EVALUATING INTEGRATION APPROACHES ADOPTED BY HEALTHCARE ORGANIZATIONS

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ABSTRACT

Healthcare organizations typically consist of large numbers of disparate Information Systems (IS). These systems have been deployed to support the specific needs of healthcare organizations. The information sharing among these heterogeneous systems has always been one of the most prominent issues facing healthcare management professionals. The non-integrated IT infrastructure is often the cause of medical errors, which often leads to fatalities. Various integration approaches have emerged and been adopted to solve the countless problems associated with poor levels of integration. However, there are still many issues remaining to be solved, such as the level of integration needed, patients' data security and process integration. The multiple integration approaches that exist have resulted in marketplace confusion, especially in those sectors such as healthcare that lack sufficient technical exposure. The authors attempt to overcome much of this confusion by analysing current integration approaches deployed in healthcare. In doing so, the benefits and barriers of these approaches are evaluated. This evaluation will help decision-makers to better understand the complexity and issues surrounding the adoption of integration approaches.

Keywords: Evaluation, Integration Approaches, Healthcare Organizations

INTRODUCTION

In many countries the structure of healthcare organizations is divided into different tiers such as primary health care centers, secondary and tertiary hospitals (11). The objective of this structure is to provide healthcare facilities to citizens at a local and regional level with continuity across different levels of hierarchy. In such a distributed environment, Information and Communication Technology (ICT) has a leading role and significant impact on the practice of healthcare. Numerous information systems using multiple technologies and ranging from computerized patients' records to department-specific decision support systems have been deployed at different levels in healthcare organizations. This has resulted in healthcare organizations having been left with numerous islands of technologies that are difficult to integrate and manage. As a result, the need to integrate these systems has increased enormously. To address the problem of improved level of integration standards, projects such as Health Level 7 (HL7), CEN/TC251, Synergy Extranet (SynEx) and Synapses have emerged within the healthcare sector. Despite the implementation of these integration approaches, there are still many problems related to their adoption. Among these are issues associated with the cost of healthcare integration standards, and the level of interoperability, which remains very low (5). In this paper a review of the literature on Information Technology (IT) adoption in healthcare area is made for a better understanding of the context, including analysis of IT solutions implemented in healthcare organizations. In doing so, the integration standards, systems and projects that have been deployed in healthcare organizations to address integration problems are discussed. The implementation of these approaches has provided significant benefits to healthcare organizations and the authors have attempted to analyse and discuss these benefits. However, there are still many problems relating to the adoption of healthcare integration approaches, and the barriers to these integration technologies are also discussed.

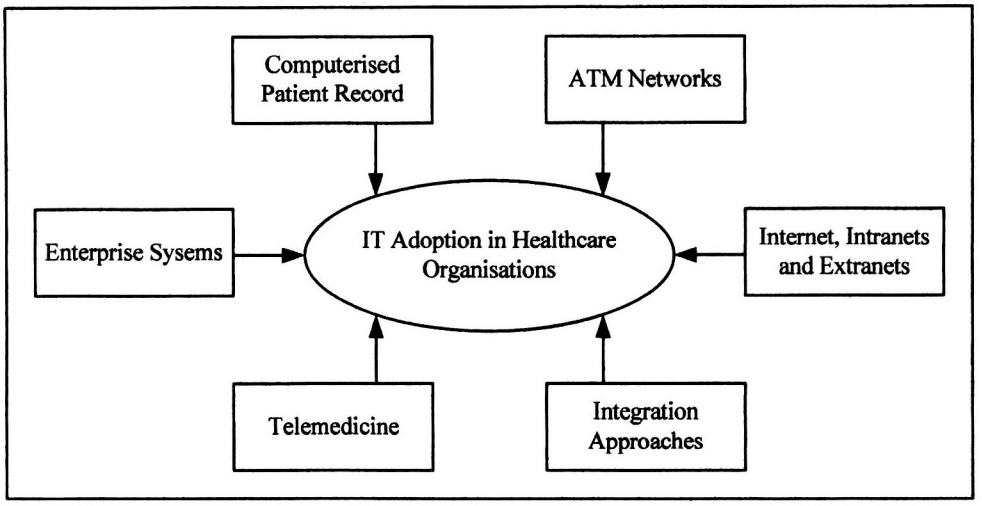
INTEGRATION STANDARDS, PROJECTS AND SYSTEMS ADOPTED IN HEALTHCARE ORGANIZATIONS

The adoption of IT in healthcare is characterized by a series of phases since the 1960s. Initially, IT adoption began in the 1960s in financial systems, which provided support to the organizations' billing, payroll, accounting and reporting systems (8). During this phase, IT adoption was clear and straightforward (e.g. elimination of clerical positions). Clinical departments took a major initiative during the 1970s that supported their internal activities such as radiology, laboratory and pharmacy (2). Financial systems once again became prominent in the 1980s, with major investments in cost accounting and materials management systems. During the 1990s, attention turned toward enterprise-wide clinical systems, including clinical data repositories and visions of a fully computerized electronic patient medical record (5). As a result, several developments in IT implementation have taken place in healthcare organizations, with IT playing an increasingly significant role in its delivery, as presented in Figure 1.

All these technological developments have been made in providing well functioning systems to healthcare organizations to improve healthcare services (10, 13). Computerized Patient Record (CPR) systems, adoption of Internet along with Intranets and Extranet, Asynchronous Transfer Mode (ATM) networks along with local area networks, wide area networks, enterprise systems, integration approaches and remote diagnostics via telemedicine have experienced significant growth in recent years (30).

This extensive use of IT in healthcare organizations has resulted in the development of various information systems. Murray (21) states that in healthcare institutions there are numerous information systems like: patients', laboratory, radiology, pharmacy, administrative and human resource management systems. These systems are presented in Table 1 with their characteristics.

FIGURE 1
Information Technology Adoption in Healthcare Organizations



The benefits of these information systems are related to the degree of integration of its data and processes (19, 20). However, the integration of such information systems in the existing, multi-architectural computing environment has been proved to be a complicated task and difficult to accomplish (38). Efforts have continued to achieve integration in healthcare organizations such as Health Level 7, CEN/TC251, Synergy Extranet (SynEx), Synapses. The description of these standards, projects and systems is presented in Table 2.

The adoption of integration standards, projects and systems has provided significant benefits to healthcare organizations and their supply chain problems. Nonetheless, healthcare organizations in part related to experience several barriers to the adoption of these approaches. There is a marketplace confusion regarding the adoption of these integration technologies due to the large variety of integration approaches. Therefore, to overcome this confusion the authors have attempted to evaluate and present the benefits and barriers of these integration approaches. This can therefore support healthcare organizations' decision makers during the analysis process of the integration technologies.

EVALUATING BENEFITS OF INTEGRATION APPROACHES

The evaluation of the benefits derived from the use of IT is considered a complex exercise (16). Khalifa (17) suggests that there is no single evaluation method that can be applied to the benefits of IT. The reason for this is that evaluation happens in many ways (e.g. formally, informally), using several criteria such as financial, technical and social (23). As a result, many authors such as Irani and Love (16) have suggested various classifications for the benefits (e.g. Strategic, Tactical and Operational). Shang and Seddon (24) proposed a model to classify the benefits into Operational, Managerial, Strategic, IT Infrastructure, and Organizational, whereas Serafeimidis and Smithson (23) have categorized the IT adoption benefits into Financial, Technical and Social.

The model proposed by Shang and Seddon (24) can be used for classifying the benefits of integration technologies adopted in healthcare organizations, for several reasons such as these benefits are derived from integrated IT infrastructure.

Based on a literature review, the authors have summarized the benefits of integration approaches adopted by healthcare organizations in Table 3, with Table 4 the evaluation of these approaches using the model developed by Shang and Seddon (24).

The classification and evaluation of the benefits indicates that at an operational level, the adoption of different integration technologies such as HL7 reduces costs (e.g. operational and personnel). From an organizational perspective, the close collaboration among the various health care originations improves the sharing of patients' clinical and medical data. From a managerial perspective, it indicates that these different integration technologies improve the quality of patient care and managerial control. From a technical perspective, these efforts achieve the integration at data level and reusability of objects. However, very little evidence has been reported that supports the integration of packaged applications. In addition, several organizational benefits are also reported by the adoption of these integration technologies, including accessibility of data and increased business efficiency. Moreover, most of the integration technologies developed in healthcare organizations are based on middleware technology (28). Middleware technology aims at reducing the impact of problems related to the development of complex applications within a heterogeneous environment (28). Therefore, in the next section the authors have attempted to present the barriers of these integration technologies.

BARRIERS OF INTEGRATION APPROACHES ADOPTED IN HEALTHCARE ORGANIZATIONS

There is much confusion regarding the approaches to healthcare information systems integration. Due to the diversity of integration approaches and standards, each of these approaches have been developed to provide specific solutions. Neither HL7 nor DICOM claim to be a panacea in solving all integration problems, with HL7 being suitable for the description of clinical signs, with DICOM only being suitable for the integration of radiology images (10, 35). The analysis of all these barriers is presented in Table 5, with Table 6 presenting an evaluation.

TABLE 1
Description of Healthcare Information Systems

Information Systems	Description	Characteristics	References
Patients' Information Systems	Various terms used in IT to describe computerization of patients' data, such as electronic medical record, patients' information system and computerized patients' record system. However, these terms are just for non-paper patients' record systems.	• Stores wide range of data about patients' clinical visits, hospitals admission notes, problem lists, allergies, discharge orders, diagnostic tests, medications, etc. • Patients' electronic data are being stored, captured, manipulated, retrieved, and transmitted for clinical and biological purposes.	Grimson et al (13), Ginneken (12), Hung (14), and Vargas and Ray (34)
Administrative Information Systems	Hospitals have implemented administrative information systems to deal with patients' admissions and discharge.	• Reduces billing errors • Increases customer satisfaction • Reduces personnel costs	Southard et al (27)
Laboratory Information Systems	Laboratory information systems are designed, developed and evolved independently from other of the information systems of the hospital.	• Provides connectivity with other equipment • Supports decision making in results diagnoses • Provides support to doctors in decision making regarding patients' treatment	Vagelatos and Sarivougioukas (33)
Telemedicine Information Systems	Telemedicine involves use of modern telecommunication technology to deliver heathcare services to remote patients.	• Designed to exchange patients' medical results, transmitted by various modalities. • Supports information exchange between doctors and specialists	Tyler (32), Egan and Liu (8), Chou and Chou (7), and Tan et al. (30)
Web Information Systems	Web applications have a crucial role in bridging the gap between healthcare providers and users, by making available the required information.	• Provides on-line access such as to patients, physicians, suppliers for required information • Facilitates communication between patients and physicians • Daily input from patients recorded and analyzed for better care.	Raghupathi and Joseph (22), Ginneken (12), and Siau (25)
Pharmacy Information Systems	Pharmacy is one of the most complex departments in healthcare organizations. In the pharmacy department, applications are developed to maintain drug records for various purposes.	• Supports maintaining drug records such as for ordering, stocking and distribution. • Supports screening for drug interactions such as drug-drug, drug-food, dose range checking, allergies, and duplicate drug protection.	Austin and Boxerman (2)
Education and Research Information Systems	In many healthcare organizations, research is a continuous process that focuses on new healthcare innovations.	• Supports further developments in research of diseases diagnoses • Opens up new dimensions of research	Ball (3), Grimson et al. (13)
Human Resources Information Systems	In the human resource department, various modules are developed to provide information and advice.	• Supports staff and management for personnel management, payrolls, superannuation policy, manpower training, employment law, staff needs and scheduled interviews	Austin and Boxerman (2)
Decision Support Systems (DSS)	In healthcare organizations, four types of DSS developed: traditional decision support systems, group decision support systems (GDSSs), executive information systems (EISs) and information warehouses.	• Facilitates in financial and scheduling domain • Supports in diseases diagnosis • Provides advice for further treatments	Ginneken (12), Southard et al (27)

These integration approaches have focused on the technological aspects, solving the connection problems between different devices, and the exchange of information between computer applications. While integrating systems with HL7 continues, development needs to obtain message standards that will track and control key processes within a hospital. Vargas and Ray (35) describe that as a recipient of HL7 messages, an application must be provided with the appropriate transport mechanism, a parser that maps the HL7 messages of interest into program data structures, and the logic to process HL7 messages. Similarly, to generate HL7 messages, an application must be provided with the appropriate transport mechanism, a translator that produces the text-based messages from program data structures, and the logic to generate HL7 messages. In addition, different autonomous systems typically communicate by exchanging messages through interfaces, but the message

mechanism only provides the interaction to separated modules (10, 11). Furthermore, the integration approaches are based on message-based technologies. Since messages can only solve the basic communication problem among the systems, this communication mechanism cannot achieve integration of the systems and cannot provide interoperability without meeting the requirements of the healthcare organization as a whole. Huston (15) states that security and confidentiality of patients' data has always been important. In an open and distributed processing environment, access control and authentication mechanism have a very important role in healthcare organizations. As patients' data may contain sensitive information such as emotional problems, psychiatric care, sexual behaviors, sexually transmitted diseases, physical abuses and so on, access to such information must be controlled as disclosure to unauthorized people can harm the patients. Patients and citizens must be assured that their information is held securely and shared based on appropriate legal, ethical and technical processes.

TABLE 2
Description of Integration Approaches

Integration Approaches	Description	References
Health Level 7 (HL7)	In 1987, HL7 was developed by Pennsylvania University Hospital to provide connectivity between hospital information systems and hospital medical equipment. Several versions of HL7 developed so far, latest version 3.0 based on XML syntax. HL7 standard provides facility for electronic data exchange. Data exchange implemented by exchanging messaging mechanism. This approach provides way of solving basic communication problems between systems and achieves data integration.	Beeler (4), Ferdinanc and Syed (9)
CEN/TC 251	In 1990, European Standardisation/Technical Committee for Medical Informatics 251 standardisation (CEN/TC 251) established. Basic implementation based on EDIFACT. Since 1999, XML is being implemented.This solution is dealing specifically with issues such as terminology, knowledge base and semantics in healthcare informatics. Architecture of this standard based on three co-operative layers, application, middleware and bit ways, each individually responsible for addressing specific needs of information systems.	Ceusters et al. (6), Spyrou et al. (29), Ferrara (11)
DICOM	In 1985, American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA) developed a standard that addressed issue of vendor-independent data formats and data transfers for digital medical images. Goals of Digital Imaging Communications in Medicine and Common Object Broker Architecture in Medicine (DICOM) are to achieve compatibility and to improve workflow efficiency between imaging systems and other information systems in healthcare.	Ferrara (10)
CORBAmed	Common Object Broker Architecture in Medicine (CORBAmed) is division of Common Object Broker Architecture (CORBA) devoted to domain of healthcare. Main objective to introduce this technology was to improve quality of care, reduce costs and improve interoperability throughout global healthcare community. CORBAmed defines standardized object-oriented interfaces between healthcare- related services and functions.	Ferrara (10), Spyrou et al. (29)
Synapses	Synapses project funded in 1995, under EU 4th framework health telemetric program. Main objective of Synapses is to solve problems of sharing data between autonomous information systems. Synapses use CEN/TC251/12265 architecture. This aims at promoting a middleware approach for healthcare information systems applications and establishing interface standards.	Spahni et al. (28)
Synergy Extranet (Synex)	European health telemetric project started in 1998. SynEx is industry-led standard of middleware products for shared and distributed health records on heterogeneous systems. Addresses issues inherent in provision and use of multimedia patient records across large enterprise-wide networks. SynEx aims to provide integration platform for both new and legacy applications deployed in healthcare organizations.	Spyrou et al. (29), Xu et al. (36)
Hansa	Healthcare Advanced Networked System (Hansa) architecture integrates different systems with middleware approach. This was achieved by using the Distributed Healthcare Environment (DHE), which provides open infrastructure, capable of integrating heterogeneous applications.	Spyrou et al. (29)

CONCLUSIONS

The literature review identifies the different IT systems adopted in healthcare organization. These include computerized patient record systems, adoption of Internet along with intranet and extranet, ATM networks, enterprise systems, integration approaches and remote diagnostics technique through telemedicine for the provision of better healthcare services. As a result, several applications are being used in healthcare organizations for various purposes, such as patient information, administrative, laboratory, telemedicine, education and research, human resource, decision support systems applications and pharmacy application.

The widespread adoption of these applications at different levels such as at primary and secondary level, were not deployed in a coordinated way but evolved as autonomous and heterogeneous applications. Thus in most cases applications function independently and do not share their information. As a result, this raises the need for adoption of integration technologies for the sharing of data and knowledge between these applications.

TABLE 3
Benefits of Integration Approaches Adopted in Healthcare

Dimensions	Benefits	Reference
Operational	• Reduce medical errors • Reduce operational cost • Reduce paperwork processes • Reduce operational cost	Liang et al. (19), Ginneken (12), Tsiknakis and Katehakis (31)
Managerial	• Improve quality of patients' care • Improve work efficiency • Improve managerial control	Zhanjun et al. (37), Ceusters et al. (6), Chwelos et al. (8)
Strategic	• Increase patients' satisfaction • Increase collaboration among hospitals • Improve decision support	Ferrara (10), Grimson et al. (13), Ginneken (12)
IT Infrastructure	• Reusability of objects • Achieve data integration • Integrate packaged applications • Reduce development risk	Altmann et al. (1), Ferdinand and Syed (9), Ferrara (10), Grimson et al. (13)
Organizational	• Improve accessibility of data • Achieve effective clinical and administrative management • Reduce hospitalization • Increase business efficiency	Ginneken (12), Zhanjun et al. (37), Liang et al. (19), Ginneken (12)

TABLE 4
Benefits Evaluation of Integration Approaches Adopted in Healthcare Organizations

Benefits	HL7	DICOM	COBR-AMED	SYNEX	SYNE-RGY	CEN/-TC 251
Operational						
Reduce medical errors	◘	◘	◘	□	□	□
Reduce paper work processes	□	□	□	□	□	□
Reduce operational cost	◘	□	□	□	□	□
Reduce personnel cost	◘	□	□	□	□	□
Managerial						
Improve quality of patients' care	◘	□	□	◘	◘	■
Improve work efficiency	□	◘	x	◘	□	◘
Improve managerial control	□	x	x	□	□	□
Strategic						
Increase patients' satisfaction	◘	□	□	□	□	◘
Increase collaboration of hospitals	◘	□	◘	■	■	■
Improve decision support	□	x	x	x	x	x
IT Infrastructure						
Reusability of objects	x	x	■	x	x	x
Achieve data integration	■	■	■	◘	◘	■
Integrate packaged applications	x	x	x	x	x	x
Reduce development risk	□	x	x	x	x	□
Organisational						
Reduce hospitalization	◘	□	□	◘	◘	◘
Improve accessibility of data	◘	◘	◘	■	■	◘
Achieve effective clinical and administrative management	■	□	◘	◘	□	□
Increase business efficiency	◘	x	x	x	x	x

Various integration approaches are adopted by healthcare organizations, such as HL7, CEN/TC251, SynEx, Synapses, DICOM and CORBAmed. This discussion identifies that most of these integration approaches are based on message-oriented middleware (MOM). MOM has a number of disadvantages which include (a) creation of single point-to-point links between different applications (b) requirement of altering the source and target application, (c) increased maintenance costs and complexity and (d) invasive nature of traditional middleware.

However, due to various integration approaches in the

marketplace there is a confusion regarding the adoption of these integration technologies in healthcare organizations. The authors have attempted to clarify this confusion by classifying the benefits and barriers of these integration approaches adopted in healthcare organizations. The benefits and barriers of these integration approaches are classified and analyzed by using the model proposed by Shang and Seddon (24). This analysis indicates that the adoption of these technologies has provided significant benefits to healthcare organizations that include improvement in the quality of patient care, managerial control, operational cost reduction and reduction of paperwork. This classification provides better understanding, and helps researchers to analyze the benefits and barriers of the integration approaches adopted.

TABLE 5
Barriers of Integration Approaches Adopted in Healthcare

Dimensions	Benefits	Reference
Operational	• High integration cost • Shared care • Physician-patient relationship • Return of investment	Carr and Moore (5), Southard et al. (27), Siau (25), Ginneken (12)
Managerial	• Lack of political will • Lack of procedure and policies	Siau (26), Raghupathi and Joseph (22)
Strategic	• Quality of patient care • Confidentiality of patient data	Raghupathi and Joseph (22), Huston (15)
IT Infrastructure	• Peer-to-peer connectivity • Access to patient data • No plug-and-play solution • Healthcare process integration	Ginneken (12), Spyrou (29), Carr and Moore (5), Grimson et al. (13)
Organizational	• Support for better healthcare • Lack of leadership and training	Grimson et al. (13), Ginneken (12)

TABLE 6
Evaluation of the Barriers of Integration Approaches Adopted in Healthcare

Barriers	HL7	DICOM	COBR-AMED	SYNEX	SYNE-RGY	CEN/-TC 251
Operational						
High integration cost	■	◘	■	■	■	■
Shared care	◘	◘	◘	◘	◘	◘
Physician-patient relationship	◘	■	■	■	■	■
Return on investment	◘	■	■	■	■	■
Managerial						
Lack of political will	◘	□	◘	◘	◘	◘
Lack of procedures and policies	◘	□	◘	□	□	◘
Strategic						
Quality of patient care	◘	x	◘	◘	◘	□
Confidentiality of patient data	◘	x	□	■	■	■
IT Infrastructure						
Peer to peer connectivity	■	◘	□	■	■	◘
Access to patient data	□	□	□	□	□	□
Healthcare process integration	□	□	□	□	□	□
No plug-and-play solution	◘	x	□	x	x	x
Organisational						
Support for better healthcare	■	◘	◘	◘	◘	■
Lack of leadership and training	■	◘	◘	◘	◘	■

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