Issues of Adoption: Can Health Services Designed for Developed Countries be Adopted in Developing Countries?

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Abstract

Electronic health record (EHR) systems are a popular mechanism for accessing health records in the developed world and have contributed towards improved and cost-effective health care management. However, the development of appropriate and scalable EHR systems in developing countries has been difficult to achieve because of certain limitations inherent in the technological infrastructure. For instance, bandwidth limitations and power outages make it difficult to guarantee dependability in terms of accessibility to the data. This paper presents a comparative study of 19 EHR systems in terms of the security and usability of these systems within the context of the developing world. The evaluation is based on a number of dimensions such as development environment, system platform, type and access control standards found in the National Institute for Standard and Technology (NIST) and Certification Commission for Health Information Technology (CCHIT). Our research indicates that all the systems evaluated require online access control decisions. Access to data on a central server is controlled by a mechanism that verifies/authenticates users or parties wanting to view/modify/edit patient records. However, solely relying on an online access control system is limiting, particularly in developing countries where access to the server can be disrupted by a number of disastrous events. Additionally, literature also reveals that all the evaluated tools were developed with the user contexts in the developed World and therefore do not represent the needs of the patients and medical practitioners in the developing countries.

Keywords

Security, Measurement, Performance, Usability.

1. Introduction

An Electronic Health Record (EHR) is a record of health-related information on an individual that is created, gathered, managed, and consulted by authorized healthcare professionals in a digital format (HIPAA, 2009). EHRs can exist on standalone computers, networked server computers, removable disks or mobile devices and can be accessible online from interconnected network systems providing the opportunity for healthcare organizations to improve health care delivery. Electronic health records enable the efficient communication of medical information and thus reduce operating costs and administrative workload (Gunter & Terry, 2005).

Over time, researchers have made significant efforts to design and implement EHR systems of which some are employer sponsored (Dossia, sponsored by Wal-Mart, BP and AT&T), provider sponsored (MyHealtheVet, sponsored by the United States Department of Veterans Affairs), and others are independent products (Microsoft HealthVault and Google Health, which were developed for profit making and open source projects respectively). However, the development of appropriate and scalable EHR systems in developing countries has been difficult to achieve (Omary, Lupiana, Mtenzi, & Wu, 2009; Tierney et al., 2010). The literature reveals many EHR systems that have not survived the test of time. Such systems include MEDCAB (Kamadjeu, Tapang, & Moluh, 2005) and FUCHIA (Tassie et al., 2002). All the available literature indicates that these systems are no longer actively in use or development.

Similarly, with the explosion of open-source EHR systems, more patients and physicians in developed countries are shifting towards accessing health information online. The $34 billion of incentives provided by the American Recovery and Reinvestment Act (ARRA) (2009) has greatly increased the development of open-source EHR systems in developed countries. The ARRA further stresses that healthcare providers should deploy EHR systems that are certified for "meaningful use" (www.healthit.gov) criteria, which includes the implementation of access control (Smith et al., 2010). The intent of meaningful use criteria is to ensure that EHR systems can interoperate with other systems in order to enable electronic exchange of health information in accordance with all laws and standards.

While previous studies have widely documented the success and failure factors of information and communication technology (ICT) solutions in developing countries, there appears to be a gap in specifically answering the question; can online health services designed for developed countries be adopted for EHR systems in developing countries? Studies conducted by Mars and Seebregts (2008), Yogeswaran and Wright (2010), and Forster et al. (2008) deal with broader issues of adoption such as technology investments, early stakeholder's participation and training. Other studies focus on policy and regulatory issues for EHR systems and give less attention to technological barriers (Coleman, 2010; Jacucci, Shaw, & Braa, 2006). In addition, most studies have been conducted for developed countries (Greenhalgh et al., 2010; Sanders et al., 2012; McGinn et al., 2011). From the perspective of the health digital divide, the available literature does not yet seem to adequately answer whether health services designed for developed countries can be adopted in developing countries. Therefore, our study seeks to answer this question, and guide researchers, development teams and regulatory organizations by assessing the potential and applicability of the current EHR systems in developing countries. The paper classifies and summarizes EHR systems and provides a framework for researchers to extract assertions and provide guided decisions. A set of assessment criteria was established to ascertain the degree to which the evaluated systems address technology constraints in developing countries, NIST (www.nist.gov) meaningful use and CCHIT certification (www.cchit.org). Using these evaluation criteria, we evaluated 19 EHR systems extracted from online search databases.

The rest of this paper is organized as follows; Section 2 presents background work on digital divide and related healthcare requirements as specified by NIST and CCHIT certification. Section 3 presents definitions and the methodology behind our evaluation. Section 4 details the evaluation results followed by conclusions based on the results of the evaluation.

2. Background

In this section, we review literature on the digital divide as it applies to E-Health systems and the NIST and CCHIT requirements for developing secure EHR systems to protect patients' records from compromise.

2.1. E-Health and Digital Divide

In the context of this study, developing countries are countries with various challenges such as frequent power outages, intermittent connectivity and lack of centralised services in addition to other Information and Communication Technology (ICT) constraints. When compared to developed countries, the gap is described as the digital divide (Brodie et al., 2000; Hsu et al., 2005). In relation to E-health, the digital divide is a form of health disparity in healthcare's access to and use of both the information technologies and health information online (Brodie et al., 2000). Barriers to the emergence of an equitable information society have led to the existence of the digital divide (Liff & Shepherd, 2004). According to "Glocal" eHealth Policy context (www.rockefellerfoundation.org), developing countries trail far behind developed countries in E-health services and the widening gap has been attributed to several challenges: failure to develop E-health roadmaps by the Governments resulted from insufficient political will, lack of e-health experts or leaders to champion E-health projects, corruption, limited resources to finance the development of the project, poverty, frequent power outages among others (Hogberg, 2005; Omary et al., 2009; Kalogriopoulos et al., 2009).

2.2. International Standards and Regulations

According to Oppliger (1996), international standards can be defined as documented agreements containing precise criteria that must be followed consistently as rules, guidelines or definitions of characteristics to ensure that any products, materials, processes or services are fit for their purpose. The acceptance and adoption of these standards is recognized by very many states and governments in Europe, Asia, Canada and some African countries (Tuyikeze, 2005; Tuyikeze & Pottas, 2005). Due to lack of standards and regulations specific to individual countries, Tuyikeze and Pottas (2005) from South Africa recommended that it is necessary to adopt other standards such as HIPPA, NIST or CCHIT certification to overcome some of the criticisms of ISO standards, such as being too general and therefore not providing stringent solutions to specific healthcare requirements. Therefore, we assembled eight evaluation criteria to represent legal requirements of the EHRs from NIST and CCHIT certification.

2.3. NIST Meaningful Use

The National Institute of Standards and Technology (NIST), known between 1901 and 1988 as the National Bureau of Standards (NBS) is an agency in US that works with industries to develop and apply technology, measurements and standards. NIST provides certification programs to ensure that E-health systems offer the necessary functionality to help healthcare providers meet meaningful use criteria. NIST provides four criteria: the first criteria requires that users be given a unique name and/or identification number for tracking; the second criteria requires that controls

should be established to permit only authorized users accessing patient's records; the third criteria requires that a user authorized for emergency situation be granted a set of privileges applicable only for emergency situation and lastly, the ability to activate emergency access roles.

2.4. Certification Commission for Health Information Technology (CCHIT)

The combination of NIST and CCHIT meaningful criteria are the driving force behind the implementation of access control in E-health systems. The goal of access control within E-health systems is to provide systems access control by ensuring that only authorized users have access to patient's information (Tuyikeze, 2005; Smith et al., 2010). In order to accomplish this goal, CCHIT provides four criteria: the first criteria requires that EHR systems must implement permissions such that users are only given least privilege; the second criteria requires administrative facilities to assign privileges to users and groups; the third criteria requires that EHR systems must implement either one of user-based access control (UBAC), context-based access control (CBAC) or role-based access control (RBAC); and lastly, EHR systems should allow a user to have their permissions removed without having to delete the user from the system. We use these criteria to analyse the systems we found in our literature search.

3. Selection criteria

Below are the criteria we used for selection and inclusion of articles in our research.

i. We did a literature search based on the following keywords; Electronic health record systems\tools\software, patient health record systems, electronic medical record systems, and personally controlled health record systems). Various databases were used to select our primary studies.

ii. We surveyed tools developed from 1999 to 2010 because it is during this time that EHR systems had gained much wider attention.

iii. The review excludes magazines, student's dissertations, newspapers and books among others. We were mostly interested in analysing tools that are currently in use. We also excluded tools and publications not written in English and studies without a sufficiently concrete description of implementation procedures. This means that the results may not be generalised to other E-health tools.

3.1. Selection Procedure

Initially, 6 online search databases were selected and a total of 157 EHR articles and systems were generated. Based on the titles, abstracts and procedures for the implementation of online health record systems, a total of 89 articles and tools were excluded. 68 articles met the selection criteria and were presented for further review. 44 articles were then excluded because despite having relevant titles, abstracts and full text, they did not present relevant tools for this study. The procedure for the selection of our articles is illustrated in figure 1.
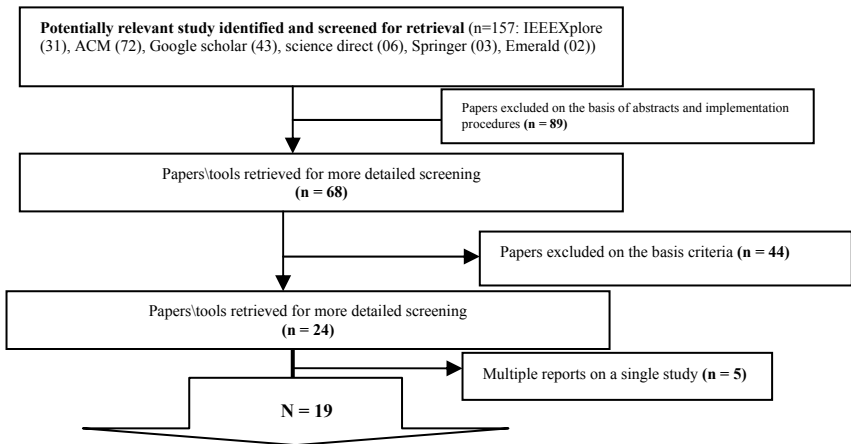
Figure 1: Review flow diagram

3.2. Evaluation Criteria

In this section, we introduce the evaluation criteria which offers an analysis of EHR systems based on three general dimensions i.e. technology, NIST meaningful use and CCHIT certification. Technological features are sub divided into development environments (DE), system platform and type. System platform (Platform) classifies tools based on web/client-server platform or desktop platform. Desktop platforms enable health care providers to record and store health information on a desktop based application. Client-server platforms use powerful servers with a high bandwidth connection to the network to hold centralized health information. System type (Type) classify tools based on whether they are meant to be purchased (p), have a complete free software downloadable version (dv) and/or meant for demonstration (d).

NIST meaningful use provides four criteria for our evaluation: **NIST-U1:** Users given unique name and/or number; **NIST-U2:** Access controls with defined user privileges; **NIST-U3:** Emergency-time only privileges for user roles; **NIST-U4:** The ability to activate emergency access roles

CCHIT certification defines four criteria for our evaluation: **CCHIT-M1:** Users are given least privilege permission set; **CCHIT-M2:** Administrative facilities to assign privileges to users; **CCHIT-M3:** Context-based access control (CBAC), user-based access control (UBAC), or role-based access control (RBAC); **CCHIT-M4:** User role revocation without deleting a user

Table 1 illustrates a classification of various EHR systems obtained from our review based on the dimensions described above.

4. Discussion

In this section, we provide a description of 19 EHR systems analyzed in table 1 and summarize information about the applicability of these tools in developing countries. We also provide information on whether the systems passed or failed each of the 11 evaluation criteria presented in section 3.2.

From the technological perspective, the biggest number of tools analysed are open source tools – those that have a complete free software downloadable version (HealthVault (www.healthvault.com), Indivo (indivohealth.org), Open EMR (www.oemr.org), iTrust (http://agile.csc.ncsu.edu/iTrust/wiki/doku.php?id=start), WorldMedcard (www.worldmedcard.com), Tolven (www.tolven.org), Myhealthfolders (myhealthfolders.com), MediCompass (https://www.medicompass.com/mcweb/default.aspx) and Dossia (dossia.org)), followed by proprietary tools – those that are owned by companies and the source code is not accessible (HealthConnect, FIS' HealthManager (www.fisglobal.com), VitalChart (www.vitalchart.com), SmartPHR (www.thesmartphr.com), Sharedhealth (www.sharedhealth.com) and Mymedicalrecords.com (www.mymedicalrecords.com)). The study further indicates that only one tool was designed for demonstration only (Mitamura et al., 2005). This therefore implies that the majority of tools in the matrix are open source tools. Dalle and Jullien (2002) argue that the openness of the source code is a key feature, which together with compatibility allows open source software to be advantageous over proprietary software. Increasingly, a vast number of proprietary tools do not mention their development environments and hence the use of "??" in the matrix.

Despite the flexibility proposed in the NIST and CCHIT certification in regard to access control, all the tools analysed used RBAC. Ferraiolo et al. (2001) highlighted that RBAC's flexibility provides the ability to simplify policy customization and make security policy management a none-technical job. The evaluation indicates that all the tools analysed are actively seeking to meet both NIST and CCHIT certification. All tools evaluated provide a set of pre-defined roles and permissions that an administrator can assign to users or groups of users. The pre-defined roles in the system represent a common role within the healthcare settings e.g. physician role, technician role etc. A user may be assigned one or more roles. Healthcare administrators have the ability to add any arbitrarily named role and assign it any number of privileges.

The evaluation further indicates that all tools met the first two NIST meaningful use criteria (NIST-U1 and NIST-U2), and only HealthVault, Indivo, VitalChart, and Dossia support emergency-time only privilege for user roles (NIST-U3). The lack of emergency access roles (NIST-U4) causes all the evaluated tools to fail to meet NIST meaningful use criteria. From the CCHIT certification, all the tools evaluated provide users with a given set of least privileges (CCHIT-M1), enables the administrator to define roles for the users that guide information access in the system (CCHIT-M2) and also allows user revocation without first having to delete users from the systems (CCHIT-M4).

Daglish and Archer (2009) argue that patients need to be in control of their data such that those responsible for patients' care can perform their duties efficiently. Other reasons why patients need access to their health records include: records at the hospital server could be unreachable due to frequent power outages and/or unreliable Internet connections. Similarly, if the patient cannot give a new doctor access to his/her existing records, redundant tests may end up being used, resulting to different portions of patient's data being scattered among multiple EHRs. This makes it difficult for the doctors to have a complete picture of the patient's treatment history.

System/Dimension	Technology			NIST- Use	Meaningful	CCHIT Criteria	
	DE	Platform	Type	NIST-U1, U2	NIST-U3, U4	CCHIT-M1, M2	CCHIT-M1, M2
HealthConnect	PerlOracle DB	Web based	p	yes	no	Conf. dependant, yes	RBAC, yes
Google Health	Java, .Net, XML, PHP, python	Web based	dv	yes	no	Conf. dependant, yes	RBAC, yes
Tool A	??	Web based	d	yes	no	yes	RBAC, yes
MEDIS	HTML, XML, JSP script language, Java? Apache & Tomcat web servers	Web based	p	yes	no	Conf. dependant, yes	RBAC, yes
Microsoft. HealthVault	.Net, Java, XML	Web based	dv	yes	Conf. dependant, no	yes	RBAC, yes
Indivo	Java, PHP, Tomcat, Apache Web Server 2.0, MySQL, PHP-Java Bridge 4.1.2	Web based	dv	yes	Conf. dependant, no	yes	RBAC, yes
FIS HealthManager	PIP, GT.M	Web based	p	yes	no	Conf. dependant, yes	RBAC, yes
VitalChart	??	Web based	p	yes	Conf. dependant, no	Conf. dependant, yes	RBAC, yes
OpenEMR	PHP, JavaScript, MySQL	Web based	dv	yes	no	Conf. dependant, yes	RBAC, yes
SmartPHR	XML??	Web based	p	yes	no	yes	RBAC, yes
Sharehealth	??	Web based	p	yes	no	yes	RBAC, yes
Dossia	XML, .Net (C#), Java, PHP	Web based	dv	yes	Conf. dependant, no	yes	RBAC, yes
iTrust	Java/MySQL, Apache Tomcat webserver	Web based	dv	yes	no	yes	RBAC, yes
WorldMedcard	PHP, .Net, Windows Server 2008, SQL server, ASP.Net, ISS,	Web based	dv	yes	no	yes	RBAC, yes
MyMedicalrecords.com	??	Web based	p	yes	no	yes	RBAC, yes
Tolven	J2EE framework, JBOSS application server, OpenLDAP	Web based	dv	yes	no	Conf. dependant, need LDAP	RBAC, yes
Myhealthfolders	.Net (aspx)	Web based	dv	yes	no	yes	RBAC, yes
Dr. I-Net	.Net (aspx)	Web based	dv	yes	no	yes	RBAC, yes
MediCompass	.Net (aspx)	Web based	dv	yes	no	yes	RBAC, yes

Table 1: Summarized Classification Matrix Showing EHR Systems versus Dimensions

However, all tools in the matrix are designed for healthcare providers – patients have little or no access to their health records. Electronic health record systems such as Microsoft HealthVault, Indivo[tm] and Dossia empower users with some access but the access must be online. In addition, all tools evaluated require online access control decisions. Solely relying on an online access control system is limiting, particularly in developing countries where access to the server is disrupted by a number of

disastrous events. When the server becomes unavailable, for example due to power outages that is common in developing countries, access control decision cannot be made, making EHRs unreachable. Studies conducted by Sunyaev, Chornyi, Mauro and Kremar (2010), Daglish and Archer (2009) highlights that any security mechanism needs to be usable; otherwise users will not use the system at all.

Furthermore, the infrastructure in developing countries is characterized by little or no Internet bandwidth, unreliable and intermittent main electricity and limited user expertise, among others (Omary et al., 2009). This implies that developing countries require context relevant tools – tools developed with the unique constraints of the developing world in mind. However, all the tools explored are developed with user contexts in the developed world and thus do not represent the needs of the users in developing world. This can be witnessed by the existing manual paper based health records in most healthcare organizations in developing countries (Omary et al., 2009; Tierney et al., 2010; Kalogriopoulos, Baran, & Nimunkar, 2009).

5. **Conclusion**

Despite the potential of EHR systems to address the challenges facing health systems in developing countries, the majority of EHR systems designed for developed countries cannot be adapted for implementation in developing countries. The failure of adoption is attributed to many factors including: 1) **Online Access Control:** The majority of EHR systems require online access control decision. When the server/database is unavailable, for example due to frequent power outages that is common in developing countries, access control decisions cannot be made, making health records unreachable; 2) **Users' Context:** The majority of EHR systems designed for developed countries were developed with the user contexts in the developed World and therefore do not represent the needs of the patients and medical practitioners in the developing countries.

We therefore feel that in order for EHR systems to satisfy the intended users specifically in developing countries, existing systems needs to be extended on mobile phones such that records can be made available when hospital servers are offline. Akinyele et al. (2011) affirmed that mobile phones (also called small handheld computers) can be used to provide health records without the need for a single server.

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