ORIGINAL ARTICLE

The maturity assessment of hospital information systems based on Electronic Medical Record Adoption Model – A comparison between private and governmental hospitals

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ABSTRACT

Today, Information Technology (IT) is considered as one of the major national development principles in each country which is applied in different fields. One of the most important fields in which IT is applied is health care and hospitals are similarly considered as most substantial organizations that use IT vastly. Although, different benchmarks and frameworks were developed to assess different aspects of Hospital Information Systems (HIS), still there was no reference model to benchmark HIS in the world until very recently. Eventually, Electronic Medical Record Adoption Model (EMRAM) which is globally a well-known model to benchmark the rate of HIS utilization in the hospitals, were emerged. Nevertheless, this model has not been introduced in majority of developing and even some developed countries in the world yet. In this study, EMRAM is applied to benchmark both governmental and private hospitals in Iran. This research is based on an applied descriptive method to assess five governmental and three private hospitals in Isfahan in 2015. This province is one of the most important provinces of Iran. The results reveal that HIS is not at the center of concern in these hospitals and are in the first and second maturity stages in accordance with EMRAM. Therefore, these types of hospitals are far away from desirable conditions and stages. Yet, the immaturity of HISs in private hospitals is more observable. This situation including the pressure of different beneficiaries such as insurance companies, has forced hospital managers to develop and enhance their HISs, especially in governmental hospitals.

Key Words: Hospital Information System, Electronic Medical Record Adoption Model, Iran

1. INTRODUCTION

Hospital Information Systems (HIS) are assisting hospital managers to overcome challenges such as monitoring operational costs and processes, secure exchange of information, management of claims, drug e-prescription, quality management, etc.[1–4] HIS is especially useful in hospitals because the system is complex with multiple factors and individuals or groups involved in the care of each patient. HIS can help prevent a variety of mistakes in such an environment.[5,6] Therefore, the utilization of different forms of HIS in hospitals is increasing[7] and many authorities have become more and more eager to apply this technology due

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to health care quality improvement and medical operational necessities.[8,9] As an example, the American Association of Hospitals has estimated that 46% of American hospitals which are using Information Technology (IT) are located at the middle and/or high level. Yet, HIS implementation is associated with some challenges including the lack of a comprehensive standard,[10,11] high cost of HIS implementation,[10,12] training costs etc.[13–15]

However, different models and frameworks have been proposed to identify the facilities and defects of HISs in the hospitals but they are mainly pure research-base and not empirical studies. Therefore, Healthcare Information and Management Systems Society (HIMSS) which was formerly known as the society of hospital management systems and particularly focused on worldwide strategic establishment of the idea of optimal utilization of IT and HISs in the hospitals, has recently proposed an HIS maturity assessment model for hospitals. This model has known as Electronic Medical Record Adoption Model (EMRAM). The main reason that EMRAM surpasses other frameworks for assessing HIS backs to this fact that many health systems strive for the triple aim which are better health for populations, improved experience for patients and lower costs overall and the EMRAM promotes these fundamental basics of care quality and helps organizations align their goals.[16] This model aims at measurement of e-Health services' maturity level in the hospitals and categorization of their HISs from zero up to seven stages (see Table 1).[16]

Table 1. EMRAM stages and specifications[16]

Stage	Cumulative Capabilities
Stage 7	Complete EMR; CCD transactions to share data; Data warehousing; Data continuity with ED, ambulatory, OP
Stage 6	Physician documentation (structured templates), full CDSS (variance & compliance), full R-PACS
Stage 5	Closed loop medication administration
Stage 4	CPOE, CDS (clinical protocols)
Stage 3	Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology
Stage 2	CDR, Controlled Medical Vocabulary, CDS, may have Document Imaging; HIE capable
Stage 1	Ancillaries - Lab, Rad, Pharmacy - All Installed
Stage 0	All Three Ancillaries Not Installed

Note. EMR: electronic medical record; CCD: continuity of care to share data; ED: emergency department; OP: operating room; HIE: health information exchange; CDSS: clinical decision support system; R-PACS: Radiology-Picture Archiving and Communication System; CPOE: Computerized Practitioner Order Entry CDS: Clinical Decision Support/Rules; CDR: clinical data repository; HIE: hospital information system

Refer to HIMSS[16] in stage 0, the organization has not installed all of the three key ancillary department systems (laboratory, pharmacy, and radiology). In stage 1, all three major ancillary clinical systems are installed (i.e., pharmacy, laboratory, and radiology). In stage 2, major ancillary clinical systems feed data to a Clinical Data Repository (CDR) that provides physician access for reviewing all orders and results. The CDR contains a controlled medical vocabulary, and the clinical decision support/rules engine (CDS) for rudimentary conflict checking. Information from document imaging systems may be linked to the CDR at this stage. The hospital may be health information exchange (HIE) capable at this stage and can share whatever information it has in the CDR with other patient care stakeholders. In stage 3, nursing/clinical documentation (e.g. vital signs, flow sheets, nursing notes, eMAR) is required and is implemented and integrated with the CDR for at least one inpatient service in the hospital; care plan charting is scored with extra points. Electronic Medication Administration Record application (EMAR) is required and is implemented and integrated with the CDR for at least one inpatient service in the hospital; care plan charting is scored with extra points. The EMAR is implemented. The first level of CDS is implemented to conduct error checking with order entry (i.e., drug/drug, drug/ food, drug/lab conflict checking normally found in the pharmacy information system). Medical image access from Picture Archive and Communication Systems (PACS) is available for access by physicians outside the Radiology department via the organization's intranet.

Moreover, in stage 4, Computerized Practitioner Order Entry (CPOE) for use by any clinician licensed to create orders is added to the nursing and CDR environment along with the second level of CDS capabilities related to evidence based medicine protocols. If one inpatient service area has implemented CPOE with physicians entering orders and completed the previous stages, then this stage has been achieved. In stage 5, A full complement of radiology PACS systems provides medical images to physicians via an intranet and displaces all film-based images. Cardiology PACS and document imaging are scored with extra points. In stage 6, Full physician documentation with structured templates and discrete data is implemented for at least one inpatient care

service area for progress notes, consult notes, discharge summaries or problem list & diagnosis list maintenance. Level three of CDS provides guidance for all clinician activities related to protocols and outcomes in the form of variance and compliance alerts. The closed loop medication administration with bar coded unit dose medications environment is fully implemented. The EMAR and bar coding or other auto identification technology, such as radio frequency identification (RFID), are implemented and integrated with CPOE and pharmacy to maximize point of care patient safety processes for medication administration. The "five rights" of medication administration are verified at the bedside with scanning of the bar code on the unit does medication and the patient ID and finally in stage 7: The hospital no longer uses paper charts to deliver and manage patient care and has a mixture of discrete data, document images, and medical images within its EMR environment. Data warehousing is being used to analyze patterns of clinical data to improve quality of care and patient safety and care delivery efficiency. Clinical information can be readily shared via standardized electronic transactions (i.e. CCD) with all entities that are authorized to treat the patient or a HIE (i.e., other non-associated hospitals, ambulatory clinics, sub-acute environments, employers, payers and patients in a data sharing environment). The hospital demonstrates summary data continuity for all hospital services (e.g. inpatient, outpatient, ED, and with any owned or managed ambulatory clinics).

Application of this model for the purpose of assessing HISs is increasing in the world. Referring HIMSS website[16] not a large number of hospitals in North America and Europe have reached the 7^{th} stage of this model (as an example only one hospital in Spain has reached stage 7); no hospital has reached 7^{th} stage in Middle east, but some UAE and Saudi Arab countries have been able to reach 6^{th} stage showing the progress of HISs in the hospitals in such countries.[16]

It should be noted, HIS is a comprehensive application to unify patient's information and to send them to different wards and centers for the purpose of rapid exchange of health care information, quality improvement, satisfaction increase and cost reduction.[17] In order to evaluate HIS capabilities and requirements, EMRAM is proposed to rank hospitals in different stages starting from 0 up to 7.[18] This model which has been proposed by Health Information Management and Systems' Association in 2006, verifies digital capabilities starting from CDR capabilities until the digital documentation of all healthcare activities in the hospitals.[19]

This model as a matured model designed for HISs assessment in the hospitals is now used all over the world.[15] This eight stages model lets the hospital authorities to analyze their HIS capabilities and compare their progress with other hospitals and countries.[20] As a result, a suitable method for benchmarking the hospitals[21] has been prepared and applied in over 5,500 hospitals in the world until now.[22] Notwithstanding these capabilities and advantages, this model is still unknown in different countries, particularly in majority of developing and even some developed countries as illustrated earlier. This paper, therefore, at first introduced EMRAM and then focuses on the methodology of this research. Thereafter, the model and methodology will be demonstrated in an assessment of private and governmental hospitals in Iran and finally, the results of these assessments will be presented.

2. METHODS

According to Sharifi et al.,[23] under the responsibility of the ministry of Health and Medical Education, 42 medical schools, 902 hospitals, over 25,000 primary healthcare centers and 120,000 active beds are available in Iranian health care system. Yet, A convenience sample of five governmental and three private hospitals in Isfahan province in Iran were used to demonstrate application of the EMRAM model of HIS assessment. This province is one of the most important provinces in various aspects and is located at the center of Iran. Hence, a number of well-known medical doctors practice in these hospitals. Overall, several of these hospitals are well-known in Iran and respected for their quality. These hospitals have normally 80 up to 1,000 beds and are known as general and professional hospitals. The method used for selection of both governmental and private hospitals was stratified sampling method. Because, there are two major types of governmental and private hospitals in Iranian health care. Different hospitals are operating in each category but the majority of them are governmental hospitals. Five governmental hospitals out of more than thirty one and three private hospitals out of seven private hospitals were selected using a simple random sampling method.

The HISs in each private hospital was acquired from private companies but in governmental hospitals the situation was different. Some hospitals were using self-developed HIS, meaning that their staff had developed an HIS for their hospitals. However, the majority of governmental hospitals were using HISs purchased from private companies. These private companies were from ether the same province or different provinces.

From the IT staffs' management point of view, also these hospitals were following different approaches. All governmental hospitals were using permanent IT staff to operate IT activities and administer their HISs. The numbers of dedicated staff to IT activities in each hospital varied from one to three persons. In one case, seven contracted staff were

assisting permanent staff to administer their HISs. However, the situation of private hospitals was completely different. In the best situation, there was only one full time staff in each hospital. It is notable to say that one of the private hospitals had no full time staff to administer their HIS and had to rely on remote administration from their contractor. In one case, there was no IT center at the hospital and researchers had to go to contractor office to ask their questions It is notable, an interview protocol was developed using the EMRAM model (`https://app.himssanalytics.org/emram/scoreTrends.aspx`). This tool was evaluated by six health IT professionals at universities and hospitals considered to be knowledge experts in HIS. Moreover, the required permission acquired from hospital owners and authorities for data collection in the selected hospitals. IT staff and HIS software developers involved in HIS at each hospital were interviewed by the authors, who are university based. The comments of all interviewees were then combined into one checklist for analysis.

3. RESULTS

It appears that hospitals are considered as the heart of health care systems in each country.[12,23] Moreover, in hospitals with HISs, these systems can serve to document and communicate data, facilitate decision making and assess quality of service provided. HISs in the hospitals are assumed as means of data transportation, decision facilitator and service quality. Nevertheless, it is important to assess the maturity of HISs in the hospitals and EMRAM is a well-known model to do this assessment. It should be noted that this is the first attempt that this model has been applied in Iranian hospitals.

The final results of this research are presented in Table 2. The eight hospitals surveyed are represented by the letters A-H. It is notable that the Zero stage is eliminated from the table due to the concept of it. In this stage it is assessed that either there is any application in the three ancillaries (Lab, Rad, Pharmacy) or not at all. It was obvious that this stage is accomplished by the entire HISs in respective hospitals. As shown in Table 2, all governmental and private hospitals have reached first stage expectations of EMRM, as well. However, hospitals' HIS maturity is different in the next stage. The findings showed that three out of five governmental and two out of three private hospitals succeeded to overcome the second stage of HIS maturity. It should be mention that the four elements of EMRAM's Stage 2 have been shown separately in the table because, while all hospitals have CDR, there is variation between hospitals in accomplishment of other elements. Again, the situation of HIS maturity was different in the third stage. The fact was that some governmental and private hospitals were able to implement the limited number of required HIS modules. Others had no HIS module or had plan to implement that in the future. As a result, none of these studied hospitals were able to reach this stage. The reason of this failure was that passing each stage requires implementation of all necessary modules in that particular stage which is not easy. For further stages, some scattered activities or plans had been accomplished in governmental hospitals but no related activities was identified in private hospitals.

As it can be seen, the results uncover some strange facts in this area. The first pinpointed issue is that the overall maturity stage of HISs in Iranian hospitals is low. The highest maturity level of both governmental and private hospitals is not more than the second stage of EMRAM. Some governmental hospitals have attempted to study the implementation of more packages but they are still at the beginning of the way.

Moreover, despite respondents' perception of service quality in private hospitals, findings show that these hospitals' managers have not invested on these services and have not paid sufficient attention to their operating HISs in their hospitals. The private hospitals were expected to be benefited from mature or semi-mature HISs in their hospitals but their HISs were so weak. During this study, it found that in one case, the HIS was administrating from outside of hospital by contactor without considering security issues. It seems the private hospital managers still do not understand the importance of HISs for them. This result is showing some different challenges which these hospitals are facing with including low level of clinical and none clinical benchmarking, poor operational care and lack of high tech technologies.

In addition, the mature HIS means that having high-tech technologies and applications such as radio frequency identification devices [RFID], CDSS [clinical decision support system] (level 3), CPOE, Data warehousing and complete EMR, etc. Yet, these mostly available technologies in the market still have not applied to health context. Furthermore, the Ministry of Health and Medical Education does not monitor both private and governmental hospitals adequately. The self-assessment of these hospitals let the policy makers to design appropriate approach to implement more matured HISs with suitable strategy. The lack of this strategy has caused to follow ad-hock approaches by different hospital managers and authorities. The final outcome is poor output with high expenses.

Finally, the eligible human resources are available in this context in Iran, but hospitals are generally suffering from professional experts whom are able to administrate, implement or develop more matured HISs in Iran or adopt the overseas versions in Iranian hospitals context.

Table 2. HIS maturity of private and governmental hospitals in accordance with EMRAM expectations

Stage	Cumulative Capabilities	A	B	C	D	E	F	G	H
1	• All three ancillaries (Laboratory, Radiology, Pharmacy) are installed	✓	✓	✓	✓	✓	✓	✓	✓
2	• CDR is available	✓	✓	✓	✓	✓	✓	✓	✓
	• Controlled Medical Vocabulary and CDS Engine (rudimentary) is there	✓	✓	✓	*	✓	✓	✓	✓
	• Document Imaging (May be) is available	✓	✓	-	-	✓	✓	-	✓
	• HIE Capable with other health care providers (May be) is available	✓	✓	-	-	✓	✓	✓	✓
3	• Nursing /Clinical (vital signs, flow sheets, nursing notes) documentation is available	*	-	-	-	-	✓	✓	✓
	• The EMAR application is implemented	*	*	-	-	-	-	-	-
	• CDSS (drug/drug, drug/ food, drug/lab conflict checking) is available	-	-	-	-	-	-	-	-
	• PACS is available outside of Radiology	✓	✓	-	-	-	-	-	-
4	• CPOE for use by any clinician is available	*	-	-	-	-	-	-	-
	• Second Level of CDS (related to evidence based medicine protocols) is available	*	-	-	✓	✓	-	-	-
5	• Closed loop medication administration (A full complement of radiology) PACS system is there	*	*	-	-	-	-	-	-
6	• Full physician documentation with structured templates and discrete data (for at least one inpatient care service area) is implemented	*	-	-	-	-	-	-	-
	• Full (level 3) of CDSS (protocols and outcomes) is available	*	*	-	-	-	-	-	-
	• The closed loop medication administration is implemented	*	*	-	-	-	-	-	-
7	• Complete EMR (Mixture of discrete data, document images, and medical images) is available	*	*	-	-	-	-	-	-
	• Data warehousing (patterns of clinical data to improve quality of care and patient safety and care delivery efficiency) is available	*	*	-	-	-	-	-	-
	• Clinical information (i.e. CCD) can be readily shared	*	*	-	-	-	-	-	-
	• The hospital demonstrates summary data continuity for all hospital services	*	-	-	-	-	-	-	-

Note. ✓ Yes; * No, but, it is in the Plan; - Not, at all; A-E are governmental hospitals and F, G, and H hospitals are private; CDR: Clinical Data Repository; CDS: Clinical Decision Support/Rules; HIE: Health Information Exchange; EMAR: Electronic Medication Administration Record; CDSS: Clinical Decision Support System; PACS: Picture Archive and Communication Systems; CPOE: Computerized Practitioner Order Entry; EMR: Electronic Medical Record; CCD: Continuity of Care to Share Data

4. DISCUSSION AND PROPOSITIONS

The comparison of the situation of these hospitals with the situation of similar hospitals in other countries gives us more clear view of the whole story. According to HIMSS,[22] two hospitals have reached 7^{th} stage of EMRAM and 27 hospitals from Malaysia, India, China, Taiwan, Singapore, Saudi Arabia and UAE have reached 6^{th} stage of EMRAM in Asia. Moreover, three and 42 hospitals have reached 7^{th} and 6^{th} stages in Europe respectively. The situation of other hospitals in other stages have not mentioned in the website. Meanwhile, the situation of USA is clearer due to emerging and expanding EMRAM in this country. HIMSS[22] uncovers that out of 5447 hospitals in USA, 3.2% are in stage 7; 15% in stages 4 and 6; 27.5% in stage five; 25.4% in stage three; 5.9% in stage two; 2.8% in stage one and 4.9% in stage Zero. These statistics reveal the huge difference between Iranian hospitals' HIS maturity and that of other countries, particularly USA.

Lack of such HIS maturity in Iranian hospitals compared with other hospitals in above countries has caused some defects. In general, Iranian health care has benefited from well-known professional medical doctors and nurses in the region. Moreover, some major high-tech medical technologies have been acquired in this country. Yet, IT has not integrated with clinical operations in these hospitals. It has caused low level of awareness between clinical and operational staffs in such clinical organizations. Moreover, there are not well defined IT based benchmarks to assess different clinical and operational activities in such hospitals. Thus, Iranian health care system cannot demonstrate its capabilities to patients in the regional well.

Considering above results and in order to mitigate the weaknesses of HISs in Iranian hospitals, following propositions were presented by professional experts who were interviewed in this research.

(1) Professional teams should be formed to make clear

strategy and emerge HISs in the hospitals at the ministry level.

(2) HIS necessities and requirements should be defined in accordance with EMRAM model and current situation of countries' infrastructure. These necessities and requirements should be shared with HIS suppliers and sellers.

(3) To reach EMRAM expectations in the hospitals, a clear centralized framework and investigation regulation should be considered for HIS suppliers and sellers' selection.

(4) IT centers and units must be benefited from educated and professional human resources. It is better to initiate a consultation committee consisted of IT staff of hospitals' pioneers equipped with more mature HISs. The main objective of this committee is to lead HIS development, implementation and enhancement in other hospitals.

(5) Transparent regulations should be defined and sent from the Ministry of Health and Medical Education to private hospital authorities and force them to adhere to requested HIS development policies.

Finally, the strategy of this research should be applied in different hospitals in different provinces to compare the finding with each other and reach better imagination of HIS maturity situation in Iranian hospitals.

5. Conclusions

This study compared the maturity of HISs based on EMRAM between private and governmental hospitals. It found that the overall maturity of HISs in governmental hospitals is higher than private hospitals. Moreover, the highest maturity level of both governmental and private hospitals is not more than the second stage of EMRAM. Meaning that, the overall maturity stage of HISs in Iranian hospitals is low. EMRAM expects different technologies and application packages to be implemented in the hospitals, but Iranian domestic HISs are suffering from poor technology and administration. In order to improve the maturity of HISs in Iranian hospitals different propositions presented to follow by professional experts at Ministry and Medical University levels.

As a future study, the authors would like to propose a roadmap of progressively implementing a mature HIS in the hospitals. This roadmap should be included but not limited to a phased plan to implement different technologies in Iranian hospitals considering their weaknesses and advantages in accordance with EMRAM expectations.

Conflicts of Interest Disclosure

The authors declare they have no conflict of interest.

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