15. Linkage to other drug information					
16. Recommendations for therapeutic drug monitor or lab tests					
Decision-support system					
17. Drug-drug interaction or contraindication alerts					
18. Drug-allergy alerts					
19. Check for maximum dosage					
20. Pediatric dosage support					
21. Age precaution dosage support					
22. Drug-disease/condition alerts					

Section 3: Prescription Dispensing and Administration

Does your hospital use PIS for the following features? Please indicate the extent to which *you* use them.

Questions	Usage Level				
	I do <i>not</i> use	I use <i>some</i> of the time	I use <i>most</i> or <i>all</i> of the time	Not active/ not available	Not applicable to my practice or specialty
23. Use of linkage of PIS to the pharmacy stock					
24. Use of the system to check for drugs' expiration date					
25. Use of the system to print drug labels					
26. Use barcode technology for outpatient prescriptions					

Section 4: Monitoring and Patient Education

Questions	Usage Level				
	I do <i>not</i> use	I use <i>some</i> of the time	I use <i>most</i> or <i>all</i> of the time	Not active/ not available	Not applicable to my practice or specialty
27. Do you use system features to monitor patients' response/progress with certain medications?					
28. Do you use system features for patient education about drugs' uses and precautions?					

Article citation:

El-Mahalli, Azza Ali ; Yamani, Wid. "Assessment of Pharmacy Information System Performance in Three Hospitals in Eastern Province, Saudi Arabia" *Perspectives in Health Information Management* (Winter, January 2016).

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