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Evaluating the Technical Infrastructure of Electronic Health Record System (SEPAS)

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Abstract

Background: Electronic Health Record (EHR) contains all information concerning individuals' health including their outpatient, inpatient, and emergency visits. For successful implementation of this system in the complex healthcare environment, the technical and non-technical factors affecting its implementation should be identified and the barriers should be eliminated. The aim of this study was to evaluate the technical infrastructures of EHR in Iran.

Methods: This study was conducted in teaching hospitals in Zahedan and Kerman, Iran in 2015. Data were collected using a researcher-made checklist developed through multiple discussion sessions with technical officers of EHR in medical universities and based on the results of previous studies. The validity of the checklist was confirmed by six health information management and medical informatics professionals. Data were analyzed by calculation of scores, frequency, and percentage for technical infrastructure using SPSS 16.

Results: In the studied hospitals, the software infrastructure gained a score of 5.75 out of 11, and the hardware-software infrastructure a score of 20.1 out of 23.Teaching hospitals in Kerman had more hardware equipment including 258 clients, 15 access points, 2 switches, as compared to hospitals in Zahedan.

Conclusion: The evaluated hospitals had a fairly favorable software infrastructure and a favorable hardware-software infrastructure. The same process is not followed for the selection and purchase of hardware equipment, and hospitals with more hardware equipment can send more patients' records to EHR. The tool developed in this study can be used to evaluate the technical infrastructure of EHR at the national level.

Keywords: Electronic Health Record, Technical Infrastructure, Hardware, Software

Introduction

Based on the article 45 of the 5th Economic, Social, and Cultural Development Program of the Islamic Republic of Iran, and to provide electronic health services and save on national resources "Electronic Health Record System" (SEPAS) was developed in Iran. According to the World Health Organization definition, Electronic Health Record (EHR) provides all health-related information concerning outpatient, inpatient, and emergency encounters, to health providers [1]. The European Union necessitates the development of an interactive EHR for improving quality of care, patient safety, public health, clinical research and health services management [2]. Implementing an EHR requires heavy financial resources and strong technical support [3]. Many barriers to the acceptance of EHR by healthcare professionals have been reported [4]. Studies showed that the implementation of information systems may be difficult due to employees resistance to change [5]. The use of EHR in the current complex health system faces technical challenges such as hardware and software problems, and non-technical challenges such as human, financial, and managerial factors. Therefore, technical and non-technical factors should be identified and resolved before implementation [6].

One of the important aspects of each EHR is its technical infrastructure (hardware and software) [7]. All functions of clinicians and administrative staff in an organization regarding data entry, review of patients past history, and recording and communication of patients care information needs the technical infrastructure of information systems [8,9]. In a study concerning the use of electronic prescriptions in primary care suggested that the implementation of electronic records requires substantial technical resources, as well as, the maintenance of technical infrastructures. Currently, SEPAS as a basis for the implementation of EHR is introduced in Iran. Although one of the main prerequisites for implementing EHR is the preparation of its technical infrastructure [6-9], it is poorly addressed in the literature. The aim of this study was to evaluate the technical infrastructure of EHR in the teaching hospitals affiliated with two large medical universities in Iran.

Methods

This descriptive cross-sectional study was conducted in 2016. The study population consisted of educational hospitals in Zahedan (Khatam-ol-Anbia, Ali-ebne-Abitaleb, Al-Zahra, and Baharan) and in Kerman (Afzalipour, Bahonar, Shafa and Shahid Beheshti). The data collection tool was a researcher-made checklist that was developed based on the results of the meetings with the technical administrators of SEPAS and the review of relevant studies [10]. Face validity and content validity of the checklist was confirmed by six health information management and medical informatics specialists.

One of the researchers completed the checklist by interviewing the hospital's informatics administrators. On average each interview lasted around two hours. The checklist had three sections. The first section consisted of 21 items concerning general information about the hospitals and their hardware equipment. The second section was composed of 8 multi-choice items (with different options) about the companies maintaining hospital information systems. The third section contained 34 dichotomous items (yes and no) to collect software (11 item) and hardware-software (23 item) related information. To analyze the data, responses to the checklist items were categorized into three parts: software, hardware-software and

hardware. Data were analyzed in SPSS 22 using descriptive statistics (about hardware infrastructure and the number of patient records sent to the Ministry of Health since the implementation of SEPAS in April 2014 to June 2016). We used a scoring method to analyze the data related to software and hardware-software infrastructure (yes/no items). In this method, we assigned score 1 to the "yes" option and 0 to the "no" option. Formula 1 was used to calculate the average score of each item. For each item, the average score of 0-0.3 was considered as undesirable, 0.31-0.6 as relatively desirable, and 0.61-1 as desirable infrastructure. Formula 2 was used to calculate the maximum obtainable score for each infrastructure. Based on this formula, the range of scores for software infrastructure was calculated between 0 and 11. For this part, the average score of 0-3.5 was considered as undesirable, 3.6-7.5 as relatively desirable, and 7.6-11 as desirable infrastructure. For the hardware-software infrastructure, the range of scores was calculated between 0 and 23 and the averages score of 0-7 was considered as undesirable, 8-11.5 as relatively desirable, and 11.6-23 as desirable infrastructure.

Study dimensions		Educational hospitals in Zahedan (n=4)	Educational hospitals in Kerman (n=4)
HIS provider	Rayavaran	2	0
	Peyvand-dadeh	1	1
	Tirazheh	1	3
Supporting mechanism of provider	Phone	3	4
	On-site worker	1	0
Mechanism for communicating problems	Correspondence	2	1
	Phone	2	2
	Email	0	1
Operating system of clients	XP	4	4
	7	4	4
	8.1	2	1
Operating system of Windows server	2003	0	0
	2008	2	1
	2012	2	3
Networking with university	Intranet	4	4
	Internet	4	4
No. communicated records to university*		140815	143927
Fixed beds		1274	1445
Average bed occupancy rate*		81.4	75.4

Table 1: General information of teaching hospitals in Kerman and Zahedan.

Formula 1:

$$\text{Score} = \frac{(\text{numerical value}[\text{weight}] \text{ of each item*the frequencyof yes responses})}{\text{the number of participants responded to that item}}$$

Formula 2: Score range=(numerical value[weight] of each item)*question frequenc

Ethical approval was received from the Research Ethics Committee of Kerman University of Medical Sciences. (Ethical number: IR.KMU.REC.1396.1340).

Results

The findings of this study (Table 1) showed that three out of four hospitals in Kerman had been using the HIS developed by Tirajeh, and two out of four hospitals in Zahedan had been using the HIS developed by Rayavran. The technical support of the HIS by these companies in all four hospitals in Kerman and in three hospitals in Zahedan was done via phone. Windows 7 and Windows XP were the most common operating systems in all eight hospitals in Zahedan and Kerman. The information systems in all hospitals were connected to the information systems in their corresponding university via the Internet and intranets. Hospitals in Kerman had a total number of 171 more beds and a less average occupancy rate (75.4) than the hospitals

in Zahedan. The hospitals in Kerman had sent 3112 more records to SEPAS than the hospitals in Zahedan.

Infrastructure	Score (Maximum=1)
Web-based HIS[1]	0.75
Domain controller HIS	0.25
Identity inquiry from Registration Organization token	0.875
Firewall security	0.625
Local firewall	0.375
Local firewall approved by the Ministry of Health	0
Non-local firewall	0.25
Non-local firewall approved by the Ministry of Health	0.25
Restrictions on easy password	0.375
Active antivirus	1
Determining access level	1
Total score	5.75

Table 2: The software Infrastructures of the Electronic Health Record system.

The information of the software infrastructures of the hospitals is shown in Table 2. These infrastructures had a relatively desirable average rating of 5.75.

Among the software infrastructures, the existence of antiviruses on clients and determination of access levels for users gained the highest score of 1 in all 8 hospitals. None of the hospitals used the local firewall approved by the Ministry of Health (score=0).

Table 3 shows the hardware-software infrastructure of the Electronic Health Record system in the hospitals. The total score of hardware-software infrastructure in the hospitals of two universities was 20.1 indicating a desirable situation. Most of the infrastructures in this area received the highest score of 1, and the functionality of connecting a HIS to other hospitals received the l

The hardware infrastructure had a better situation in hospitals in Kerman (Table 4) so that the number of hardware in these hospitals was 258 clients, 15 access points, 2 switches, 54 RAMs, 3 cores and 1 raid higher as compared to hospitals in Zahedan. Also, the capacity of the computer RAMs was 2 gigabytes higher in Kerman. Hospitals in Zahedan had 18 more hard drives but the capacity of their hard drives was 118 gigabytes less compared to hospitals in Kerman.

Infrastructure	Score (Maximum =1)
Internal network	1
Connection map for HIS clients	0.875
Wireless access	0.5
Access through wired and cable lines	1
Optical fiber	0.625
[1]	0.75
[2]	1
Wireless card	0.375
[3]	0.75
Backup on storage devices	1
Preserving the confidentiality of electronic information	1
Software supporting policies	0.875
Hardware supporting policies	1
Maintenance and backup policies	1
Developing software supporting policies	0.875
Developing hardware supporting policies	1
Developing maintenance and backup policies	1
Codes and standard definitions	1
Certificate of compliance with SEPAS standards	1
Certificate of HIS performance assessment	1
Digital imaging equipment	1
[4]	0.75
Possibility of connecting PACS to other hospitals	0
Total score	20.1

Table 3: The hardware-software infrastructures of the Electronic Health Record System.

Discussion

Research findings showed that educational hospitals in Kerman and Zahedan have a relatively desirable software infrastructure. Most hospitals use web-based HIS. The use of firewalls and active antivirus on HIS clients in all hospitals is desirable. Also, the access levels for the users in different departments and units are defined and the patients' identity is inquired appropriately in hospitals of both universities.

Nevertheless, no standard or managerial regulation is followed for the selection of local or non-local firewalls [11]. In a systematic review about the privacy and confidentiality of patients information in EHR, suggested that EHR should encrypt data to improve information security and to ensure patients about the secure accessibility and confidentiality of their information. Likewise, the results of this study indicated that hospitals work in accordance with national standards

and guidelines related to the security, confidentiality and authorized access to information. It seems that due to inadequate management and supervision of the firewalls in hospitals, and the poor knowledge of IT staff for selecting a firewall, each hospital chooses a local or non-local firewall according to its policy.

The results showed that educational hospitals in Zahedan and Kerman have a desirable hardware-software infrastructure. According to the study by Meeks [11] one of the most common concerns about the safety of EHR implementation is the software security and the faulty hardware configuration concerning users access. Another concern is obsoleteness of software and the need for a software upgrade or replacement, as well as, insufficient knowledge of IT support staff in this area. These can lead to interference of technical with non-technical issues and threaten the safety of EHR. Thirteen out of twenty-four hardware-software items of the hospitals had a desirable situation. The most important reasons for compliance with hardware-software requirements were the obligation of Ministry of Health to comply with them in the hospital accreditation program, and the supervision of the deputy for treatment of universities. Since eight of these thirteen items are scored in the hospital accreditation program, it appears that hospitals complied with these items in order to earn a higher accreditation score.

In terms of hardware equipment, the hospitals in Kerman had more equipment than the hospitals in Zahedan. This resulted in transferring more patient records from hospitals in Kerman to SEPAS, despite their lower average bed occupancy rate. Since, the majority of the information transferred to SEPAS are patients identification and financial information, having more hardware equipment, such as clients, access points, and switches, in a hospital leads to transferring more patients record to SEPAS. This can also provide access to the Internet and intranet for more users and subsequently result in recording and communication of the information of more records to SEPAS. According to Li [12] it is necessary to assess EHR readiness and acceptance; hardware equipment, network infrastructure, support staff, and applications prior to the implementation of an EHR. Lorenzi [13] Proposed a number of solutions for the information technology challenges including the design of switches for the transmission of high-volume data such as imaging data, normalization of the data in databases, using SQL Server 2008, limiting the duration of online access to patient records and rectifying the current HIS deficiencies. EHR is not fully implemented in Iran, and mostly identification and financial information are communicated to SEPAS. However, it is planned to communicate all clinical information in the future. There is a high variation in the collection of information by different systems supported by the Iranian Ministry of Health such as the Integrated Health System (SIB) and the National Health Network (SHAMS). Since variation in data collection impedes data exchangeability [14]. Therefore, succeeding to a real EHR depends upon systems interoperability which may take many years to achieve.

Infrastructure	Hospitals in Zahedan	Hospitals in Kerman
Server	10	9
Client	320	578
Access point	45	60
Switch	53	55
Hard disk	40	22
The capacity of hard disks	457G	575G
RAM	24	78
The capacity of RAM	30G	32G
Core	12	15
Raid	2	3

Table 4: The frequency of hardware Infrastructures of the Electronic Health Record System in two groups of Hospitals.

We collected the professional viewpoints of staff having the most related expertise--including SEPAS technical staff, IT experts, and medical informatics specialist-- for the design and development of the data collection tool. Given the lack of a standard tool for the assessment and validation of the technical infrastructures of the systems in hospitals, the checklist developed in this study can be used as an accreditation measures in the hospital accreditation program. The results showed that in order to increase the accreditation score of each hospital, the infrastructure items that are mandated by the accreditation program were completely met by the hospitals. Since the technical infrastructure of EHR highly impacts the accreditation score of a hospital, it is recommended that the control and accreditation office of Iranian Ministry of Health adds this measure to its hospital accreditation program. One of the limitations of this research was the limited number of studies addressing the evaluation of the EHR technical infrastructure. Therefore, the authors developed the checklist based on the review of other relevant studies and the knowledge of the specialists and technical staff of SEPAS. Insufficient knowledge of the hospitals IT supporting staff concerning EHR and its objectives was another limitation. Hence, clear explanations about the mission and concept of EHR and its standards were provided to these staff.

Conclusion

The current software infrastructure of the hospitals in Iran is relatively desirable and their software-hardware infrastructure is desirable. No standard or consistent procedure is followed for purchasing hardware equipment, so that a single-specialty hospital may have more facilities and equipment than a general hospital. According to the findings, hospitals with more hardware equipment can communicate the information of more patients' records to EHR. Hence, the existence of a good technical infrastructure can improve the communication of the information. It is suggested that the Ministry of Health use a standard tool to assess all hardware and software infrastructure and equipment of hospitals in accordance with existing standards. The checklist developed in this study can be used as the starting point for evaluating the technical infrastructure of an EHR at the hospital level.

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