Evaluating the Adoption of Enterprise Application Integration in Healthcare Organisations

Abstract

Healthcare organisations are exploiting the use of Information Technology (IT) to automate and improve their clinical and business processes. Decisions regarding IT implementations are often made at departmental level with each department developing Information Systems based on its needs, beliefs, practices and expertise. As a result, IT infrastructures in healthcare organisations often consist of a number of autonomous and heterogeneous systems. The integration of these systems is therefore amongst the most urgent priorities for healthcare organisations to meet the increasing clinical, organisational and managerial needs. Enterprise Application Integration (EAI) has emerged to provide significant benefits to organisations. EAI overcomes data and processes integration problems and reduces the overall integration cost through reduction of integration time and maintenance cost. As a result, many organisations are embracing EAI to overcome their integration problem. However, it appears through a critical review of the literature that the EAI has not been widely studied in healthcare organisations. This work therefore evaluates the adoption of EAI in healthcare organisations. This has lead to development of a conceptual framework that determines critical factors which influence the EAI adoption. Fuzzy Cognitive Mapping (FCM) simulation is used to demonstrate the causal inter-relationships between these identified factors. A qualitative case study strategy is used to examine the proposed framework and causal inter-relationships among the factors of the framework in three hospitals in United Kingdom. The analysis of empirical data demonstrates multiple inter-relationships of the influencing factors for the adoption of EAI in hospitals. FCM simulation provides insights into better understanding about interdependencies of the factors that influence EAI adoption. This research makes novel contribution at two levels. First, at the conceptual level, as it incorporates factors identified separately from the area of integration technologies and healthcare informatics. These factors are used for the development of a framework for the evaluation of EAI adoption in healthcare organisations. Second, the application of FCM simulation identifies casual inter-relationships among the EAI adoption factors. This enhances the quality of the evaluation process, and highlights the importance of each factor and its inter-relationship with other factors. The proposed framework can be used as a decision-making tool to support management of the healthcare when taking decisions regarding the adoption of EAI. Additionally, it can be used by researchers to analyse and understand the adoption of EAI.

Keywords: Healthcare organisations, Enterprise Application Integration, Evaluation, Framework, Fuzzy Cognitive Mapping
Introduction

The non-integrated Information Technology (IT) infrastructure causes medical errors that are related to the loss of human lives (Raghupathi and Josph, 2002). As the information needed is not available on time, errors usually occur in prescribing, administering and dispensing drugs to patients (Cowan, 2004). It is reported that the limitations of healthcare systems are related to the loss of 64 persons per day (23,360 people per annum) in the UK, due to problems related to medical errors. Thus, the need for integration becomes critical for healthcare sector (Khoumbati et al., 2004).

Over the years, healthcare organisations have deployed various integration solutions such as Health Level 7 (HL7), CEN/TC251, Synergy Extranet (SynEx), Synapses, Digital Imaging and Communication in Medicine (DICOM) and Electronic Data Interchange (EDI) to address systems integration problems. Also many healthcare organisations turned to the implementation of Enterprise Resource Planning (ERP) systems to solve the year 2000 (Y2K) problems. All these technologies have a number of disadvantages, as they:

- require point-to-point interconnections
- are invasive in nature and cause changes to applications code
- result in complex solutions with high maintenance cost
- cannot support the process integration

To this end, Enterprise Application Integration (EAI) has emerged to overcome integration problems at all levels (e.g data and process). As a result, many large organisations are turning to EAI as a means of solving data and process integration problems. However, it appears through a critical review of the literature that the evaluation of EAI adoption has not been widely studied in healthcare organisations. Therefore, healthcare organisations seek answers for the impact of EAI adoption, as it will help them in understanding the factors such as benefits, barriers and costs that influence the adoption of EAI in such organisations.

Research carried out during this study will evaluate the adoption of EAI in healthcare organisations. In doing so, a framework will be developed that investigates several factors that are influencing such adoption. Although these influential factors are well analysed in the literature there is a need to understand, evaluate and explain them in the area of healthcare. In seeking to address this issue, this research uses Fuzzy Cognitive Mapping (FCM) as a technique to identify causal inter-relationships among the EAI adoption factors. This will enhance the quality of the evaluation process, emphasises the importance of each
factor and its inter-relationship with other factors, and seek to support healthcare organisations’ decision makers in exploring the implications surrounding EAI adoption.

This chapter introduces the focus of interest of this thesis. It presents the need for integration and discusses the information systems integration problems in healthcare organisations. The aim, objectives and an overview of the context of each chapter in the present thesis are provided here.

Need for Information Systems Integration in Healthcare Organisations

At an organisational level, the structure of healthcare organisations is divided into different tiers such as primary health care centres, secondary and tertiary hospitals (Ferrara, 1998). 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 (Tsiknakis et al., 1996). In such a distributed environment, Information and Communication Technology (ICT) has a leading role and significant impact on the practice of healthcare at all levels.

For the past decades, organisations have focused on the latest technological innovations to overcome their organisational problems and automate their business processes. As a result, there was rarely a single approach for implementing Information Systems (IS), as organisations have developed their applications without a common enterprise architectural planning (Markus and Tanis, 1999). Nowadays, dozens, if not hundreds of different types of open and proprietary systems exist in organisations (Chalmeta et al., 2001). Many of these systems have their own database, networking, and operating systems. As a result, the majority of companies were left with a collection of disparate and, in many cases, incompatible systems (Erasala et al., 2002). Therefore, this diversity of heterogeneous systems causes numerous problems due to the non-integrated infrastructure, some of which include:

- Interconnections of applications
- High operational and maintenance cost
- Decline in productivity

According to Chalmeta et al., (2001), the first approach towards industry integration was focused mainly on the technological aspects, solving the connection problems among different devices, and the exchange of information between computer applications. Themistocleous et al., (2001) and Puschmann and Alt (2001) estimate that for \( x \) applications, a total of \( x^2(x-1)/2 \) interconnections are needed when each application is interconnected with the rest of the applications. Interconnecting applications is a very
difficult task. To achieve interconnectivity among applications, programmers map data from the source’s application format to the targets, since applications require compatible data to store and manipulate them. In support of this, programmers invade and alter the code of systems to map data and create these interconnections (Themistocleous et al., 2001). However, this is a complex and time-consuming process.

In addition, the maintenance of applications is a problem which costs more time and money. Each interface usually requires some amount of time to build, and then time and effort directed to maintenance (Puschmann and Alt, 2001). Therefore, the maintenance of these interconnected IT solutions becomes a significant issue of concern. The reason for this is that changes in one system often require the altering of all interconnected applications (Brown and Vessey, 2003; Blobel, 2005). Thus, due to systems heterogeneity, organisations need more experts to maintain these applications. As a result, the operational cost increases for many reasons, such as efforts required to co-ordinate and maintain systems. Thus, the organisations spend at least 40% of their IT budget to solve the integration problem (Puschmann and Alt, 2001).

Enterprise Resource Planning systems were deployed in hospitals as a solution to their integration problem (Grimson et al., 2000). Although ERP systems consist of a set of internally integrated modules that automate businesses process, they were not designed to incorporate other autonomous applications. In addressing this limitation, a diversity of technologies, techniques and tools can be used to piece them together (Loos, 2000). ERP was supposed to provide relief to the IT departments struggling with the challenges of managing many systems and interfaces.

The implementation of these integration approaches has provided significant benefits to healthcare organisations (Bernd and Holena, 1997; Orgun and Vu, 2005). Nevertheless, there are still many problems relating to their adoption. Among others the cost of the development of healthcare integration standards is high and the level of interoperability remains very low (Carr and Moore, 2003). Furthermore, the integration of the heterogeneous IS in healthcare is needed to support various issues such as:

- Clinical and administrative tasks,
- Better healthcare,
- Patients’ data security,
- Interoperability,
- Healthcare process integration, and
- Utilisation of valuable legacy systems and new technologies.
All these factors reported in this section lead to the need for integration. Healthcare organisations started seeking ways to integrate their applications in a flexible, manageable and maintainable IT infrastructure. Thus, there is a demand for a technology that can provide the flexible, manageable and maintainable integrated IT infrastructure for healthcare organisations. To this end, EAI was introduced to support organisations in meeting this demand.

**Enterprise Application Integration**

Many definitions exist in the normative literature for EAI, with Themistocleous *et al.*, (2000) evaluating and analysing them. The majority of the articles on EAI use the Linthicum (1999) definition. According to Linthicum (1999) EAI is the:

> “Unrestricted sharing of information between two or more enterprise applications. A set of technologies that allow the movement and exchange of information between different application and business process within and between organisations”

Linthicum (1999, p. 345)

EAI has been introduced as a solution to intra and inter-organisational systems and process integration. For various reasons, it results in more organised business process, achieves Return On Investment (ROI), increases collaboration among partners, achieves process integration and reduces cost (Themistocleous *et al.*, 2001). In addition, EAI aims at integrating individual applications into a seamless whole, enabling business process and data to speak to one another across applications (Stal, 2002). EAI can efficiently incorporate custom applications, packaged systems and e-business solutions into a flexible and manageable infrastructure (Irani *et al.*, 2003). The benefits that EAI provides are very important, as they reduced the costs of integration and the redundancy of data (Themistocleous, 2004; Sharif *et al.*, 2005). Evidences from case studies published in the area of EAI reports a 50% cost reduction (Themistocleous and Irani, 2002; Sharif *et al.*, 2005). Moreover, EAI support strengthened the supply chain and improved the relationships between organisations and suppliers.

**Research Aim and Objectives**

The lack of common enterprise IT infrastructures has resulted in a plethora of heterogeneous and non-integrated systems. Clearly, there is real need to bridge these systems together, as they will improve the delivery of healthcare services. In results, the amount of medical errors caused by the non-integrated nature of these systems and
associated with the loss human lives will be significantly decreased. To this end EAI has emerged to overcome integration problems at all levels in a more flexible and manageable way (Themistocleous and Irani, Z, 2002; Sharif et al., 2005). It provides the infrastructure to rapidly connect and interface information between intra-organisational and inter-organisational applications (Pinkston, 2001). EAI also provides a flexible infrastructure to integrate heterogeneous platforms (Stal, 2002; Skoumpopoulou and O’Kane, 2004). Evidences from the normative literature supports that EAI can be used to create an integrated infrastructure in healthcare organisations. Therefore, EAI can integrate different information systems at the internal hospital level and at external country level with other hospitals and General Practitioners (GPs) (Khoumbati et al., 2005). The internal hospital level integrated IT infrastructure may provide the facility to share data among different applications connected with each other. In addition to that EAI can support healthcare organisations to improve clinical and business processes. Therefore, EAI might be considered as an integration solution for healthcare organisations. However, to the best of the researchers’ knowledge, there is limited empirical research reported on the evaluation of EAI in healthcare. Therefore, it is not clear which factors influence the decisions for its adoption, and what is the causal relationship of these factors. Hence, there is a need to identify these factors and their causal relationships.

In exploring EAI, this study seeks to expand the knowledge on EAI, and will focus on understanding the adoption of EAI in healthcare organisations. In doing so, healthcare organisations may benefit from the EAI evaluation framework. This will help in gaining a better understanding of the factors such as cost, benefits and barriers associated with the adoption of EAI. Therefore, the proposed model may help healthcare organisations to understand the impact of EAI on the performance of the healthcare organisation for providing better healthcare services and reducing medical errors.

The aim of this research is therefore to:

Evaluate the adoption of Enterprise Application Integration in healthcare organisations with a particular focus on identifying the influential factors and their causal interrelationships on the adoption process. In doing so, resulting in the development of a frame of reference that translates into a model that can be used to support decision-making

**Research Objectives**

In order to meet this aim, the research focuses on the following specific research objectives:
Objective 1: Critically review the literature in the area of healthcare organisation with a particular focus on health informatics.

Objective 2: To develop and validate the conceptual framework for the evaluation of EAI adoption in healthcare organisations.

Objective 3: To identify causal relationships among the factors of the model that can support on overall decision-making process.

Objective 4: To develop and propose a framework for the evaluation of EAI adoption in healthcare organisations.

Objective 5: To present conclusions and offer a novel contribution to the domain of healthcare organisations and EAI.

Research Novelty and Contribution

The outcome of this research has extended the boundaries of knowledge through making a novel contribution to the area of EAI evaluation in healthcare organisations. The researcher proposed the following contributions:

- **Evaluation and Analysis of Benefits and Barriers of the Integration Approaches.** The first contribution of this research is the evaluation and analysis of the benefits and barriers of the integration approaches and projects adopted in healthcare organisations. This makes a novel contribution, due to confusion regarding the adoption of these integration approaches in healthcare organisations. Therefore, the evaluation has attempted to clarify this confusion by classifying and identifying their benefits and barriers. This provides the support to the healthcare organisations decision makers during evaluation of these integration approaches.

- **Framework for Evaluation of EAI Adoption in Healthcare Organisations.** Another important contribution of this work is the development of an evaluation framework for EAI adoption in healthcare organisations. The development of this framework is based on critical analysis of the literature and empirical findings. The proposed framework suggests that the identified factors namely: Benefits, Barriers, Costs, Evaluation Frameworks, IT Infrastructure, IT Sophistications, IT Support, Internal Pressures, External Pressures, Organisation size, Compatibility, Telemedicine, Patient satisfaction, Physicians and administrator’s relationships, education and security and confidentiality influences the adoption of EAI in
healthcare organisations. The application of FCM demonstrates the inter-relationship of the influencing factors for the adoption of EAI in the case hospital. This shows how decision maps are constructed, and how numeric values are assigned to represent inter-relationship of each factor. The use of an FCM approach has enhanced the quality of the evaluation process, and shows the importance of each factor and its inter-relationship with other factors. This has provided insights to better understanding of interdependencies of the factors that influence EAI adoption. This approach may support the quality of decision making in healthcare organizations, when considering the adoption of EAI. Further, it can support the researchers to analyse and understand the adoption process of EAI. In addition, it provides better support to the decision makers while deciding the adoption of EAI.

- **Model for Adoption of Integration Technologies.** This dissertation proposes a model for the adoption of integration technologies. This has been achieved by evaluating the established models for integration technologies adoption from the normative literature. The researcher proposes that key factors (e.g. benefits, costs, IT infrastructure, IT sophistication, internal pressures and external pressures) in proposed model can be used as constructs that explains influential factors for the adoption of integration technologies. The proposed model is important, as it might explain issues that can effect the introduction of new integration technologies. Thus, it extends the body of knowledge and contributes towards the development of a model for the adoption of these technologies.

**Avenues for Future Research**

Research can usually be further developed and the research presented here is no exception. Thus, in the light of the reflections and the limitations it is recommended that further work could usefully be pursed as follows:

- The framework for EAI adoption in healthcare organisations was based on three case organisations in the United Kingdom. The organisational structure of UK is relatively different from the other parts of the world and the context covers relatively low population. Therefore, the results of this research can not be generalised for the whole population. The researcher thus recommends validating this framework in the context of different countries.
• Another important recommendation is to conduct the FCM-based evaluation of the revised framework for EAI adoption. The reason for this is that due to the shortage of time the researcher was unable to do so. This will provide a broader view of EAI adoption factors and will provide support to decision makers in understanding these benefits.

• A recommendation for the future study may be the detailed analysis of all the factors related to EAI adoption. In doing so, the factors affecting the EAI adoption in the healthcare area need to be analysed according to the different healthcare actors, as this will support the multiple actors in fully realising the adoption factors.

• This research has found the EAI adoption benefits realisation is an important issue. Therefore, it is recommended to transform the proposed EAI benefits taxonomy into a large-scale survey questionnaire, instead of using interpretive epistemology. A large-scale survey will give the opportunity to determine the identification and validation of the EAI adoption benefits in the context of healthcare organisations, and will contribute in better decision making regarding EAI adoption.

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