Towards the Development of a Novel Evaluation Framework for Information Systems in the Healthcare Sector

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Keywords: Evaluation Frameworks, Healthcare Information Systems.

Abstract: The paper is submitted as part of doctoral consortium. In this paper, the aim and objectives of research are presented. Overviews of medical informatics research area and evaluation studies in healthcare are given. A review of existing evaluation frameworks which identify through literature review is briefly described. Research methodology is proposed whereby this research will employ mainly qualitative method using a case study strategy.

1 INTRODUCTION

Information systems play an increasingly important role in developing the structure and functions of healthcare sector services. Thousands of millions of dollars are being spent on the procurement of new systems with the aim to improve organization performance as well as the quality of patient care. According to Lee et al. (2008), implementation of any new information systems is estimated to take approximately 18 months to be fully operationalised.

Decision makers often believe that technology will bring benefits to health care and should embrace it. However, evidence from various studies on implementation of information systems in this sector has demonstrated that sometimes such implementations do fail (Southon et al., 1999). On the other hand, there is also evidence that the same system implemented in two different settings resulted in different outcomes; in one setting it has been widely accepted but in others it has been rejected by the users (Gremy et al., 1999). Thus, identifying the risks for successful implementation becomes crucial to avoid unnecessary consequences.

Effective evaluation of healthcare information systems are necessary in order to ensure systems adequately meet the requirements and information processing needs of users and health care organizations. Much research has been carried out to identify those critical factors that need to be evaluated to ensure successful implementation of health information systems and frameworks have been developed to represent those factors (Yusof et al., 2008; Shaw, 2002; Despont-Gros et al., 2005; Schaper and Pervan, 2007). Although there are many existing evaluation frameworks, we believe that better representation of those critical factors can be proposed. The theoretical significance of this work is that it will use well-established theory in information systems to inform the proposed framework.

1.1 Aim of this Research

The ultimate aim of this research is to critically analyse existing evaluation frameworks, identify the limitations that may be improved upon and to investigate if it is possible to build a better evaluation framework that not only captures the critical factors but also shows the link between those factors that are important for successful implementation of health information system. In order to achieve this aim, the following objectives have been identified:

- To investigate the critical factors that influence the implementation of information systems through a thorough literature review.
- To investigate existing evaluation frameworks and analyze the strengths and limitations of each.
• To identify suitable well-established information systems (IS) theory to be adapted in the development of the framework.
• To propose a new evaluation framework, making use of the identified information systems (IS) theory in order to overcome the limitations of existing frameworks.
• To determine proper methods to validate the proposed evaluation framework.

2 BACKGROUND

2.1 Overview of Medical/Health Informatics Research

The Medical Informatics field has evolved over the past 50 years. According to Collen (1986), the earliest published paper in medical informatics appeared in the 1950s, the number of paper published increased rapidly in 1960s and the field of medical informatics was identified as a new specialty in the 1970s. This area has been around for more than 50 years and its importance realized from the publication of many journals on medical informatics such as the International Journal of Medical Informatics (IJMI), the Journal of the American Medical Informatics Association (JAMIA), the Medical Informatics and Decision Making (BMC), the Journal of Health Informatics in Developing Countries (JHIDC), the Journal of Medical Internet Research (JMIR), the Health Informatics Journal, the Electronic Journal of Health Informatics and many more.

According to Abdul-Kareem et al. (2000), the very first symposium on Computer Applications in Medical Care was held in 1970 and, as a result of that symposium, several medical informatics journals were launched and in the 1980s the first comprehensive textbook was written as an introductory text for an informatics course.

Based on articles published in various journals, we can say that in Medical Informatics researchers are actively engaged in a range of topics which include the impact of IT on the patient-provider relationship, patient care, social technical issues, implementation issues, as well as evaluation issues.

Medical Informatics (MI) / Health Informatics is a research field that focuses on realizing the potential use of computers in the area of health care, which has produced a valuable body of knowledge on health care information technology. The core goal of this field is to directly improve clinical care through the use of information technology. To achieve this goal, medical informatics researchers examine the design of IT applications to address the practicalities of health care delivery, with a focus on clinical users (e.g. nurses, physicians, pharmacists). An important focus in medical informatics research is to develop an understanding of the individual, group and organizational influences on IT development, adoption and its use (Chiasson et al., 2007).

The working group on technology assessment was established in 1990, following-up on the recommendation made at the IMIA_ISTAHC (the International Medical Informatics Association and the International Society of Technology Assessment in Health Care) working conference. The aim of this working group is to further develop the field of technology assessment and quality development in health informatics (Gennip, 1999). Since then, much work on technology assessment/evaluation has been published, which is elaborated on in the following section.

2.2 An Overview of Evaluation Studies in Health Care

2.2.1 Definition

The term ‘evaluate’ is defined in the Cambridge Advanced Learner’s Dictionary as “to judge or calculate the quality, importance, amount or value of something”. Thus, healthcare IT evaluation can be defined as an act of judging, or calculating the quality, importance, amount or value of IT systems in the health care setting. In the healthcare context, evaluation has been defined as “the act of measuring or exploring attributes of Health Information Systems (in planning, development, implementation or operation), the result of which informs a decision to be made concerning that systems in a specific context” (Yusof and Papazafeiropoulou, 2008). Evaluation is carried out to seek answers to the following (Friedman and Wyatt, 1997):

1. Why: the objective of evaluation?
2. What: aspects of focus of evaluation?
3. Who: which stakeholders’ perspective is going to be evaluated?
4. When: which phase in the system development life cycle?
5. How: methods of evaluation?

2.2.2 Why: The Objective of Evaluation?

Evaluation is carried out for many reasons. The importance of evaluation as cited by various authors in the literature is given in Table 1. Hence, it is generally
agreed that implementation of new systems in healthcare needs thorough evaluation in order to determine their benefits (effectiveness).

2.2.3 What and Who?

There are usually four main major stakeholders that are interested in evaluation work. Each of these stakeholders has their own concerns and questions on the implementation of the health information systems. Evaluation should cover all relevant stakeholders’ perspectives — the organization, the user of the system, the developer, as well as the patients (Wyatt and Wyatt, 2003). Table 2 presents some of the concerns/questions that each stakeholder may have. The outcome of evaluation will basically try to answer some of the above concerns raised by the stakeholders.

2.2.4 When to Evaluate?

Evaluation can be carried out during each of the three main phases of the system development life cycle — pre-implementation (development), during implementation, and post-implementation routine operation (Yusof and Papazafeiropoulou, 2008). As stated in Grant et al. (2002), there are four phases of evaluation whereby in phase 1, evaluation is performed in design, prototyping and testing the functional system and its components, phase 2 involves evaluating prototypes of the integrated systems at designated sites, phase 3 involves evaluation after a period of mature use and finally, phase 4 involves continuing periodic evaluation.

2.2.5 How to Evaluate?

There are two distinct approaches for evaluation; the objectivist approach and the subjectivist approach (Wyatt and Wyatt, 2003; Friedman and Wyatt, 1997). Table 3 presents the differences between these two approaches.

The main limitation of the objectivist approach is that it cannot provide an answer as to why and how a system works within a specific setting. If a system fails, we cannot know the answer. Qualitative approach is said to be able to provide answer for ‘why’ and ‘how’ questions which can not be answered by a quantitative approach (Ash and Berg, 2003). That is why many researchers now tend to use the subjectivist approach when undertaking evaluation work (Collen, 1986; Friedman and Wyatt, 1997; Kaplan, 2001a; Gremy et al., 1999).

2.3 An Overview of Evaluation Frameworks

2.3.1 Definition

Information technology is defined in Cambridge Advanced Learner’s Dictionary as “the science and activity of using computers and other electronic equipment to store and send information”. Hence, a definition that can be adopted for health information system can be “any computer based information system that collects process and disseminates health related data”.

The first development of health information systems was the clinical specialist diagnosis systems, developed in the 1970s (Southon, 1999). According to Goodman and Ahn (1999), medical information technologies are used for in many areas including administrative and institutional management, personnel management, patient care and other activities such as admission systems, automated laboratory systems, computer-assisted surgery and many more.

The term ‘framework’ is defined in Cambridge Advanced Learner’s Dictionary as
1. “a supporting structure around which something can be built”, or
2. “a system of rules, ideas or beliefs that is used to plan or decide something”.

As defined by Despont-Gros et al. (2005) “an evaluation framework is a decisional space defined by the characteristics of the evaluation context that helps in the selection of the appropriate approaches”. The importance of an evaluation framework as cited by various authors in the literature is given in Table 4.

2.3.2 Overview of Early Studies on Evaluation Frameworks

In order to carry out evaluation, a number of authors have proposed and developed frameworks as presented below.

- The design-reality gap model (Heeks, 2006)

The framework was believed to be robust in explaining multiple cases of HIS success and failure. The dimensions of the framework as proposed are:

- Information — Information quantity, quality and flow; informal information.
- Technology — Computer hardware and software; telecommunication; other healthcare technology
- Process — Information-handling, decision making, action/transaction; other healthcare processes; informal processes.
Table 1: An overview of the importance of evaluation.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Importance of Evaluation</th>
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<tbody>
<tr>
<td>Yusof and Papazafeiropoulou (2008)</td>
<td>“Evaluation is challenging as the decision making in design, development, purchase or management in HIS all requires evaluation. Evaluation can be used to improve HIS through past experience to identify more effective techniques or methods, investigate failure and learn from previous experience.”</td>
</tr>
<tr>
<td>Yusof et al. (2008)</td>
<td>“The benefits derived from a Health Information System (HIS) require rigorous evaluation.”</td>
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<td>Shaw (2002)</td>
<td>“…none of them provide a comprehensive framework for evaluation that highlights and addresses all aspects of healthcare that may be affected by the use of ICTs.”</td>
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<td>Meijden et al. (2003)</td>
<td>“Only a thorough evaluation study can show whether or not a specific system was successful in a specific setting.”</td>
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<tr>
<td>Kushniruk and Patel (2004)</td>
<td>“Effective evaluations of healthcare information system are necessary in order to ensure systems adequately meet the requirements and information processing needs of users and health care organizations.”</td>
</tr>
<tr>
<td>Nahm et al. (2007)</td>
<td>“The assessment outcome of CIS implementation is vital not only to justify the cost within organization but also to promote the national agenda to improve healthcare information technology.”</td>
</tr>
<tr>
<td>Wyatt and Wyatt (2003)</td>
<td>“Even if system is effective when installed, it may rapidly lose its edge as the health system around it changes, making repeated evaluation necessary, to take account of the changing health context.”</td>
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Table 2: An overview of stakeholders’ concerns or questions.

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Concerns/ Questions</th>
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| Decision Makers | Will the users accept the system?  
|               | How committed are they to use the system?                                           |
| Users         | Are all necessary facilities (e.g. training support, network infrastructure, etc.) provided?  
|               | Do I have necessary skills to use the system?                                      |
|               | How useful and easy is it to use the system?                                       |
|               | How safe and secure is the system?                                                 |
| Developers    | Has the system met all the user requirements?                                      |
| Patients      | Is the system safe and will it help me?                                            |

Table 3: A summary of the differences between an objectivist and a subjectivist approach.

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<thead>
<tr>
<th>Author(s)</th>
<th>Objectivist</th>
<th>Subjectivist</th>
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<tbody>
<tr>
<td>Wyatt and Liu (2002)</td>
<td>Objectivist evaluation is an evaluation approach that uses experimental designs and statistical analyses of quantitative data.</td>
<td>Subjectivist approach is an evaluation approach that relies on qualitative data which can be derived from observation, interview, and analysis of documents and other artefacts.</td>
</tr>
<tr>
<td>Meijden et al. (2003)</td>
<td>Objectivist study in which subjects, variables and data collection methods are selected. Objectivist studies descriptive, comparative or correlation studies</td>
<td>Subjectivist studies which are conducted in natural environment of the subjects without manipulating it and in which themes of interest emerge during the study. Subjectivist studies include case studies. Case studies are empirical in nature and study a phenomenon in its natural context.</td>
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Table 4: An overview of the importance of using an evaluation framework.

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<tr>
<th>Author(s)</th>
<th>Importance/ Need for an Evaluation Framework</th>
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<tbody>
<tr>
<td>Ammenwerth et al. (2006)</td>
<td>“…a framework (the FITT framework) to better analyse the socio-organisational-technical factors that influence IT adoption.”</td>
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<tr>
<td>Heathfield et al. (1997)</td>
<td>“Evaluation project led us to believe that the development of an evaluation framework for health care IS is an important step towards realising the benefits of such systems. Without such a framework, it is not possible to identify those factors which are the most important determinants of success, understand the relationship between these factors or make predictions based upon the assessment of these factors.”</td>
</tr>
<tr>
<td>Palm et al. (2006)</td>
<td>“Since CIS is a complex system which supports various functionalities and tasks for various user profiles, we found it necessary to design an evaluation instruments, which addressed these different dimensions across all main components of the CIS.”</td>
</tr>
<tr>
<td>Despont-Gros et al. (2005)</td>
<td>“…a general evaluation framework would be a good tool for descriptions and explanation of findings”</td>
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- ICT and OTs: A model of information and communication technology acceptance and utilisation by occupational therapists (Schaper and Pervan, 2007)

  The framework was developed to examine acceptance and utilisation issues among health professionals to improve the success of IS implementation in the health sector. Two established models were used to build the framework, which are the ‘Unified Theory of Acceptance and Use of Technology’ model by Venkatesh et al. (2003) and the ‘Technology Acceptance Model’ by Davis (1989). Factors identified that are important for acceptance are categorised as the technological context, the individual context and the implementation context.

- CHEATS: a generic information and communication technology evaluation framework (Shaw, 2002)

  The proposed framework consists of six dimensions which are clinical, human and organisational, educational, administrative, technical and social.

- TEAM: Total Evaluation and Acceptance Methodology (Grant et al., 2002)

  This framework is based on three dimensions: role, time, and structure. The theory is derived from how the information system relates to general system, the properties of information flow and the relation between a system to its model.

- Understanding IT acceptance by individual professional: Towards an integrating view (Yi et al., 2006)

  The framework was build based on their theories of a ‘technology acceptance model’ by Davis (1989), planned behaviour and innovation diffusion. Research model were tested in the context of personal digital assistant acceptance by healthcare professionals. Factors that influence the acceptance were verified through the testing of the model.

- Comprehensive Health Technology Assessment (Kazanjian and Green, 2002)

  The framework has five dimensions, each of which has its own indicators and targets or goals. Those dimensions are population at risk, population impact, economic concern, social context and technology assessment activity. The model is aimed to provide an empirical, evidence-based foundation for health technology decisions.

- A model based on human interaction models (Despont-Gros et al., 2005)

  A model that can be used to perform summative evaluation of user interaction with computer and information systems (CIS) from an end-user point of view was proposed. The model is aimed to formalize the attitude of users towards CIS and to identify the dimensions for evaluation. The model proposed was based on ‘IS Success Model’ by DeLone and McLean (2003), ‘Technology Acceptance Model’ by Davis (1989) and also ‘Task-technology Fit’ model by Goodhue (1995).
HOT-fit: An evaluation framework for health information systems: human, organization and technology-fit factors (Yusof et al., 2008)

The proposed framework is constructed so that it is capable of being useful in conducting a thorough evaluation study and will assist researchers and practitioners to unfold and understand the perceived complexity of HIS evaluation. The model was developed based on an 'IS Success Model' by Citrdelone2003 and an IT-Organization fit model. Factors that are identified as critical for successful implementation are technology, human and organizational factors.

FIIT — Fit between Individual, technology and Task (Ammenwerth et al., 2006)

The framework is believed to provide better analyses on socio-organizational-technical factors that influence information technology adoption. The model referred to an 'IS Success model' by DeLone and McLean (2003), a 'Technology Acceptance Model' by Davis (1989), and an information technology adoption model. According to the author, IT adoption in a clinical environment depends on the fit between the attributes of the individual users, attributes of technology and attributes of the clinical tasks and process.

4Cs evaluation framework (Kaplan, 2001b)

This paper suggests a social interactionist approach that draws on social science theory, incorporates multiple methods (including both quantitative and qualitative methods), and addresses a variety of evaluation issues. The author identified four interrelated areas that are important when conducting evaluation: communication, care, control and context. The author suggested that this approach is applicable to evaluate any informatics and clinical practices guideline implementation.

Based on early observations, some of these frameworks can be improved or better presented. The importance of fit between the factors that are involved in evaluation has been described by several authors (Ammenwerth et al., 2006; Kaplan, 2001b; Goodhue, 1998). Success or failure of information systems implemented in the organization depends not only on those critical factors but also on the fit between those factors. We believe that fit is an important feature that must be presented in the evaluation framework which we find missing in most of above evaluation frameworks Heeks (2006); Schaper and Pervan (2007); Shaw (2002); Grant et al. (2002); Kazanjian and Green (2002).

Most of these frameworks were developed based on influences from other disciplines. As stated by Chiasson et al. (2007), “as healthcare organizations increasingly adopt IT across a broad range of functions and process, the challenges with developing, implementing and using health care will continue to grow. Drawing theories and methods developed on other disciplines could be beneficial to further research”.

As described by Lorenzi (1999), the medical informatics field requires methods and models from other disciplines. Current practitioners and students are encouraged to design their research efforts around researched and accepted concepts from other disciplines into medical informatics research.

3 RESEARCH METHODOLOGY

The type of approach that will be used in this study is subjectivist. Qualitative method by means of a case study strategy will be employed because it helps in obtaining a full description of the healthcare setting and also to understand why the system functions well or poorly in a particular setting.

An initial contact with our clinical collaborators was made in April 2008, who have recently deployed the Distiller software (SlidePath, 2008) to be used within a clinical research setting. During this initial meeting, information on the functions and use of the Distiller software were provided. The Distiller software is basically a web-based data collection and management tool which can be used in a wide variety of laboratory and clinical research settings to manage histopathological data, including image data. It also provides facilities to clinically assess the data, such as online scoring of the histological images. During this initial meeting also, those users that will be involved in the initial phase of the case study were identified.

A pilot study on the Distiller software will lead to the initial development of the first proposed evaluation framework. A field study will be conducted to test this framework. The framework will be used as a guideline in the evaluation of Distiller software. During the evaluation phase, users will be interviewed, their use of the system will be observed and document analysis will be performed. The duration of this field study is proposed to be three to four months.

The data will be collected by means of audio and hand-recording. This data will then be transcribed into field notes and will be analyzed. To further test and validate our proposed evaluation framework, we
plan to conduct further case studies (to be identified later) with more users.

Two types of evaluation will be performed which are summative and formative evaluation. Summative evaluation is designed with an objective to demonstrate the value of a mature (implemented) information system, while formative evaluation is designed with an objective of improving the information systems under study by providing the developers with feedback or user comments (Friedman and Wyatt, 1997).

4 EXPECTED OUTCOME

The outcome of this research is expected to be a critical evaluation of existing frameworks for health information systems. Independent evaluation of other people’s frameworks will be carried out. Any limitations of these existing frameworks will be captured in our proposed new evaluation framework. It is hoped that this might lead to insights on improvement of the existing evaluation frameworks. We believe that such a framework will serve as an evaluation tool for those stakeholders that want to conduct future evaluation studies.

ACKNOWLEDGEMENTS

Noor Azizah KS Mohamadali would like to gratefully acknowledge the funding received from both the Public Service Department of Malaysia and from the International Islamic University of Malaysia that is helping to sponsor this research.

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