E-health readiness assessment from EHR perspective

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E-HEALTH READINESS ASSESSMENT FROM EHR PERSPECTIVE

by

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Abstract

Many countries (especially developing countries) are plagued with critical healthcare issues such as chronic, infectious and pandemic diseases, a lack of basic healthcare programmes and facilities and a shortage of skilled healthcare workers. E-Health (healthcare based on the Internet technologies) promises to overcome some problems related to the reach of healthcare in remote communities. Electronic Health Record (EHR) (consisting of all diagnostic information related to a patient) forms the core of any E-Health system. Hence the success of an E-Health system is very much dependent on the success of the EHR systems. Although interest in automating the health record is generally high, the literature informs us that they do not always succeed in terms of adoption rate and/or acceptance, even in developed countries. The success of the adoption tends to be low for resource constrained (e.g. insufficient E-Health infrastructure) developing countries. As part of the effort to enhance EHR acceptance, readiness assessment for the innovation becomes an essential requirement for the successful implementation and use of EHR (and hence E-Health).

Based on a thorough literature review, several research gaps have been identified. In order to address these gaps, this thesis (based on design science research methodology) presents E-Health Readiness Assessment Methodology (EHRAM). It involves a new E-Health Readiness Assessment Framework (EHRAF), an assessment process and several techniques for analysing the assessment data to arrive at a readiness score. The EHRAF (Model) integrates the components from healthcare providers' and organisational perspectives of existing E-Health readiness evaluation frameworks. The process of EHRAM (Method) starts with the development of a set of hierarchical evaluation criteria based on EHRAF. This leads to the questionnaire development for data collection. The data is analysed in EHRAM using a number of statistical and data mining techniques. The instantiation part of the design science research involves an automated tool for the implementation of EHRAM and its application through a case study in a developing country.

Table of Contents

Acronym List

Continuity of Care Record (CCR)

Clinical Document Architecture (CDA)

Clinical Decision Support (CDS)

Checklist Driven Software Evaluation Methodology (CDSEM)

Cooperative methodology for Management of E-business Networks and Services (CoMENS)

Commercial Off The Shelf (COTS)

COTS-based Integrated System Development Method (CISD)

Customer Relationship Management (CRM)

Electronic Consent (E-Consent)

Electronic Health (E-Health)

Electronic Healthcare Delivery (eHCD)

Electronic Health Records (EHR)

EHR systems (EHRs)

Electronic Prescribing (E-Prescribing)

Electronic Resources (E-Resources)

E-Health Readiness Assessment Framework (EHRAF)

E-Health Readiness Assessment Methodology (EHRAM)

E-Health Readiness Assessment Tool (EHRAT)

Generic Evaluation Approach for the E-Health systems (GEA4EH)

Information and Communication Technologies (ICT)

Information Systems (IS)

Information Technology (IT)

Organisational Information Technology/Systems Innovation Readiness Scale (OITIRS)

Organisational and functioning Readiness for Change (ORC)

Off-The-Shelf-Option (OTSO)

Quality Improvement (QI)

Return on Investment (ROI)

Stand-alone Reminder System (SRS)

World Health Organisation (WHO)

Publications Arising from This Thesis

1. J. Li, L. Land, S. Chattopadhyay and P. Ray, 'An Approach for E-health System Assessment & Specification'. IEEE 10th International Conference on e-Health Networking, Application & Services, 7-9 July 2008, Singapore.

2. S. Chattopadhyay, J. Li, L. Land and P. Ray 'A Framework for Assessing ICT Preparedness for e-Health Implementation'. IEEE 10th International Conference on e-Health Networking, Application & Services, 7-9 July 2008, Singapore.

3. L. Land, J. Li, S. Chattopadhyay and P. Ray ‘Evaluation of Patient Health Records Status: Preliminary Results of WHO Project based on Data from Vietnam’. (Accepted) ISAP 2007, 8 December, 2007, Montreal, Canada.

Chapter 1
Introduction

1.1. E-Health

Healthcare services are increasingly needed by people and should be efficiently provided and made fully accessible to all (Haglund, 2002). Electronic health (E-Health) has arose to improve or enable health and healthcare (Nykanen, 2006). According to Silber (2003), “application of information and communication technologies (ICT) across the whole range of functions that affect health”, E-Health, an emerging field in the intersection of medical informatics, public health and business, refers to health services and information delivered or enhanced through the Internet and related technologies (Eysenbach, 2001). E-Health kicks off a revolution to traditionally paper-based health and healthcare. As the main sponsor of this revolution, World Health Organisation (WHO) (2005) claimed E-Health applications as the use of digital data transmitted, sorted and retrieved electronically – in support of healthcare, both at the local site and at a distance. E-Health directly supports prevention, patient diagnosis and patient management and care. There is therefore a consensus that E-Health includes applications of information communication technologies to promote healthcare services support, delivery and education.

1.2. Research Problems

Many countries (especially developing countries) are plagued with critical healthcare issues such as chronic, infectious and pandemic diseases, a lack of basic healthcare programmes and facilities and a shortage of skilled healthcare workers (WHO, 2006; Watts & Ibegbulam, 2005). Electronic Health Record (EHR) forms the foundation of E-Health system because EHR consists of three components, which have been identified and developed by Dicksin et al. (2004): direct care EHR functions, supportive EHR requirements, and EHR information infrastructure. With the

introduction of EHR systems, the tension from above mentioned healthcare issues can be at least defused by providing evidence-based healthcare (Overhage et al. 2001) and increasing medical practice efficiency (Ammenwerth et al. 2004).

Information systems researchers have recognised the problem of sustainability and complexity in health information systems implementations especially in developing countries (e.g. (Braa et al. 2004; Miscione, 2007)). This is evidenced by the encouragement to undertake high-visibility and high impact research that takes a greater macro focus when examining the transformational nature of IT (Agarwal & Lucas, 2005; Walsham et al. 2007). In the healthcare area in developing countries, this means that researchers should take a more holistic view of the environment in which the health information systems are implemented and deployed. Accordingly, soliciting data are required from diverse stakeholders at different levels of healthcare and related organisations who have (in)direct interest in such projects (e.g. distributed researchers, potential end users, technical developers, programme sponsors). Evaluation research by studying the context of healthcare information systems implementation fits in with this recommendation.

Evaluation undertaken before E-Health system development (pre-implementation) is particularly pertinent due to its complexity (BC eHealth Steering Committee, 2005). As with the implementation of any information system in an organisational context, the acceptance of any information system requires proper planning and management for change (Callioni, 2006). With EHR implementations, change occurs not simply due to the introduction of Information Communication Technology (ICT) infrastructure but also because the job design of interconnected health professionals should be reengineered to effectively and efficiently accommodate the technology (Eric et al., 2006). EHR implementations represent a disruptive change in the healthcare workplace.

1.3. Motivation of Research

There are several motivations for this study. First, EHR systems can improve healthcare practice by providing evidence-based healthcare (Overhage et al. 2001) and increasing medical practice efficiency (Ammenwerth et al. 2004). The literature, however informs us that they do not always succeed in terms of adoption rate and/or acceptance, even in developed countries (e.g. the US (Burt & Hing, 2005) and Japan (Sumita et al. 2006)). The success of the adoption tends to be low for resource constrained developing countries (Watts et al. 2005; Diero et al. 2006) as a result of insufficient E-Health infrastructure and other resources (Watts & Ibegbulam, 2005).

Second, evaluation research which takes a greater macro focus when examining the transformational nature of IT is believed to have high-visibility and high impacts on the implementation of E-Health systems (Agarwal & Lucas, 2005; Walsham et al. 2007). Most evaluation studies conducted in the healthcare context take place in the post-implementation phase, which is, after the E-Health system is delivered (Ammenwerth et al. 2001; Chen et al. 2006; Makoul et al. 2001; Overhage et al. 2001; Pabst et al. 1996; Poissant et al. 2005; Schmidt, 2006; Warshawski et al. 1994). While post implementation evaluations are crucial for assessing the merit, success and value of systems, contributing to evidence-based practices, and 'learning from experience' (Alexander, 2007), the benefits of exploring the process use of evaluations has recently been argued (Forss, Renien, & Carlsson, 2007). Pre-implementation evaluation aims to give direction for decision making with regard to subsequent development or implementation tasks (Brender, 2006). During this analysis and the planning stage, the evaluation for E-Health systems covers (Brender, 2006):

- Relevance: Whether the solution is entirely able to solve the current problems and meet the demands and requirements of the organisation?
- Problem Areas: Where are the weakness and the elements of risk in the solution?
- Feasibility: Does the organisation have the resources needed to implement the

chosen solution?

- Completeness and consistency: Is the solution a coherent entity that is neither over nor undersized?
- Elements of Risk: Are there any external conditions outside organisational control that will involve substantial risk to the project?

E-Health readiness assessment, a type of pre-implementation evaluation, becomes an essential requirement prior to implementation (Jennett et al. 2003; Demiris et al. 2004). E-Health readiness assessment provides the readiness status of the organisations. Subsequent action taken that addresses areas of unsatisfactory level of readiness would hopefully facilitate changes resulting from E-Health system impmentation.

1.4. Thesis Organisation

1.4.1. Research Contributions

This thesis has benefitted from an ongoing WHO eHCD project involving six countries, which launched in 2006. The idea of E-Health readiness study emanated from the analysis and discussions of pre-study phase of this project that has three phases: pre-study, system implementation and poststudy. The focus of this thesis is on the development of an assessment methodology at the pre-implementation stage of EHR systems so as to assess the status of E-Health readiness.

The key objectives for this thesis are:

1. to identify key components for E-Health readiness assessment and develop an E-Health readiness assessment framework,
2. to develop a process of E-Health readiness assessment,
3. to develop a tool facilitating the assessment process, and

4. to evaluate the methodology with framework evaluation criteria and a case study

1.4.2. Thesis Outline

In Chapter 2, the issues in paper-based health records are discussed. Then, a thorough literature review is conducted and the importance of EHR pre-implementation evaluation is highlighted, particularly for developing countries. Also, research gaps are identified related to the evaluation.

In order to address the gaps, Chapter 3 develops an E-Health readiness assessment methodology based on design science research methodology, including an E-Health readiness assessment model, a method to assess E-Health readiness and an E-Health readiness assessment instantiation for the assessment data analysis.

Right after the development of the methodology is the evaluation with framework evaluation criteria and a case study in Chapter 4. The criteria, based on another thorough literature review on frameworks in healthcare domain, are developed so as to evaluate the E-Health readiness assessment model. As well, the case study is conducted with assessment data collected in the two healthcare centres in Vietnam (WHO data).

I summarise the contributions of this thesis in Chapter 5, also including some limitations for this thesis and future work.

Chapter 2
Literature Review

Paper health records have been in use for nearly two thousand years (Scott, 2006). Even then, patient data are seldom being efficiently organised even within one organisation (Suomi, 2006). When they are represented in applications covering several organisations, the situation becomes even more complicated (Suomi, 2006). Forty years ago the vision for EHR systems was born in order to solve this problem and health informatics experts at the time thought that EHR would be adopted in health industry within a few years, but little happened mainly because healthcare industry was not ready for the electronic age (Waegemann, 2004, Suomi, 2006). In this chapter, the review starts by defining EHR and describing its functionalities. Then, issues existing in paper health records which can be typically addressed by EHR are individually discussed. Next, EHR studies are reviewed from the perspectives of developed and developing countries. This will identify the importance of evaluation study before EHR implementation, especially in developing countries. Subsequently, healthcare status evaluation research is introduced, involving evaluations before and after E-Health systems are implemented. Particularly, E-Health readiness evaluation is highlighted. Based on the preceding literature review, research gaps will be identified and research questions consequently generated.

2.1. Electronic Health Records (EHR)

2.1.1. Definition of EHR

A number of developed countries, such as Sweden, Denmark and Australia have implemented some form of EHR (Taylor et al. 2002; Terry, 2004) although the type and extent of the developed EHR systems may not be the same (Watson, 2006). In essence, EHR is a repository of information regarding the health status of a subject of

care (patient or consumer) in computer processable form (ISO Technical Report). This definition has a narrow coverage and does not elaborate on core activities and supportive functionalities, which reflect modern healthcare practice.

The basic EHR concept model (Figure 2.1) represents a general clinical decision process and contains four activities (circles) that are documented in four information entities, i.e., diagnosis, goal, intervention and result (Bernstein et al., 2005). In order to effectively support information flow, EHR systems have the functionality to store longitudinal health information and data, and enable results management, order management, decision support, electronic communication and connectivity, patient support, administrative processes and reporting (Tang, 2003). Accordingly, EHR should also cover the core activities and the supportive functionalities in the information flow other than patients' data to bring about an ameliorated healthcare routine.

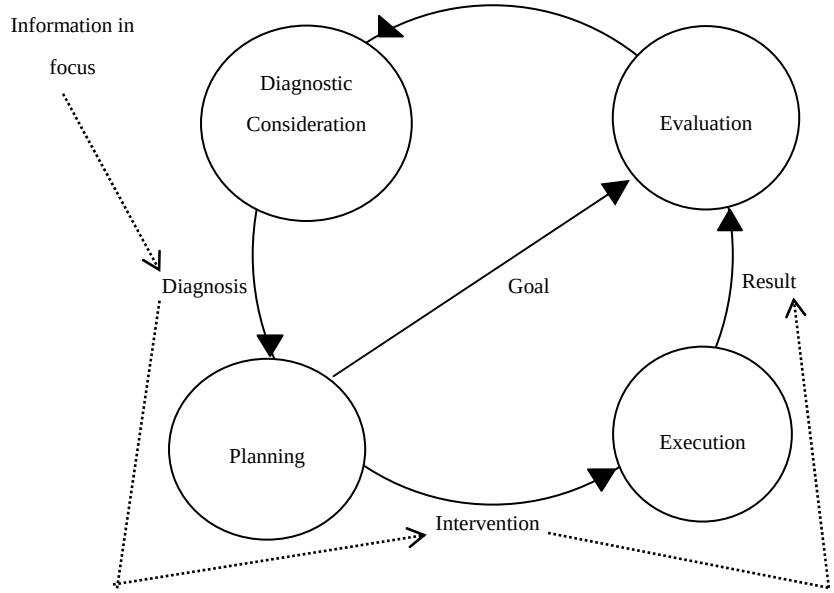

Figure 2.1. The basic EHR model – concept level (Modified from Bernstein et al., 2005)

2.1.2. EHR vs. Paper Health Records

With the definition and coverage of EHR, essential differences between paper health records and EHR, i.e., location, readability, accessibility, traceability, supported care process and data self sorting have been identified (Bakker, 2007; Veselý et al., 2006; Bates et al., 2003; Kuperman et al., 2001; Warshawsky et al. 1994; Allan et al. 2000). (See Table 2.1)

	Paper Health Records	**EHR**
Location (Bakker, 2007)	Generally viewed only at one location (where the physical document is present)	Can be viewed from a multiple locations
Readability (Bakker, 2007)	Easily and directly read	Software needed to transform the digital data into a readable presentation
Accessibility (Bakker, 2007)	Access data all or None	Granted different levels of authorisation to access digital data
Traceability ((Bakker, 2007)	Impossible to record who has seen the data and when	Keep a trial of the use
Supported care process (Veselý et al. 2006; Bates et al. 2003; Kuperman et al. 2001)	No	Physician order entry, appointments, prescription and dose guidelines and so forth
Data self sorting (Warshawsky et al. 1994; Allan et al. 2000)	No	Yes

Table 2.1. Differences between Paper Health Records and EHR

Due to the differences, the advantages offered by EHR over paper health records can be recognised. Patient health records with EHR are no longer restricted to the data generated within their local healthcare establishment. Data about the health history of patients and their current health status (which may be recorded by multiple healthcare professionals at different locations) will be presented in a coherent and legible way. Secondly, access rules can be made explicit and strictly adhered to. Thirdly, the care process can be supported in logistic sense, e.g. physician order entry, appointments, as well as protocols and guidelines used to support the behaviour and decision-making of healthcare professionals. Moreover, EHR are viable for 24 hour access, data self sorting, loss avoidance of records (dependant on resilience), audit trail of document use (Suomi, 2006). All of these superiorities of EHR achieve modern healthcare

practice by providing multiple functions, such as evidence-based healthcare (Overhage et al. 2001) and increasingly efficient medical practice (Ammenwerth et al. 2004).

2.1.3. Structure of EHR

Through extensive reviews by healthcare providers, vendors, and other stakeholders, the following EHR structure have been identified and developed by Dicksin et al. (2004): direct care EHR functions, supportive EHR requirements and EHR information infrastructure, which were independent with regard to technology or implementation strategy. (See Figure 2.2)

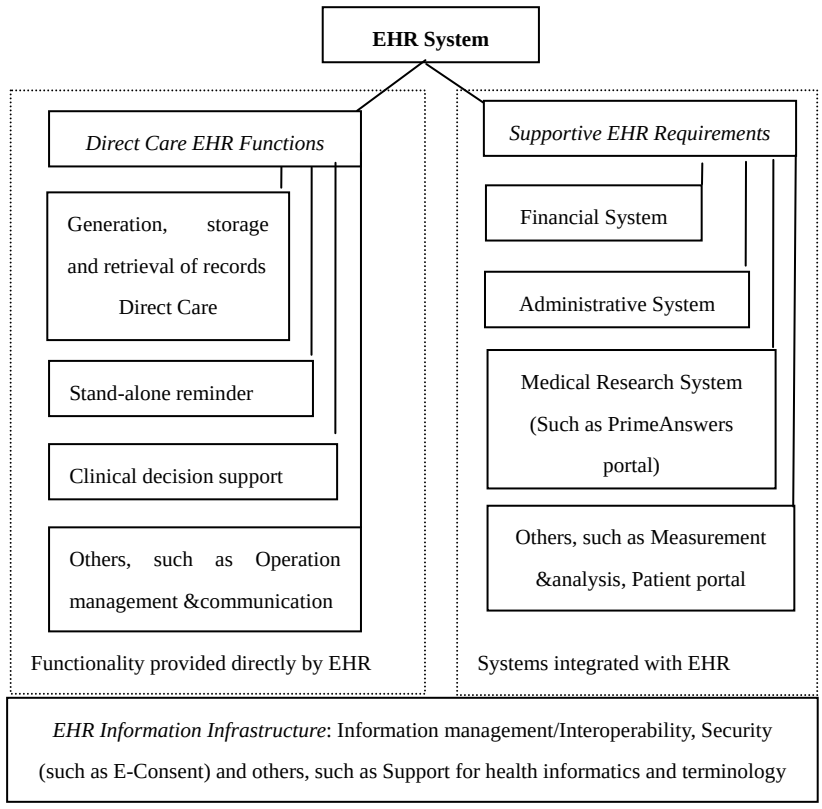

Figure 2.2. Structure of EHR

Direct Care EHR functions enable delivery of healthcare and offer clinical decisions (Dicksin et al. 2004). For example, when a patient presents symptoms of a common cold, a Direct Care EHR function will enable the physician to record that event.

Additionally, stand-alone reminder functions and clinical decision-support functions within the direct care EHR section will respectively offer illegitimate prescription and contraindication alerts for the medication given to the patient who has the symptoms of a cold (Veselý et al. 2006; Bates, Kuperman et al., 2003; Kuperman et al., 2001).

Supportive EHR requirements assist with the administrative and financial requirements associated with the delivery of healthcare (Dicksin et al. 2004). Also, they provide inputs to the systems that perform medical research, promote public health, and seek to improve the quality of healthcare delivered (Dicksin et al. 2004; Ketchell et al., 2005). For example, supportive EHR requirements electronically query local immunisation registries during the encounter to ensure that the child is currently registered, and then determine the child's immunisation status. After treatment, supportive EHR requirements will report any immunisation to an immunisation registry and will provide any encounter data required by financial and administrative systems (Dicksin et al. 2004).

EHR Information Infrastructure provides a framework for the proper operation of the direct care functions and supportive EHR requirements, and offer EHR technical capabilities that are essential, yet transparent, to the user (Dicksin et al. 2004). This subset of EHR structure is concerned about EHR security (control access and privacy protection), EHR information and records management (provision of the ability to access, manage and verify accuracy and completeness of EHR information with patient participation, and to audit the use of and access to EHR information), interoperability (provision of automated health delivery processes and seamless exchange of key clinical and administrative information through standards-based solutions) and so on (Dicksin et al. 2004; Coiera et al., 2004; Galpottage et al., 2005; Tang et al., 2006; ISO Technical Report (ISO-TR20514); Tessier et al., 2003).

Although the complete structure of EHR which assumed that a basic technical environment existed (Dicksin et al. 2004) has been delineated, to what extent it has been implemented is still an issue. A study demonstrated that few functions of EHR systems were used in practice and physicians used the systems for far fewer tasks than the systems supported (Laerum et al. 2001). The systems were used for only 2 to 7 of the tasks, mainly associated with reading patient data (Laerum et al. 2001). Identification of the issues in paper health records helps to specify EHR requirements and thus allows EHR systems to more precisely cater for healthcare practitioners' and patients' real needs.

2.2. Issues in Paper Health Records

Paper health records systems do not involve any form of electronic records. The proceeding discussion helps to understand what the existing paper health records issues are and how EHR systems can partially address some of these issues in paper health records.

2.2.1. Limited Access and Sharing of Patient Records

As paper health records can generally be viewed and generated only at one location (where the physical document is present) (Bakker, 2007), data about patients' health history and current situation cannot be easily shared, particularly when the care is delivered by a variety of healthcare professionals at multiple locations. Additionally, with different ways of representing patient records, they cannot be easily reconciled. As a result, duplication of effort in patient history takes place. EHR systems provide a possibility that patient data can be viewed from multiple locations in a computer processable form, stored and transmitted securely and be accessible by multiple authorised users (ISO Technical Report (ISO-TR20514); Bakker, 2007).

The establishment of shared healthcare must be supported by distributed, interoperable information systems (Blobel, 2006). Seamless healthcare information exchange and interoperability between EHR implementations need to specify a variety of uniform clinical information data sets (Tessier et al., 2003). Differing standards (e.g. ASTM International Continuity of Care Record (CCR) (Jeffrey et al., 2006) and the HL7 Clinical Document Architecture (CDA) (Müller et al., 2005)) and data architectures used in various healthcare providers have proven to be another obstacle for healthcare practitioners to share patients' records (Jeffrey et al., 2006). In contrast, specification of a minimal set of essential standards that have the property of supporting interoperability (the ability to exchange clinical information reliably) even facilitates rapid adoption of sharable EHR (Zdon & Middleton, 1999; Middleton et al. 2005; Kemper et al. 2006; Goossen et al. 2002; Halamka et al. 2006; Bates, 2005).

2.2.2. Inefficient Documentation of Patient Records

Provision of quality care requires the documentation of clinical information, which as an intrinsic aspect of routine clinical activity, is essential from both professional and legal standpoints (Lee et al. 1996). If health records were manually generated and stored, it would be difficult to retrieve them from a physical pile of paper documents and documentation becomes considerably time-consuming (Warshawsky et al. 1994). Since paper-based health records do not enforce unique patient id, illegitimate diagnoses will result from wrong retrievals. Patient records may be lost or mixed up. Illegible handwriting makes patient records hard to read, so they cannot be efficiently shared amongst physicians. By contrast, when physicians employ an electronic documentation process, this will result in improvement in the generation, storage and retrieval of standardised patient records. Physicians with paper-based healthcare look forward to a new intervention if it reduces their documentation time (Allan et al. 2000) even though the time savings do not directly translate into better patient care (Lee et al. 1996).

Time efficiency is recognised as an important facilitator of EHR implementation (Bate et al. 2003; Kuhn et al. 2001; LaDuke, 2001). There is inconsistent evidence as to whether EHR delivers healthcare more efficiently (Pabst et al. 1996; Ammenwerth et al. 2001). In order to identify factors that may explain efficiency differences across studies, a systematic review of the literature from 1966 to January 2004 was performed by Poissant et al. (2005). They examined the impact of EHR on documentation time of physicians and nurses. The studies (Poissant et al. 2005) that observed clinicians relatively soon after implementation time (three months or less) showed a slight reduction in documentation time, while those that waited longer tended to show increases in documentation time. This is possibly because once clinicians become familiar with the system, they begin to take advantage of its different functionalities and thus may appear to be less efficient (Poissant et al. 2005). Another reason may be that most projects have intensive support in the early implementation phase and that support may decrease over time (Poissant et al. 2005). Based on these reasons, the optimal time period for assessment of time efficiencies at post-implementation of EHRs remains a challenge and requires further research.

Overall, expectations of EHR implementation projects that documentation time will be decreased are unlikely to be fulfilled (Poissant et al. 2005). The lengths of physician-patient encounter components and record use, however, did positively change (Warshawsky et al. 1994), such as accessing a patient chart (Bates et al. 1994), maintaining patients' report forms (Tierney et al. 1993), electronic messaging, prescription maintenance, remote access, (Clarke et al. 2005) and finding answers to patient questions with reference tools of EHR (Ketchell et al., 2005). As a whole, EHR generates time efficiency of the physician-patient encounters.

2.2.3. Breached Patient Privacy

Patient privacy breach is a critical problem in paper-based healthcare practice. In a

shared environment where healthcare services are offered by multiple healthcare professionals (Gritzalis et al. 2004; Blobel, 2004) (e.g. physicians, nurses and health administrators), patient health records must be accessible to all of them. Paper health records cannot control the degree and extent of access. The records can even end up in the hands of unauthorised persons. Therefore, privacy and security of patient information can be seriously breached.

E-Consent, a proposed component of EHR has come up against privacy and security problems (Coiera et al., 2004; Galpottage et al., 2005). It functions to store patients' consent about particular healthcare affairs. E-Consent is different from verbal consent, as patients' consent can be embedded into day-to-day medical practice by information technology. The E-Consent extension will not merely allow the patient to explicitly express her/his agreement for an information transaction, but also empowers the patient to control cross-institutional transmission of her/his data (Bergmann et al., 2007).

Medical practice convention can heavily impair the effectiveness of E-Consent. One of the striking features of medical practice is that physicians rely far more on informal interpersonal information exchange than formal paper or computer records to satisfy their information requests (Coiera & Clarke, 2004). This is often because conversation is a more appropriate mechanism for information exchange (Coiera & Clarke, 2004). 50% of information requests by physicians in a health care centre were met by a colleague rather than documented sources (Covell et al., 1985) and about 60% of a physician's time in a healthcare centre is devoted to talk (Tang et al., 1996). As a result, E-Consent that struggles for regulating access to electronic patient records will only protect a small proportion of all information transactions (Coiera & Clarke, 2004).

Embedding routine E-Consent checks may substantially impede clinical work on every request for patients' records in an environment such as accident and emergency

(A&E). Imposing extra duties because of the introduction of the system, without removing existing tasks, will limit the capacity of physicians to perform their jobs in a time-critical way (Coiera & Clarke, 2004).

E-Consent can still be rather cumbersome for the patients who are concerned about their privacy (Bakker, 2007). They need to address all systems where his/her data are stored to find out whether undesired access has taken place or was attempted and by whom (Bakker, 2007). An easier way is to keep trails of system access and data operations. What a user has retrieved from systems could be recorded within his/her workstation or in a repository, with time stamps. Assessment could be subsequently conducted on these recordings. In addition to being relatively passive to protect the security of the system and privacy of patients, the easier means would require additional storage capacity in workstations, in particular if digital images also have to be stored (Bakker, 2007).

E-Consent and the system trails are both technical controls, partly against the breach of the security of patient information. Considerations need also to be taken of non-technical controls, such as constituting laws, improving healthcare practitioners' professional ethic codes by education programmes, categorizing information sensitivity and other issues.

2.2.4. Incomplete and Inaccurate Health Records

Complete and accurate patient records provide the full picture of patient health status and therefore help prevent errors in diagnoses and prescriptions. With the fragmented nature of healthcare system, patients receive care at multiple locations (Bakker, 2007). If healthcare in these locations was based on paper records, it would be difficult to share patient information, particularly with the different ways of representing it. As a result, duplication of efforts in history takes place and it is impossible to maintain up-to-date patient health records (Staroselsky et al., 2006). This issue can be partially alleviated with information management of EHR information infrastructure.

Even if EHR was implemented, most patients still found errors that they wanted to fix when they were allowed to view their own health records (Pyper et al. 2004). Having patients provide information for potential inclusion in EHR could be valuable in heightening complete and up-to-date records (Staroselsky et al., 2006). At present, patients represent an underutilized source of information in that they know an enormous amount about their own health, but few mechanisms are set up in place to allow them to contribute the information to their records (Ball & Lillis, 2001). Patient portals (websites that allow patients to view and comment on portions of their medical records outside of a physician visit) have subsequently emerged and started to be integrated into EHR. While EHR systems function to serve the information needs of healthcare professionals, the portal captures health data entered by individuals and provides information related to the care of their own health. Hence patient portals help patients take a more active role in their own health and also enhance the completeness and accuracy of patient records (Tang et al., 2006).

In principle, these dynamic and critical health data generated from EHR and patient portals must be preserved and capable of real-time access on a 7/24/365 basis for perhaps 125 years (Scott, 2007). Overloaded digital information is challenging not only its categorisation but also scalability of preservation system. A variety of solutions to data preservation can be adopted in different cases, typical approaches including data refreshing, data migration, data emulation, extensibility, data filtering, and backward compatibility (Garrett et al., 1996). There is no unique norm to select approach for data preservation, as it heavily depends on practically independent factors and their respective priorities, such as time consumption, limited cost, expected outcome, technical ability or even individual preferences.

2.2.5. Wrong Prescription

Even if paper health records provided complete and accurate patient records, illegitimate prescriptions could still be made. This is because prescriptions in

paper-based healthcare are fully dependent on the limitation of physicians' individual knowledge on diseases and new drugs, as well as their experience. One series of studies showed that an EHR system, which included electronic prescribing (E-Prescription), contained more complete medication lists than did comparable paper records (Tang et al., 1999). Once a stated diagnosis or a chosen treatment by physicians or clinicians is not in agreement with common medical knowledge, the system warns the user and suggests more probable diagnosis or more appropriate action (Veselý et al. 2006). In order to achieve this, EHR usually uses set of logical if-then rules, which could be extracted from medical guidelines (Veselý et al., 2006). This is called Stand-alone Reminder System (SRS). (Figure 2.3) The aim of E-Prescribing is not only to improve the safety and appropriateness of prescriptions in accordance with medical guidelines, but also to save labour by reducing pharmacy callbacks for illegible prescriptions and renewal requests (Veselý et al. 2006).

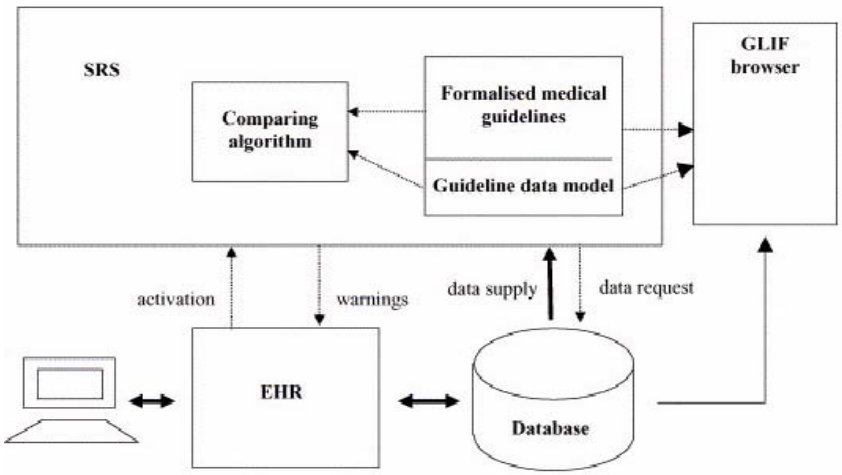

Figure 2.3. SRS and EHR system communication: Medical guidelines presentation and comparing with Electronic Health Record. (Veselý et al., 2006)

2.2.6. Wrong Medicine Dosage

Wrong medicine dosage in paper health records is partially attributable to a lack of access to complete patient records. Even though they are able to access the records, if

the prescribing physicians with insufficient knowledge about dosage fail to consider relevant patient characteristics, they can also cause considerable harm (Gandhi et al., 2003; Kaushal et al., 2001; Bates et al., 1995; Field et al., 2001). For example, renal insufficiency and advanced patient age call for lower than usual medication doses, and drug-drug interactions can become lethal sometimes. Such information is not available to an inexperienced physician or one who is not up to date on drug information.

Clinical decision support (CDS) systems can improve medication safety. Complied with guidelines by means of conflating expertise opinions, medical knowledge, previous clinical practices, and patients' data like weight and allergy status, a CDS review can assure instant, accurate, and reliable and computer-generated orders (Bates, Kuperman et al., 2003; Kuperman et al., 2001). CDS systems must not impede but support clinical workflows through speedy, available, and usable algorithms that provide parsimonious, clear, concise, and actionable warnings and advice (Ash et al., 2004; Kuperman et al., 2001).

The CDS categories are differentiated into two stages, *basic* and *advanced* (Kuperman, Bobb et al., 2007). Compared with categories of advanced CDS, those of the *basic* are more straightforward, representing a suitable starting point for most healthcare organisations (Kuperman, Bobb et al., 2007). They include drug-allergy checking, basic dosing guidance, formulary decision support, duplicate therapy checking, and drug–drug interaction checking. *Advanced* decision support should be implemented once the basic is in place and working well with good user acceptance, including dosing support for renal insufficiency and geriatric patients, guidance for medication-related laboratory testing, drug–disease contraindication checking, and drug–pregnancy checking (Kuperman, Bobb et al., 2007). Nonetheless, many of the most important financial and safety benefits of CDS will be well realized after advanced CDS features are implemented (Johnston et al., 2003), so the expectation of Return On Investment (ROI) for sponsors and the prospective improvement of

healthcare services in patients' safety may not be achieved at the beginning of CDS implementation.

2.2.7. Lack of Assistance to Answer Repeated Patients' Questions

Physicians using paper health records do not have enough resources for assistance in answering patients' questions. When recurring questions were observed mainly on drug information, patient education, immunizations, travel health, dermatological images, therapy, diagnostic rules for injuries, dietary counselling and uncommon presentations of common conditions (Ketchell et al. 2005), physicians using paper health records had to utilise scarce resources to duplicate efforts for different patient visits. Physicians indicated that they preferred presentation of information in the context of a typical patient visit: short, quick answer; link to longer contextual summary; and full source or document (Ketchell et al. 2005). A physicians' preference was for quick access to information within a resource in the form of summary charts, tables, and answers (Ely et al. 2005).

The PrimeAnswers portal satisfied the physicians' needs by providing a customised reference portal designed to reduce time and effort at the point of care (Ketchell et al., 2005). The objective of the portal is to create a filtered and customised set of content that would 1) make best available evidence as accessible as commonly used textbooks; 2) design automated methods to search the most commonly used external clinical reference systems; and 3) integrate information objects frequently used during the clinic day (e.g., calculators, tables, patient handouts). The portal primarily increased physician use of reference tools and resulted in a perception of improved patient care (Ketchell et al., 2005). An absolute majority of them realized the expected benefits of PrimeAnswers. 88% and 87% of the respondents respectively found that PrimeAnswers was easier and faster to find answers during a clinic day. As well, provided information led to improved healthcare to patients (88%).

PrimeAnswers is the first step to solve the problem of matching a physician's question to a specific answer embedded in a larger document or set of documents. The next step is to standardize the internal structure of reference documents (Ketchell et al., 2005).

The above section summarised the key issues of paper health records systems followed by explanations/examples how E-Health tools can overcome these issues.

2.3. Review of EHR Studies in Developed and Developing Countries

The purpose of this section is to review the EHR literature, particularly from developed and developing countries' perspectives, to summarise the outcome of EHR studies and subsequently identify research gaps in the literature.

2.3.1. Review Methodology

The review methodology of published EHR articles I have adopted involves five steps, similar to those taken by Schwarz et al (2007). This review examines 15 years of the relevant literature. The first three steps allow the location and identification of relevant articles. The last two steps focus on analysing the content of chosen articles. These steps specifically are: 1) Selecting (searching) articles for review; 2) Filtering relevant articles; 3) Identifying their objectives and study results; 4) Grouping articles according to studied countries; 5) Clustering their objective. Each of these steps is described in turn below.

Step 1: Selection of articles for review

The types of journals or databases most likely to publish EHR articles are first

identified. These include Web of Science, JAMIA, Medline, PubMed, CINAHL, PsychInfo, ERIC, ProQuest Science Journals. The articles examined are based on the following criteria: (a) the words “electronic health records” or related terms, such as “computerized medical records”, “electronic medical records” and “digital medical records”, appear in their titles, abstracts or key words; and the words “developing/developed countries” appear in their titles, abstracts, key words or text body; b) published year is between 1994 and 2008 inclusive; and (c) if the number of the search results based on criterion a) and b) is over 200 (e.g. Medline), only select articles from "core clinical journals" or “health technology assessment journals”. (Table 2.2)

Database (DB) or Journals (J)	The number of articles
Web of Science (DB)	7
JAMIA (J)	159
Medline (DB)	173
PubMed (DB)	31
CINAHL (DB)	124
PsycInfo (DB)	0
ERIC (DB)	0
ProQuest Science Journals (DB)	0

Table 2.2. The articles selected from identified sources

Step 2: Filtering relevant articles

After finding a set of articles from identified sources, the following types of articles are filtered out:

a. Articles which never mentioned or used the term “electronic health records” or related terms in the entire text, title or abstract, but had EHR papers listed in the reference section. These articles were ignored after a quick scan to see if the article included more than a casual citation to that reference.
b. Articles which never mentioned “developing countries” or “developed countries” or the name of countries in the title or abstract.
c. Articles without empirical evidence.

As a result, the EHR articles included for review are listed in Table 2.3:

Database (DB) or Journals (J)	The number of articles
Web of Science (DB)	7
JAMIA (J)	41
Medline (DB)	48
PubMed (DB)	11
CINAHL (DB)	30
PsycInfo (DB)	0
ERIC (DB)	0
ProQuest Science Journals (DB)	0
Total number	137

Table 2.3. Sources of articles included for review

Step 3: Identification of objectives and results

Abstracts and full text are scanned to identify objectives and study results of the articles. Relevant text is extracted or was re-typed verbatim. For example, one paper titled *E-Prescribing Collaboration in Massachusetts: Early Experiences from Regional Prescribing Projects.,* illustrated key issues that made implementation difficult, and clarified the impact of various types of functionality. That study identified ten key barriers: (1) previous negative technology experiences, (2) initial and long-term cost, (3) lost productivity, (4) competing priorities, (5) change management issues, (6) interoperability limitations, (7) information technology (IT) requirements, (8) standards limitations, (9) waiting for an "all-in-one solution," and (10) confusion about competing product offerings including hospital/Integrated Delivery System (IDN)–sponsored projects (Halamka et al. 2006).

Step 4: Grouping articles

After identifying the content, the articles are grouped into “Developed countries” and “Developing countries” according to the World Health Organisation (WHO) country categorisation. The objective and study results of each article are also included and

summarized.

Step 5: Clustering objective

In this step, common themes centred on the objectives of the EHR articles are identified for pre- and post-implementation studies, which happen before and after EHR is technically developed to deliver into medical practice. All citations firstly used to group articles are noted. These citations and common themes are then used to cluster articles with similar objectives (Table 2.4). The resulting clusters represent another level of abstraction. The figures shown in the table are the number of unique studies for groups.

Countries	EHR Related Research Topic	
Developed 116 (88%)	Pre-implementation 16 (12%)	● Evaluation of status quo, such as health information standards, legal obstacles, impact of information technology, overview of socio-technical issues, physicians' practice, priority areas for action and legislative, ICT technological levels and accessibility of professional knowledge (Yasnoff et al. 2004; Niland et al. 2006; Landon et al. 2005; McCormick et al. 2007; Zvárová et al. 2002) ● Potential issues in EHRs, including storage and transmission formats, and terminology standards (Coenen et al. 2001; Kalra, 1994) ● Motivations for EHRs, such as natural disasters and immunisation (Kozma, 2006; Urquhart et al. 2007) ● Infrastructure and platform planning, including an architectural framework and a security infrastructure (Blobel et al. 2005; Stead et al. 2005) ● Strategies or recommendations, such as progress promotion in the application of information technology to improve public health, developing co-ordinated approach to EHRs, building information infrastructure and accelerating the development and adoption of EHRs (Yasnoff et al. 2001; Briggs, 2001; Stead et al. 2005; Sim et al. 2001; Coenen et al. 2001; Kalra, 1994; McCormick et al. 2007; Zvárová et al. 2002; Kalra, 1994; Detmer, 1997)
	Post-implementation 100 (76%)	● EHR adoption rate, factors influential to EHR adoption and suggestions to stimulate EHR adoption (Bates et al. 2003; Sicotte et al. 2006; Middleton et al. 2005; Kemper et al. 2006; Shiffman et al. 2004; Callen et al. 2008; Simon et al. 2007; McCray et al. 2000; Darroch et al. 2003; Goossen et al. 2002; Halamka et al. 2006; Schade et al. 2006; Menachemi et al. 2006; Ash et al. 2005; Iakovidis, 1998; Jha et al. 2006; Loomis et al. 2002; Southon et al. 1997; Scott et al. 2005; Fullerton et al. 2006; Antohi et al. 2007; Gans et al. 2005; Bates, 2005; Kawamoto et al. 2007; Thakkar et al. 2006; May, 2005; Aarts et al. 2004; Vanmeerbeek, 2004)

		• Evaluation and methods, such as evaluating the effects of the usage of EHRs, EHR adoption, and quality and availability of scanned documents in EHRs, and developing methods of measuring validity and utility of EHRs (Hassey et al. 2001; van der Meijden et al. 1999; Persell et al. 2006; Stewart et al. 2007; Knaup et al. 2006; Protti, 2007; Simon et al. 2007; Laerum et al. 2001; Garrido et al. 2005; Linder et al. 2007; Duke et al. 2002; Schade et al. 2006; Grajek et al. 1997; Dwight et al. 2004; Menachemi et al. 2006; Fiks et al. 2007; Embi et al. 2004; Albert et al. 2007; Gans et al. 2005; Moo et al. 2007; Fleming et al. 2006; Campbell et al. 1997; Simon et al. 2007; Menachemi et al. 2006; Thakkar et al. 2006; Ash et al. 2004; Morris et al. 1997; Obstfelder et al. 2006; Porth et al. 1999; Ash et al. 2007; Vedvik et al. 2006; Miller et al. 2007; Sackett et al. 2006; Bertelsen et al. 2005; Park et al. 2005;) • Functions in use and functionality demanded of primary care, such as clinical decision support and electronic prescribing systems (Miller et al. 2005; Darroch et al. 2003; Laerum et al. 2001; Halamka et al. 2006; Fiks et al. 2007; Southon et al. 1997; Albert et al. 2007; Antohi et al. 2007; Wolf et al. 2007; Simon et al. 2007; Menachemi et al. 2006; Ash et al. 2007; Vedvik et al. 2006) • Issues in EHRs in practice, i.e., Standard of data set, completeness, Security and Access, Data preservation (Goossen et al. 1998; Willison et al. 2007; Knaup et al. 2006; Rothstein et al. 2007; Pribik et al. 2000; Orfanidis et al. 2004; van der Haak et al. 2002; Richesson et al. 2007; Boaden et al. 2006; Wigefeldt et al. 1997; France, 1999; Petrisor et al. 2002; Goossen et al. 2002; Iakovidis, 1998; Paterson et al. 2004; Wang et al. 2004; Curtis et al. 2007; France et al. 2000; Bernstein et al. 2003; Willison et al. 2003; Magnusson, 2001; Karra et al. 2000; Simons et al. 2005; Safran et al. 2007; Markwell et al. 1999) • Other use of EHR other than healthcare, such as facilitating clinical governance, documentation of the return on investment, health research, healthcare practitioners' performance measures, support to billing system and student education (El-Hayes et al. 2006; Grieger et al. 2007; Willison et al. 2007; Persell et al. 2006; Lasko et al. 2006; Tang et al. 2007; Duke et al. 2002; Dwight et al. 2004; Wood et al. 1999; Muller et al. 2002; Willison et al. 2003; Ralston et al. 2004; De Clercq et al. 2006; Bani-Issa, 2005; Safran et al. 2007; Sequist et al. 2005) • Strategies, plans or recommendations, such as for innovation of Health Information Systems and promotion of EHR use, a multiple perspectives model of clinical information system implementation, and intelligent interfaces and structured data entry for data quality issue (Ciccarese et al. 2005; Ceusters, 2001; Rothstein et al. 2007; Callen et al. 2008; Orfanidis et al. 2004; McCray et al. 2000; France, 1999; Hjertkvist, 1998; Ash et al. 2005; van der Lubbe et al. 1997; Jha et al. 2006; Curtis et al. 2007; Fullerton et al. 2006; France et al. 2000; Moo et al. 2007; van der Werff, 1997; Kawamoto et al. 2007; Miller et al. 1997; Karra et al. 2000; Vedvik et al. 2006; Miller et al. 2007; van Mulligen et al. 2008; Leiman et al. 2008; Markwell et al. 1999)
Developing	Pre-implementation	• Evaluation: needs on the functionalities of an EHR and determine the difference

16 (12%)	3 (2%)	of needs among MR administrators' groups and expert groups (Hwang et al. 2006) ● Potential issues in EHRs: not standardised reference terminology (Coenen et al. 2001) ● Strategies, plans or recommendations, such as promoting convergence toward a reference terminology and processes involved in the development of EHRs up to the point of implementation (Coenen et al. 2001; Hannan et al. 2000)
	Post-implementation 13 (10%)	● Factors influential to EHR adoption and suggestions to stimulate EHR adoption (Sek et al. 2007; Kamadjeu et al. 2005; Leung et al. 2003) ● Evaluation, such as assessment of nurses' perceptions of and attitudes toward EHRs and users' satisfaction on EHRs, identifying critical success factors to EHR adoption, determining the availability of EHRs in teaching and general hospitals and identifying key issues related to the design and implementation of EHRs (Sek et al. 2007; Kamadjeu et al. 2005; Allen et al. 2007; Sequist et al. 2007; Fraser et al. 2005; Rotich et al. 2003; Ahn et al. 2006; Tierney et al. 2007; Choi et al. 2006) ● Issues in EHRs in practice, i.e., Security and Access, data preservation, Standard of data set (Sek et al. 2007; Cheung et al. 2007; Tierney et al. 2006) ● Other use of EHR other than healthcare: clinical research (Diero et al. 2006) ● Strategies, plans or recommendations: resolving the key issues identified during the development and implementation of the system, i.e., user involvement, the choice of an appropriate terminology, pre-existing data collection culture and leadership issues to promote good medical practice and routine availability of consultation data (Kamadjeu et al. 2005)

2.4. Clustering EHR articles for developed and developing countries

Although the number of the yielded statements related to the objectives of the EHR articles is close for developed and developing countries (respectively 11 and 8), an overwhelming majority of studies were conducted for developed countries and EHR studies in developing countries have fallen far behind those in developed countries (12% vs. 88%). Furthermore, most of studies happened after EHR systems were implemented (86%). Accordingly, more effort is needed to put into pre-implementation studies, particularly in developing countries.

2.3.2. Summary of Issues in EHR in Developed and Developing Countries

Some of the issues in paper health records can be well addressed by EHR systems

(EHRs), such as breached privacy of patients', incomplete and inaccurate health records and wrong prescriptions. Nevertheless, with the introduction of EHR to healthcare practice, other issues subsequently arise (Sood et al. 2008).

Most of them have been identified in both developed and developing countries. *Standard EHR data sets*, which are capable of operating on a wide variety of computer hardware and will also be able to communicate with many different information systems (Kalra, 1994), are needed to support information exchange via EHR (Goossen et al. 1998; Pribik et al. 2000; Orfanidis et al. 2004; Richesson et al. 2007; Wigefeldt et al. 1997; France, 1999; Goossen et al. 2002; Bernstein et al. 2003; Markwell et al. 1999; Coenen et al. 2001) and thus to support the adoption of the EHRs (Goossen et al. 2002). One study in developing countries had a particular purpose, which was for supporting the management and monitoring of patients with HIV and their care programs (Tierney et al. 2006). Another issue which has been highlighted is *accessibility and confidentiality* of EHRs (Willison et al. 2007; Rothstein et al. 2007; van der Haak et al. 2002; Boaden et al. 2006; Petrisor et al. 2002; Magnusson, 2001; Karra et al. 2000; Simons et al. 2005; Sek et al. 2007), but EHRs *for the secondary use* need to balance with privacy, confidentiality and public interest (Paterson et al. 2004), such as research (Willison et al. 2003; Safran et al. 2007), payment, marketing, and other business applications and so on (Safran et al. 2007). *Data preservation* (Cheung et al. 2007; Curtis et al. 2007) poses the last common issue. This is directly related to completeness and accuracy of health records, which was discussed in Section 2.2.4.

The remnant issues in EHRs are only identified in the studies for developed countries. This can be caused by the smaller number of the studies for developing countries. Due to external paper-based documents, a complete EHR is currently not possible (Knaup et al. 2006). The quality and availability of the scanned, indexed and integrated paper documents in EHR become a subsequent concern for healthcare practice. Knaup et al.'s (2006) study demonstrated that the quality of the scanned, indexed and integrated

paper documents in the EHR was high and the availability was sufficient. Furthermore, as discussed in Section 2.2.4, patients represent an underutilized source of information in that they know an enormous amount about their own health, but few mechanisms are set up in place to allow them to contribute the information to their own records (Ball & Lillis, 2001). Accordingly, there is a need for patients to have greater control over their health information by providing patient access to their EHRs (Iakovidis, 1998; Wang et al. 2004), such as Patient Gateway (Wang et al. 2004).

Organisations have to take all of these issues into account when EHR systems are developed or innovated for future implementation, partly because some of the issues, such as standard EHRs data sets for interoperability have been identified as a decisive factor for EHR adoption (Middleton et al. 2005; Kemper et al. 2006; Goossen et al. 2002; Halamka et al. 2006; Bates, 2005).

2.3.3. Importance of Pre-implementation Evaluation in Developing Countries

The issues discussed in Section 2.3.2 such as a lack of standard EHR data sets for interoperability have negative effects on EHR adoption. On the other hand, positive impact or value of EHR facilitates EHR adoption (Middleton et al. 2005; Kemper et al. 2006; Leung et al. 2003) and delivers many benefits to stakeholders as discussed in Section 2.2. Although EHR has been shown to be positively influential to direct/indirect healthcare, its adoption is still problematic in both developed and developing countries (Menachemi et al. 2006; Ash et al. 2005; Menachemi et al. 2006; Vanmeerbeek, 2004; Gans et al. 2005). Pre-implementation evaluation contributes to increasing EHR adoption by assessing various needs at different levels prior to the implementation of the system, thereby acting as an impetus for improving the readiness status of the organisation implementing the system. This is especially pertinent for developing countries due to their usually lower level of readiness in

multiple dimensions (Watson, 2006). These countries should address major issues (e.g. the availability of information technology, technical/IT expertise and skills, and data processing facilities) (Watson, 2006). Also, the evaluation enables customization of the system and sufficient pre-planning to ensure minimal workflow disruptions during and after the implementation (Fullerton et al. 2006).

EHR systems have positively affected direct/indirect healthcare. With respect to the effects on direct healthcare, efficient medical practice has been recognized (Protti, 2007; Schade et al. 2006; Thakkar et al. 2006; Leung et al. 2003; Fraser et al. 2005; Rotich et al. 2003; Choi et al. 2006) by:

- Reducing the length of patients' stay in the hospital without evidence of adverse effects on mortality or readmission rates (Dwight et al. 2004);
- Reducing the use of ambulatory care while maintaining quality and allowing doctors to replace some office visits with telephone contacts even though EHRs were not associated with better quality ambulatory care (Garrido et al. 2005).

After the EHR implementation in Kenya, for example, patient visits were 22% shorter and patients spent 58% less time with providers and 38% less time waiting; clinic personnel spent 50% less time interacting with patients, two thirds less time to interact with each other, and thus more time in personal activities (Rotich et al. 2003).

EHR systems improve quality and consistency of care as shown by more sharing of patient records amongst multiple healthcare providers (Schade et al. 2006; Moo et al. 2007; Leung et al. 2003; Kamadjeu et al. 2005; Sequist et al. 2007), higher levels of completeness, accuracy, validity, and utility of EHRs for clinical diagnoses (Hassey et al. 2001; Embi et al. 2004; Sek et al. 2007), providing better clinical decision support (van der Meijden et al. 1999; Stewart et al. 2007; Protti, 2007) and electronic prescribing (Schade et al. 2006), as well as better support of the pharmacy (Allen et al. 2007).

EHR systems reduce missed opportunities for vaccination at both sick and well visits and significantly improve immunisation rates for young children by an EHR-based clinical alert intervention for routine pediatric vaccinations (Fiks et al. 2007). Also, EHR systems are more sensitive than general practice registers in identifying diabetic subjects (Morris et al. 1997) and they support additional clinical problems including nutrition and child health (Allen et al. 2007).

Also, EHR systems have impact on healthcare administration and consultation – these are not directly related to the actual diagnosis and treatment of patients, but the existence of EHR tools will assist these processes (e.g. availability of easy reporting tools), as well as any healthcare administrative functions arising from the core functionalities of EHR (e.g. reduction of secretaries). The effects of EHR systems on indirect healthcare are reflected in the reduction of the number of secretaries (Bertelsen et al. 2005), increased revenue generation and potential shielding from malpractice claims (Schade et al. 2006), efficient medical billing (Duke et al. 2002), enhancement of knowledge-based resource linkages within EHRs (Albert et al. 2007), availability of easy reporting tools (Allen et al. 2007), better database synchronisation tools (Allen et al. 2007) and improved modules to collect laboratory data (Allen et al. 2007).

After an EHR implementation, patients showed high satisfaction with the physician and 70.9% of patients reported excellent satisfaction with their physician (Fleming et al. 2006). Also, nurses' positive perceptions and attitudes to EHRs were identified; Choi et al. 2006). This result shows that nurses were generally accepting of the implementation of a new EHR system (Ahn et al. 2006).

Although EHRs have been shown to deliver a number of benefits such as improved quality and consistency of care, and improved practice efficiencies that have both timesaving and revenue generating (Middleton et al. 2005; Kemper et al. 2006), their implementation posed unintended consequences in both developed and developing

countries as evidenced by the low (rate of) adoption of EHR (Menachemi et al. 2006; Ash et al. 2005; Menachemi et al. 2006; Vanmeerbeek, 2004) (Gans et al. 2005; Harrison et al. 2007). For example, in 2005 in the US, approximately 23.9 percent of physicians used EHRs in the ambulatory setting while 5 percent of hospitals used computerised physician order entry (Jha et al. 2006). A complete EHR system was available in only 9% healthcare organisations in the Republic of Korea (Park et al. 2005). Further, few functions of EHR systems were used in healthcare practice. Physicians used the systems for far fewer functions than the systems supported. The systems were used for only two to seven of the functions, mainly associated with reading patient data (Laerum et al. 2001).

In order to systematically understand the implementation problem associated with EHR, the factors facilitating or hindering EHR implementation have been identified from the public, organisational, systemic and healthcare providers' perspectives. Each of these is described below.

Public: concerned with EHR-related policies enacted by governments. Legitimate policies accelerate utilisation of EHRs (Bates et al. 2003; Middleton et al. 2005; Jha et al. 2006), which should help organisations to afford EHRs and produce more EHR-related quality improvement (QI) gains, including through grants and QI performance rewards (Miller et al. 2007). In addition, policies should address financial incentives and interoperability (Bates, 2005).

Organisational: involves organisational culture, business strategy and internal management. Organisational factors can take the following forms:

1) Financial incentives (e.g. involve the cost of implementing and maintaining the systems decreases (Middleton et al. 2005; Kemper et al. 2006; Halamka et al. 2006), the cost of hardware (Thakkar et al. 2006) and reimbursement (Bates, 2005)).

2) Educational, marketing and supporting activities for both healthcare providers' community and healthcare consumers (Middleton et al. 2005; Fullerton et al. 2006;

Leung et al. 2003). For example guideline documents as a knowledge source promotes authentic translation of domain knowledge (Shiffman et al. 2004).

3) Organisational culture, environment (Callen et al. 2008; Ash et al. 2005; Scott et al. 2005; Kamadjeu et al. 2005) and size (Thakkar et al. 2006). The large-scale developments of integrated health services present great challenges to the efficient and reliable implementation of information technology in large and divisionalized organisations (Southon et al. 1997).

4) Leadership (Callen et al. 2008; Scott et al. 2005; Kamadjeu et al. 2005).

5) Change management and implementation strategy (Darroch et al. 2003; Halamka et al. 2006; Fullerton et al. 2006).

6) Preparation, which enables customisation of the system and sufficient pre-planning to ensure minimal workflow disruptions during and after implementation (Fullerton et al. 2006).

7) User involvement (Kamadjeu et al. 2005).

8) Enough capital investments (Leung et al. 2003).

9) Time cost (Leung et al. 2003).

Systemic: concerned with technical issues and evaluation outcomes associated with EHR systems. Systemic factors can take the following forms:

1) Promotion of EHR standards for interoperability (Middleton et al. 2005; Kemper et al. 2006; Goossen et al. 2002; Halamka et al. 2006; Bates, 2005).

2) Demonstrated impact or value of EHRs in practice, such as improved quality and consistency of care, practice efficiencies (Middleton et al. 2005; Kemper et al. 2006; Leung et al. 2003) or lost productivity (Halamka et al. 2006; Schade et al. 2006).

3) Information technology (IT) requirements (Halamka et al. 2006).

4) Demanded functionality (Darroch et al. 2003; Halamka et al. 2006).

5) Service-Oriented, core services include the Decision Support Service, the Common Terminology Service, and the Retrieve, Locate, and Update Service (Kawamoto et al. 2007).

Healthcare providers: refers to healthcare providers' past technology experience and their perception about EHR systems. The factors can take the following forms:

1) Previous positive/negative technology experiences (Halamka et al. 2006).

2) Healthcare providers' perception about EHRs (Loomis et al. 2002; Sackett et al. 2006), such as concerns about changes in workflow (Ash et al. 2005; Ash et al. 2007) and the management which eliminates traditional information and communication routines (Obstfelder et al. 2006).

EHR adoption was significantly low three years ago in the US (Burt & Hing, 2005), nevertheless since then there has been a massive adoption of EHR systems (e.g. Kaiser Permanente, one of the largest insurance companies, going completely digital). Past experience of EHR adoption in the US tells us that the low rate of EHR adoption was attributed to both macro-level factors from public, organisational and systemic perspepctives (e.g. healthcare policy) and micro-level barriers from healthcare providers' perspective (e.g. physicians' perception about EHR technological complexity). The methodologies used for research vary considerably and provide different insights (Vishwanath & Scamurra, 2007). A broad spectrum of the methodologies is observed: quantitative surveys (Connell et al. 2004; Lee et al. 1996; Weiner et al. 1999), observations (Patterson et al. 2004), qualitative focus groups (Lyons et al. 2005; Wallis & Rice, 2006), ethnographic studies (Saleem et al. 2005), and even using personal intuition and experience (McDonald, 1997). The different insights are reflected as dissimilar types of barriers. Some focus on human factors such as training and support (e.g. Patterson et al. 2004) or software related barriers such as false alarms and eye contact (e.g. Saleem, 2005); while others exclusively focus on the antecedents of satisfaction, such as lack of perceived ease of use and usefulness, as potential barriers (e.g. Connell et al. 2004; Weiner et al. 1999).

With the various research methodologies, attained results (different factors influential to EHR adoption) will make it difficult for policy makers to clearly understand, measure, and alleviate the barriers (Vishwanath et al. 2007). Their study starting with

brainstorming of barrier statements, then sorting and rating of issue statements, presented a comprehensive, empirically based mode to work out this problem. The results demonstrate standardisation and interoperability are core issues; also important are technical issues and the cost-benefit of adopting EHR. However, psychosocial issues, the main focus of diffusion research, seem relatively peripheral.

As discussed in Section 2.2, the issues existing in paper health records (e.g. limited acess and sharing of patient records and wrong prescription) can have negative impacts on healthcare outcome and quality. With the introduction of EHR systems, these issues can be partially addressed by providing evidence-based healthcare (Overhage et al. 2001) and increasing medical practice efficiency (Ammenwerth et al. 2004). Although interest in automating the health record is generally high in both developed and developing countries (Watson, 2006), the adoption of EHR systems still tremendously differs from one to another. Some developed countries like Sweden, The Netherlands, and Australia have more than half of their primary care physicians using EHR, respectively 90% in Sweden, 62% in Denmark and 55% in Australia (Taylor et al. 2002; Terry, 2004). In other developed countries, when information technology was also available (Watson, 2006), adoption nonetheless appeared to be significantly lower, only 1.2% of all hospitals and 2.6% of all clinics adopted EHR in Japan (MHLW, 2002) and less than 18% of physicians used EHR in their offices in the US (Burt & Hing, 2005). In the study by Watson (2006), the key obstacle of low EHR adoption was certainly not the availability of information technology alone, but more likely other factors such as the availability of technical support, and the cost of changing to an electronic system. This latter factor is exacerbated when there is insufficient healthcare funding or using electronic systems is out of reach to many healthcare practitioners such as healthcare providers and administrators (Watson, 2006).

While EHR adoption has been low in developed countries, the success of EHR adoption has also been low for developing countries which are generally resource

constrained (e.g. insufficient E-Health infrastructure) (Watts et al. 2005; Diero et al. 2006). From an organisational perspective, sufficient preparation and pre-planning enable customisation of the system and ensure minimal workflow disruptions during and after implementation (Fullerton et al. 2006). Only one relevant study was found in developing countries, which assessed needs on the functionalities of an EHR and determined the difference of the needs among administrators' groups and expert groups (Hwang et al. 2006).

Current healthcare in developing countries is primarily based on manual patient records although some of them (e.g. Vietnam and India) are planning for the introduction of a nationwide EHR (Watson, 2006). Costs, available information technology infrastructure (including a lack of data processing facilities), and a lack of technical expertise and computer skills of staff are major issues which would need to be addressed before EHR implementation is possible (Watson, 2006). In other words, the evaluation of these issues **before** EHR implementation becomes indispensable for the future success of EHR (adoption and) implementation..

2.4. Healthcare Status Evaluation

Information systems researchers have recognised the problem of sustainability and complexity in health information systems implementations especially in developing countries (e.g. (Braa et al. 2004; Miscione, 2007)), as evidenced by the encouragement to undertake high-visibility and high impact research that takes a greater macro focus when examining the transformational nature of IT (Agarwal & Lucas, 2005; Walsham et al. 2007). This means that researchers should take a more holistic view of the environment in which the health information systems are implemented and deployed. Accordingly, data are required from diverse stakeholders at different levels of healthcare and related organisations who have (in)direct interest in such projects (e.g. distributed researchers, potential end users, technical developers,

programme sponsors). By studying the context of healthcare information systems implementation, evaluation research fits in with this recommendation.

Evaluation has been defined as an act of measuring or exploring properties of an information system (in planning, development, implementation, or operation phase), the result of which informs a decision to be made concerning that system in a specific context (Ammenwerth et al. 2004). This definition considers evaluations that happen at different phases of an information system lifecycle and thus help to achieve sustainability in its implementations. In brief, evaluation is a broad term for various methods and strategies for identifying the effects and assessing the value, feasibility, or other qualities of a technology, programme, or policy (Field, 1996).

2.4.1. Pre-implementation Evaluation

Evaluation before E-Health system implementation (pre-implementation) is particularly pertinent due to its complexity (BC eHealth Steering Committee, 2005). As with the implementation of any information system in an organisational context, system acceptance requires proper planning and management for change (Callioni, 2006). With EHR implementations, for example, change occurs not simply due to the introduction of Information Communication Technology (ICT) infrastructure, but also because the job design of interconnected health professionals should be reengineered to effectively and efficiently accommodate the technology (Eric et al., 2006). Hence, EHR implementations represent a disruptive change in the healthcare workplace. In order to succeed in this change, a champion within the organisation who often takes the lead in seeing through implementation needs to be maximally involved with his/her team to ensure the wildest possible success for the competitive collaboration in the project (More et al. 2002). A champion is recognised for his/her leadership, which has been identified as one of the factors influential to EHR adoption (Callen et al. 2008).

During planning stage, the aspects of evaluation for health information systems involve (Brender, 2006):

- Relevance: assessing whether the solution is entirely able to solve the current problems and meet the demands and requirements of the organisation;
- Problem Areas: identifying the weakness and the elements of risk in the solution;
- Feasibility: assessing the organisational resources needed to implement the chosen solution;
- Completeness and Consistency: assessing whether the solution is a coherent entity that is neither over nor undersized; and
- Elements of Risk: assessing whether there are any external conditions outside organisational control that will involve substantial risk to the project.

Accordingly, numerous methods can be used, e.g. balanced scorecard (Gordon et al. 1999; Protti, 2002), field study (Brender, 1999), focus group interview (Stewart et al. 1990), organisational readiness (Campbell et al. 2001; Demiris et al. 2004; Jennett et al. 2003, 2004; Overhage et al. 2005; Wickramasinghe et al. 2005; Khoja et al. 2007) and so on (Brender, 2006). E-Health readiness assessment, for example, is an essential requirement prior to implementation (Jennett et al. 2003; Demiris et al. 2004), as a way of identifying the potential causes of failure to innovate. A lack of readiness shows organisational inability to undergo transformation during the implementation of EHR (Blender, 2006).

2.4.2. Post-implementation Evaluation

Most evaluation studies conducted in the healthcare context take place in the post-implementation phase, which is, after an E-Health system is delivered (Ammenwerth et al. 2001; Chen et al. 2006; Makoul et al. 2001; Overhage et al. 2001; Pabst et al. 1996; Poissant et al. 2005; Schmidt, 2006; Warshawski et al. 1994). Although some evaluation methodologies have been utilised for Commercial Off The

Shelf (COTS) software packages like COTS-based Integrated System Development Method (CISD), Off-The-Shelf-Option (OTSO) and Checklist Driven Software Evaluation Methodology (CDSEM), each of them merely emphasizes one or more critical aspects of COTS software evaluation (Ammenwerth et al. 2001).

Given the complexity of E-Health systems, the evaluation of such systems best employs frameworks which have a broad coverage of evaluation criteria. Here, such a framework is summarised, based on the Cooperative methodology for Management of E-business Networks and Services (CoMENS (Ray, 2003)) previously developed. CoMENS was designed and prescribed to express evaluation criteria at various levels (Dean, 2000). CoMENS uses the philosophy of the CISD with respect to three critical considerations: functionality, interoperability and performance, the central theme of OTSO – the construction of a product evaluation criteria hierarchy, and checklist-based evaluation methodology called CDSEM. CoMENS also integrates a template-based approach for the definition of requirements (Ray, 2003). A hierarchical model proposed in the CoMENS for the evaluation of integrated management systems uses inputs from the evaluation methodologies adopted from a number of disciplines such as telecommunications and software engineering (Ray, 2003). This framework addresses the complexity of E-Health system development with multi-disciplinary inputs and the proposed template can be used as a baseline for the reporting and analysis of information for the evaluation of E-Health systems.

While post-implementation evaluations are crucial for assessing the merit, success and value of systems, contributing to evidence-based practices, and ‘learning from experience’ (Alexander, 2007), the benefits of exploring the process use of evaluations have recently been argued (Forss, Renien, & Carlsson, 2007). For this study, evaluation will be executed at the pre-implementation stage of EHR systems. It will help decision makers understand readiness status for EHR systems and also suggest corresponding strategies in order to reduce the risk of their failure after introduction.

2.5. E-health Readiness Evaluation Frameworks

In order to investigate multiple healthcare providers' view (e.g. physicians, nurses and administrative personnel) for the readiness evaluation of E-Health applications, Campbell et al. (2001) developed a readiness framework by conducting semi-structured interviews (regarding both the video and computer components of telemedicine), followed by thematic analysis. Results of thematic analysis reveal six themes (Campbell et al. 2001):

- Turf: a threat to healthcare providers' livelihood or professional autonomy or both;
- Efficacy: desire to know that E-Health applications will fill a functional need in healthcare providers' practice before they invest time and money in making such a big change;
- Practice context: barriers to adopting E-Health applications;
- Apprehension: as a human aversion to change;
- Time to learn: hesitancy among the providers to take the time to learn a new technology and to persuade patients of its worth;
- Ownership: participants who were professionally and emotionally invested in the technology – stakeholders who acknowledged its benefits, adapted it to their needs, and tried to help others learn.

These six themes comprise the framework to understand three categorised organisational settings, i.e., "fertile soil, somewhat fertile soil, and barren soil" (Campbell et al. 2001). Change strategies are also suggested to every readiness setting. Campbell et al. provided a mechanism for determining and then dealing with three different levels of readiness for implementing E-Health applications. Nevertheless, the mechanism does not involve organisational, public or patient readiness for E-Health (only from healthcare providers' view). Furthermore, Campbell et al.'s framework has not been tested.

Another readiness evaluation study followed the philosophy of existing readiness scales (the Organisational Information Technology/Systems Innovation Readiness Scale (OITIRS) and the organisational and functioning readiness for change (ORC) scale); the evaluation is also from the healthcare providers' viewpoint. This framework involves staff profiles, *staff exposure to technology* and *institutional resources* (Demiris et al. 2004). Using previously validated instruments, it captures organisational readiness for E-Health. Demiris et al.'s framework, however, seems to focus solely on assessing practitioner readiness instead of organisational readiness, as instruments primarily includes staff profiles and staff exposure to technology.

By contrast, the readiness framework from Jennett et al. (2003; 2004) is relatively comprehensive in terms of the evaluation scope. Sixteen semi-structured telephone interviews to four sets of stakeholders (patient, practitioner, organisation and public) (Project report for CANARIE, 2002) were conducted to examine complex social, political, organisational and infrastructure factors. As a result, four types of readiness were found:

- Core readiness refers to the realisation of needs and expressed satisfaction with the present situation and conditions;
- Engagement readiness involves the active participation of people in the idea of E-Health. In this process, people weigh the advantages and disadvantages of E-Health, assess risk, and question E-Health as a solution;
- Structural readiness focuses on the establishment of efficient structures as a foundation for successful E-Health projects within an organisation for example, human, technical, training, policy and funding;
- Concern of non-readiness is expressed as a perceived lack of need or a failure to recognize a need for change and implementation of E-Health technology. (Jennett et al. 2005)

Six common factors mentioned below were identified within each type of the readiness (Jennett et al. 2005):

1. *Core readiness* refers to recognised need for the service by evaluators, along with an expressed dissatisfaction with existing service or circumstance;
2. *Structural readiness* is concerned with whether an organisation includes adequate human resources, training, policies, funding and appropriate equipment that functioned properly or was easily repaired;
3. *Projection of benefits* means the benefits E-Health could bring, such as reduce the need to travel and improve access to service;
4. *Assessment of risk* involves healthcare practitioners' demands on working time and professional liability to decide whether to trust the information available to them through web-based applications for practitioners; privacy and the obtaining of reliable information for patients; a fear that E-Health services would replace the existing healthcare system is reflected for the public perspective; a financial risk especially in a short term is presented for organisations;
5. *Practitioners' awareness and education* refer to understanding the various applications, their potential benefits and limitations;
6. *Intra-group and inter-group dynamics* means communication and cooperation within or across the communities of interest.

Jennett et al.'s framework suggests a method to determine overall readiness categorisation. It stresses the importance of end-users' ownership of innovation adoption by assessing organisational, health provider, public and patient readiness for E-Health. However, tool reliability has not been assessed and the study provides little information regarding demographics or current technological practices.

Another proposed framework by Wickramasinghe et al. (2005) is concerned with three domains relevant to E-Health readiness – practitioner, organisation and public; it highlights the key elements that are required for successful E-Health initiatives. Wickramasinghe et al.'s framework provides a tool that allows analysis beyond the quantifiable data into a systematic synthesis of the major four impacts and four pre-requisites, and the implications of these pre-requisites and impacts to the goals of

E-Health, such as efficiency, evidence-based and preventive medicine. (Figure 2.4)

Wickramasinghe et al.'s framework contains four main prerequisites.

- Information communication technology (ICT) architecture/ infrastructure: a sound technical infrastructure (phone lines, fibre trunks and submarine cables, telecommunications, electricity, access to computers etc) is an essential ingredient to the undertaking of E-Health initiatives by any nation;

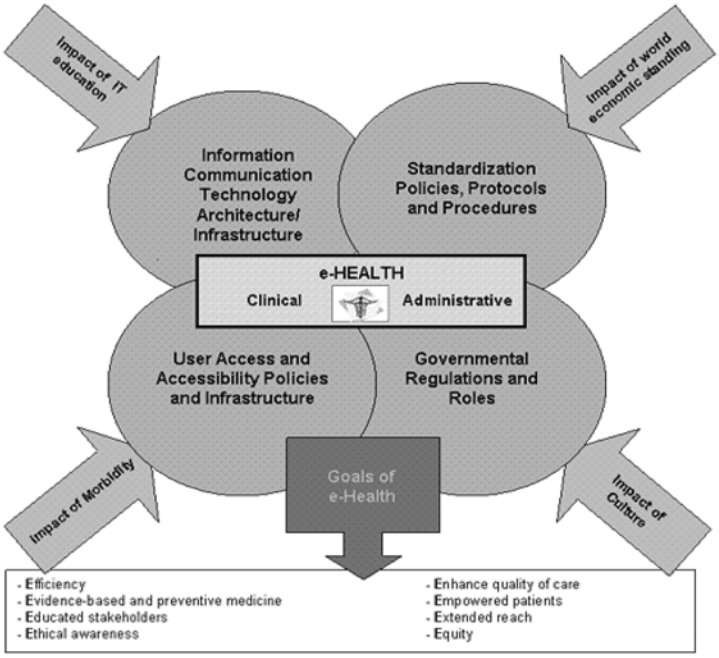

Figure 2.4. E-health Readiness Framework, Wickramasinghe et al. (2005)

- Standardisation policies, protocols and procedures: E-Health by definition spans many parties and geographical dimensions. To enable such far reaching coverage, a significant amount of document exchange and information flow must be accommodated. Standardisation is the key to this, using widely and universally accepted protocols such as TCP/IP and http;
- User access and accessibility policies and infrastructure: access to e-commerce is defined by the WTO (World Trade Organisation) as consisting of two critical components: access to internet services and access to e-services (Panagariya, 2000). The former deals with the user infrastructure whereas the latter pertains to

specific commitments to electronically accessible services;

- Governmental regulation and control: the key challenges regarding E-Health use include: cost effectiveness; i.e., less costly than traditional healthcare delivery; functionality and ease of use, i.e., they should enable and facilitate many uses for physicians and other healthcare users by combining various types and forms of data as well as being easy and secure to use.

Four impacts of E-Health are embedded in Wickramasinghe et al.'s framework.

- Impact of IT education: an educated population boosts the E-Health initiative;
- Impact of world economic standing: awareness of importance and critical role of Internet in a country's economy;
- Impact of morbidity rate: education/awareness and overall health standing of a country;
- Impact of cultural/social dimensions: culture, traditions and the like.

Wickramasinghe et al.'s framework based on multiple perspectives, including organisational (e.g. ICT infrastructure), practitioner (e.g. user access) and public (e.g. governmental regulation) can be used to assess the potential of a country and its readiness for E-Health as well as its ability to maximise the goals of E-Health.

The study of Overhage et al. (2005) involves system readiness evaluation other than practitioner and organisational readiness by analysing secondary data that communities submitted for funding better healthcare programmes. Descriptive statistics and subjective evaluation were used to explore seven dimensions that an expert review panel had judged to be important determinants of a community's success in creating a health information exchange, i.e., clinical component, demonstration of community commitment and leadership, matching funds, overall technical readiness, plans for sustainable business model, use of data standards, use of replicable and scalable tools. Nevertheless, the objective of Overhage et al.'s study was not explicitly stated; it seems to be funding allocation rather than readiness

evaluation because the data were the basis for an invitation to submit a proposal for the funding. Tool reliability or validity was not assessed. Furthermore, a scoring mechanism was not provided to determine readiness.

Although reviewed frameworks were not tested (Campell, 2001; Jennett 2003; 2004; Overhage, 2005), a recent study by Khoja et al. (2007) aimed to test the reliability of E-Health readiness evaluation tools for both Managers and healthcare providers with four categories of measurements in developing countries. Separate scores (Cronbach's alpha) were measured for each of the four categories in both the tools. (Figure 2.5) Scores of core-readiness, learning readiness/technological readiness, societal readiness and policy readiness for both tools were all observed higher than 0.80 and show high reliability.

Category		Cronbach's Alpha Score	
		For Managers	For Healthcare Providers
Overall		0.94	0.91
Core readiness	i) needs-assessment and dissatisfaction with status quo; ii) awareness about E-Health in the organisation; iii) comfort with the use of technology; iv) trust in technology; v) planning of E-Health projects; vi) overall willingness and satisfaction; and vii) integration of technology;	0.92	0.86
Learning readiness	i) use of ICT in enhancing education for healthcare providers; and ii) involvement of healthcare providers in E-Health projects;		0.88
Technological readiness	i) speed and quality of ICT; ii) availability of service and support; iii) availability and affordability of hardware and software; and iv) training in ICT;	0.86	
Societal readiness	i) communication with other organisations and communities; ii) sharing of locally relevant content; iii) provision of care in collaboration with other institutions; iv) consideration of socio-cultural factors among staff; and v) consideration of sociocultural factors among clients;	0.91	0.81
Policy readiness	i) ICT related regulations; ii) policies regarding licensure, liability and reimbursement; iii) awareness and support for ICT among politicians; and iv) awareness and support for ICT among institutional policymakers.	0.89	0.92

Figure 2.5. Cronbach's Alpha Score, Khoja et al. 2007

Each of the items within the respective four categories for managers or healthcare providers showed Pearson's correlation coefficient greater than 0.35 ($p<0.05$), so all the items in these categories relate appropriately with other items in the same category (Khoja et al. 2007). Although Khoja et al.'s framework can guide the users to take appropriate measures and may also be used to quantitatively assess and improve E-Health readiness, the idea of E-Health is relatively new to healthcare centres in developing countries and thus it would be hard to adopt all the suggested measures to assess all levels of service.

Framework articles are an important type of publication commonly used to synthesise the research literature on a topic area and they provide a thorough description and evaluation of the work done in an area, setting directions for future research (Webster & Watson, 2002; Davis, 2003). Realising the value of framework articles is not without challenge since these articles are the product of analysing a substantial volume of literature which is often difficult to organise around specific themes (Schwarz et al., 2007). There is, therefore, a need for a set of criteria that can guide authors to develop framework articles (Schwarz et al., 2007). To identify and define the criteria, Schwarz et al. (2007) developed a clear understanding of what constitutes framework articles.

2.6. Gaps in the Literature

2.6.1. Inconsistent Coverage of E-Health Readiness Evaluation Components

Evaluators - and decision makers - must accept that E-Health evaluation may serve different purposes for different stakeholders, and therefore concede that no single evaluation framework or methodology is totally objective (Gagnon et al. 2005). The reviewed frameworks in section 2.5, for example, were derived from different

perspectives to evaluate E-Health readiness. (Table 2.5) Most studied components within the frameworks reflect healthcare providers' and organisational perspectives, however these components are different more or less from one framework to another. In terms of the components from organisational perspective, ICT architecture/ infrastructure was highlighted but core readiness, identified from Jennett et al.'s framework (2003, 2004, 2005), was neglected in Wickramasinghe et al.'s (2005). This is why E-Health evaluation is often criticised for the poor quality of research design, the lack of common outcome indicators and the absence of an agreed theory (Gagnon et al. 2005).

Author and date	Patient	Provider	System	Organisational	Public
Campbell et al. 2001		√			
Demiris et al. 2004		√			
Jennett et al. 2003, 2004, 2005	√	√		√	√
Overhage et al. 2005		√	√	√	
Wickramasinghe et al. 2005		√		√	√
Khoja et al. 2007		√		√	

Table 2.5. Different perspectives of E-Health readiness framework

2.6.2. No Criteria for Evaluating E-Health Frameworks

The framework evaluation criteria (Schwarz et al.'s, 2007) cannot be used directly to evaluate E-Health frameworks. In terms of article selection for review to develop the criteria, although non-IS journals were also selected to increase the external validity of their findings because of their long history and established reputation as the main publication outlets for framework articles, a representative sample of North American journals might predispose the findings towards a more positivist stream of thinking acknowledged within the reviewed journals (Schwarz et al., 2007). More importantly, no healthcare related article was incorporated for the review. Another limitation rests on the criteria definition. Most of criteria are overly high level and thus lead to ambiguities. Therefore, the review requires an inclusion of electronic health and framework related articles. Also, the criteria need to be revised by adding more precise and detailed explanations for framework evaluation for the healthcare domain.

2.6.3. Lack of Empirical Evidence Regarding Problems Related to Paper-based Health Records

In Section 2.2., the discussed issues in paper health records lack empirical evidence (IOM Report, 1999). This has key decision makers entertain doubts about E-Health's effectiveness, which, in turn, limits public leadership, private investment, and the long-term integration of E-Health into the health and technological mainstream (Miller, 2007). A set of data collected by WHO at EHR pre-implementation stage in participating developing countries may contain empirical confirmation of the issues; plus find out other issues not yet identified in the literature.

2.6.4. Few EHR Pre-implementation Evaluation Studies in Developing Countries

According to the examination of published EHR articles in Section 2.3, it is observed that few EHR evaluation studies have been conducted before its implementation, especially in developing countries. Major issues in these countries, such as costs, available information technology, lack of technical expertise and computer skills of staff, and lack of data processing facilities need to be addressed before implementation is possible (Watson, 2006). In other words, evaluation of these issues before EHR implementation becomes indispensable for the future success in terms of its adoption.

2.7. Research Question

In order to fill the gaps found in section 2.6., the research question is
What is the methodology for assessing E-Health readiness from an EHR perspective?

'E-Health Readiness' in this context is defined as the degree to which healthcare providers and organisations are prepared for the implementation of EHR systems;
'Healthcare providers' includes physicians, IT staff and administrators.

To develop the methodology, we need to: (Figure 2.6)

A1. Develop a framework for assessing E-Health readiness and define its components based on the literature in Section 2.5; (see Section 3.2)
A2. Develop a procedure to assess the components; (see Section 3.3)
A3. Develop a tool to automatically process assessment data to reveal E-Health readiness; (see Section 3.4)
A4. Validate the methodology which in turn requires:
    A4.1. criteria for evaluating the frameworks in healthcare domain; (see Section 4.1)
    A4.2. a case study (see Section 4.2)

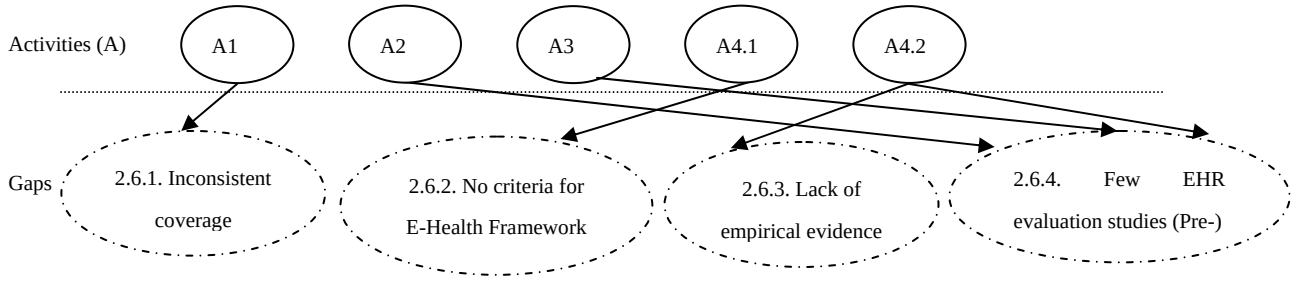

Figure 2.6. Gaps in Literature and Research Questions

2.8. Chapter Summary

This chapter began with EHR definition and introduction of its functionalities. After this, there was a discussion of the issues in paper health records, some of which can be typically addressed by EHR. Based on a thorough literature review, the importance of EHR pre-implementation evaluation was highlighted, particularly for developing countries. Also, several gaps were identified related to the evaluation. In order to address these gaps, the next chapter will develop the E-Health readiness assessment methodology based on design science research methodology.

Chapter 3
E-Health Readiness Assessment Methodology (EHRAM)

Evaluation research is categorised as summative and constructive assessment (Brender, 2006). The former assesses properties of the object in a decision-making context whereas the latter facilitates decision making with regard to subsequent development or implementation tasks (McGowan et al. 2008).

Most evaluation studies conducted in the healthcare context take place in the post-implementation phase, which is, after an E-Health system is delivered (Ammenwerth et al. 2001; Chen et al. 2006; Makoul et al. 2001; Overhage et al. 2001; Pabst et al. 1996; Poissant et al. 2005; Schmidt, 2006; Warshawski et al. 1994). While post implementation evaluations more likely used for summative assessment are crucial for assessing the merit, success and value of systems, and contribute to evidence-based practices and 'learning from experience' (Alexander, 2007), the benefits of exploring the process use of evaluations have recently been argued (Forss, Renien, & Carlsson, 2007). As discussed in Section 2.3.3, major issues such as available information technology and computer skills of staff would need to be addressed in developing countries before EHR implementation is possible (Watson, 2006). As a type of pre-implementation evaluation method, E-Health readiness assessment serves as preventive action for failure to innovate because of organisational inability to undergo transformation during the implementation of an information system (Brender, 2006). Rather, E-Health readiness assessment helps decision makers enhance EHR adoption (Demiris et al. 2004). Nonetheless, no E-Health readiness assessment methodology has been found. Although aforementioned frameworks in Section 2.5 were proposed for E-Health readiness assessment, there are limitations in them as discussed in Secton 2.6.1.

In this chapter, a new methodology will be developed to assess E-Health readiness. This includes the introduction of design-science research methodology in Information Systems (IS) discipline, an E-Health readiness assessment framework, an assessment process and an automated tool for the implementation of EHRAM.

3.1. Design Science

Two paradigms, i.e., behavioral science and design science characterise much of the research in the IS discipline (March and Smith 1995). The behavioral science paradigm develops and verifies theories that explain or predict human or organisational behavior whereas the design science paradigm extends the boundaries of human and organisational capabilities by creating new and innovative artifacts (Hevner et al. 2004). The artifacts, implemented in an organisational context, are often the object of study in IS behavioral-science research (Hevner et al. 2004). The theories seek to predict or explain phenomena with respect to the artifact's use (intention to use), perceived usefulness, and impact on individuals and organisations depending on system, service, and information quality (DeLone and McLean 1992, 2003; Seddon 1997).

March and Smith (1995) identified two design processes and four design artifacts produced by design science research in IS. The two processes involve build and evaluate and the artifacts are constructs, models, methods and instantiations. *Constructs* provide the language in which problems and solutions are defined and communicated (Schön 1983). *Models* use constructs to represent a real world situation--the design problem and its solution space (Simon 1996). Models aid problem and solution understanding. *Methods* define processes. They provide guidance on how to solve problems, that is, how to search the solution space. *Instantiations* show that constructs, models, or methods can be implemented in a working system. These are concrete prescriptions that enable IS researchers and

practitioners to understand and address the problems inherent in developing and successfully implementing information systems within organisations (March and Smith 1995; Nunamaker et al. 1991).

This work builds a model (in Section 3.2), methods (in Section 3.3) and an instantiation (in Section 3.4) for E-Health readiness assessment, which have been evaluated by framework evaluation criteria and a case study (in Section 4). Hence the output of the research is designed artifacts and the methodology used is design science research.

3.2. E-Health Readiness Assessment Model

Existing E-Health readiness frameworks (Campbell et al. 2001; Demiris et al. 2004; Jennett et al. 2003, 2004; Overhage et al. 2005; Wickramasinghe et al. 2005; Khoja et al. 2007) were criticised in Section 2.6.1 for their inconsistent coverage of evaluation components from healthcare providers' and organisational perspectives. An E-Health readiness assessment framework will be developed by integrating the studied components of each framework.

3.2.1. Components of E-Health Readiness Assessment

The components below are drawn on from the frameworks discussed in Section 2.6.

Core readiness refers to evaluators' realisation of problems in documentation of clinical information and healthcare providers' satisfaction with paper health records. Provision of care requires the documentation of clinical information as an intrinsic aspect of routine clinical activity and is essential from both professional and legal standpoints (Allan et al. 2000). Accordingly, core readiness assessment is concerned about patient records generation, storage and retrieval with paper-based health record systems. In particular, it involves documentation efficiency of patient records, patient privacy and the degree of physicians' satisfaction with completeness and accuracy of

patient records and of sharing patient records, as discussed in Section 2.2. The more serious problems are realised and higher dissatisfaction is expressed, the more ready healthcare organisations and providers are to adopt new practices (EHR) to create change (Jennett et al. 2002; Jennett et al. 2005); and vice versa.

Engagement is healthcare providers' exposure to EHR systems and willingness to accept EHR training (Campbell et al. 2001). Their exposure to EHR systems is reflected as

- Realised potential benefits (Campbell et al. 2001; Demiris et al. 2004; Jennett et al. 2003, 2005), e.g. efficient documentation of patient records
- Limitations (Jennett et al. 2003, 2005), e.g. individual IT knowledge
- Expectations: e.g. better sharing patient records
- Potential impacts (Demiris et al. 2004; Khoja et al. 2007), e.g. providing complete and accurate patient records
- Anticipated problems (Demiris et al. 2004; Khoja et al. 2007), e.g. not providing electronic power continuous

If over half of the healthcare providers express their fear or concern about any potentially negative impact, but have not recognised benefits of EHR and are not willing to accept EHR training, low readiness is the assessment for the engagement component. The fear or concern includes high investment and budget, limited individual IT knowledge and discontinuous electronic power. In terms of the benefits, efficient documentation of patient records, protected patient privacy, complete and accurate patient records as well as better sharing patient information are included at least.

In contrast, high readiness is the assessment for organisations where less than half of the healthcare providers express their fear or concern about any potentially negative impact, and over half healthcare providers have recognised the benefits of EHR and are willing to accept EHR training.

Technological readiness aims to determine the existing ICT infrastructure (hardware required for EHR applications and network), other available electronic resources (e-resources) (EHR related software and IT support personnel), as well as healthcare providers' past IT experience (Campbell et al. 2001; Demiris et al. 2004; Jennett et al. 2003, 2004; Wickramasinghe et al. 2005; Khoja et al. 2007). If a healthcare organisation possesses all the items enumerated below, the technological readiness is assessed to be high.

- Hardware required for EHR applications: (1). Laptop; (2). Desktop; (3). Monitor; (4). Printer; (5). Document scanner; (6). Photocopier; (7). Phone; (8). TV based conferencing; (9). PC based conferencing; (10). Web cam connected; (11). Digitalised X-Ray Equipment; (12). High resolution digital cam monitored on a Microscope
- Network: Internet access
- EHR related software: (1). Maintenance of EHR; (2). Electronic Healthcare training; (3). To send emails; (4). Standard software package (i.e., Anti-Virus and Operation System)
- IT support personnel: (1). Users of computer for E-Health; (2). Provision of technical support; (3). Technical support personnel
- Healthcare providers' past IT experience: (1). Frequency of using PC; (2). Frequency of using e-media (e.g. emails and Internet); (3). Training or direct experience in using EHR

Medium technological readiness is assessed for the healthcare organisations that have at least got desktops, monitors, printers, document scanners, photocopiers, phones and web cams connected for Hardware; Internet access for Network; standard software package and to send emails for EHR related software; users of computer for E-Health and technical support personnel for IT support personnel; and over half healthcare providers using PC frequently for Healthcare providers' past IT experience.

Societal readiness assesses communication links of healthcare organisations with

other institutions (e.g. with hospitals and administrative centres) and provision of care in collaboration with other healthcare organisations (e.g. connected diagnostic facilities like pathology/radiology etc) (Khoja et al. 2007). Also, it assesses internal communication among healthcare providers (e.g. mediums, such as face to face, telephone and emails, and their frequency) (Khoja et al. 2007).

If a healthcare organisation where over half healthcare providers use more than one type of communication medium and their use frequency is all higher than 50%, has communication links to both hospitals and administrative centres, and provides care in collaboration with other healthcare organisations, societal readiness is placed high. Low societal readiness results when there is no communication links, provision of care in collaboration with other healthcare organisations, nor a single communication medium or infrequent communication.

3.2.2. Integrated E-Health Readiness Assessment Framework

The E-Health Readiness Assessment Framework (EHRAF) makes an assumption that a typical EHR system, as discussed in Section 2.1.3 will be fully implemented. Evaluators can directly use this framework for organisations that plan to or will implement EHR systems. It includes four main readiness components: **core** (Jennett et al. 2003, 2004; Khoja et al. 2007), **engagement** (Campbell et al. 2001; Demiris et al. 2004; Jennett et al. 2003, 2005; Khoja et al. 2007), **technological** (Campbell et al. 2001; Demiris et al. 2004; Jennett et al. 2003, 2004; Wickramasinghe et al. 2005; Khoja et al. 2007) and **societal readiness** (Khoja et al. 2007). Each component can be assessed as one of three different levels: high, medium and low (Table 3.1), based on the definition of the components in Section 3.2.1.

3.2.2.1. Core Readiness

Core readiness assessment result (R(Core)) (high, medium or low) is determined by the variables (V), i.e., efficient documentation of patient records (V(ED)), protected

patient privacy (V(PP)), satisfaction of completeness and accuracy (V(CA)) as well as of sharing patient records (V(SR)). For each variable, the value is either 1 (“True”) or 0 (“False”). According to the definition of core readiness in Section 3.2.1,

IF (V(ED) = 1 and V(PP) = 1 and V(CA) = 1 and V(SR) = 1)

  R(Core) = “Low”;

ELSE

  IF (V(ED) = 0 and V(PP) = 0 and V(CA) = 0 and V(SR) = 0)

    R(Core) = “High”;

  ELSE

    R(Core) = “Medium”;

Therefore, core readiness assessment result is expressed as follows:

R(Core) = {V(ED), V(PP), V(CA), V(SR) }……..(1).

or

R(Core)=((V(ED)∧V(PP)∧V(CA)∧V(SR))=1?“Low”:((V(ED)∨V(PP)∨V(CA)∨V(SR))=0? “High”:“Medium”))……...(1*).

Where, Relational-Algebra Operations and Logic Conditional IF are incorporated.

3.2.2.2. Engagement Readiness

Engagement readiness assessment result (R(Engagement)) is dependent on healthcare providers’ fear or concern about any potentially negative impact (V(FN)), recognition of benefits of EHR (V(RB)) and their willingness to accept EHR training (V(WT)). For each variable, the value is either 1 (“True”) or 0 (“False”). Engagement readiness assessment result can be formulated as

R(Engagement) = {V(FN), V(RB), V(WT)}……(2).

or

R(Engagement)=(((V(FN)=0)∧(V(RB)=1)∧(V(WT)=1))=1?“High”:(((V(FN)=1)∧(V(RB)=0)∧(V(WT)=0))=1? “Low”: “Medium”))……..(2*).

3.2.2.3. Technological Readiness

Technological readiness assessment result (R(Technological)) can be expressed in detail as follows:

R(Technological)={V(LT),V(DT),V(MT),V(PT),V(DS),V(PC),V(PH),V(TVC),V(PCC),V(WC),V(XR),V(DCM),V(IA),V(EHRM),V(ET),V(SE),V(SS),V(EHU),V(TS),V(FUC),V(FUE),V(TUE)}……....(3)

.or

R(Technological)=(((V(LT)>0)∧(V(DT)>0)∧(V(MT)>0)∧(V(PT)>0)∧(V(DS)>0)∧(V(PC)>0)∧(V(PH)>0)∧(V(TVC)>0)∧(V(PCC)>0)∧(V(WC)>0)∧(V(XR)>0)∧(V(DCM)>0)∧(V(IA)=1)∧(V(EHRM)=1)∧(V(ET)=1)∧(V(SE)=1)∧(V(SS))=1)∧(V(EHU)>0)∧(V(TS)>0)∧(V(FUC)=1)∧(V(FUE)=1)∧(V(TUE)=1))=1?“High”:((V(DT)>0)∧(V(MT)>0)∧(V(PT)>0)∧(V(DS)>0)∧(V(PC)>0)∧(V(PH)>0)∧(V(WC)>0)∧(V(IA)=1)∧(V(SE)=1)∧(V(SS))=1)∧(V(EHU)>0)∧(V(TS)>0)∧(V(FUC)=1))=1?“Medium”: “Low”))……(3*).

Where, ICT hardware and network includes laptop (V(LT)), desktop (V(DT)), monitor (V(MT)), printer (V(PT)), document scanner (V(DS)), photocopier (V(PC)), phone (V(PH)), TV based conferencing (V(TVC)), PC based conferencing (V(PCC)), web cam connected (V(WC)), digitalised X-Ray equipment (V(XR)), high resolution digital cam monitored on a microscope (V(DCM)) and Internet access (V(IA)); software involves maintenance of EHR (V(EHRM)), electronic healthcare training (V(ET)), to send emails (V(SE)) and standard software packages (V(SS)); IT support personnel is measured with users of computer for E-Health (V(EHU)) and technical support personnel (V(TS)); and healthcare providers’ past IT experience: frequency of using PC (V(FUC)), frequency of using e-media (V(FUE)) and training or direct experience in using EHR (V(TUE)).

The value for the most variables in equation (3) is numeric, i.e., V(LT), V(DT),

V(MT), V(PT), V(DS), V(PC), V(PH), V(TVC),V(PCC),V(WC),V(XR),V(DCM), V(EHU) and V(TS). The value for the rest is either 1 (“True”) or 0 (“False”).

3.2.2.4. Societal Readiness

Societal readiness assessment result (R(Societal)) is dependent on the communication links to both hospitals (V(HP)) and administrative centres (V(AC)), provision of care in collaboration with other healthcare organisations (V(CO)), internal communication frequency (V(ICF)) and medium (V(ICM)). For the variables except V(ICM), value is either 1 (“True”) or 0 (“False”). The value of V(ICM) is defined as 0 for single medium (e.g. face to face) used for internal communication and 1 for more than one communication medium. Societal readiness assessment result can be formulated as

R(Societal) = {V(HP), V(AC), V(CO), V(ICF), V(ICM)}…..……...(4).

or

R(Societal)=(((V(HP)=1)∧(V(AC)=1)∧(V(CO)=1)∧(V(ICF)=1)∧(V(ICM)=1))=1? “High”:(((V(HP)=0)∧(V(AC)=0)∧(V(CO)=0)∧((V(ICF)=0)∨(V(ICM)=0)))=1?“ Low”: “Medium”))……..(4*).

Dependent upon the results of E-Health readiness assessment for individual components (Table 3.1), several implications can be drawn as in Table 3.2 (Wickramasinghe et al. 2005). These implications, however, may not be suitable for all cases. This is because the framework has an assumption that the typical EHR system will be fully implemented. For example, a healthcare organisation which will only implement basic EHR functions, such as patient records’ generation, storage and retrieval, is assessed high for core, high for engagement, high for societal but medium for technological readiness because of not having all the enumerated hardware equipments. In this case, evaluation for technological readiness needs to be adjusted. Then, this organisation can begin to structure EHR initiatives.

Assessment	R(Core)	R(Engagement)	R(Technological)	R(Societal)
High readiness	V(ED)=0, V(PP)=0, V(CA)=0, V(SR)=0	V(FN)=0, V(RB)=1, V(WT)=1	V(LT)>0, V(DT)>0, V(MT)>0, V(PT)>0, V(DS)>0, V(PC)>0, V(PH)>0, V(TVC)>0, V(PCC)>0, V(WC)>0, V(XR)>0, V(DCM)>0, V(IA)=1, V(EHRM)=1, V(ET)=1, V(SE)=1, V(SS)=1, V(EHU)>0, V(TS)>0, V(FUC)=1, V(FUE)=1, V(TUE)=1	V(HP)=1, V(AC)=1, V(CO)=1, V(ICF)=1, V(ICM)=1
Medium readiness	Other cases, such as V(ED)=1, V(PP)=0, V(CA)=0, V(SR)=0	Other cases, such as V(FN)=1, V(RB)=1, V(WT)=1	V(DT)>0, V(MT)>0, V(PT)>0, V(DS)>0, V(PC)>0, V(PH)>0, V(WC)>0, V(IA)=1, V(SE)=1, V(SS)=1, V(EHU)>0, V(TS)>0, V(FUC)=1	Other cases, such as V(HP)=1, V(AC)=0, V(CO)=0, V(ICF)=1, V(ICM)=0
Low readiness	V(ED)=1, V(PP)=1, V(CA)=1, V(SR)=1	V(FN)=1, V(RB)=0, V(WT)=0	Other cases, such as V(DT)=0, V(MT)>0, V(PT)>0, V(DS)>0, V(PC)>0, V(PH)>0, V(WC)>0, V(IA)=1, V(SE)=1, V(SS)=1, V(EHU)>0, V(TS)>0, V(FUC)=1	V(HP)=0, V(AC)=0, V(CO)=0, (V(ICF)=0 Or V(ICM)=0)

Table 3.1. Integrated E-Health Readiness Assessment Framework (EHRAF)

Core	Engagement	Technological	Societal	Implications
High	High	High	High	Organisations noted for being pioneers and leaders in all four of the readiness components are assessed to have high readiness for EHR implementation. They can begin to structure EHR initiatives. The challenge for them would be to maintain a high status of readiness with respect to all the components.
High High	High High ……..	High Low ……..	Low Low ……	More emphasis is needed for upgrading the deficiencies which cause organisations to score low or medium readiness in the respective component. On the other hand, these organisations continue to maintain their high status on the readiness components on which they currently rank highly.
Low	Low	Low	Low	For organisations which are rated low in readiness with respect to all four readiness components, much preparatory work is required to be ready for successful EHR implementation.

Table 3.2. Implications of E-Health Readiness Assessment for Combinations of Different Levels of readiness for Each Individual Components of EHRAF

3.3. E-Health Readiness Assessment Method

The Generic Evaluation Approach for the E-Health systems (GEA4EH) (Li et al. 2008) proposes an approach for the assessment and requirement specification of E-Health systems. The assessment process has been modified as shown in Figure 3.1, so as to highlight the reiteration of assessing E-Health readiness, i.e., once the readiness assessment is done and then the organisation takes action to improve the deficiencies, the second readiness assessment can be conducted. A set of hierarchical evaluation criteria based on EHRAF has been developed. The criteria include those that have been raised in the literature and also require input from researchers with healthcare expertise to ensure their completeness and accuracy. This is followed by the definition of each evaluation parameter. Subsequently, a questionnaire is designed for interviews with groups of healthcare practitioners (including doctors, nurses, administration officers, IT technicians and any other stakeholders) in order to determine significant parameters. Statistical analysis (e.g. cross tabulation tests, statistically significant correlations ($p<0.05$)) is undertaken to assess the current E-Health readiness status of the given context. If there is a need to conduct another readiness study, the assessment process will restart from the development of hierarchical evaluation criteria or E-Health readiness study, which is dependent upon whether the questionnaire needs to be modified. The assessment outcomes feed into the requirement specification of E-Health system implementation.

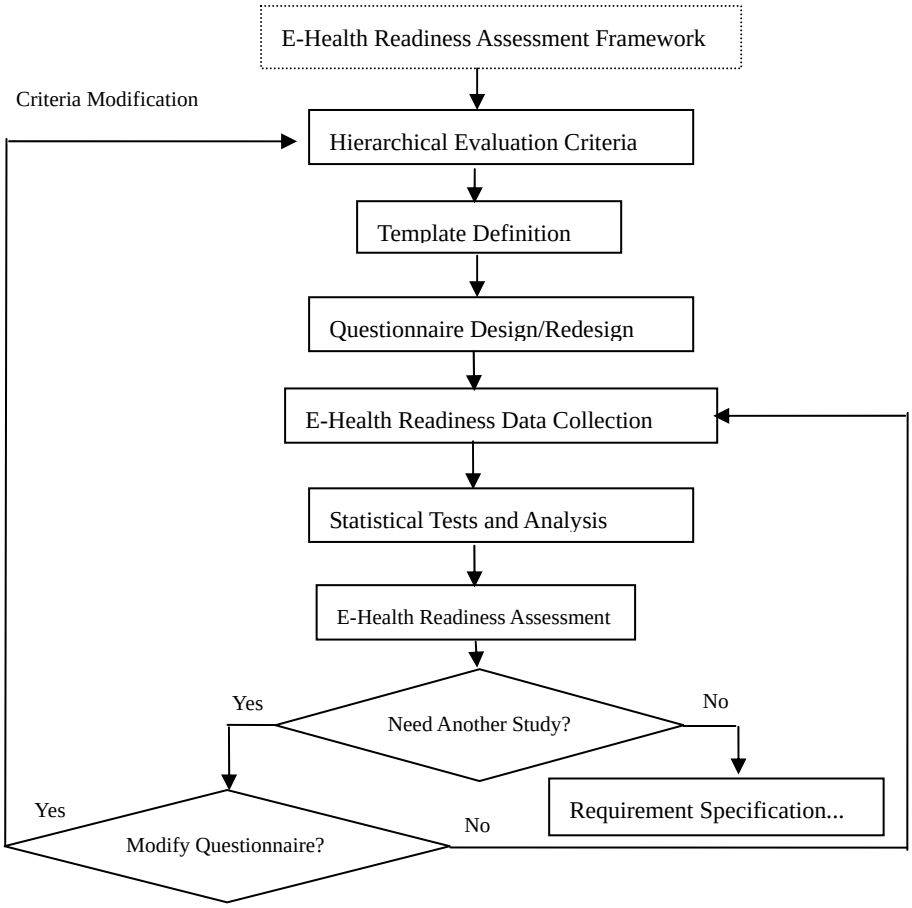

Figure 3.1. E-Health Readiness Assessment Method

3.3.1. Hierarchical Evaluation Criteria

E-business systems do not have any commonly agreed evaluation parameters (Dean, 2000). In particular, E-Health, as an emerging E-business application, does not have a set of well-defined evaluation criteria. A part of the thesis aims to mitigate the difficulties with the establishment of parameters for E-Health readiness assessment by modifying CoMENS hierarchical evaluation criteria, rather than developing the parameters from scratch. The hierarchical model has been modified by incorporating the E-Health readiness assessment framework (for details, see Appendix 1). For instance, core readiness is partly determined by Generating records with paper health records systems, which is reflected by four measures, such as Average time and so forth. So part of the hierarchical E-Health readiness assessment criteria are shown as

Figure 3.2. For each attribute at the bottom, there is one corresponding question from the questionnaire to measure it.

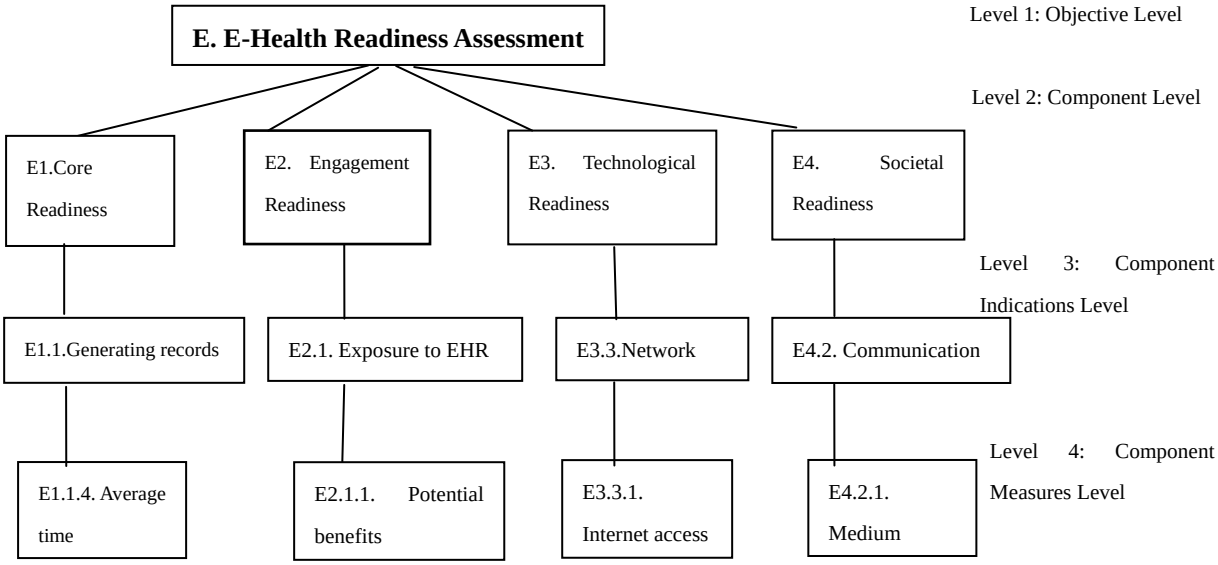

Figure 3.2. Part of Hierarchical E-Health Readiness Assessment Criteria

3.3.2. Template Definition

The evaluation parameters in the criteria are defined as quantitative items (Ray, 2003). These items are specified by evaluators. Efforts are required to achieve maximum consistency of definition across different parameters by defining generic parameters (Dean, 2000). The definition of each evaluation template within the hierarchical criteria involves Name, Categorised As, Defined As, Type and Value. (Table 3.3; Details see Appendix 2) Categorised As is the name of directly linked template at the upper level; Defined As gives the definition of the template; Type covers the data type - nominal, ordinal, interval, ratio (statistic terms) and narrative; Value provides the actual data. Such a proposed template in the CoMENS can be used for the reporting and analysis of information for the evaluation of E-Health systems (Ray, 2003).

Name	Categorised As	Defined As	Type	Value
Of the parameter	Which broad category the parameter falls into	Explains its purpose and intended usage	Nominal/Ordinal/Interval/Ratio/Narrative	How the parameter quantified, giving units in which values are expressed
Example:				
E1.1. Generating records	*Core Readiness*			
E1.1.4. Average time	Generating records	Taken to record patient	Ratio	Minutes
E2.1. Exposure to EHR	*Engagement Readiness*			
E2.1.1. Potential benefits	Exposure to EHR	Benefit the healthcare community and patient health outcomes	Nominal	a. minimal time for recording and retrieving relevant patient information: No 0/Yes 1 b. minimal time to diagnosis & treatment: No 0/Yes 1 c. confidentiality of patient information: No 0/Yes 1
E3.3.Network	*Technological Readiness*			
E3.3.1. Internet access	Network		Nominal	No 0/Yes 1
E4.2. Communication	*Societal Readiness*			
E4.2.1. Medium	Communication	Currently used to interact with colleagues or other members of the profession	Nominal	Face-to-face, Telephone or Email 0/More than one medium 1

Table 3.3. Definition of Evaluation Templates

3.3.3. Questionnaire Design

WHO has collected data with a questionnaire to understand healthcare status quo in a number of developing countries (e.g. Vietnam) where there are plans to implement E-Health systems. However, the data are not yet analysed and synthesized to reveal

the readiness status. Based on the hierarchical E-Health readiness assessment criteria and template definition, the questionnaire was modified. (Appendix 3)

Three categories of data need to be collected in healthcare organisations. Accordingly, three groups of healthcare practitioners are involved: physicians, IT staff and administrators. Physicians are responsible for patient visits, education concerning prevailing health problems and the methods of preventing and controlling them. IT staff are mainly involved in IT infrastructure maintenance and information technology upgrade. Administrators take responsibility for supporting routine healthcare delivery.

Category 1 (Established Background & Settings):

Aim: To establish background and settings for health care

Interviewee: Health administrator

Total number of interviews: 1 for each participating healthcare centre

Involve: Communication links of healthcare organisations with other institutions (e.g. with hospitals and administrative centres) and provision of care in collaboration with other healthcare organisations (e.g. connected diagnostic facilities like pathology/radiology and the like).

Category 2 (Existing Infrastructure & E-resources Available):

Aim: To determine the existing infrastructure and electronic resources available

Interviewee: IT staff

Total number of interviews: 1 for each participating healthcare centre

Involve: Provided ICT applications, such as EHR; Hardware, such as laptop and desktop; Network, such as Internet access; Software, such as to send emails; IT support personnel, such as users of computer for E-Health.

Category 3 (Baseline Data for Electronic Health Records)

Subcategories:

1. Existing Local Healthcare Status

2. Perception of E-Health Record & Potential Benefits of EHR
3. Determination of Post-Training

Aim: to evaluate the healthcare scenario prior implementing EHR

Interviewee: Physicians

Total number of interviews: 10 for each participating healthcare centre

Involve: Generating records with paper health records, such as Average time; Storing and Retrieving records with paper health records, such as Accessibility/Confidentiality and Degree of complete and accurate records; Exposure to EHR, such as potential benefits and anticipated problems; Self-assessment, such as willingness for EHR training; Past IT experience, such as frequency of using PC; Communication, such as medium and frequency to communicate with others.

In the light of the E-Health readiness assessment framework described in Section 4.1, it is observed that the categories of data contain the information required for the evaluation of different readiness components (Table 3.4.)

	Core (Readiness)	**Engagement**	**Technological**	**Societal**
Category 1				Communication links and connected diagnosis facilities
Category 2			Provided ICT applications; Hardware; Network; Software; IT support personnel	
Category 3	Generating records; Storing and Retrieving records	Exposure to EHR; Self-assessment (Willingness for EHR training)	Past IT experience	Communication (Medium and Frequency)

Table 3.4. Collected Data and Readiness Components

3.3.4. E-Health Readiness Data Collection

HTTP://www.surveymonkey.com provides registered users with a platform to create their own online surveys for data collection. Based on the modified questionnaire in Section 3.3.3, two online surveys were created (Appendix 4):

1. Responses from healthcare administrators and IT staff will be collected from the web link, http://www.surveymonkey.com/s.aspx?sm=3hryMFDJzc5eRrF75e4Tjw_3d_3d. This survey covers three aspects: organisaional information (e.g. communication links with other institutions), hardware and network (e.g. number of laptop and Internet access), and software and IT personnel (e.g. software for electronic healthcare training and number of technical support personnel).
2. Physicians use the other web link http://www.surveymonkey.com/s.aspx?sm=rx6KOh2_2fqh_2fU1rNmfsdh_2fQ_3d_3d to contribute to the assessment data. This survey collects data from physicians, and includes metrics addressing current healthcare practice (e.g. average time for patient record generation, storage and retrieval), physicians' exposure to EHR (e.g. potential benefits of EHR), and physicians' IT experience and comunication (e.g. frequently used computers and communication medium among physicians).

The above data could also be collected using interviews. In order to validate the process of the methodology, relevant assessment data collected by members of WHO in two healthcare centres in Vietnam (WHO data) have been reported in this thesis.

3.3.5. Statistical Analysis and E-Health Readiness Assessment

The answers to the questionnaires are then coded and cleaned, before statistical analysis. (Table 3.5) Coding is necessary to convert qualitative to quantitative units in accordance with the definition of each evaluation template so as to ease some quantitative analysis; this especially applied for parameters under E1 sub-branches which address issues relating directly to the paper health records status. For example, when the answer from an interviewed physician is "yes, very much" to the question

"In your view does the current system of recording patient medical history and information provide complete and accurate patient records?", the value 5 is filled in on a scale where 1 stands for "not satisfied at all" and 5 stands for "very satisfied". The raw qualitative data can also be used to substantiate quantitative results. Care was taken to ensure consistency in coding through consultations and multiple iterations.

	Coding	*Cleaning*	*Structuring*	*Analysis*
E1	Convert qualitative to quantitative units so as to ease some quantitative analysis, based on template definition	Reduce noise and redundancy in the data set	Categorise parameters into Variable or Constant matrix	1. Identify potential significant relationships between variables via conducting Cross Tabulation tests with Variable parameters (SPSS, $p<0.05$); 2. descriptive statistics
E2,3,4				Thematic analysis with descriptive statistics to evaluate the readiness

Table 3.5. Data Processing

Data cleaning (deletion of un-meaningful or redundant responses) is also necessary to reduce noise in the data. Data structuring aims to sort 11 parameters under E1 sub-branches into two matrixes, Variable Matrix and Constant factor Matrix. The parameter with multiple values will be grouped into the first matrix and subsequently used to do cross tabulation tests. In contrast, the parameters in Constant factor Matrix are with a constant value, simply to provide static healthcare contexts underneath the dynamic correlations found with the cross tabulation tests.

Due to the exploratory nature of the study and the limited data types, the aim was not to understake causal analysis to establish relationships between variables under E1 sub-branches. Rather, the study was to identify potential significant interactions between variables by conducting exhaustive cross tabulations between pairs of parameters. Cross tabulation test results are usually presented as a contingency table which is used to record and analyse the relationship between two or more variables simultaneously in a matrix format (Manning et al. 2006). Each cell shows the number of respondents that gives a specific combination of responses. Cross tabulation therefore helps to search for patterns of interaction. If certain cells contain

disproportionately large (or small) numbers of cases, then this suggests that there might be a pattern of interaction. Then homing in on those parameters which give rise to statistically significant correlations ($p<0.05$), helps explain the status of paper health records in healthcare centres. Descriptive statistics have also been used to address problems in the documentation of clinical information.

With respect to the variables under E2, E3 and E4 sub-branches (see Figire 3.2.), thematic analysis will be executed incorporating descriptive statistics in order to assess the readiness status of the healthcare organisation. Engagement readiness (E2), for example, is determined by physicians' exposure to EHR systems (e.g. potential benefits and impacts) and willingness to accept EHR training, as discussed in Section 3.2.1. The output from the coding and cleaning stages will be processed with descriptive statistics (i.e., Percentage) as follows (Table 3.6):

Items	Values	Percentage
Potential Benefits of EHR (physicians' perception)	Minimal time for recording and retrieving relevant patient information	(Data based on the online surveys)
	Minimal time to diagnosis & treatment	(Data based on the online surveys)
	Confidentiality of patient information etc	(Data based on the online surveys)
Limitation of EHR systems	High investment and Budget	(Data based on the online surveys)
	Have the IT knowledge	(Data based on the online surveys)
	Provide stability of electronic power	(Data based on the online surveys)
Expectations in improvement of healthcare	Providing & sharing timely information	(Data based on the online surveys)
	Minimal time for recording and retrieving relevant patient information	(Data based on the online surveys)
	Improve capacity of diagnosis & treatment	(Data based on the online surveys)
Potential impacts of implementing EHR systems	Support for telemedicine	(Data based on the online surveys)
	Better providing information	(Data based on the online surveys)
	Support for science research	(Data based on the online surveys)
Anticipated Problems caused by EHR system use	Lack of Budget	(Data based on the online surveys)
	Limitation of IT knowledge	(Data based on the online surveys)
	Provision of electronic power not continuous	(Data based on the online surveys)
Willing to accept the training for EHR use	Yes	(Data based on the online surveys)
	No	(Data based on the online surveys)

Table 3.6. Method for E-Health Engagement Readiness Assessment

According to EHRAF, if over half of the physicians express their fear or concern about any of high investment and budge, limited individual IT knowledge and discontinuous electronic power, but have not recognised benefits of EHR, such as efficient generation and retrieval of patient records, and are not willing to accept the training for EHR use, engagement readiness is low. In contrast, high readiness is for organisations where less than half physicians express their fear or concern about any potentially negative impact, and over half physicians have recognised benefits of EHR and are willing to accept EHR training.

Different steps in the process require various techniques (Table 3.7.)

Step of the Process	Techniques
1. Hierarchical Evaluation Criteria 2. Template Definition	CoMENS
3. Questionnaire Design	Questionnaire design
4. E-Health Readiness Study	Data collection
5. Statistical Tests and Analysis	Statistics Data Analysis

Table 3.7. Techniques Required in the Process

3.4. E-Health Readiness Assessment Instantiation

In order to automate EHRAM, online surveys[1] can be created for data collection (surveymonkey.com) and an E-Health Readiness Assessment Tool (EHRAT), a designed artifact, has been built and tested for the data analysis. All the survey or interview data from different healthcare providers will be imported into EHRAT without any change. Database tables, Forms, Queries and Macros of Microsoft Access were used to develop EHRAT. Importantly, EHRAT provides the main function of processing the assessment data to reveal E-Health readiness status in terms of the core, engagement, technological and societal readiness, as well as corresponding

[1] Surveymonkey has been used to create online surveys for data collection, but any suitable online survey application can be used.

implications.

3.4.1. Functions of EHRAT

The EHRAT provides functions not only for adding and editing the assessment data from the online surveys but also for processing the data to reveal organisational E-Health readiness and subsequently retrieving history of the readiness assessment. (Figure 3.3) With the EHRAT, the data can be added with two interfaces respectively for healthcare administrators and IT staff, and physicians. The edit function is provided to update and delete the added data. The output of EHRAT is used to assess E-Health readiness and to retrieve the assessment result when needed in the future. Additionally, the definition of the four readiness components and how to respectively position them into high, medium or low readiness level are embedded into the output.

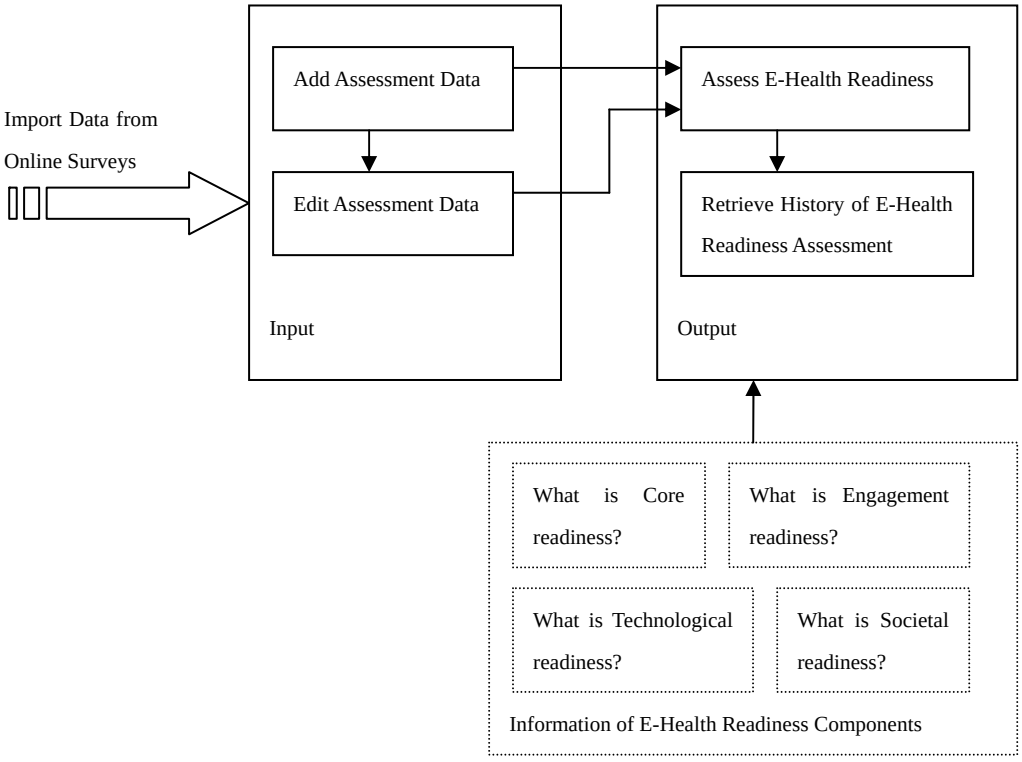

Figure 3.3. Functions of EHRAT

3.4.2. Rules of EHRAT

The rules of EHRAT refer to those which were used to manipulate the input data to reveal E-Health readiness. In order to position individual readiness components into high, medium or low level, eight equations were proposed in Section 3.2.2. Nonetheless, these equations are still high level with a view to the collected data, so they need to be more detailed with Relational-Algebra Operations and Logic Conditional IF to indicate the processing of the data.

- If a variable in these equations is measured by a question which needs to be answered by only an IT technician or administrator, the value of this variable is directly filled with the answer. For example, the value of V(LT) which is measured by the question “Number of Laptop” can be filled with the answer from an IT technician without any change.
- If a variable is measured by a question which needs to be answered by physicians, the value of this variable is dependent on the average value of the answers. For example, V(PP) is measured by the question “staff with authorised access to patient records 1) physicians, or 2) physicians and assistants such as nurse/technician/secretary etc”. According to the definition of evaluation templates, if patient records can only be accessed by physicians, the value is 0; otherwise, the value is 1. Then, the answers from different physicians are averaged, if the averaged value is small than 0.5, the patient privacy is considered to be protected in this healthcare organision (the value of V(PP) is filled with “1”); and vice versa.
- Otherwise a variable is measured by more than one question, the relationship between the value of this variable and the answers to these questions will be respectively discussed below, such as V(ED) in the core readiness component.

3.4.2.1. Core Readiness

7 items from the data collection were used to measure V(ED), V(PP), V(CA), V(SR) in the equation 1. They are respectively, Average number of patient visit each year (Measure(ANP)), Number of physicians (M(NP)), Average time for generating records (M(ATGR)), Average time for storing and retrieving records (M(ATSR)), Accessibility/Confidentiality of records (M(ACR)), Degree of complete and accurate records (M(DCAR)) and Satisfactory of sharing patient records (M(SSR)).

Formulation of V(ED):

The routine core activities for physicians do not merely involve patient visits but also involve other responsibilities such as education concerning prevailing health problems and the methods of preventing and controlling them. Assumed, all physicians in a healthcare organisation spend 60 minutes*8 hours per day and 5 days per week on healthcare and half of this time on patient visits only. The organisational maximum throughput is 60*8*(5/7)*365*M(NP). By comparison with (average(M(ATGR))+average (M(ATSR)))* M(ANP), if 60*8*(5/7)*365*M(NP)> (average(M(ATGR))+average (M(ATSR)))* M(ANP), which means the healthcare organization can meet the need of patient visits, clinical documentation is considered to be efficient, i.e., V(ED) is 1 (“True”); otherwise V(ED) is 0 (“False”).

So V(ED) can be expressed as follows,

V(ED)=((60*8*(5/7)*365*M(NP)>(ç（avg(M(ATGR)))+ç（avg(M(ATSR))))* M(ANP))?1:0)…….(5).

Formulation of V(PP):

V(PP) the value of which is dependent up on M(ACR) can be expressed as

V(PP)=(ç（avg(M(ACR)))<0.5?1:0)……(6).

Formulation of V(CA):

V(CA) is measured by M(DCAR) and can be expressed as

V(CA)=(ç（avg(M(DCAR)))>3?1:0)……(7).

Formulation of V(CA):

V(SR) is measured by M(SSR) and can be expressed as

V(SR)=(ç（avg(M(SSR)))>3?1:0)……..……(8).

The relationships between the measures and variables for the core readiness assessment is summarised in the Table 3.8.

Measures	Variables	Formulation
M(ANP), M(NP), M(ATGR), M(ATSR)	V(ED)	V(ED)=((60*8*(5/7)*365*M(NP)>(ç(avg(M(ATGR)))+ç(avg(M(ATSR))))* M(ANP))?1:0)
M(ACR)	V(PP)	V(PP)=(ç(avg(M(ACR)))<0.5?1:0)
M(DCAR)	V(CA)	V(CA)=(ç(avg(M(DCAR)))>3?1:0)
M(SSR)	V(SR)	V(SR)=(ç(avg(M(SSR)))>3?1:0)

Table 3.8. Measures and Variables for Core Readiness Assessment

So the equation 1 can be formulated in detail with equation 5, 6, 7 and 8:

R(Core)={((60*8*(5/7)*365*M(NP)>(ç（avg(M(ATGR)))+ç（avg(M(ATSR))))* M(ANP))?1:0),(ç（avg(M(ACR)))<0.5?1:0),(ç（avg(M(DCAR)))>3?1:0),(ç（avg(M(SSR)))>3?1:0)}……..……..……..(9).

3.4.2.2. Engagement Readiness

8 items from the data collection were used to measure V(FN), V(RB), V(WT) in the equation 2. They are respectively High investment and Budget (M(HI)), Limitation of IT knowledge (M(LIT)), Electronic power not continuous (M(DP)), Minimal time for recording and retrieving relevant patient information (M(ED)), Confidentiality of patient information (M(PP)), Better provision of information (M(CAR)), Providing & sharing timely information: (M(BS)), and Need training for EHR use (M(WT)).

Formulation of V(FN):

As discussed in Section 3.2.1, V(FN) is measured by M(HI), M(LIT) and M(DP) and can be expressed as

V(FN)=(((ç（avg(M(HI)))>0.5?1:0)∨(ç（avg(M(LIT)))>0.5?1:0) ∨ (ç（avg(M(DP)))>0.5?1:0))=1?1:0).……(10).

Formulation of V(RB):

As discussed in Section 3..2.1, V(RB) the value of which is dependent up on M(ED), M(PP), M(CAR) and M(BS) can be expressed as

V(RB)=(((ç（avg(M(ED)))>0.5?1:0)∧(ç（avg(M(PP)))>0.5?1:0)∧(ç（avg(M(CAR)))>0.5?1:0)∧(ç（avg(M(BS)))>0.5?1:0))=1?1:0).……(11).

Formulation of V(WT):

V(WT) is measured by M(WT) and can be expressed as

V(WT)=(ç（avg(M(WT)))>0.5?1:0)……..…….……(12).

The relationships between the measures and variables for the engagement readiness assessment is summarised in the Table 3.9.

Measures	Variables	Formulation
M(HI), M(LIT), M(DP)	V(FN)	V(FN)=(((ç(avg(M(HI)))>0.5?1:0)∨(ç(avg(M(LIT)))>0.5?1:0)∨(ç(avg(M(DP)))>0.5?1:0))=1?1:0)
M(ED), M(PP), M(CAR), M(BS)	V(RB)	V(RB)=(((ç(avg(M(ED)))>0.5?1:0)∧(ç(avg(M(PP)))>0.5?1:0)∧(ç(avg(M(CAR)))>0.5?1:0)∧(ç(avg(M(BS)))>0.5?1:0))=1?1:0)
M(WT)	V(WT)	V(WT)=(ç(avg(M(WT)))>0.5?1:0)

Table 3.9. Measures and Variables for Engagement Readiness Assessment

So the equation 2 can be formulated in detail with equation 10, 11 and 12:

R(Engagement)={(((ç（avg(M(HI)))>0.5?1:0)∨(ç（avg(M(LIT)))>0.5?1:0)∨(ç（avg(M(DP)))>0.5?1:0))=1?1:0), (((ç（avg(M(ED)))>0.5?1:0)∧(ç（avg(M(PP)))>0.5?1:0)∧(ç（avg(M(CAR)))>0.5?1:0)∧(ç（avg(M(BS)))>0.5?1:0))=1?1:0), (ç（avg(M(WT)))>0.5?1:0)}…….…….……..(13).

3.4.2.3. Technological Readiness

22 items found from the data collection were used respectively to measure V(LT),V(DT),V(MT),V(PT),V(DS),V(PC),V(PH),V(TVC),V(PCC),V(WC),V(XR),V(DCM),V(IA),V(EHRM),V(ET),V(SE),V(SS),V(EHU),V(TS),V(FUC),V(FUE),V(TUE) in the equation 3. They are Number of laptop (M(LT)), desktop (M(DT)), monitor (M(MT)), printer (M(PT)), document scanner (M(DS)), photocopier (M(PC)), phone (M(PH)), TV based conferencing (M(TVC)), PC based conferencing (M(PCC)), web cam connected (M(WC)), digitalised X-Ray equipment (M(XR)) and high resolution digital cam monitored on a microscope (M(DCM)), Internet access (M(IA)), Software for maintenance of EHR (M(EHRM)), Software for electronic healthcare training (M(ET)), Software to send emails (M(SE)), Standard software packages (M(SS)), Number of computer users for E-Health (M(EHU)) and technical support

personnel (M(TS)), Frequency of using PC (M(FUC)), Frequency of using e-media (M(FUE)) and Training or direct experience in using EHR (M(TUE)).

The values of the variables from V(LT) to V(TS) can be directly filled with the measures from M(LT) to M(TS), so the formulation is V(x)=M(x), e.g. V(LT)=M(LT).

Formulation of V(FUC) and V(FUE):

The values of V(FUC) and V(FUE) are respectively dependent on the average value of M(FUC) and M(FUE), thus V(FUC) and V(FUE) can be expressed as

V(FUC)=(ç（avg(M(FUC)))>0.5?1:0)……..……..……(14).

V(FUE)=(ç（avg(M(FUE)))>0.5?1:0)……..……..……..……(15).

Formulation of V(TUE):
V(TUE) is measured by M(TUE) and can be formulated as

V(TUE)=(ç（avg(M(TUE)))>0.5?1:0)……...……(16).

The relationships between the measures and variables for the technological readiness assessment is summarised in the Table 3.10.

So the equation 3 can be formulated in detail with equation 14, 15 and 16:

R(Technological)={M(LT),M(DT),M(MT),M(PT),M(DS),M(PC),M(PH),M(TVC),M(PCC),M(WC),M(XR),M(DCM),M(IA),M(EHRM),M(ET),M(SE),M(SS),M(EHU),M(TS),(ç（avg(M(FUC)))>0.5?1:0),(ç（avg(M(FUE)))>0.5?1:0),(ç（avg(M(TUE)))>0.5?1:0) }……...……..……..(17).

Measures	Variables	Formulation
M(LT)	V(LT)	V(LT)= M(LT)
M(DT)	V(DT)	V(DT)= M(DT)
M(MT)	V(MT)	V(MT)= M(MT)
M(PT)	V(PT)	V(PT)= M(PT)
M(DS)	V(DS)	V(DS)= M(DS)
M(PC)	V(PC)	V(PC)= M(PC)
M(PH)	V(PH)	V(PH)= M(PH)
M(TVC)	V(TVC)	V(TVC)= M(TVC)
M(PCC)	V(PCC)	V(PCC)= M(PCC)
M(WC)	V(WC)	V(WC)= M(WC)
M(XR)	V(XR)	V(XR)= M(XR)
M(DCM)	V(DCM)	V(DCM)= M(DCM)
M(IA)	V(IA)	V(IA)= M(IA)
M(EHRM)	V(EHRM)	V(EHRM)= M(EHRM)
M(ET)	V(ET)	V(ET)= M(ET)
M(SE)	V(SE)	V(SE)= M(SE)
M(SS)	V(SS)	V(SS)= M(SS)
M(EHU)	V(EHU)	V(EHU)= M(EHU)
M(TS)	V(TS)	V(TS)= M(TS)
M(FUC)	V(FUC)	V(FUC)=(ç(avg(M(FUC)))>0.5?1:0)
M(FUE)	V(FUE)	V(FUE)=(ç(avg(M(FUE)))>0.5?1:0)
M(TUE)	V(TUE)	V(TUE)=(ç(avg(M(TUE)))>0.5?1:0)

Table 3.10. Measures and Variables for Technological Readiness Assessment

3.4.2.4. Societal Readiness

5 items found from the data collection were used respectively to measure V(HP), V(AC), V(CO), V(ICF), V(ICM) in the equation 4. They are the communication links to both Hospitals (M(HP)) and Administrative centres (M(AC), Connected diagnostic facilities (M(CO)), Frequency to communicate with others (M(ICF)) and Communication medium (M(ICM)).

The values of the variables including V(HP), V(AC) and V(CO) can be directly filled with the measures of M(HP), M(AC) and M(CO), so the formulation is V(x)=M(x), e.g. V(HP)=M(HP).

Formulation of V(ICF):

The value of V(ICF) is dependent on the average value of M(ICF) and thus V(ICF) can be expressed as

V(ICF)=(ç（avg(M(ICF)))>0.5?1:0)……...…….…….……(18).

Formulation of V(ICM):

V(ICM) is measured by M(ICM) and can be formulated as

V(ICM)=(ç（avg(M(ICM)))>0.5?1:0)……..……(19).

The relationships between the measures and variables for the societal readiness assessment is summarised in the Table 3.11.

Measures	Variables	Formulation
M(HP)	V(HP)	V(HP)= M(HP)
M(AC)	V(AC)	V(AC)= M(AC)
M(CO)	V(CO)	V(CO)= M(CO)
M(ICF)	V(ICF)	V(ICF)=(ç(avg(M(ICF)))>0.5?1:0)
M(ICM)	V(ICM)	V(ICM)=(ç(avg(M(ICM)))>0.5?1:0)

Table 3.11. Measures and Variables for Societal Readiness Assessment

So the equation 4 can be formulated in detail with equation 18 and 19:

R(Societal)={M(HP),M(AC),M(CO),(ç（avg(M(ICF)))>0.5?1:0),(ç（avg(M(ICM)))>0.5?1:0)}…….……..(20).

3.4.2.5. Summary of Rules

Based on the discussion in Section 3.2.2 and 3.4.2, the rules of EHRAT are summarised as Table 3.12.

Readiness Component Assessment	Equations
R(Core)	1, 1*, 9
R(Engagement)	2, 2*, 13
R(Technological)	3, 3*, 17
R(Societal)	4, 4*, 20

Table 3.12. Summary of Rules of EHRAT

3.4.3. Implementation

Database tables, Forms, Queries and Macros of Microsoft Access are used to implement the functions presented in Section 3.4.1.

3.4.3.1. Tables

3 Microsoft Access Database tables are designed for EHRAT, i.e., Main, Physician and Implication. In Appendix 5, each table presents Field Name and Data Type from the definition of the Microsoft Access Database tables, and corresponding Assessment Results, Variables or Measures which were discussed in Section 3.4.2. Table 3.13 and Table 3.14 show an example.

Field Name	Data Type	Assessment Results, Variables or Measures
OrganisationName*	Text (50)	
NumberPhysicians	Number	M(NP)
AvAnnualNumberPatientVisit	Number	M(ANP)
CoreEfficiency	Number	V(ED)
CoreReadiness	Text (6)	R(Core)

Table 3.13. Main (* stands for a KEY)

Field Name	Data Type	Variables or Measures
Physician ID*	Counter	
OrganisationName	Text (50)	
PhysicianName	Text (20)	
Time4Generation	Number	M(ATGR)
Time4Storage&Retrieval	Number	M(ATSR)

Table 3.14. Physician (* stands for a KEY)

There are relationships between the Microsoft Access Database tables. (Figure 3.4)

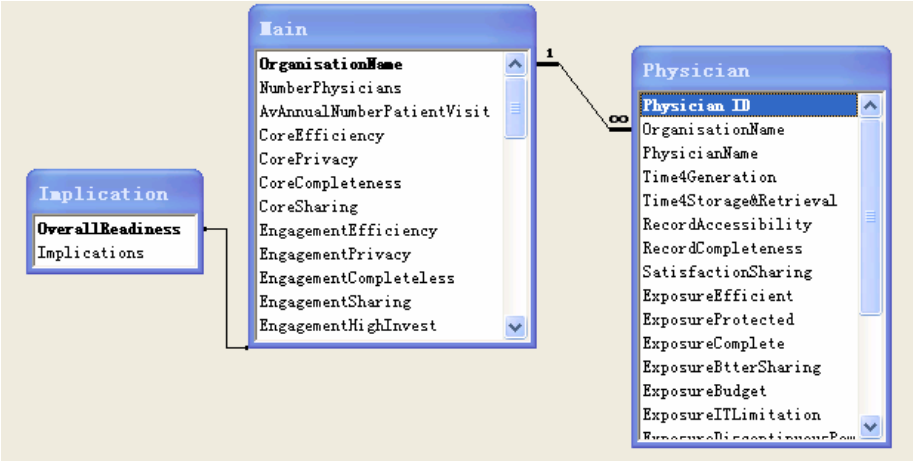

Figure 3.4. Relationships between Tables

3.4.3.2. Forms, Macros and Queries

The Forms with different purposes (Table 3.15) are used to implement functions presented in Section 3.4.1. (Figure 3.5)

Functions	Forms	Purposes
	FormMain	Home page
Add Assessment Data	FormInsertOrganisation	Add assessment data from healthcare administrators and IT staff
	FormInsertPhysician	Add assessment data from physicians
Edit Assessment Data	FormQuery4FormEdit	Select an organisation to edit assessment data
	FormEditOrganisation	Edit assessment data from healthcare administrators and IT staff
	FormEditPhysician	Edit assessment data from physicians
Assess E-Health Readiness	Form4Readiness	Select an organisation to assess the status of E-Health readiness
	FormReadiness	Report the status of the organisational E-Health readiness
	FormReadinessDetail	Report the details of the organisational E-Health readiness
Retrieve History of E-Health Readiness Assessment	FormHistoryReadiness	Select an organisation to retrieve the readiness assessment history
	FormSingleHistoryReaediness	Show the history of the readiness assessment
	FormSingleHistoryReadinessDetails	Show the details of the readiness assessment history
What is Core readiness?	FormInfoCore	Show the definition of core readiness
What is Engagement readiness?	FormInfoEngagement	Show the definition of engagement readiness
What is Technological readiness?	FormInfoTech	Show the definition of technological readiness
What is Societal readiness	FormInfoSocietal	Show the definition of societal readiness

Table 3.15. Purposes of Forms

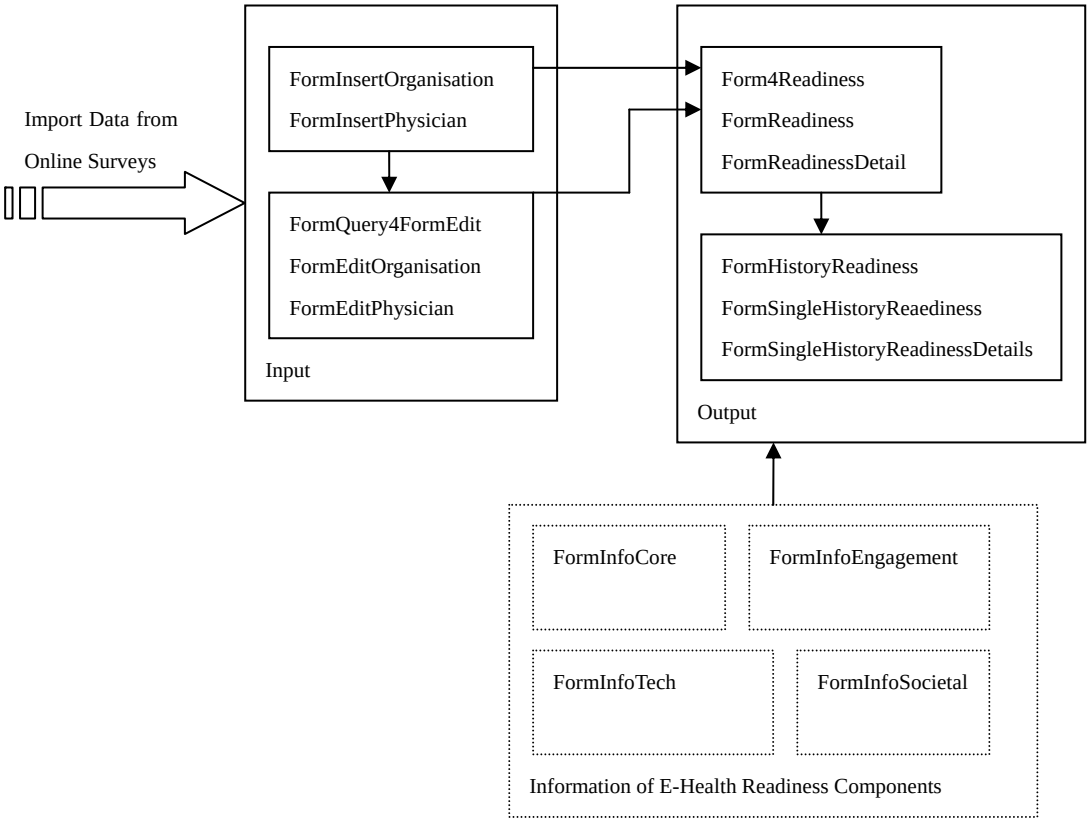

Figure 3.5. Implementation of EHRAT Function

In total, 48 Macros and 63 Queries of Microsoft Access are developed and embedded into the 16 Forms. (See Appendix 6 and the Microsft Access programme in the CD) For example, the Macro MacroOpenFormReadiness and Queries such as UpdateCoreEfficiency0 and QueryCoreHigh1 are invoked by the form Form4Readiness. (Table 3.16) The development of each Query is based on a corresponding equation disccused in Section 3.4.2.

Forms	Macros	Queries	Corresponding Equations
Form4Readiness	MacroOpenFormReadiness	UpdateCoreEfficiency0 UpdateCoreEfficiency1	Equation 5
		QueryCoreHigh1 QueryCoreLow2 QueryCoreMedium3	Equation 9
		……..	……..

Table 3.16. Forms, Macros and Queries Used for EHRAT

3.4.3.3. Source Code

The main function of EHRAT is processing the assessment data to reveal E-Health readiness. The Macro MacroOpenFormReadiness is invoked by the form Form4Readiness to implement this function and the relevant source code is provided in Appendix 7.

3.4.3.4. EHRAT Validation

The data collected by the WHO eHCD project in some healthcare centres were input and processed with EHRAT. Then, the readiness assessment results, summarised in Table 3.17, have been approved by two E-Health experts involved in this project.

Healthcare Centre	Core	Engagement	Technological	Societal
Organisation 1	Medium	Medium	Low	Medium
Organisation 2	High	Medium	Low	Medium
Organisation 3	Medium	Medium	Low	Medium
Organisation 4	Medium	Medium	Low	Medium
Organisation 5	High	Medium	Low	Medium
Organisation 6	Medium	Medium	Low	Medium
Organisation 7	High	Medium	Low	Medium
Organisation 8	High	Medium	Low	High
Organisation 9	High	Medium	Low	High
Organisation 10	Medium	Medium	Low	Medium
Organisation 11	Medium	Medium	Low	Medium
Organisation 12	High	Medium	Low	Medium
Organisation 13	Medium	Medium	Low	High
Organisation 14	Medium	Medium	Low	Medium
Organisation 15	Medium	Medium	Low	Medium
Organisation 16	Medium	Medium	Low	Medium
Organisation 17	Medium	Medium	Low	Medium
Organisation 18	High	Medium	Low	Medium
Organisation 19	Medium	Medium	Low	Medium
Organisation 20	Medium	Medium	Low	Medium

Table 3.17. Readiness Assessment Results for Healthcare Centres

3.5. Chapter Summary

This chapter has presented E-Health Readiness Assessment Methodology (EHRAM) based on design science research methodology which includes two design processes and four design artifacts in IS. The artifacts are constructs, models, methods and instantiations. First, an E-Health readiness assessment model (EHRAF) has been developed by integrating the studied components of the review frameworks in Section 2.5. Four components were identified, i.e., core, engagement, technological and societal readiness. Each component can be assessed as one of three different levels: high, medium and low.

Second, the method was presented to assess E-Health readiness. A set of hierarchical evaluation criteria based on EHRAF was developed. This was followed by the definition of each evaluation parameter. Subsequently, a questionnaire was designed for interviews or online surveys with groups of healthcare practitioners in order to determine significant parameters using statistical analysis (e.g. cross tabulation tests, statistically significant correlations ($p<0.05$)) and more importantly to assess the current E-Health readiness status of the given context. The assessment outcomes can feed into the requirement specification of E-Health system implementation.

Third, an E-Health readiness assessment instantiation (EHRAT) has been developed for the data analysis. All the survey or interview data can be imported into EHRAT without any change and automatically processed to reveal E-Health readiness status in terms of the core, engagement, technological and societal readiness, as well as corresponding implications. Some data from the WHO eHCD project were input and processed with EHRAT. Then, the readiness assessment results have been approved by the E-Health experts involved in this project.

The two processes of design science research methodology involve build and evaluate. In this chapter, EHRAM has been built. The next chapter will evaluate EHRAM with framework evaluation criteria and a case study.

Chapter 4
Evaluation of EHRAM

The evaluation of the presented EHRAM will be conducted with framework evaluation criteria and a case study. The framework evaluation criteria aim to assess the validity of EHRAF. The case study is following the process of EHRAM to reveal E-Health readiness status in two healthcare centres in Vietnam. In the meantime, the data from these centres will be input and processed with EHRAT. EHRAT, consequently, can be tested by comparing the readiness assessment results from the case study and the output of EHRAT.

4.1. Framework Evaluation Criteria

Realising the value of framework articles is not without challenge since these articles are the product of analysing substantial volume of literature that is often difficult to organise around specific themes (Schwarz et al., 2007). This challenge suggests the need for a set of criteria, which can guide both reviewers and authors of these articles. Thus, Schwarz et al. (2007) developed a clear understanding of what constitutes framework articles and criteria for evaluating them. However, the framework evaluation criteria cannot be used directly to evaluate E-Health frameworks, as discussed in Section 2.6.2. To fill the gap, the review step requires an inclusion of electronic health and framework related articles, so subsequently the evaluation criteria for framework evaluation developed by Schwarz et al. (2007) need to be revised to incorporate healthcare contexts. The commentary proceeds as follows. First of all, the procedure is described for selecting, evaluating and classifying published articles in the healthcare domain. This is followed by a detailed description of the findings, centred on the stated purpose or objective of these articles. In the final section, a list of criteria is suggested for assessing all framework articles in the healthcare domain.

4.1.1. Development of Criteria for Framework Evaluation in The Healthcare Domain

The examination of published framework articles involves six steps, similar to those undertaken by Schwarz et al (2007). The first three steps facilitate location and identification of relevant articles. The last three steps focus on analysing the content. These steps specifically are: (1) Selecting (searching) articles for review; (2) Filtering relevant articles; (3) Identifying their content and structure; (4) Evaluating content and structure; (5) Grouping of articles according to their stated purposes; and (6) Clustering analysis and validation, a validity procedure used by researchers to search for convergence among multiple sources of information and methods of data collection and analysis (Patton, 2002; Creswell & Miller, 2000). Each of these steps is described in turn below.

Step1: Selection of articles for review

The types of journals most likely to publish E-Health framework articles are first identified by interviewing experts in the healthcare domain. The articles examined are based on the following criteria: (a) the words framework and electronic health (E-Health) appear in their titles, abstracts or key words; or the words evaluation, framework and electronic health (E-Health) appear in their titles, abstracts or key words, and healthcare anywhere; and (b) they are published in peer reviewed journals that publish framework articles in the healthcare domain. The evaluation articles are separately selected, as it is believed that their inclusion helps to increase the validity of the findings, particularly supporting development of an evaluation framework for E-Health readiness. The articles selected based on these criteria were drawn from the following databases or journals: Web of Science, JAMIA, Medline, PubMed, CINAHL, PsychInfo, ERIC, ProQuest Science Journals, EMBASE and Evi.sagepub.com. (Appendix 8)

Step 2: Filtering relevant articles

After finding a set of articles from identified sources, the following types of articles were filtered out:

a. Articles which never mentioned or used the term “framework” in the entire text, title or abstract, but had framework papers listed in the reference section. These articles were ignored after a quick scan to see if the article included more than a casual citation to that reference.
b. Articles that used the terms only when referring to another person’s work, or an entire literature, such as “Porter’s framework” or the “transaction cost framework”. In addition, a framework sometimes is simply used as an alternative term in place of “stream of research”, “this line of reasoning”, “concept”, “idea”, as in “legal framework”, “transaction cost framework” and so on. These articles were eliminated after confirming that they primarily elaborated on how they used these “frameworks”. .

As a result, the framework articles for review are finally established. (Appendix 9)

Step 3: Identification of content and structure

Abstracts and full text were scanned to identify the definition, usage and purpose of the articles. Relevant text was extracted or was re-typed verbatim. For example, one paper titled *Access and Authorisation in a Global e-Health Policy context*, provides guidance in four policy areas related to telehealth: organisational context, human resources, technology and equipment, and clinical standards and outcomes, to avoid potentially jeopardized E-Health because decisions made in one jurisdiction might hamper, even prevent, an E-Health opportunity in another (Scott et al. 2004).

Step 4: Evaluation of content and structure

Once the content and structure were identified, evaluation was added to the database, including (a) what the article was trying to accomplish; (b) whether the article had any structure; (c) whether the objective of the article was to evaluate the status of the field or to suggest future research and; (d) whether the article was comprehensive or selective. A summary of the purpose, the structure, and the objective of each article were also included in the database and are summarised in Appendix 10. Importantly, the main evaluations of the article were the objective (purpose) and structure of the framework, and characteristics of a good framework, as espoused by Schwarz et al. (2007).

Step 5: Grouping of purposes

In this step, common themes centred on the purpose/objectives of framework articles were identified and grouped. All citations first used to establish the evaluated purpose of the article in Step 4 were noted. These citations and common themes were then used to group articles with similar objectives, structures, and characteristics. This step yields 42 statements related to the purpose/objectives of framework articles. Based on the perceived commonality of the themes, the purposes of the frameworks were grouped into eleven clusters. The resulting clusters represented another level of abstraction (Schwarz et al. 2007).

Step 6: Cluster analysis and validation

These statements were analysed within, and across the clusters so as to ensure consistency and independence. The abstracted clusters were then given labels and reviewed once more for consistency. As a result, reassessment and relabeling was performed for some articles. This step was repeated until a consensus was reached on the labels for abstracted categories of the purposes. In the final analysis, articles were

reassigned to appropriate clusters. This step ensured that there was consistency across and within the clusters.

4.1.1.1. Purpose of Framework Articles

The preceding examination proposed 11 purposes associated with framework articles in the healthcare domain, as detailed in Appendix 10.

1. To integrate previous research studies. As E-Health is multi-disciplinary, an output of this process is a cohesive model or table that unifies the separate research streams in the healthcare domain.
2. To assist researchers to theorise about a phenomenon, as an input to the development and testing theory in the E-Health domain.
3. To aid the collection of data for study of an E-Health issue by identifying and differentiating methodologies.
4. To aid the interpretation of data, as a guide for the analysis of empirical data.
5. To provide a new focus within a research stream. This new focus can be theoretical, methodological, or philosophical, but the objective is to inform E-Health researchers of areas that should be focused upon as the research stream moves forward.
6. To aid the understanding of the relationships between theoretical concepts and focus on explanations for why these relationships have occurred.
7. To synthesise academic literature in a meaningful way, offering guidelines and advice to E-Health practitioners including decision makers, evaluators and managers and so on.
8. To propose the legitimate boundaries for an E-Health area (i.e., what is and what is not appropriate for the area)
9. To help organise the specific concepts already studied in an E-Health area
10. To propose solutions to practical issues not studied yet in a research stream. This also aims to offering guidelines and advice to E-Health practitioners as Purpose 7 does, but not heavily supported by academic literature.

11. To facilitate future research in E-Health evaluation, as well as design and implementation of E-Health research projects.

Most of the purposes (except 10 and 11) have been identified in Schwarz et al.'s study (2007). Although those purposes associated with framework articles are considered mutually exclusive, attention should also be paid to those articles which have more than a unique purpose. For instance, the framework article (Khoja et al. 2007) integrated previous research studies, and also proposed the legitimate boundaries for the E-Health area.

A close examination of the above 11 objectives of frameworks suggests that an overarching objective of a framework in the healthcare domain is to find new opportunities for research and subsequently synthesise and integrate prior research, with a view to assist major stakeholders (e.g. formulation and implementation of E-Health policies for practitioners and academics).

4.1.1.2. Characterising Framework Articles

The previous discussion and analysis suggests underlying dimensions to characterise framework articles in the healthcare domain, which have been completely identified in Schwarz et al.'s study (2007). These dimensions, i.e., the objective (Dimension1), comprehensiveness (Dimension2), the relationship with the boundary of the research stream (Dimension3), the temporal nature (Dimension4), the elements examined (Dimension5) and the substantive output (Dimension6) provide a basis for integrating the preceding similarities and differences in the elicited purposes. A framework focuses on the integration of previous literature, but it only needs to examine that portion of the literature necessary to adequately unify the particular research streams being considered rather than being comprehensive. Extending the argument about the need for a framework to present a cohesive and comprehensive theoretical system, the framework subsequently gives a definition of what does (and does not) constitute the

boundary of research stream. Furthermore, the framework is concerned with higher-level concepts and relationships among these concepts. It tends to have a prospective focus and thus can be used prescriptive of defining what lies ahead. Finally, the output of the framework (represented using models, tables, figures and/or descriptions of key variables) results from an attempt to conceptualise subject areas.

4.1.1.3. Framework Articles: Definition and Criteria for Evaluation

Drawing from the framework article taken from IS (Schwarz et al. 2007), a framework in the healthcare/E-Health area can be defined as an exposition of a set of concepts, values and practices that constitutes a way of understanding or studying the research issues related to E-Health within a body of knowledge. This exposition is intended to integrate or to summarise a research topic from a researcher's perspective (Schwarz et al. 2007).

So as to guide E-Health researchers/reviewers in the development of frameworks and the assessment of the quality of these frameworks, a set of criteria are suggested as Table 4.1. Criteria 1 to 17 were directly borrowed from the desirable qualities of a framework (Schwarz et al., 2007) but have been revised by adding detailed explanations. The final criterion was identified with the new findings documented in Section 4.1.1.1. As a whole, these criteria reflect multiple approaches to understanding the structure of the frameworks, such as eleven associated purposes and six underlying characteristic dimensions. A note of caution is warranted here – these criteria should not be used by authors and reviewers as a *checklist* to assess the relative goodness of a given framework; rather, the list of criteria suggests desirable qualities for framework articles in the healthcare domain.

Criteria	Explanation	Source * Purpose (P) and Dimension (D)
1. Identify areas for future research	This new focus can be theoretical, methodological, or philosophical, but the objective is to inform E-Health researchers of areas that should be focused upon as the research stream moves forward.	P 5 and D 4
2. Has high internal consistency	To aid in the understanding of the relationships between theoretical concepts and focus on explanations for why these relationships have occurred.	P 6
3. Aids researchers in understanding the research area	Extending the argument about the need for a framework to present a cohesive and comprehensive theoretical system, a framework defined what does (and does not) constitute the boundary of the stream.	D 3
4. Contains fundamental concepts that endure	To help organise the specific concepts already studied in an E-Health area -- to assess and organise important variables.	P 9
5. Has only a few elements or dimensions	This is determined with only a portion of the literature necessary to adequately unify the particular research streams being considered rather than being comprehensive.	D 2
6. Can be reflected in a simple graphic or table	The output of framework articles consists of models, tables and so forth, resulting from an attempt to conceptualise subject areas based on a portion of literature.	D 6
7. Captures the critical aspects that are useful to describe a phenomenon	To assist researchers to theorise about a phenomenon, as an input to the development and testing theory in healthcare domain.	P 2
8. Is clear	The logic of a framework requires clearness.	Writing skill
9. Is concise	The description of a framework needs to be concise.	Writing skill
10. Is useful (defined as how well it frames the body of knowledge)	A framework does a contribution to the body of knowledge in E-Health studies	The value of research
11. Should either provide a good fit with previously obtained results or offer and explanation of inconsistency in results		The requirement of literature review
12. Tells us clearly what is covered, and what is not covered by it	To propose the legitimate boundaries for an E-Health area (i.e., what is and what is not appropriate for the area).	P 8
13. Has clear guidelines telling us what to expect for a problem within that framework		D 6
14. Is intellectually coherent	This can be achieved by integrating previous research studies. An output of this process is a cohesive model or table that unifies the separate research streams in E-Health domain based on previous studies.	P 1
15. Contains mutually exclusive and collectively exhaustive categories	High level concepts and relationships among these concepts are concerned in framework articles.	D 5
16. Is supported by current theoretical understanding of the concepts and provides a tool for explaining observations from the environment	To synthesise academic literature in a meaningful way, offering guidelines and advice to E-Health practitioners including decision makers, evaluators and managers and so on.	P 7
17. Identifies all the component concepts, articulates their characteristics, and provides some type of interaction expression between the concepts	The identification of concepts and articulation of their characteristics are accomplished by integrating previous research studies. In terms of interaction expression between the concepts, the framework needs to help organise the specific concepts and understand their relationships.	P 1, P 6 and P 9
18. Facilitates future research in E-Health domain	The research involves E-Health evaluation, as well as design and implementation of E-Health research projects. The facilitation can be accomplished by aiding in the collection of data and in the interpretation of data or other ways.	P 3, P 4 and P 11

Table 4.1. Criteria to assess the quality of framework articles in healthcare domain

4.1.2. Application of Framework Evaluation Criteria

4.1.2.1. Framework with Six Dimensions

EHRAF can be characterized into six dimensions identified in Section 4.1.1.2, i.e., the objective, comprehensiveness, the relationship with the boundary of the research stream, the temporal nature, the elements examined, and the substantive output.

- Objective and comprehensiveness: examines that portion of literature (Campbell et al. 2001; Demiris et al. 2004; Jennett et al. 2003, 2004, 2005; Wickramasinghe et al. 2005; Khoja et al. 2007) necessary to adequately identify the E-Health readiness components from healthcare providers' and organisational perspectives and thus reveals E-Health readiness status in healthcare organisations.
- Relationship with the boundary of the research stream and temporal nature: presents a cohesive and comprehensive theoretical system by justifying the need for E-Health. Also, it gives a definition of what does (and does not) constitute the boundary of the stream. Healthcare issues exist in many countries, as mentioned in Section 1.2 and discussed in Section 2.2. Based on a thorough literature review in Section 2.3, the importance of EHR pre-implementation evaluation, especially for developing countries, was highlighted. E-Health readiness assessment as a part of E-Health pre-implementation evaluation becomes an essential requirement prior to implementation. Existing E-Health readiness frameworks however were observed to be inconsistent in their coverage, therefore E-Health evaluation is often criticised for the poor quality of research design, the lack of common outcome indicators and the absence of an agreed theory (Gagnon et al. 2005). In order to solve this problem, EHRAF constitutes the boundary of E-Health readiness assessment by integrating the components of each reviewed framework from healthcare providers' and organisational perspectives. Importantly, E-Health readiness can also involve the components from patients, system or public perspectives according to future evaluation needs.
- Elements examined and substantive output: the output (Table 3.1 and Table 3.2) results from an attempt to conceptualise subject areas based on a portion of the

literature. By integrating the components of reviewed frameworks, four components: core readiness, engagement readiness, technological readiness and societal readiness were identified to assess E-Health readiness. As a result, EHRAF (Table 3.1) and implications of E-Health readiness assessment for individual components (Table 3.2) represent the output of the E-Health readiness assessment in a simple way.

4.1.2.2. Framework with Purposes

EHRAF serves multiple purposes. First, it implies future research areas in the healthcare/E-Health domain. As discussed in Section 4.1.2.1, more components from different perspectives such as patients' and public can be included in E-Health readiness assessment according to future evaluation needs. In other words, researchers' awareness is raised of the potential implications of different perspectives. Further, the readiness assessment framework can also be tailored for other E-Health systems, such as telemedicine and e-referral systems.

Second, EHRAF helps to organise and assess the specific concepts already studied in an E-Health area (four readiness assessment components). The framework provides guidelines in Section 3.3 to individually assess core readiness, engagement readiness, technological readiness and societal readiness. Subsequently, different implications and suggestions were drawn for decision makers.

The third purpose of EHRAF is to propose legitimate boundaries for an E-Health area (i.e., what is and what is not appropriate for the area). E-Health readiness can be evaluated from multiple perspectives. However, only the components from healthcare providers' and organisational perspectives were studied in this case. Therefore, this framework helps to understand the scope of E-Health readiness assessment.

Lastly, EHRAF integrates previous literature in an actionable way, offering guidelines and advice to E-Health practitioners, i.e., evaluators and decision makers. It

synthesises the components of reviewed frameworks, providing evaluators with a method to determine the status of E-Health readiness. Based on the assessment results, decision makers can take corresponding actions as suggested in the framework to facilitate EHR acceptance after its implementation.

4.1.2.3. Results of Framework Evaluation with Criteria

EHRAF does not only match up with six characteristic dimensions of frameworks in general, but also serves multiple purposes in the healthcare domain. Furthermore, the framework presents other legitimate features required by the framework evaluation criteria.

- The logic from the need to the outcome is clear, as discussed in Section 4.1.2.1;
- The description of EHRAF turns out to be concise and it also provides clear guidelines about what to expect for a problem. Four components were initially identified to assess E-Health readiness from healthcare providers' and organisational perspectives. For each component, it offers instructions to place the readiness into three different levels, high, medium and low. With the results of E-Health readiness assessment for individual components, suggestions were provided for decision makers;
- EHRAF contributes to the body of knowledge in E-Health. The contribution can be reflected by suggesting areas of future research, organising the specific concepts already studied and proposing the legitimate boundaries for an E-Health area, which are the first three purposes discussed in Section 4.1.2.2.

4.2. Case Study

This study utilises archive data collected by WHO in Vietnam to reveal core readiness, engagement readiness, technological readiness and societal readiness for EHR systems. The data were collected in two healthcare centres (Gialoc and Hoaiduc, both

about 120-140 km to Hanoi, the nearest large city). Table 5.1 shows the basic statistics of these centres. The population of Hoaiduc is 11 times as that of Gialoc. Although Hoaiduc has more access to specialist physicians, a similar number of general physicians serve each centre. Furthermore, the number of patient visits per general physician per annum is substantially high (9230.8 vs. 6250, in Hoaiduc and Gialoc, respectively); Hoaiduc's general physicians have a workload (using patient visit data) of about 48% higher than those in Gialoc. These statistical data demonstrate a much greater shortage of general physicians in Hoaiduc. Moreover, Gialoc is better served in terms of the ratio of nurses and technical officers, per population.

Healthcare centres	General Physicians	Specialist Physicians	Nurses	Technical officers	Population served	Average no. of patient visits per annum
Hoaiduc	13	16	28	9	174,114	120,000
Gialoc	12	10	34	8	15,500	75,000

Table 5.1. Basic statistics of participating healthcare centres in Vietnam

From Section 4.2.1 to Section 4.2.5, the readiness assessment is conducted manually, i.e. without assistance of EHRAT. Section 4.2.6 processes the same set of WHO data with EHRAT and then makes a comparison of the readiness assessment results.

4.2.1. Core Readiness

4.2.1.1. Result Summary

The results of core readiness parameters are summarised as follows:

- Patient health records are manually generated within two healthcare centres and the physicians use a standard format to input patient information.
- 32% of the physicians independently take the responsibility for health record generation whereas the remnant shares the responsibility with their assistants, i.e., nurses, technicians, secretaries. (Table 5.2.) Nonetheless, the role in the record maintenance is 100 percent enacted by the physicians.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Physician	6	30.0	31.6	31.6
	Physician and Assistants	13	65.0	68.4	100.0
	Total	19	95.0	100.0	
Missing	System	1	5.0		
Total		20	100.0		

Table 5.2. Responsibility for health record generation

- 90% of the physicians spend 15 minutes or more in generating patient records in Hoaiduc (Table 5.3.) while the record generation in Gialoc consumes 70% physicians even more than 25 minutes. (Table 5.4.)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	12	1	10.0	10.0	10.0
	15	6	60.0	60.0	70.0
	30	3	30.0	30.0	100.0
	Total	10	100.0	100.0	

Table 5.3. Time for record generation in HOAIDUC (Minutes)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15	2	20.0	20.0	20.0
	20	1	10.0	10.0	30.0
	25	2	20.0	20.0	50.0
	35	3	30.0	30.0	80.0
	40	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Table 5.4. Time for record generation in GIALOC (Minutes)

- In terms of current procedures for storage and retrieval of patient health records, locked filing cabinets/ cupboards are used and standard format for the storage is by means of Copies-Number and type, By department and Alphabetic and Date wise (75%). (Table 5.5.)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Copies Number and Type	2	10.0	10.0	10.0
	By Department	2	10.0	10.0	20.0
	Alphabetic and Date wise	1	5.0	5.0	25.0
	All above	15	75.0	75.0	100.0
	Total	20	100.0	100.0	

Table 5.5. Standard Format for storage

- The records can be accessed by all physicians and assistants (80%) without multiple accessibility control. (Table 5.6.)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Physician	4	20.0	20.0	20.0
	Physician and Assistants	16	80.0	80.0	100.0
	Total	20	100.0	100.0	

Table 5.6. Record Accessibility

- For storage and retrieval of patient records, it takes 15 minutes or longer for the vast majority of the physicians in both centres. (Table 5.7. and Table 5.8.)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10	2	20.0	20.0	20.0
	15	3	30.0	30.0	50.0
	20	1	10.0	10.0	60.0
	30	3	30.0	30.0	90.0
	60	1	10.0	10.0	100.0
	Total	10	100.0	100.0	

Table 5.7. Time for record storage and retrieval in HOAIDUC (Minutes)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10	2	20.0	20.0	20.0
	15	2	20.0	20.0	40.0
	17	1	10.0	10.0	50.0
	20	1	10.0	10.0	60.0
	30	4	40.0	40.0	100.0
	Total	10	100.0	100.0	

Table 5.8. Time for record storage and retrieval in GIALOC (Minutes)

- Incomplete and inaccurate patient records pose an issue in the healthcare centres. 50% of physicians interviewed in Gialoc are not satisfied with it at all (Table 5.9.) whereas 70% in Hoaiduc have medium or even lower satisfaction. (Table 5.10.) Generally speaking, physicians are not content with the completeness and accuracy of patient records.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	5	50.0	50.0	50.0
	Not satisfied	4	40.0	40.0	90.0
	Medium	1	10.0	10.0	100.0
	Quite satisfied	0			
	Satisfied	0			
	Total	10	100.0	100.0	

Table 5.9. Degree of completeness and accuracy of health records in GIALOC

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	1	10.0	10.0	10.0
	Not satisfied	1	10.0	10.0	20.0
	Medium	5	50.0	50.0	70.0
	Quite satisfied	3	30.0	30.0	100.0
	Satisfied	0			
	Total	10	100.0	100.0	

Table 5.10. Degree of completeness and accuracy of health records in HOAIDUC

- The satisfaction with sharing patient records is not high. 83% (5 respondents out of 6) in Hoaiduc and 66% (5 of 8) in Gialoc are only quite satisfied. (Table 5.11. and Table 5.12)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	1	10.0	16.7	16.7
	Quite satisfied	5	50.0	83.3	100.0
	Total	6	60.0	100.0	
Missing	System	4	40.0		
Total		10	100.0		

Table 5.11. Satisfaction of sharing health records in HOAIDUC

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not satisfied at all	2	20.0	25.0	25.0
	Medium	1	10.0	12.5	37.5
	Quite satisfied	5	50.0	62.5	100.0
	Total	8	80.0	100.0	
Missing	System	2	20.0		
Total		10	100.0		

Table 5.12. Satisfaction of sharing health records in GIALOC

4.2.1.2. Issues in Paper Health Records with Cross Tabulation Tests

In total, 8 items with variable values have been used for cross tabulation tests, i.e., healthcare centre, staff responsibility for patient record generation, time for patient records generation, standard format for patient record storage, accessibility and confidentiality of patient records, time for patient records storage and retrieval, completeness and accuracy of patient records and physician satisfactory of sharing patient records. Of the 28 cross tabulation tests done, only 7 have been found to be significant (significance value of the test is smaller than 0.05).

The summary is generated from significant correlations ($p<0.05$) between pairs of parameters. For each significant correlation, a contingency table is presented

indicating the distribution of frequencies between the concerned parameters. The analysis focuses on those cells which contain disproportionately large (or small) numbers of cases, which suggests that there might be a pattern of interaction. The proceeding analysis helps understanding of the present paper health records systems.

Inefficiency in Generating Patient Health Records

		Time for generating patient records (Minutes)							Total
		12	15	20	25	30	35	40	
Healthcare Centre	Vietnam-GIALOC	0	2 (20%)	1 (10%)	2 (20%)	0	3 (30%)	2 (20%)	10 (100%)
	Vietnam-HOAIDUC	1 (10%)	6 (60%)	0	0	3 (30%)	0	0	10 (100%)
Total		1	8 (95%)	1	2	3	3	2	20

Table 5.13. Cross Tabulation between "healthcare centres" and "time for generating patient records"

Table 5.13 shows that in Gialoc, it takes at least 15 minutes to generate all patient health records, the median time being 35 minutes. In Hoaiduc, 90% of all patient health records take at least 15 minutes to be generated, the median time is 15 minutes. Therefore, the healthcare centre in Hoaiduc is substantially more efficient than Gialoc. When combined, the overall data also show inefficiency in generating patient health records: 95% of patient health records take at least 15 minutes to be generated.

Storage and retrieval of patient records consumes 15 minutes or even longer for a significant majority of the physicians in both centres. So the time spent by a physician on each patient visit (only considering the record generation, storage and retrieval) will be at least 30 minutes. Hypothetically, if all 13 general physicians and 16 specialist physicians in Hoaiduc spend 8 hours per day and 5 days per week on patient visits only, the throughput will be a maximum of 120,971 patient visits per annum. The routine core activities for physicians however do not merely involve patient visits but also involve other responsibilities, such as education concerning prevailing health problems and the methods of preventing and controlling them. By contrast with the reported number (average annual number of patient visits in Hoaiduc is 120,000),

time efficiency apparently becomes a problem with inefficient patient record generation, storage and retrieval.

Dissatisfaction with incomplete and inaccurate patient records

Table 5.14 shows that in Gialoc, 90% of the respondents were dissatisfied with the completeness and accuracy of patient records; the remaining 10% of respondents reported medium satisfaction only. In Hoaiduc, 20% of respondents reported dissatisfaction, and 50% reported moderate levels of satisfaction. Therefore in terms of completeness and accuracy of patient records, respondents in Hoaiduc seem more satisfied. Overall in both healthcare centres, 55% respondents were dissatisfied whereas 30% were moderately satisfied. Therefore, there is much room for improvement on this parameter.

		Completeness and accuracy of patient records				Total
		Not Satisfied at all	Not satisfied	Medium	Quite satisfied	
Healthcare Centre	Vietnam-GIALOC	5 (50%)	4 (40%)	1 (10%)	0 (0%)	10 (100%)
	Vietnam-HOAIDUC	1 (10%)	1 (10%)	5 (50%)	3 (30%)	10 (100%)
Total		6 (30%)	5 (25%)	6 (30%)	3 (15%)	20 (100%)

Table 5.14. Cross tabulation between "healthcare centres" and "completeness and accuracy of patient records"

Table 5.15 illustrates a similar point, but compares whether the responsibility for patient record generation affects the physicians' satisfaction of completeness and accuracy of patient records. Overall, 52.6% of the respondents rated the completeness and accuracy of patient records as being not satisfied or not satisfied at all. This parameter fares worse when only physicians are responsible for generating patient records – respondents reported that 83.4% were not satisfied or not satisfied at all. By comparison, when the burden of generating patient records was also shared with assistants, fewer (38.5%) were not satisfied or not satisfied at all. This could be due to physicians being too overworked and having no one to share their burden of generating these records. Overall, no respondents reported that they were satisfied

with the completeness and accuracy of patient records.

		Completeness and accuracy of patient records				Total
		Not Satisfied at all	Not satisfied	Medium	Quite satisfied	
Staff responsible for patient record generation	Physician	1 (16.7%)	4 (66.7%)	0	1 (16.7%)	6 (100%)
	Physician and assistants	4 (30.8%)	1 (7.7%)	6 (46.1%)	2 (15.4%)	13 (100%)
Total		5 (26.3%)	5 (26.3%)	6 (31.6%)	3 (15.8%)	19 (100%)

Table 5.15. Cross Tabulation between "staff responsible for patient record generation" and "completeness and accuracy of patient records"

Lack of access and confidentiality to patient records when generated by multiple staff (physicians and their assistants)

Table 5.16 shows that when physicians themselves generate patient records, patients records can be accessed by physicians only or both physicians and their assistants (50% respectively). Nevertheless the situation considerably changes once the responsibility for record generation is shared by all the workers, respondents reported that in 92% of the cases, access and confidentiality become an issue. It therefore appears that in paper-based patient health records, access and confidentiality to these records are key issues, particularly when patient records are generated by both physicians and their assistants.

		Accessibility and confidentiality of patient records		Total
		Physician	Physician and assistant	
Staff responsible for patient record generation	Physician	3 (50%)	3 (50%)	6 (100%)
	Physician and assistants	1 (7.7%)	12 (92.3%)	13 (100%)
Total		4 (21%)	15 (79%)	19 (100%)

Table 5.16. Cross Tabulation between "staff responsible for patient record generation" and "accessibility and confidentiality of patient records"

Dissatisfaction of sharing patient records

Table 5.17 shows that there is higher level of satisfaction with sharing patient records when both physicians and assistants are responsible for generating patient records (compared with if only physicians are responsible for generating records). However, the overall level of satisfaction with sharing is not high – no respondents reported to feel satisfied.

		Satisfaction of sharing patient records			Total
		Not at all	Medium	Quite	
Staff responsible for record generations	Physician	3 (60%)	0	2 (40%)	5 (100%)
	Physician and assistants	0	1 (12.5%)	7 (87.5%)	8 (100%)
Total		3 (23%)	1 (7.7%)	9 (69.2%)	13 (100%)

Table 5.17. Cross Tabulation between "staff responsible for patient record generation" and "satisfaction of sharing patient records"

4.2.1.3. Core Readiness Assessment

While two participating health centres were different in key areas such as the number of staff and population served, they are also similar in many others aspects. Patient health records in these centres were all paper-based only. Unsurprisingly, some issues were identified related to patient records generation, storage and retrieval:

- inefficiency in generating and retrieving patient health records
- incomplete and inaccurate patient records, and more dissatisfaction when only physicians generated patient records.
- lack of access and confidentiality to patient records when generated by multiple staff (physicians and their assistants)
- dissatisfaction of sharing patient records

The empirical evidence represents the realisation of problems in documentation of clinical information, which can typically be addressed by EHR systems. Also, it

demonstrates physicians' dissatisfaction with present paper health records in terms of completeness and accuracy of patient records and sharing patient records. Accordingly, the core readiness is high.

4.2.2. Engagement Readiness

4.2.2.1. Result Summary

The results of engagement readiness parameters are shown as follows: (Table 5.18.)

Items	Values	Gialoc	Hoaiduc	Total Percentage
Potential Benefits of EHR (physicians' perception)	Minimal time for recording and retrieving relevant patient information	40%	90%	65%
	Minimal time to diagnosis & treatment	80%	60%	70%
	Confidentiality of patient information etc	70%	80%	75%
Limitation of EHR systems	High investment and Budget	70%	90%	80%
	Have the IT knowledge	80%	90%	85%
	Provide stability of electronic power	0	10%	5%
Expectations in improvement of healthcare	Providing & sharing timely information	30%	70%	50%
	Minimal time for recording and retrieving relevant patient information	20%	70%	45%
	Improve capacity of diagnosis & treatment	60%	80%	70%
Potential impacts of implementing EHR systems	Support for telemedicine	0	10%	5%
	Better providing information	60%	60%	60%
	Support for science research	0	10%	5%
Anticipated Problems caused by EHR system use	Lack of Budget	40%	40%	40%
	Limitation of IT knowledge	100%	100%	100%
	Provision of electronic power not continuous	10%	10%	10%
Willing to accept the training for EHR use	Yes	100%	100%	100%
	No	0	0	0

Table 5.18. Results for physicians' Perception of EHR

- The need for better provision of information has been recognised as one of major potential impacts by virtue of EHR applications (60% in both Hoaiduc and Gialoc). Minimal time for recording and retrieving relevant patient information (65%) and providing and sharing timely information (50%) reflect improved information provision.

- Another potential benefits with EHR intervention, such as minimal time for diagnosis and treatment and confidentiality of patient information have also been recognised, 70% and 75% respectively.
- Few physicians (5%) are aware that EHR can support science research and another potentially positive impact of EHR, support for telemedicine, has not been recognised either.
- Limitation of IT knowledge is a main anticipated problem for EHR implementation (100%).
- High investment and budget appear to be a big concern (80%) whereas 40% physicians anticipate there will be a problem.
- Provision of discontinuous electronic power would be a problem from physicians' viewpoint (10%).
- 100% physicians are willing to accept training for prospective EHR use.

4.2.2.2. Engagement Readiness Assessment

Potential benefits and positive impacts of EHR systems have been recognised by physicians in both centres. Section 3.5.2.1 presented main issues with the existing paper health records, i.e., inefficient documentation of clinical information, incompleteness and accuracy of the records, lack of access and confidentiality to patient records and dissatisfaction of sharing patient records. The results of engagement readiness showed that over half of the physicians in Hoaiduc had recognised that EHR would be a solution to these issues. Physicians' exposure to EHR benefits in Gialoc is not as positive and comprehensive as it is in Hoaiduc. Minimal time for recording and retrieving relevant patient information were perceived by 40% of the physicians interviewed in Gialoc and only 30% perceived that EHR can provide and share timely information.

Regarding potentially negative impacts of EHR systems from physicians' standpoint, limitation of IT knowledge is a primary concern in both sites. EHR implementations

represent a disruptive change in the healthcare workplace. The change involves not only the introduction of new equipment, but also the job design of interconnected healthcare professionals which should be reengineered to effectively and efficiently accommodate the technology (Eric et al., 2006). This change is probably why all the physicians interviewed are willing to accept the training for EHR use.

Overall, medium readiness is assessed for the engagement component in both sites even though physicians' exposure to the EHR benefits in Gialoc is slightly different from that in Hoaiduc. More than half of the physicians in Hoaiduc have recognised the benefits of EHR and all these interviewed physicians are willing to accept training for EHR use, but all of them express a primary concern about limited individual knowledge about IT.

4.2.3. Technological Readiness

4.2.3.1. Result Summary

The results of technological readiness parameters are summarised as follows: (Table 5.19. and Table 5.20.)

Vietnam healthcare centres		*Gialoc*	*Hoaiduc*
Provided ICT applications	EHR application		Dermatology,e-referral
	Other Application	Finance Unit, Statistics unit	
Network /hardware	Hardware	Desktop 4; Monitor 3; Printer 2	Desktop 11; Monitor 1; Printer 2; Photocopier 1
	Standard Software	Windows XP; Antivirus	Windows XP and 98; Antivirus
	Internet Access	No	No
Software	Maintenance of EHR	No	No
	E-Healthcare training	No	No
	To send emails	No	No
Personnel	Users of computer for E-Health	5	5
	Provision of technical support	Yes	Yes
	Technical support personnel	10	20

Table 5.19. ICT Infrastructure and Other Available E-resource

- A few ICT applications have been used in both healthcare centres, finance and statistics units in Gialoc, dermatology and e-referral in Hoaiduc.
- Two participating healthcare centres have a little hardware equipment (desktops, monitors, printers in Gialoc, desktop, monitor, printer and photocopier in Hoaiduc).
- No Internet Access for both sites.
- Software packages (Windows Operation System and Anti-virus, no any software for maintenance of EHR, E-Healthcare training or to send emails.
- Computer users for E-Health (5 for both healthcare centres), provision of technical support and technical support personnel for IT maintenance (10 in Gialoc and 20 in Hoaiduc respectively).

Vietnam	GIALOC (10 physicians)	HOAIDUC (10)
Frequency of Using PC	50% often use computer; 40% do not; 10% no response	20% often use computer; 70% do not; 10% no response
Purpose of Using PC	80% of the physicians (who often use computer) for updating information	50% of the physicians (who often use computer) for typing letter, and the other 50% for updating information
Frequency of Using E-media	50% using e-media; the rest do not.	20% using e-media; the rest do not.
Purpose of Using E-media	100% of the physicians using e-media for exchanging information	100% of the physicians using media for exchanging information
Training or direct experience in using EHR	None	None
Self Assessment: Training Need For EHR	100% think training is necessary	100% think training is necessary

Table 5.20. Past E-equipment Using Experience

- The percentage of physicians who often use PCs or e-medias is not greater than 50% in both healthcare centres (50% in Gialoc, 20% in Hoaiduc).
- No physician has had EHR training or have direct EHR use experience
- Training for EHR use is perceived to be necessary by all the physicians.

4.2.3.2. Technological Readiness Assessment

Existing available ICT infrastructure and e-resources are highly insufficient to support EHR implementations. Although two healthcare centres have limited quantity of hardware equipment (4 desktops, 3 monitor, 2 printers in Gialoc; 11 desktops, 1 monitor, 2 printers, 1 photocopier in Hoaiduc), the infrastructure requirement for the typical EHR implementation nevertheless is much more than these. There is no Internet access for both healthcare centres. In terms of software, no application is available for the maintenance of EHR, E-Healthcare training or to send emails even though there are some standard software packages (Windows Operation System and Anti-virus).

IT support personnel and physicians' past IT experience are other indispensable factors to determine technological readiness. Both healthcare centres have computer users for E-Health, provision of technical support and technical support personnel for IT maintenance. This has made a positive impact on their technological readiness. However, a small percentage of the physicians (20% in Hoaiduc and 50% in Gialoc) with IT background need more training in order to use EHR effectively. For all the interviewed physicians, regardless of whether they have IT experience or not, EHR training is necessary whereas for those who do not often use a PC or rarely use it, basic PC operation training should be undertaken prior to EHR training. The limitation of physicians' IT knowledge lowers the technological readiness assessment.

Insufficient ICT infrastructure and e-resources, as well as a low level of physicians' past IT experience, resulted in a low level of technological readiness in both healthcare centres.

4.2.4. Societal Readiness

4.2.4.1. Result Summary

The results of societal readiness parameters are summarised as follows:

- There is no communication links for both healthcare centres with other institutions (e.g. with hospitals and administrative centres) or provision of care in collaboration with other healthcare organisations (e.g. connected diagnostic facilities like pathology/radiology etc).
- Face-to-face and telephone are used as primary communication mediums between physicians in both healthcare centres. In Hoaiduc, all the interviewed physicians have face-to-face communication and 60% of them also use the telephone to communicate. The situation in Gialoc is slightly different. The percentage of the physicians using face-to-face as a communication medium is close to the percentage of these doing telephone (70% and 60% respectively). (Table 5.21, Table 5.22)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Face-to-face	4	40.0	40.0	40.0
	Face-to-face and Telephone	6	60.0	60.0	100.0
	Total	10	100.0	100.0	

Table 5.21. Communication medium between colleagues in HOAIDUC

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Face-to-face	4	40.0	40.0	40.0
	Telephone	3	30.0	30.0	70.0
	Face-to-face, Telephone and Email	1	10.0	10.0	80.0
	Face-to-face and Telephone	2	20.0	20.0	100.0
	Total	10	100.0	100.0	

Table 5.22. Communication medium between colleagues in GIALOC

- Frequent face-to-face communication occurs among all the physicians in both healthcare centres, while the other primary communication medium (telephone) is only frequently used by a small proportion of physicians (30% in Hoaiduc and 40% in Gialoc). (Table 5.23)

Frequent Use of Mediums	Hoaiduc Centre	Gialoc Centre
Face-to-face	100%	100%
Telephone	30%	40%

Table 5.23. Communication Frequency between two mediums in both centres

4.2.4.2. Societal Readiness Assessment

Societal readiness is determined by communication links for healthcare organisations with other institutions (e.g. with hospitals and administrative centres), provision of care in collaboration with other healthcare organisations (e.g. connected diagnostic facilities like pathology/radiology etc), frequent communication and communication mediums among healthcare providers (face to face, telephone, emails). There is no communication links or network facilities connected to both healthcare centres. Although physicians' frequent communication is dependent upon both face-to-face and telephone in the two centres, over half of the physicians (70%) interviewed in Gialoc only use single communication medium. Therefore, low readiness and medium readiness are scored respectively for the societal component in Gialoc and Hoaiduc.

4.2.5. Implications

With the preceding E-Health readiness assessment for individual readiness components, their implications can be drawn as shown in Table 5.24. If both healthcare centres are planning to fully implement a typical EHR system, more emphasis is needed for upgrading the deficiencies on the engagement, technological and societal readiness components while they continue to maintain their high status on the core readiness component.

Healthcare Centre	Core	Engagement	Technological	Societal	Implications
Hoaiduc	High	Medium	Low	Medium	More emphasis is needed for upgrading the deficiencies which cause organisations to score low or medium on the respective component. On the other hand, these organisations continue to maintain their high status on the readiness components on which they currently rank high.
Gialoc	High	Medium	Low	Low	

Table 5.24. Implications of E-Health Readiness Assessment for Individual Components in Hoaiduc and Gialoc

Deficiencies on the technological readiness component are reflected by a lack of ICT infrastructure, e-resources as well as physicians' limited IT background. There have been limited ICT equipment (i.e., desktops, monitors, printers and photocopiers) and applications (finance and statistics units, dermatology and e-referral) in the healthcare centres whereas the infrastructure requirement for the typical EHR implementation is much more than what is available, such as document scanners, phones, digitalised X-Ray equipments, high resolution digital cam monitored on a Microscope and Internet access. Also, no application has been properly maintained for proper integration with EHR system. There is also a lack of (ICT) facilities/personnel to support E-healthcare training or to send emails. In order to improve EHR implementation, more ICT infrastructure and e-resource need to be introduced.

Limited physicians' IT knowledge and experience result in medium engagement readiness. The training strategy should be made before EHR implementation. For example, basic PC operation training should be undertaken prior to EHR training for physicians and related healthcare staff. Physicians' perception of EHR systems needs to be more positive by incorporating education and awareness plans. This type of programmes can improve healthcare staff in understanding what EHR benefits are and how EHR can improve their performance. This strengthens physicians' willingness to accept training for EHR use and subsequently enhance EHR implementation success.

Medium/Low readiness for the societal readiness component is caused by the lack of communication links or network facilities connected to the healthcare centres and infrequent use of multiple communication mediums. Communication links of both healthcare centres with other institutions (e.g. with hospitals and administrative centres) and provision of care in collaboration with other healthcare organisations (e.g. connected diagnostic facilities like pathology/radiology etc) should be incrementally constructed. Secondly, frequent communication with multiple mediums, especially emails, can be enhanced by PC operation training to those who have never or rarely used PC or e-Media before.

In the meantime, high status should be maintained on the core readiness component. With the understanding of the status of paper health records in Section 4.2.1., some broad requirements of EHR systems that should be incorporated are to:

- ensure patients' records can be generated by multiple workers when needed;
- ensure patient records can be generated efficiently;
- ensure healthcare workers can access patient records efficiently when needed, and security and privacy issues are ensured especially in cases of multiple access; (further exploration is required for who the sharers are, and how and what type of information needs to be shared); and
- explore options to improve the completeness and accuracy of patient health records, as well as exploring ways to improve the human-computer interactional design of the EHR systems to suit end users (e.g. use of well designed forms for generating records, possibly with automated data validation checks or even introduction of patient portals as discussed in Section 2.2.4.).

These broad requirements generated from the above analysis are the start for the consideration and development of more detailed requirements for EHR systems.

4.2.6. Readiness Assessment Result with EHRAT

The same set of data was also processed with EHRAT and the readiness assessment results for Hoaiduc and Gialoc are respectively shown in Figures 5.1 and 5.2.

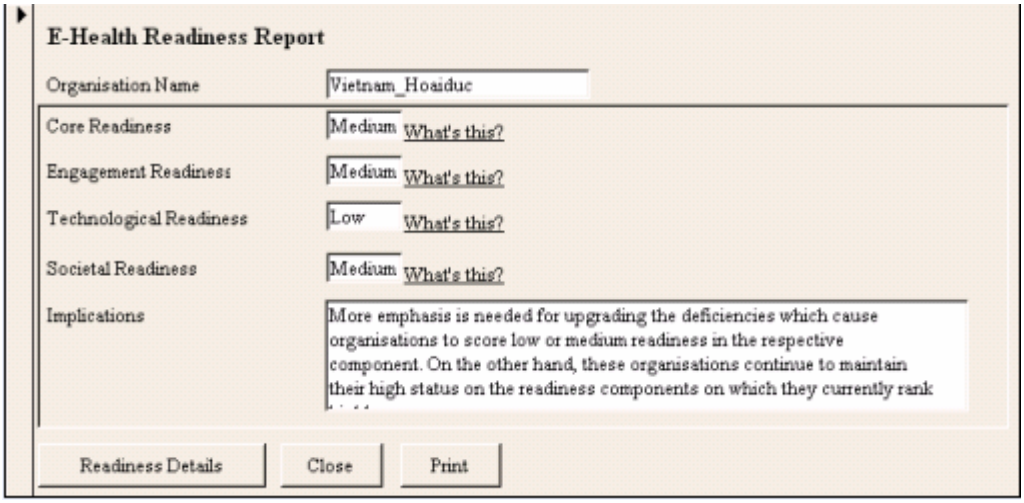

Figure 5.1. Readiness Assessment Results in Hoaiduc

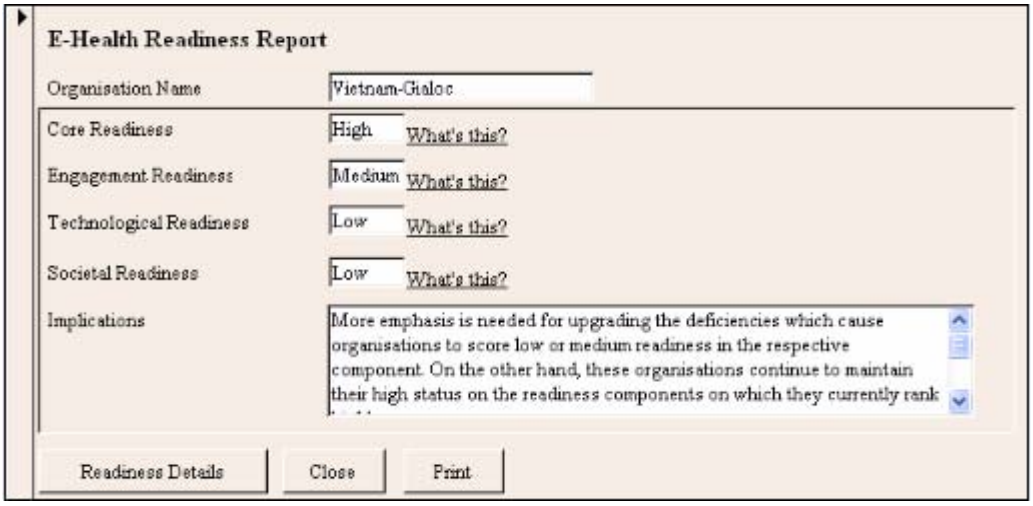

Figure 5.2. Readiness Assessment Results in Gialoc

The assessment results shown in Table 5.24, and Figure 5.1 and Figure 5.2 are identical except for the core readiness component in Hoaiduc. The core readiness was assessed high in Section 4.2.1 whereas the output of EHRAT is medium. As discussed in 3.2.2.1, core readiness assessment result (R(Core)) is determined by the variables: V(ED), V(PP), V(CA) and V(SR). For each variable, the value is either 1 (“True”) or

0 (“False”). Table 5.25 shows the values of the variables respectively from Section 4.2.1 and the output of EHRAT.

Core readiness assessment result	From Section 4.2.1	Output of EHRAT
R(Core)	High	Medium
V(ED)	0	0
V(PP)	0	0
V(CA)	0	1
V(SR)	0	0

Table 5.25. Value of Variables for Core Readines in Hoaiduc

It is observed that the core readiness assessment results are not identical because of different values of V(CA). The value of V(CA), according to the rules for core readiness in Section 3.4.2.1, is determined by whether the value of ç(avg(M(WT)) is greater than 3 (Equation 7). The value of M(WT) was filled on a scale where 1 stands for “not satisfied at all” with completeness and accuracy of patient records and 5 stands for “very satisfied”. Although Table 5.14 in Section 4.2.1 shows that in Hoaiduc, 20% of respondents reported dissatisfaction and 80% reported moderate or higher levels of satisfaction, the value of V(CA) was still filled with 0 because it was suggested that more room for improvement was required on this parameter.

4.3. Chapter Summary

This chapter presented the development of framework evaluation criteria for the evaluation of EHRAF. Based on a thorough literature review on frameworks in the healthcare domain, 18 criteria were identified. These criteria reflect different purposes and multiple characteristics of these frameworks. It has been discussed that EHRAF does not only match with six characteristic dimensions of the frameworks in general, but also serves multiple purposes in the healthcare domain. As well, a case study was conducted with assessment data collected in the two healthcare centres in Vietnam. The assessment results were nearly identical to the output of EHRAT.

Chapter 5
Conclusions

5.1. Summary

The importance of E-Health pre-implementation evaluation, especially in developing countries, has been discussed in Section 2.3.3. Nevertheless, most evaluation studies conducted in the healthcare context took place in the post-implementation phase. Even so, E-Health pre-implementation evaluation is still criticised in Section 2.6.1 for poor quality of research design, the lack of common outcome indicators and the absence of an agreed theory. Accordingly, this thesis has contributed to the development of the E-Health Readiness Assessment Methodology (EHRAM) using design science research methodology.

5.2. Contributions

Chapter 1 has discussed the background and motivation for this work with reference to recent work. This was followed by a thorough literature review in Section 2.3 which highlighted the importance of EHR pre-implementation evaluation, particularly for developing countries. Furthermore, several research gaps were identified related to the evaluation. In order to address these gaps, this thesis presented EHRAM. It involved:

- a new E-Health readiness assessment framework (EHRAF);
- a process for the readiness assessment; and
- a tool for the readiness assessment (EHRAT).

The following sections have covered the research and practical contributions, and summarise the results for this thesis.

5.2.1. Research Contributions

5.2.1.1. E-Health Readiness Assessment Framework (EHRAF)

EHRAF (Model) was developed by integrating the components from healthcare providers' and organisational perspectives of the existing E-Health readiness evaluation frameworks. It included four readiness components: core, engagement, technological and societal readiness. Each component can be rated as one of three different levels: high, medium and low. Evaluators can directly use this framework for organisations that plan to or will implement EHR systems. EHRAF contributes to the body of knowledge in E-Health. EHRAF implies future research area, organises the specific concepts already studied and proposes the legitimate boundaries for an E-Health area, which were discussed in Section 4.1.2.2.

5.2.1.2. Process for Readiness Assessment

The process of EHRAM (Method) started with the development of a set of hierarchical evaluation criteria based on EHRAF. This led to the questionnaire modification for data collection from groups of healthcare practitioners (including physicians, administration officers and IT technicians). The data were analysed using a number of statistical and data mining techniques in order to determine significant parameters (e.g. cross tabulation tests, statistically significant correlations ($p<0.05$)) and more importantly, to assess the current E-Health readiness status of the given context. The assessment outcomes fed into the requirement specification of E-Health system implementation.

5.2.1.3. Evaluation of EHRAM

The evaluation of EHRAM has been conducted with the framework evaluation criteria and a case study. Through another thorough literature review in Section 4.1,

the criteria for the evaluation of frameworks in the healthcare/E-Health domain have been developed. The criteria reflect multiple approaches to understanding the structure of the frameworks and EHRAF met these criteria as discussed in Section 4.1.2. The case study used a set of data collected in two healthcare centres in Vietnam from the WHO eHCD project and revealed their E-Health readiness status.

5.2.2. Practical Contributions

5.2.2.1. Tool for Readiness Assessment (EHRAT)

In order to automate the use of EHRAM, online surveys have been created for data collection (surveymonkey.com) and more importantly EHRAT (Instantiation) has been developed for data analysis. The survey or interview data from different healthcare providers can be imported into EHRAT. EHRAT provided the main function of processing the data to reveal E-Health readiness status in terms of the core, engagement, technological and societal readiness, as well as corresponding implications (see Table 3.2.). In order to validate EHRAT, some data from the WHO eHCD project were used and the readiness assessment results were approved by two E-Health experts involved in this project.

5.2.2.2. Implications of the Case Study

As a result of the E-Health readiness assessment for individual readiness components, the implications in Section 4.2.5 provided decision makers in the two healthcare centres in Vietnam with suggestions to facilitate the E-Health implementation succeess. Also, broad requirements for EHR systems were generated for the consideration and development of more detailed requirements.

5.3. Limitations

There are some limitations for this thesis:

- The amount of data available was insufficient for the full validation of EHRAM. The sample size for each studied healthcare centre was small.
- Current framework (EHRAF) has limited capability in predicting the success of E-Health in the context of measures such as physicians' acceptance. More measures are needed to predict physicians' acceptance of EHR systems, but the available archive data did not capture these measures.
- Each readiness component in EHRAF was assessed as one of three different levels: high, medium and low (discretely defined). Real life levels are more fuzzy in nature, i.e. continuous scales.

5.4. Future Work

Although a methodology (EHRAM) has been developed for assessing E-Health readiness, there is a need for further investigation in this area. The future work involves:

- There is need for more sophisticated EHRAF (perhaps incorporating fuzzy levels) in order to get more realistic assessment results.
- More studies are required to validate EHRAM. For example, similar case studies can be conducted to assess E-Health readiness in other developing countries.
- E-Health readiness assessment in this thesis was conducted from EHR perspective and in the future it can be studied from the perspective of holistic E-Health systems (e.g. telemedicine and e-referral systems). The future study is supposed to start with the modification of the readiness components but focus on the coverage of the core readiness, as other E-Health systems using

the same platform (e.g. ICT infrastructure, communication links, healthcare providers) that EHR uses provide different types of service.

- The current E-Health readiness assessment framework (EHRAF) was only concerned with healthcare providers' and organisational readiness. A more comprehensive framework needs to incorporate components from patients', system and public perspectives according to future evaluation needs.

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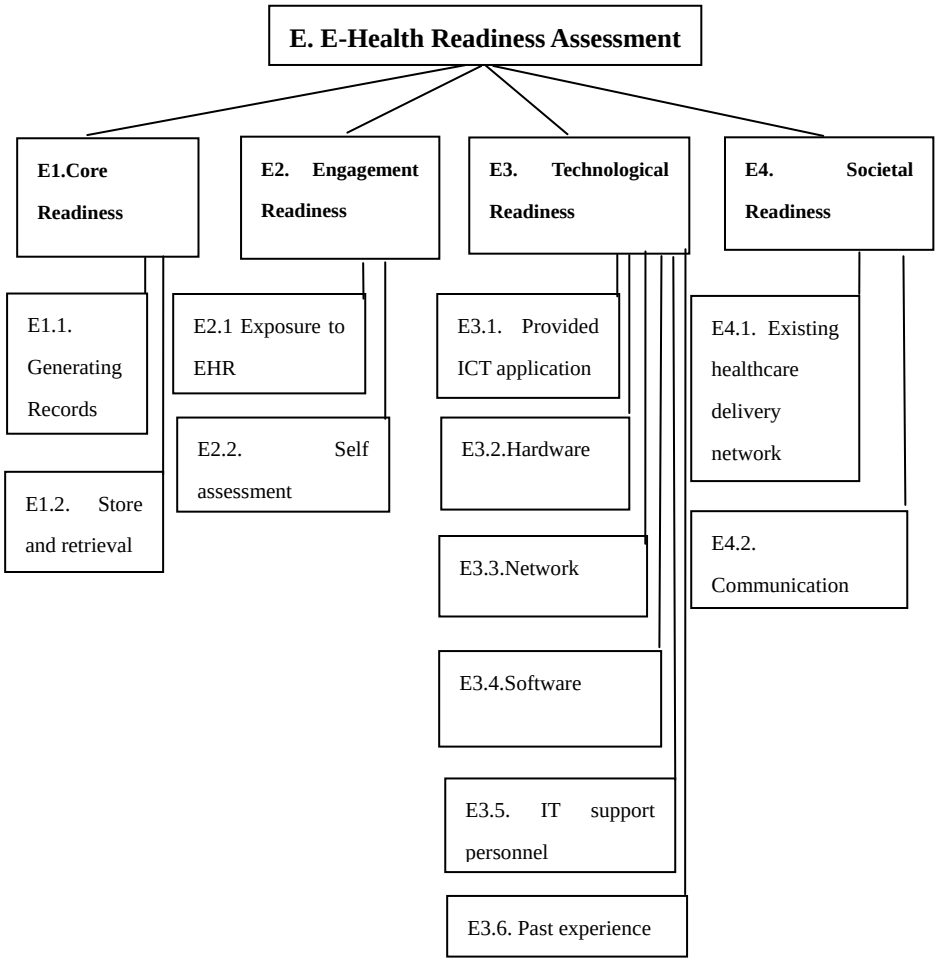
Appendix 1 Hierarchical E-Health Readiness Assessment Criteria



E1. Core Readiness

E1.1. Generating records
E1.1.1. Means of recording (Paper-based)
E1.1.2. Staff responsible
E1.1.3. Standard format
E1.1.4. Average time

E1.2. Storing & retrieval
E1.2.1. Staff responsible
E1.2.2. Means of storage (Locked filing cabinets)
E1.2.3. Standard format
E1.2.4. Accessibility/confidentiality

E1.2.5. Average time
E1.2.6. Degree of complete and accurate records
E1.2.7. Satisfactory of sharing patient records

E2. Engagement Readiness

E2.1. Exposure to EHR
E2.1.1. Potential benefits
E2.1.2. Limitations
E2.1.3. Expectations
E2.1.4. Potential impacts
E2.1.5. Anticipated problems

E2.2. Self-assessment
E2.2.1. Need training for EHR use
E2.2.2. How much time (No data)

E3. Technological Readiness

E3.1. Provided ICT applications
E3.1.1. EHR
E3.1.2. Other ICT applications

E3.2. hardware
E3.2.1. Laptop
E3.2.2. Desktop
E3.2.3. Monitor
E3.2.4. Printer
E3.2.5. Document scanner
E3.2.6. Photocopier
E3.2.7. Phone
E3.2.8. TV based conferencing
E3.2.9. PC based conferencing
E3.2.10. Web cam connected
E3.2.11. Digitalised X-Ray Equipment
E3.2.12. High resolution digital cam monitored on a Microscope

E3.3. Network
E3.3.1. Internet access

E3.4. Software
E3.4.1. Maintenance of EHR
E3.4.2. Electronic Healthcare training

E3.4.3. To send emails
E3.4.4. Standard software

E3.5. IT support personnel
E3.5.1. Users of computer for E-Health
E3.5.2. Provision of technical support
E3.5.3. Technical support personnel

E3.6. Past experience
E3.6.1. Frequency of using PC
E3.6.2. Purpose for using pc
E3.6.3. Frequency of using e-media
E3.6.4. Purpose for using e-media
E3.6.5. Training or direct experience in using EHR

E4. Societal Readiness

E4.1. Existing health care delivery network
E4.1.1. Social network (Communication links to both hospitals and administrative centres, and provision of care in collaboration with other organisations (e.g. connected diagnostic facilities))
E4.2. Communication
E4.2.1. Medium
E4.2.2. Frequency to communicate with others (Yes)

Appendix 2 Definition of Evaluation Templates

Name	Categorised As	Defined As	Type	Value
E1.1. Generating records	*Core Readiness*			
E1.1.1. Means of recording	Generating records		Nominal	Handwritten 1/Dictaphone 2/ Transcription 3
E1.1.2. Staff responsible	Generating records	Who responsible for recording	Nominal	Physician 0/ Physician and Assistant ((Nurse, Technician, or Secretary): 1
E1.1.3. Standard format	Generating records	For collecting information	Nominal	No 0/Yes 1
E1.1.4. Average time	Generating records	Taken to record patient	Ratio	Minutes
E1.2. Storing & retrieval	*Core Readiness*			
E1.2.1. Staff responsible	Storing & retrieval	Who responsible for maintaining records	Nominal	Physician 0/ Physician and Assistant ((Nurse, Technician, or Secretary): 1
E1.2.2. Means of storage	Storing & retrieval	The way to store records	Nominal	Locked 1 or unlocked 2 filing cabinets
E1.2.3. Standard format	Storing & retrieval	For storage	Nominal	Alphabetic 1; Date wise 2; Copies-Number and type 3; Alphabetic and Date wise 5; By department 4; All 6
E1.2.4. Accessibility/confidentiality	Storing & retrieval	who can access patient records	Nominal	Physician 0/ Physician and Assistant ((Nurse, Technician, or Secretary): 1
E1.2.5. Average time	Storing & retrieval	For a record retrieval per patient	Ratio	Minutes
E1.2.6. Degree of complete and accurate records	Storing & retrieval	Check the quality of patients recorded	Interval	Graded user opinion (scale 1-5). 5 stand for quite satisfied. Subjective judgment between 1 and 5.
E1.2.7. Satisfactory of sharing patient records	Storing & retrieval	Check the quality of patients recorded	Interval	Graded user opinion (scale 1-5). 5 stand for quite satisfied. Subjective judgment between 1 and 5.
E2.1. Exposure to EHR	*Engagement Readiness*			
E2.1.1. Potential benefits	Exposure to	Benefit the	Nominal	a. minimal time for recording and

	EHR Potential benefits	healthcare community and patient health outcomes		retrieving relevant patient information: No 0/Yes 1 b. minimal time to diagnosis & treatment: No 0/Yes 1 c. confidentiality of patient information: No 0/Yes 1
E2.1.2. Limitations	Exposure to EHR Potential benefits	Of EHR system.	Nominal	*a.* High investment and Budget: No 0/Yes 1 b. Have the IT knowledge: No 0/Yes 1 c. Provide stability of electronic power: No 0/Yes 1
E2.1.3. Expectations	Exposure to EHR Potential benefits	In terms of its ability to remedy some of the current problems or improve efficiency/quality of health care or service provided.	Nominal	*a.* Providing & sharing timely information: No 0/Yes 1 b. Minimal time for recording and retrieving relevant patient information: No 0/Yes 1 c. Improve capacity of diagnosis & treatment: No 0/Yes 1
E2.1.4. Potential impacts	Exposure to EHR Potential benefits	Of implementing an EHR system at the health centre.	Nominal	*a.* Support for telemedicine: No 0/Yes 1 b. Better providing information: No 0/Yes 1 c. Support for science research: No 0/Yes 1
E2.1.5. Anticipated problems	Exposure to EHR Potential benefits	May arise from the use of EHR systems	Nominal	*a.* Lack of Budget: : No 0/Yes 1 b. Limitation of IT knowledge: No 0/Yes 1 c. Provide electronic power not continuous: No 0/Yes 1
E2.2. Self-assessment	*Engagement Readiness*			
E2.2.1. Need training for EHR use	Self-assessment	Need training for efficient use of an EHR system?	Nominal	No 0/Yes 1
E2.2.2. How much time	Self-assessment	How much time can be spent on training	Ratio	Hours
E3.1. Provided ICT applications	*Technological Readiness*			
E3.1.1. EHR	Provided ICT applications		Nominal	No 0/Yes 1

E3.1.2. Other ICT applications	Provided ICT applications		Narrative	
E3.2.Hardware	*Technological Readiness*			
E3.2.1. Laptop	Hardware	No. of laptop	Ratio	Numbers
E3.2.2. Desktop	Hardware	No. of desktop	Ratio	Numbers
E3.2.3. Monitor	Hardware	No. of monitor	Ratio	Numbers
E3.2.4. Printer	Hardware	No. of printer	Ratio	Numbers
E3.2.5. Document scanner	Hardware	No. of document scanner	Ratio	Numbers
E3.2.6. Photocopier	Hardware	No. of photocopier	Ratio	Numbers
E3.2.7. Phone	Hardware	No. of phone	Ratio	Numbers
E3.2.8. TV based conferencing	Hardware	TV based video conferencing systems	Ratio	Numbers
E3.2.9. PC based conferencing	Hardware	PC based video conferencing systems	Ratio	Numbers
E3.2.10. Web cam connected	Hardware	Web cam connected to the laptop/desktop	Ratio	Numbers
E3.2.11. Digitalised X-Ray Equipment	Hardware	Any computer connected with digitalised X-Ray Equipment	Ratio	Numbers
E3.2.12. High resolution digital cam monitored on a Microscope	Hardware	Any computer connected with the high resolution digital cam monitored on a Microscope	Ratio	Numbers
E3.3.Network	*Technological Readiness*			
E3.3.1. Internet access	Network		Nominal	No 0/Yes 1
E3.4. Software	*Technological Readiness*			
E3.4.1. Maintenance of HER	Software	Software for maintenance of HER	Nominal	No 0/Yes 1
E3.4.2. Electronic Healthcare training	Software	Software for Electronic Healthcare training	Nominal	No 0/Yes 1
E3.4.3. To send emails	Software	Access to software to send emails	Nominal	No 0/Yes 1

E3.4.4. Standard software	Software	(OS, Office suit, Anti-virus)	Nominal	No 0/Yes 1
E3.5. Personnel	*Technological Readiness*			
E3.5.1. Users of computer for E-Health	Personnel	No. of users of computer for E-Health	Ratio	Numbers
E3.5.2. Provision of technical support	Personnel	Provision of technical support for the infrastructure	Nominal	No 0/Yes 1
E3.5.3. Technical support personnel	Personnel	No. of technical support personnel	Ratio	Numbers
E3.6. Past experience	*Technological Readiness*			
E3.6.1. Frequency of using PC	Past experience	Whether often using PC	Nominal	No 0/Yes 1
E3.6.2. Purpose for using pc	Past experience	For what purpose	Narrative	
E3.6.3. Frequency of using e-media	Past experience	Whether often using e-media (e.g. email)	Nominal	No 0/Yes 1
E3.6.4. Purpose for using e-media	Past experience	For what purpose	Narrative	
E3.6.5. Training or direct experience in using EHR	Past experience	Have had training or experience in using EHR?	Nominal	No 0/Yes 1
E4.1. Existing health care delivery network	*Societal Readiness*			
E4.1.1. Social network	Existing health care delivery network	Communication links to both hospitals and administrative centres, and provision of care in collaboration with other organisations (e.g. connected diagnostic facilities)	Nominal	a. Hospitals: No 0/Yes 1 b. Administrative centres: No 0/Yes 1 c. Connected diagnostic facilities: No 0/Yes 1
E4.2. Communication	*Societal Readiness*			
E4.2.1. Medium	Communication	Currently used to interact with	Nominal	Face-to-face, Telephone or Email 0/ More than one medium 1

		colleagues or other members of the profession		
E4.2.2. Frequency to communicate with others	Communication	Whether often interacting with others	Nominal	No 0/Yes 1

Appendix 3 Questionnaire for Interview

CATEGORY 1

Aim: to establish background and settings for health care

Interviewee: A health administrator or healthcare worker

Name & address of healthcare centre (country):
Name of interviewee:
Designation & role:
Interview date:
Name of interviewer:
Qualifications of interviewer:

Q1.
Briefly describe the geographical location and settings of your healthcare setting?
(a). Name of District & State:

(b). Nearest big city:

(c). Topography (eg. Mountains/ Rivers/ Plains/ Coast/ Island etc.):

(d). Other details

Q2.
Briefly describe the existing healthcare delivery network of your healthcare setting:
(a). Category of your healthcare centre :
e.g. primary Health Centre, Community Health Centre, Clinic, Small/ Regional/ District Hospital or Major Hospital (with specialist facilities)

(b). Describe the social network to your healthcare centre:
Communication links to both hospitals and administrative centres
Provision of care in collaboration with other organisations (e.g. connected diagnostic facilities, such as pathology/radiology etc)

(c). Staff at your healthcare centre:
No. of general physicians,
No. of specialist physicians

No. of paramedics
No. of nurses
No. of technical officers
Others

Q3.
Briefly describe the communities served by your healthcare centre.
(a). Total Population of region served:

(b). Average annual number of patient visits:

(c). Other details:

CATEGORY 2

Aim: to determine the existing infrastructure & electronic resources available

Interviewee: IT support staff/ officer

Name & address of healthcare centre (country):
Name of interviewee:
Designation & role:
Interview date:
Name of interviewer:
Qualifications of interviewer:

Q1.
Is the centre providing any ICT application?
e.g. Dermatology, Ecg Diagnostics, Radiology, Histopathology, EHR, E-referrals, E-learning or others

Q2.
Briefly introduce the Network/Hardware in the centre.
(a). No. of Laptop:

(b). No. of Desktop:

(c). No. of Monitor:

(d). No. of Printer:

(e). No. of Document Scanner:

(f). No. of Photocopier:

(g). No. of Phone (ISDN/Normal):

(h). TV Based Video Conferencing Systems (Yes/No):

(i). PC based Video Conferencing Systems (e.g. Webcam Connected to PC): Yes/No

(j). No. of Web Cam or Digital Camera connected to the Laptop/PC:

(k). No. of computer connected with the Digitalized X-Ray Equipment:

(l). No. of computers connected with the high resolution Digital camera Monitored on

a Microscope:

(m). What are the standard Software and Operating Systems Installed on the Laptop and the PC

a. Windows XP/ Windows 98/Linux/ Other Windows /Other Operating Systems
b. MS Office /Other Office software suit
c. Antivirus, Spy ware remover etc

(n). Do you have Internet access?

If yes,

what is the connectivity Options? ADSL/SDSL/SHDSL/Dialup/ISDN/Other

what is the bandwidth for Internet Connectivity? e.g. 64/64 kbps, 64/32 kbps, 256/256 kbps, 512/256 kbps, 512/512 kbps (Here 64/64 kbps means 64 kbps Upstream and 64 kbps Downstream bandwidth)

Q3.

Software

(a). Do you have any Software installed for Maintenance of Electronic Health care Record?

(b). Do you have any Software installed for Electronic Health care Training?

(c). Do you have access to Software to send Emails?

Q4.

Personnel

(a). How many users of Computers for healthcare delivery do you have?

(b). Do you have arrangement for providing technical Support for the infrastructure?

If yes, how many Technical Support personnel are involved?

CATEGORY 3

Aim: baseline data for electronic patient records and electronic referrals

Interviewees: 10 physicians

Name & address of healthcare centre (country):
Name of interviewee:
Designation & role:
Interview date:
Name of interviewer:
Qualifications of interviewer:

(A)
Existing local healthcare status

Q1.
Do you conduct your clinical practice as an individual clinician or in a clinical team? If you work in team do you need to share patient records with other clinicians?

Q2.
What is the current system of generating patient health records?
(a). Means of recording, e.g. handwritten, dictaphone & transcription etc)

(b). Staff responsible (eg. physicians, or physicians and assistants such as nurse/technician/secretary etc)

(c). Standard format for collecting information (eg. a form, minimum fields for clinical notes etc)

(d). Average time spent on generation of patient record per patient:

Q3.
What is the current system of storing and retrieving patient health records?
(a). Who is responsible for maintaining patient health records – healthcare professionals or patient?

(b). If healthcare professionals are responsible for maintaining health records, what is the current procedure for storage and retrieval of patient records (eg. means of storage - locked/unlocked filing cabinets/ cupboards, standard format for storage - alphabetically/date wise/ copies- number & type, security)
(c). Accessibility (staff with authorised access to patient records e.g. physicians, or

physicians and assistants such as nurse/technician/secretary etc)

(d). Average time for record storage and retrieval per patient:

Q4.
In your point of view, does the current patient record system provide complete and accurate patient records?

Q5.
If you work in a clinical team, is the format and quality of patient records satisfactory for effective sharing of patient information?

Q6.
Does the current patient record system provide optimal cost effectiveness and efficiency of health care or service? For example does the current system allow optimal patient throughput/ minimal time for generating and retrieving relevant patient information/ minimal time to diagnosis & treatment/ confidentiality of patient information etc?

Q7.
What are the main limitations/drawbacks of the current system of generating, storing and retrieving patient records?

Q8.
How do you currently interact/ communicate with colleagues or other members for your profession? (i.e., medium of communication, such as face to face, telephone, email etc)

Q9.
How often do you usually interact/ communicate with colleagues or other members for your profession?

(B)
Perception of E-Health record and potential benefits of EHR

Q1.
From your point of view, what will EHR systems potentially benefit the healthcare community and patient health outcomes?
(a). Minimal time for recording and retrieving relevant patient information?

(b). Minimal time to diagnosis & treatment?

(c). Improved confidentiality of patient information etc?

(d). Other

Q2.
What are the limitations of EHR systems?
(a). High investment and Budget?

(b). Individual limited IT experience?

(c). Provide stability of electronic power?

(d). Other

Q3.
If an EHR system was implemented at your centre, what would be your expectations in terms of solving some current problems or improving efficiency/quality of health care or service provided?
(a). Providing & sharing timely information?

(b). Minimal time for recording and retrieving relevant patient information?

(c). Improve capacity of diagnosis and treatment?

(d). Other

Q4.
What could be other potential impacts of implementing an EHR system at your health centre?
(a). Support for telemedicine?

(b). Better providing patient information?

(c). Support for science research?

(d). Other

Q5.
What problems do you anticipate that may arise from the use of EHR systems at your centre?
(a). Lack of Budget?

(b). Limatation of IT knowledge?
(c). Provide electronic power not continuous?

(d). Other

(C)
Determination of Post-Training

Q1.
Do you often use a personal computer and for what purpose?

Q2.
Do you often use any form of electronic media (such as email/ the internet) and for what purpose?

Q3.
Have you ever had training or direct experience in using electronic health record systems? If yes, please give details of types of training received or your experiences with electronic health record systems used.

Q4.
Do you think you need training for the use of an EHR system? If you think you do, how much time can you spend in being trained?

Appendix 4 Online Survey

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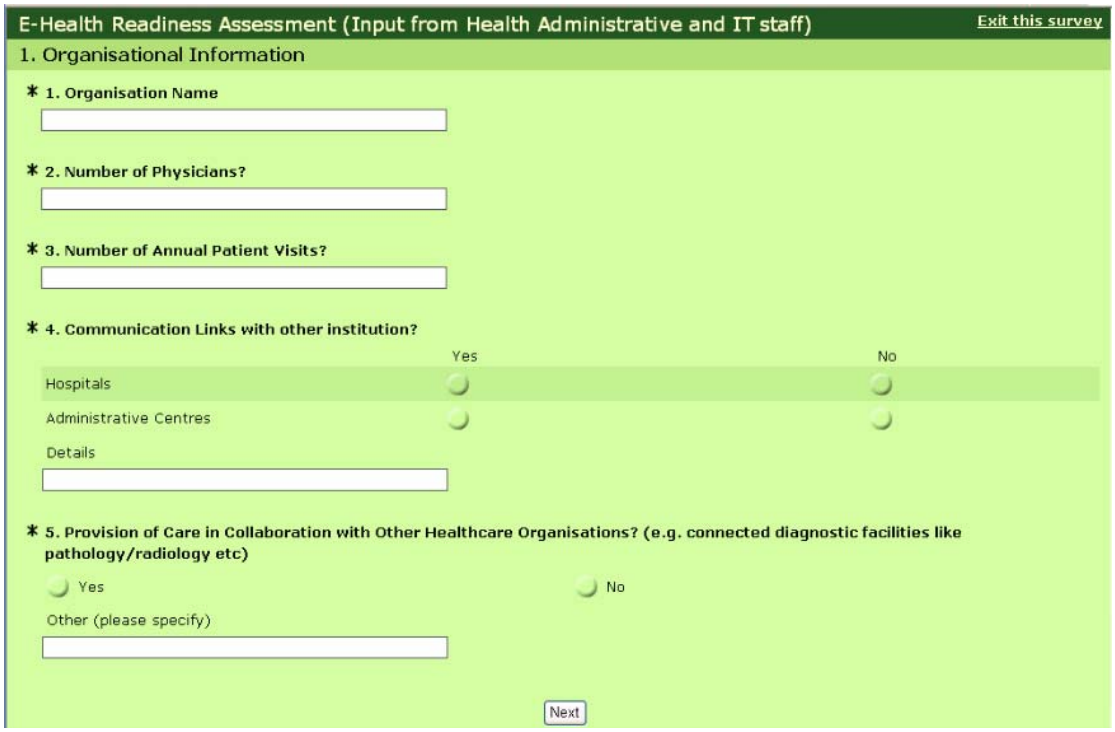
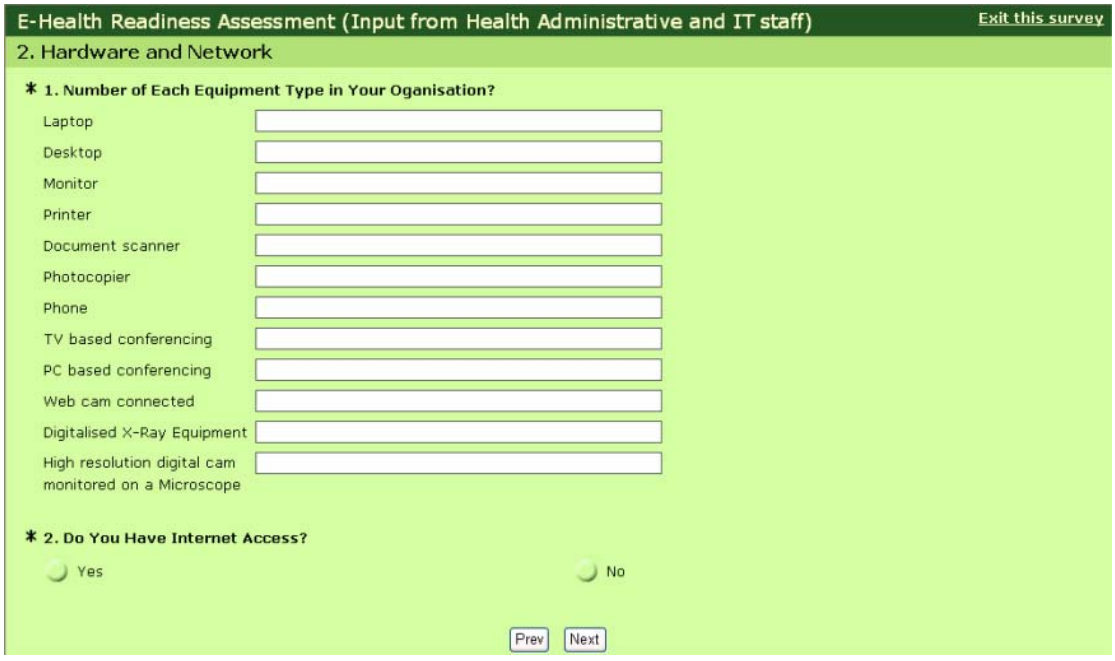





E-Health Readiness Assessment (Input from Health Administrative and IT staff) Exit this survey

3. Software and IT personnel

* 1. Which Types of Software Does Your Organisation Have?

	Yes	No
Maintenance of EHR		
Electronic Healthcare Training		
To Send Emails		
Standard Software Package (i.e. Anti-Virus and Operation System)		

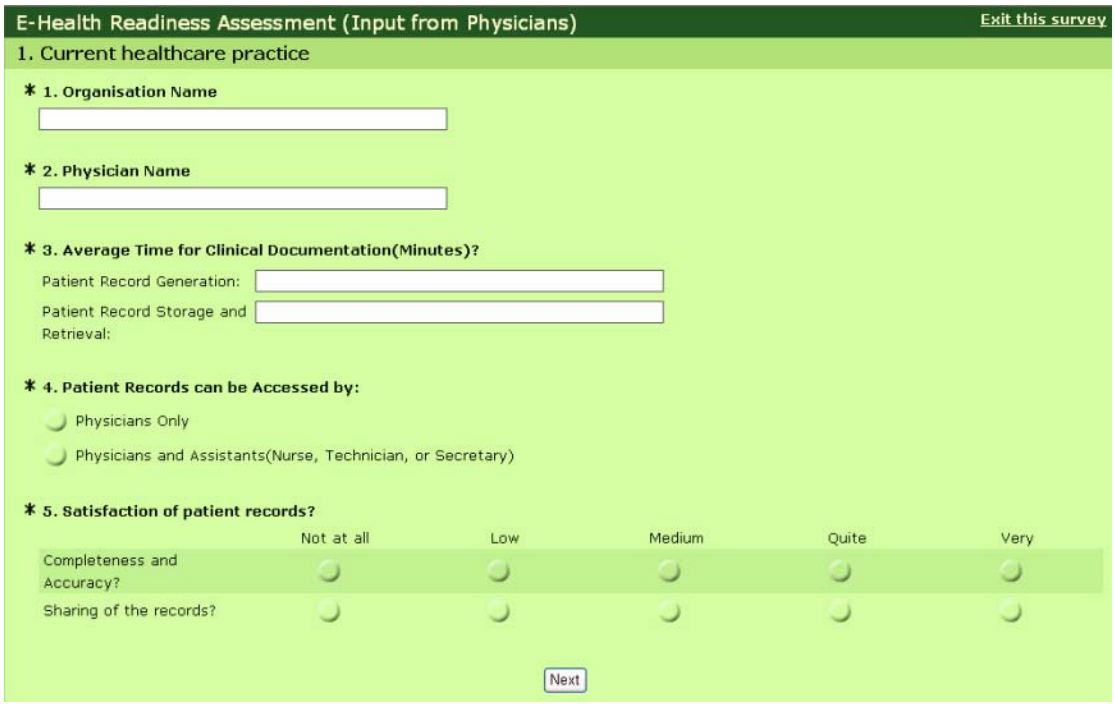
* 2. IT Support Personnel?

Number of Computer Users for E-Health

Number of Technical Support Personnel

Prev Done

http://www.surveymonkey.com/s.aspx?sm=rx6KOh2_2fqh_2fU1rNmfsdh_2fQ_3d_3d


E-Health Readiness Assessment (Input from Physicians) Exit this survey

1. Current healthcare practice

* 1. Organisation Name

* 2. Physician Name

* 3. Average Time for Clinical Documentation(Minutes)?

Patient Record Generation:

Patient Record Storage and Retrieval:

* 4. Patient Records can be Accessed by:

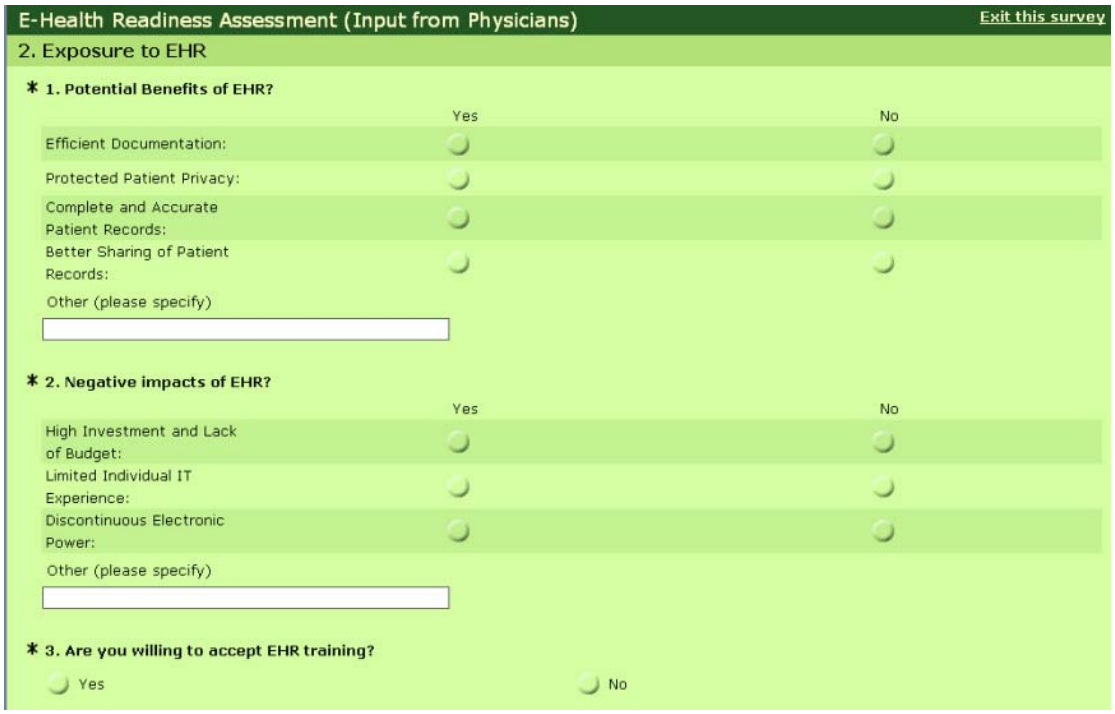
Physicians Only

Physicians and Assistants(Nurse, Technician, or Secretary)

* 5. Satisfaction of patient records?

	Not at all	Low	Medium	Quite	Very
Completeness and Accuracy?					
Sharing of the records?					

Next



E-Health Readiness Assessment (Input from Physicians) Exit this survey

2. Exposure to EHR

* 1. Potential Benefits of EHR?

	Yes	No
Efficient Documentation:	○	○
Protected Patient Privacy:	○	○
Complete and Accurate Patient Records:	○	○
Better Sharing of Patient Records:	○	○

Other (please specify)

* 2. Negative impacts of EHR?

	Yes	No
High Investment and Lack of Budget:	○	○
Limited Individual IT Experience:	○	○
Discontinuous Electronic Power:	○	○

Other (please specify)

* 3. Are you willing to accept EHR training?

○ Yes ○ No

E-Health Readiness Assessment (Input from Physicians) Exit this survey

3. Physicians' IT Experience and Communication

* 1. Past IT Experience

	Yes	No
Frequently Used Computers?	○	○
Frequently Used E-Media? (e.g. Email and Internet)	○	○
Got EHR Training/Using Experience?	○	○

* 2. Frequent Communication for Healthcare Profession?

○ Yes ○ No

Communication Medium? (e.g. Face to Face, Telephone and Email)

Done

Appendix 5 Tables for EHRAT

Field Name	Data Type	Assessment Results, Variables or Measures
OrganisationName*	Text (50)	
NumberPhysicians	Number	M(NP)
AvAnnualNumberPatientVisit	Number	M(ANP)
CoreEfficiency	Number	V(ED)
CorePrivacy	Number	V(PP)
CoreCompleteness	Number	V(CA)
CoreSharing	Number	V(SR)
EngagementEfficiency	Number	ç(avg(M(ED))
EngagementPrivacy	Number	ç(avg(M(PP))
EngagementCompleteless	Number	ç(avg(M(CAR))
EngagementSharing	Number	ç(avg(M(BS))
EngagementHighInvest	Number	ç(avg(M(HI))
EngagementLimitedIT	Number	ç(avg(M(LIT))
EngagementDiscontinuousPower	Number	ç(avg(M(DP))
EngagementWillingness	Number	ç(avg(M(WT))
TechHardwareLaptop	Number	M(LT)
TechHardwareDesktop	Number	M(DT)
TechHardwareMonitor	Number	M(MT)
TechHardwarePrinter	Number	M(PT)
TechHardwareScanner	Number	M(DS)
TechHardwarePhotocopier	Number	M(PC)
TechHardwarePhone	Number	M(PH)
TechHardwareTVConf	Number	M(TVC)
TechHardwarePCConf	Number	M(PCC)
TechHardwareWebcam	Number	M(WC)
TechHardwareXray	Number	M(XR)
TechHardwareCamMicroscope	Number	M(DCM)
TechNetworkInternet	Number	M(IA)
TechSoftwareEHRMaintenance	Number	M(EHRM)
TechSoftwareETraining	Number	M(ET)
TechSoftwareEmail	Number	M(SE)
TechSoftwareStandard	Number	M(SS)
TechPersonnelEHealthUser	Number	M(EHU)
TechPersonnelTechnicalSupport	Number	M(TS)
TechExperienceFrequencyPC	Number	V(FUC)
TechExperienceFrequencyEMedia	Number	V(FUE)
TechExperienceEHR	Number	V(TUE)
SocietalFacilityDiagnostic	Number	M(CO)

SocietalFacilityHospital	Number	M(HP)
SocietalFacilityAdmin	Number	M(AC)
SocietlCommunicationFrequency	Number	M(ICF) and M(ICM)
CoreReadiness	Text (6)	R(Core)
EngagementReadiness	Text (6)	R(Engagement)
TechReadiness	Text (6)	R(Technological)
SocietalReadiness	Text (6)	R(Societal)
OverallReadiness	Text (6)	

Table Main (* stands for a KEY)

Field Name	Data Type	Variables or Measures
Physician ID*	Counter	
OrganisationName	Text (50)	
PhysicianName	Text (20)	
Time4Generation	Number	M(ATGR)
Time4Storage&Retrieval	Number	M(ATSR)
RecordAccessibility	Number	M(ACR)
RecordCompleteness	Number	M(DCAR)
SatisfactionSharing	Number	M(SSR)
ExposureEfficient	Number	M(ED)
ExposureProtected	Number	M(PP)
ExposureComplete	Number	M(CAR)
ExposureBtterSharing	Number	M(BS)
ExposureBudget	Number	M(HI)
ExposureITLimitation	Number	M(LIT)
ExposureDiscontinuousPower	Number	M(DP)
FrequentComputer	Number	M(FUC)
FrequentE-Media	Number	M(FUE)
EHRExperience	Number	M(TUE)
Willingness2Training	Number	M(WT)
CommunicationMedium	Number	M(ICM)
CommunicationFrequency	Number	M(ICF)

Table Physician (* stands for a KEY)

Field Name	Data Type	Variables or Measures
OverallReadiness*	Text (6)	
Implications	Memo	

Table Implication (* stands for a KEY)

Appendix 6 Forms, Macros and Queries Used for EHRAT

Forms	Macros	Queries	Corresponding Equations
FormMain	Main->Insert Main->Edit Main->Readiness Main->History CloseAllForms		
FormInsertOrganisation	MacroAddOrganisation	QueryAddOrganisation	
	MacroCloseFormInsertOrganisation MacroInsertOrganisation->Physician Insert->Edit Insert->Readiness Insert->History		
FormInsertPhysician		QuerySelect4InsertOrganisation ->Physician	
	MacroAddPhysician	QueryAddPhysician	
	MacroInsertPhysician->Organisation MacroMsgAddSuccessful		
FormQuery4FormEdit		Query4FormEdit	
	Edit->Readiness Edit->History Edit->Insert MarcoSelect2Edit		
FormEditOrganisation		QuerySelect2Edit	
	MacroEditOrganisation->Physician MacroEditSuccessful MacroCloseformEditOrganisation		
	MacroDeleteOrganisation	QueryDeleteOrganisation	
	MacroUpdateOrganisation	QueryUpdateOrganisation	
		QuerySelectPhysician	
FormEditPhysician		QuerySelect4EditPhysicians	
	MacroEditPhysician->Organisation MacroEditSuccessful MacroCloseFormEditPhysician		
	MacroUpdatePhysician	QueryUpdatePhysician	
	MacroDeletePhysician	QueryDeletePhysician	

Form4Readiness		Query4FormReadiness QueryMAIN-PHYSICIAN	
	Readiness->Edit Readiness->Insert Readiness->History		
	MacroOpenFormReadiness	UpdateCoreEfficiency0 UpdateCoreEfficiency1	Equation 5
		UpdateCorePrivacy1 UpdateCorePrivacy0	Equation 6
		UpdateCoreCompleteness1 UpdateCoreCompleteness0	Equation 7
		UpdateCoreSharing1 UpdateCoreSharing0	Equation 8
		EngagementEfficiency1 EngagementEfficiency0 EngagementPrivacy1 EngagementPrivacy0 EngagementCompleteness1 EngagementCompleteness0 EngagementSharing1 EngagementSharing0	Equation 11
		EngagementHighInvest1 EngagementHighInvest0 EngagementLimitedIT1 EngagementLimitedIT0 EngagementPower1 EngagementPower0	Equation 10
		EngagementWillingness1 EngagementWillingness0	Euqation 12
		TechFrequencyPC1 TechFrequencyPC0	Equation 14
		TechEHRexperience1 TechEHRexperience0	Equation 16
		SociCommunication1 SociCommunication0	Equation 18 Equation 19
		TechFrequencyE-media1 TechFrequencyE-media0	Equation 15
		QueryCoreHigh1 QueryCoreLow2 QueryCoreMedium3	Equation 9
		QueryTechHigh1 QueryTechMedium2 QueryTechLow3	Equation 17
		QueryEngagementHigh1	Equation 13

		QueryEngagementLow2 QueryEngagementMedium3	
		QuerySocietalHigh1 QuerySocietalLow2 QuerySocietalMedium3	Equation 20
		QueryOverallHigh1 QueryOverallLow2 QueryOverallMedium3	
FormReadiness		QueryforFormReadiness	
	MacroCloseFormReadiness MacroReadiness->ReadinessDetail		
FormReadinessDetail	MacroReadinessDetails->Readiness MacroCloseFormReadinessDetail		
FormHistoryReadiness	MacroOpenFormSingleHistoryReadiness	Query4ReadinessHistory	
	History->Edit History->Readiness History->Insert		
FormSingleHistoryReaediness		QuerySingleHistoryReaediness	
	MacroHistory->HistoryDetails MacroCloseFormSingleHistoryReaediness		
FormSingleHistoryReadinessDetails	MacroHistoryDetails->History MacroCloseFormSingleHistoryReadiness Details		
FormInfoCore	CloseFormInfoCore		
FormInfoEngagement	CloseFormInfoEngagement		
FormInfoTech	CloseFormInfoSocietal		
FormInfoSocietal	CloseFormInfoTech		

Appendix 7 Source Code for Macro MacroOpenFormReadiness

```
'------------------------------------------------------------
' Form4Readiness
'
'------------------------------------------------------------

Private Sub Readiness__Insert_Click()
On Error GoTo Err_Readiness__Insert_Click

    Dim stDocName As String

    stDocName = "Readiness->Insert"
    DoCmd.RunMacro stDocName

Exit_Readiness__Insert_Click:
    Exit Sub

Err_Readiness__Insert_Click:
    MsgBox Err.Description
    Resume Exit_Readiness__Insert_Click

End Sub

Private Sub Readiness__Edit_Click()
On Error GoTo Err_Readiness__Edit_Click

    Dim stDocName As String

    stDocName = "Readiness->Edit"
    DoCmd.RunMacro stDocName

Exit_Readiness__Edit_Click:
    Exit Sub

Err_Readiness__Edit_Click:
    MsgBox Err.Description
    Resume Exit_Readiness__Edit_Click

End Sub
```

```
Private Sub Assess_EHR_Readiness_Click()
On Error GoTo Err_Assess_EHR_Readiness_Click

    Dim stDocName As String

    stDocName = "MacroOpenFormReadiness"
    DoCmd.RunMacro stDocName

Exit_Assess_EHR_Readiness_Click:
    Exit Sub

Err_Assess_EHR_Readiness_Click:
    MsgBox Err.Description
    Resume Exit_Assess_EHR_Readiness_Click

End Sub

Private Sub Readiness__History_Click()
On Error GoTo Err_Readiness__History_Click

    Dim stDocName As String

    stDocName = "Readiness->History"
    DoCmd.RunMacro stDocName

Exit_Readiness__History_Click:
    Exit Sub

Err_Readiness__History_Click:
    MsgBox Err.Description
    Resume Exit_Readiness__History_Click

End Sub


'-----------------------------------------------------------
' MacroOpenFormReadiness
'
'-----------------------------------------------------------
Function MacroOpenFormReadiness()
On Error GoTo MacroOpenFormReadiness_Err

    DoCmd.OpenQuery "UpdateCoreEfficiency1", acViewNormal, acEdit
```

```
DoCmd.OpenQuery "UpdateCoreEfficiency0", acViewNormal, acEdit
DoCmd.OpenQuery "UpdateCorePrivacy1", acViewNormal, acEdit
DoCmd.OpenQuery "UpdateCorePrivacy0", acViewNormal, acEdit
DoCmd.OpenQuery "UpdateCoreCompleteness1", acViewNormal, acEdit
DoCmd.OpenQuery "UpdateCoreCompleteness0", acViewNormal, acEdit
DoCmd.OpenQuery "UpdateCoreSharing1", acViewNormal, acEdit
DoCmd.OpenQuery "UpdateCoreSharing0", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementEfficiency1", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementEfficiency0", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementPrivacy1", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementPrivacy0", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementCompleteness1", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementCompleteness0", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementSharing1", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementSharing0", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementHighInvest1", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementHighInvest0", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementLimitedIT1", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementLimitedIT0", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementPower1", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementPower0", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementWillingness1", acViewNormal, acEdit
DoCmd.OpenQuery "EngagementWillingness0", acViewNormal, acEdit
DoCmd.OpenQuery "TechFrequencyPC1", acViewNormal, acEdit
DoCmd.OpenQuery "TechFrequencyPC0", acViewNormal, acEdit
DoCmd.OpenQuery "TechFrequencyE-media1", acViewNormal, acEdit
DoCmd.OpenQuery "TechFrequencyE-media0", acViewNormal, acEdit
DoCmd.OpenQuery "TechEHRexperience1", acViewNormal, acEdit
DoCmd.OpenQuery "TechEHRexperience0", acViewNormal, acEdit
DoCmd.OpenQuery "SociCommunication1", acViewNormal, acEdit
DoCmd.OpenQuery "SociCommunication0", acViewNormal, acEdit
DoCmd.OpenQuery "QueryCoreHigh1", acViewNormal, acEdit
DoCmd.OpenQuery "QueryCoreLow2", acViewNormal, acEdit
DoCmd.OpenQuery "QueryCoreMedium3", acViewNormal, acEdit
DoCmd.OpenQuery "QueryEngagementHigh1", acViewNormal, acEdit
DoCmd.OpenQuery "QueryEngagementLow2", acViewNormal, acEdit
DoCmd.OpenQuery "QueryEngagementMedium3", acViewNormal, acEdit
DoCmd.OpenQuery "QueryTechHigh1", acViewNormal, acEdit
DoCmd.OpenQuery "QueryTechMedium2", acViewNormal, acEdit
DoCmd.OpenQuery "QueryTechLow3", acViewNormal, acEdit
DoCmd.OpenQuery "QuerySocietalHigh1", acViewNormal, acEdit
DoCmd.OpenQuery "QuerySocietalLow2", acViewNormal, acEdit
DoCmd.OpenQuery "QuerySocietalMedium3", acViewNormal, acEdit
DoCmd.OpenQuery "QueryOverallHigh1", acViewNormal, acEdit
```

```
    DoCmd.OpenQuery "QueryOverallLow2", acViewNormal, acEdit
    DoCmd.OpenQuery "QueryOverallMedium3", acViewNormal, acEdit
    DoCmd.OpenForm "FormReadiness", acNormal, "", "", , acNormal


MacroOpenFormReadiness_Exit:
    Exit Function

MacroOpenFormReadiness_Err:
    MsgBox Error$
    Resume MacroOpenFormReadiness_Exit

End Function

'-----------------------------------------------------------
' QueryMAIN-PHYSICIAN
'
'-----------------------------------------------------------

SELECT Main.*, Physician.*
FROM Main INNER JOIN Physician ON Main.OrganisationName=Physician.OrganisationName
WHERE ((Main.OrganisationName)=Forms!Form4Readiness!Combo2);

'-----------------------------------------------------------
' UpdateCoreEfficiency0
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.CoreEfficiency = 0
WHERE ((Main.AvAnnualNumberPatientVisit*((Select Avg(Physician.Time4Generation) from [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)+(Select Avg(Physician.[Time4Storage&Retrieval]) from [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)))>=(Main.NumberPhysicians*60*8*(1/2)*365*(5/7)));

'-----------------------------------------------------------
' UpdateCoreEfficiency1
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.CoreEfficiency = 1
WHERE ((Main.AvAnnualNumberPatientVisit*((Select Avg(Physician.Time4Generation) from [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)+(Select Avg(Physician.[Time4Storage&Retrieval]) from [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)))<(Main.NumberPhysicians*60*8*(1/2)*365*(5/7)));
```

```
'-------------------------------------------------------
' UpdateCorePrivacy1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.CorePrivacy = 1
WHERE (Select Avg(Physician.RecordAccessibility) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)<0.5;

'-------------------------------------------------------
' UpdateCorePrivacy0
'
'-------------------------------------------------------
UPDATE [QueryMAIN-PHYSICIAN] SET Main.CorePrivacy = 0
WHERE (Select Avg(Physician.RecordAccessibility) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)>=0.5;

'-------------------------------------------------------
' UpdateCoreCompleteness1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.CoreCompleteness = 1
WHERE (Select Avg(Physician.RecordCompleteness) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)>3;

'-------------------------------------------------------
' UpdateCoreCompleteness0
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.CoreCompleteness = 0
WHERE (Select Avg(Physician.RecordCompleteness) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)<=3;

'-------------------------------------------------------
' UpdateCoreSharing1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.CoreSharing = 1
WHERE (Select Avg(Physician.SatisfactionSharing) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)>3;
```

```
'-------------------------------------------------------
' UpdateCoreSharing0
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.CoreSharing = 0
WHERE (Select Avg(Physician.SatisfactionSharing) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)<=3;

'-------------------------------------------------------
' EngagementEfficiency1
'
'-------------------------------------------------------
UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementEfficiency = 1
WHERE (Select Avg(Physician.ExposureEfficient) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)>0.5;

'-------------------------------------------------------
' EngagementEfficiency0
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementEfficiency = 0
WHERE (Select Avg(Physician.ExposureEfficient) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)<=0.5;

'-------------------------------------------------------
' EngagementPrivacy1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementPrivacy = 1
WHERE (Select Avg(Physician.ExposureProtected) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)>0.5;

'-------------------------------------------------------
' EngagementPrivacy0
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementPrivacy = 0
WHERE (Select Avg(Physician.ExposureProtected) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)<=0.5;
```

```
'-------------------------------------------------------
' EngagementCompleteness1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementCompleteless = 1
WHERE (Select Avg(Physician.ExposureComplete) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)>0.5;

'-------------------------------------------------------
' EngagementCompleteness0
'
'-------------------------------------------------------
UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementCompleteless = 0
WHERE (Select Avg(Physician.ExposureComplete) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)<=0.5;

'-------------------------------------------------------
' EngagementSharing1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementSharing = 1
WHERE (Select Avg(Physician.ExposureBtterSharing) From [QueryMAIN-PHYSICIAN] Group
by Main.OrganisationName;)>0.5;

'-------------------------------------------------------
' EngagementSharing0
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementSharing = 0
WHERE (Select Avg(Physician.ExposureBtterSharing) From [QueryMAIN-PHYSICIAN] Group
by Main.OrganisationName;)<=0.5;

'-------------------------------------------------------
' EngagementHighInvest1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementHighInvest = 1
WHERE (Select Avg(Physician.ExposureBudget) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)>0.5;
```

```
'-----------------------------------------------------------
' EngagementHighInvest0
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementHighInvest = 0
WHERE (Select Avg(Physician.ExposureBudget) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)<=0.5;

'-----------------------------------------------------------
' EngagementLimitedIT1
'
'-----------------------------------------------------------
UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementLimitedIT = 1
WHERE (Select Avg(Physician.ExposureITLimitation) From [QueryMAIN-PHYSICIAN] Group
by Main.OrganisationName;)>0.5;

'-----------------------------------------------------------
' EngagementLimitedIT0
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementLimitedIT = 0
WHERE (Select Avg(Physician.ExposureITLimitation) From [QueryMAIN-PHYSICIAN] Group
by Main.OrganisationName;)<=0.5;

'-----------------------------------------------------------
' EngagementPower1
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementDiscontinuousPower = 1
WHERE (Select Avg(Physician.ExposureDiscontinuousPower) From [QueryMAIN-PHYSICIAN]
Group by Main.OrganisationName;)>0.5;

'-----------------------------------------------------------
' EngagementPower0
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementDiscontinuousPower = 0
WHERE (Select Avg(Physician.ExposureDiscontinuousPower) From [QueryMAIN-PHYSICIAN]
Group by Main.OrganisationName;)<=0.5;
```

```
'-------------------------------------------------------
' EngagementWillingness1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementWillingness = 1
WHERE (Select Avg(Physician.Willingness2Training) From [QueryMAIN-PHYSICIAN] Group
by Main.OrganisationName;)>0.5;

'-------------------------------------------------------
' EngagementWillingness0
'
'-------------------------------------------------------
UPDATE [QueryMAIN-PHYSICIAN] SET Main.EngagementWillingness = 0
WHERE (Select Avg(Physician.Willingness2Training) From [QueryMAIN-PHYSICIAN] Group
by Main.OrganisationName;)<=0.5;

'-------------------------------------------------------
' TechFrequencyPC1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.TechExperienceFrequencyPC = 1
WHERE (Select Avg(Physician.FrequentComputer) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)>0.5;

'-------------------------------------------------------
' TechFrequencyPC0
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.TechExperienceFrequencyPC = 0
WHERE (Select Avg(Physician.FrequentComputer) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)<=0.5;

'-------------------------------------------------------
' TechEHRexperience1
'
'-------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.TechExperienceEHR = 1
WHERE (Select Avg(Physician.EHRExperience) From [QueryMAIN-PHYSICIAN] Group by
Main.OrganisationName;)>0.5;
```

```
'-----------------------------------------------------------
' TechEHRexperience0
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.TechExperienceEHR = 0
WHERE (Select Avg(Physician.EHRExperience) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)<=0.5;

'-----------------------------------------------------------
' SociCommunication1
'
'-----------------------------------------------------------
UPDATE [QueryMAIN-PHYSICIAN] SET Main.SocietlCommunicationFrequency = 1
WHERE ((Select Avg(Physician.CommunicationFrequency) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)>0.5) And ((Select Avg(Physician.CommunicationMedium) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)>0.5);

'-----------------------------------------------------------
' SociCommunication0
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.SocietlCommunicationFrequency = 0
WHERE ((Select Avg(Physician.CommunicationFrequency) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)<=0.5) Or ((Select Avg(Physician.CommunicationMedium) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)<=0.5);

'-----------------------------------------------------------
' TechFrequencyE-media1
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.TechExperienceFrequencyEMedia = 1
WHERE (Select Avg(Physician.[FrequentE-Media]) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)>0.5;

'-----------------------------------------------------------
' TechFrequencyE-media0
'
'-----------------------------------------------------------

UPDATE [QueryMAIN-PHYSICIAN] SET Main.TechExperienceFrequencyEMedia = 0
```

```
WHERE (Select Avg(Physician.[FrequentE-Media]) From [QueryMAIN-PHYSICIAN] Group by Main.OrganisationName;)<=0.5;

'-----------------------------------------------------------
' QueryCoreHigh1
'
'-----------------------------------------------------------

UPDATE Main SET CoreReadiness = "High"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And ((CoreEfficiency)=0) And ((CorePrivacy)=0) And ((CoreCompleteness)=0) And ((CoreCompleteness)=0));

'-----------------------------------------------------------
' QueryCoreLow2
'
'-----------------------------------------------------------

UPDATE Main SET CoreReadiness = "Low"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And ((CoreEfficiency)=1) And ((CorePrivacy)=1) And ((CoreCompleteness)=1) And ((CoreCompleteness)=1));

'-----------------------------------------------------------
' QueryCoreMedium3
'
'-----------------------------------------------------------

UPDATE Main SET CoreReadiness = "Medium"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And ((CoreReadiness)<>"High") And ((CoreReadiness)<>"Low"));

'-----------------------------------------------------------
' QueryEngagementHigh1
'
'-----------------------------------------------------------

UPDATE Main SET EngagementReadiness = "High"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And ((EngagementEfficiency)=1) And ((EngagementPrivacy)=1) And ((EngagementCompleteless)=1) And ((EngagementSharing)=1) And ((EngagementHighInvest)=0) And ((EngagementLimitedIT)=0) And ((EngagementDiscontinuousPower)=0) And ((EngagementWillingness)=1));
```

```
'---------------------------------------------------------
' QueryEngagementLow2
'
'---------------------------------------------------------

UPDATE Main SET EngagementReadiness = "Low"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And
((EngagementEfficiency)=0) And ((EngagementPrivacy)=0) And ((EngagementCompleteless)=0)
And ((EngagementSharing)=0) And (((EngagementHighInvest)=1) Or ((EngagementLimitedIT)=1)
Or ((EngagementDiscontinuousPower)=1)) And ((EngagementWillingness)=0));

'---------------------------------------------------------
' QueryEngagementMedium3
'
'---------------------------------------------------------

UPDATE Main SET EngagementReadiness = "Medium"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And
((EngagementReadiness)<>"High") And ((EngagementReadiness)<>"Low"));

'---------------------------------------------------------
' QueryTechHigh1
'
'---------------------------------------------------------

UPDATE Main SET TechReadiness = "High"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And
((TechHardwareLaptop)>0) And ((TechHardwareDesktop)>0) And ((TechHardwareMonitor)>0)
And ((TechHardwarePrinter)>0) And ((TechHardwareScanner)>0) And
((TechHardwarePhotocopier)>0) And ((TechHardwarePhone)>0) And ((TechHardwareTVConf)>0)
And ((TechHardwarePCConf)>0) And ((TechHardwareWebcam)>0) And ((TechHardwareXray)>0)
And ((TechHardwareCamMicroscope)>0) And ((TechNetworkInternet)=1) And
((TechSoftwareEHRMaintenance)=1) And ((TechSoftwareETraining)=1) And
((TechSoftwareEmail)=1) And ((TechSoftwareStandard)=1) And ((TechPersonnelEHealthUser)>0)
And ((TechPersonnelTechnicalSupport)>0) And ((TechExperienceFrequencyPC)=1) And
((TechExperienceFrequencyEMedia)=1) And ((TechExperienceEHR)=1));

'---------------------------------------------------------
' QueryTechMedium2
'
'---------------------------------------------------------

UPDATE Main SET TechReadiness = "Medium"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And
```

```
((TechReadiness)="aaaaaa") And ((TechHardwareDesktop)>0) And ((TechHardwareMonitor)>0)
And ((TechHardwarePrinter)>0) And ((TechHardwareScanner)>0) And
((TechHardwarePhotocopier)>0) And ((TechHardwarePhone)>0) And
((TechHardwareWebcam)>0) And ((TechNetworkInternet)=1) And ((TechSoftwareEmail)=1) And
((TechSoftwareStandard)=1) And ((TechPersonnelEHealthUser)>0) And
((TechPersonnelTechnicalSupport)>0) And ((TechExperienceFrequencyPC)=1));

'------------------------------------------------------------
' QueryTechLow3
'
'------------------------------------------------------------

UPDATE Main SET TechReadiness = "Low"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And
((TechReadiness)<>"High") And ((TechReadiness)<>"Medium"));

'------------------------------------------------------------
' QuerySocietalHigh1
'
'------------------------------------------------------------

UPDATE Main SET SocietalReadiness = "High"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And
((SocietalFacilityDiagnostic)=1) And ((SocietalFacilityHospital)=1) And
((SocietalFacilityAdmin)=1) And ((SocietlCommunicationFrequency)=1));

'------------------------------------------------------------
' QuerySocietalLow2
'
'------------------------------------------------------------

UPDATE Main SET SocietalReadiness = "Low"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And
((SocietalFacilityDiagnostic)=0) And ((SocietalFacilityHospital)=0) And
((SocietalFacilityAdmin)=0) And ((SocietlCommunicationFrequency)=0));

'------------------------------------------------------------
' QuerySocietalMedium3
'
'------------------------------------------------------------

UPDATE Main SET SocietalReadiness = "Medium"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And
((SocietalReadiness)<>"High") And ((SocietalReadiness)<>"Low"));
```

```
'-----------------------------------------------------------
' QueryOverallHigh1
'
'-----------------------------------------------------------

UPDATE Main SET OverallReadiness = "High"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And ((CoreReadiness)="High")
And ((EngagementReadiness)="High") And ((TechReadiness)="High") And
((SocietalReadiness)="High"));

'-----------------------------------------------------------
' QueryOverallLow2
'
'-----------------------------------------------------------

UPDATE Main SET OverallReadiness = "Low"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And ((CoreReadiness)="Low")
And ((EngagementReadiness)="Low") And ((TechReadiness)="Low") And
((SocietalReadiness)="Low"));

'-----------------------------------------------------------
' QueryOverallMedium3
'
'-----------------------------------------------------------

UPDATE Main SET OverallReadiness = "Medium"
WHERE (((OrganisationName)=Forms!Form4Readiness!Combo2) And
((OverallReadiness)<>"High") And ((OverallReadiness)<>"Low"));
```

Appendix 8 Selected Articles to develop framework evaluation Criteria

Database (DB) or Journals (J)	Criterion (a)	The number of articles
Web of Science (DB)	Framework and electronic health (E-Health)	20
	+Evaluation	134
JAMIA (J)	Framework and electronic health (E-Health)	2
	+Evaluation	16
Medline (DB)	Framework and electronic health (E-Health)	42
	+Evaluation	90
PubMed (DB)	Framework and electronic health (E-Health)	49
	+Evaluation	11
CINAHL (DB)	Framework and electronic health (E-Health)	9
	+Evaluation	18
PsycInfo (DB)	Framework and electronic health (E-Health)	4
	+Evaluation	3
ERIC (DB)	Framework and electronic health (E-Health)	3
	+Evaluation	1
ProQuest Science Journals (DB)	Framework and electronic health (E-Health)	1
	+Evaluation	9
EMBASE (DB)	Framework and electronic health (E-Health)	24
	+Evaluation	61
Evi.sagepub.com (DB)	Framework and electronic health (E-Health)	/
	+Evaluation	52

Appendix 9 Articles for review to develop framework evaluation Criteria

Database (DB) or Journals (J)	Criterion (a)	The number of final articles
Web of Science (DB)	Framework and electronic health (E-Health)	6
	+Evaluation	13
JAMIA (J)	Framework and electronic health (E-Health)	0
	+Evaluation	4
Medline (DB)	Framework and electronic health (E-Health)	19
	+Evaluation	15
PubMed (DB)	Framework and electronic health (E-Health)	23
	+Evaluation	6
CINAHL (DB)	Framework and electronic health (E-Health)	4
	+Evaluation	6
PsycInfo (DB)	Framework and electronic health (E-Health)	2
	+Evaluation	1
ERIC (DB)	Framework and electronic health (E-Health)	0
	+Evaluation	0
ProQuest Science Journals (DB)	Framework and electronic health (E-Health)	0
	+Evaluation	1
EMBASE (DB)	Framework and electronic health (E-Health)	14
	+Evaluation	14
Evi.sagepub.com (DB)	Framework and electronic health (E-Health)	/
	+Evaluation	3

Appendix 10 Purposes of a Framework Article

Abstracted purpose	Evaluated purpose
To integrate previous research studies	● To organise/structure/relate a large body of findings (Ammenwerth et al. 2003; Philips et al. 2004) ● To locate different E-Health research efforts into the big picture (Bell et al. 2004; Dansky et al. 2006) ● To integrate across standard organisational perspectives (Chute et al. 1998) ● To integrate across theoretical perspectives (Connell et al. 2007; Jennett et al. 2003; 2004; 2005 ; Khoja et al. 2007) ● To integrate across disciplines (González et al. 2006; Gregory et al. 1995; Hypponen et al. 2007) ● To encourage dialog across perspectives (Philips et al. 2004)
To theorise about a phenomenon	● To categorise data to understand research background (Ali et al. 2007; Orfanidis et al. 2004) ● To study support environment and thus facilitate the development, evaluation, or clinical practice of E-Health applications (Ammenwerth et al. 2003; Bell et al. 2004; Hanrahan et al. 2006; Olabarriaga et al. 2007) ● To accommodate a specific E-Health workflow model (Grammatikou et al. 2000)
To aid the data collection	● To differentiate between methodologies (Kwahk et al. 2002) ● To introduce an exploratory methodology to conduct E-Health evaluation （Moehr et al. 2006）
To aid the interpretation of data	● To do a systematic collection, organisation and analysis of data (Barber et al. 2007; Miscione, 2007; Sellitto et al. 2005) ● To assess the situation in a particular case (Dorr et al. 2007) ● How to understand cases (secondary data)（Orfanidis et al. 2006）
To provide a new focus within a research stream	● To assess goals, methods and hopes of future study (Blobel, 2007) ● To raise awareness of researchers of the potential of different perspectives (Blobel, 2007; Oliver et al. 2005; Winkelman et al. 2005) ● Suggesting avenues for future research (Gunasekaran et al. 2006; King et al. 2005; Philips et al. 2004; Winkelman et al. 2004) ● To systematically bring new research areas into focus (Han et al. 2001) ● Future research would be cumulative (Sharma et al. 2005)
To aid the understanding of the relationships between theoretical concepts	● Understanding relationships (or explaining ‘why’ or ‘how’ or ‘process’) (Hoyo-Barbolla et al. 2006; Ammenwerth et al. 2003; Baynon et al. 1998) ● Serves as a theoretical justification (literature review section, typically) of hypotheses by defining linkages (Doran et al. 2007; González et al. 2006) ● To describe relationships among elements at a different level than theory (further theory development will expand/deepen these relationships and/or develop hypotheses) (Ruelland et al. 2003)
To synthesize previous research in an actionable way for practitioners	● To help evaluators or decision makers recognise evaluation issues which have not received sufficient attention (Autti-Ramo et al. 2007; Booth, 2004; King et al. 2005) ● To provide evaluators/ implementers with a methodology to address issues concerning the E-Health applications (Bell et al. 2004; BeuscartZephir et al. 1997; Cramp et al. 2001; Demiris et al. 2004; Gunasekaran et al. 2006; Hypponen et al. 2007; Jian et al. 2007; Kaplan, 1997; Kaufman and Starren, 2006; Keen et al. 1995; Keppell et al. 2001; Khandelwal 2006; Kwahk et al. 2002; Oliver et al. 2005; Oliver et al. 2004; Orfanidis et al. 2004; Ruelland et al. 2003; Sellitto et al. 2005; Wickramasinghe et al. 2005; Winkelman et al. 2004) ● To orient organisational (or IT functional) activities around the central theme (Connell et al. 2007;

	González et al. 2006; Saranummi et al. 2007) ● For managers to decide whether a variable is worth spending time/money on (Dixon et al. 1999) ● To guide healthcare practitioners to improve healthcare outcome (Doran et al. 2007; von Krogh et al. 2005) ● To help decision makers/managers focus on critical success factors (Demiris et al. 2004; Green et al. 2006; Oliver et al. 2004; Sittig et al. 2005; Wickramasinghe et al. 2005) ● To help decision makers/implementers deliver E-Health applications (Hanrahan et al. 2006) ● To educate evaluators/implementers/decision makers by providing underlying structure <electronic survey domain> (Karras et al. 2006) ● To provide evaluators and decision makers with evaluation methodologies throughout the stages of system development (Kaufman et al. 2006) ● To provide healthcare organisations/ decision makers with a methodology to address issues concerning the E-Health applications (Maldonado et al. 2007; Scott et al. 2004; Tulu et al. 2005; von Krogh et al. 2005) ● To provide decision tool to aid decision makers/managers in picking E-Health applications, based on outcome (Demiris et al. 2004; Oliver et al. 2004; Wickramasinghe et al. 2005) ● To make practice and research more systematic (Winkelman et al. 2004)
To propose the legitimate boundaries for a research area	● To understand the scope of evaluation issues (Autti-Ramo et al. 2007; BeuscartZephir et al. 1997; Jennett et al. 2003; 2004; 2005 ; Khoja et al. 2007) ● To understand the scope of E-Health issues (Campbell et al. 2001; Kluge, 2000)
To help organise the specific concepts already studied in a research stream	● To assess and organise important variables (Buccoliero et al. 2007; Campbell et al. 2001; Gregory et al. 1995; Hypponen et al. 2007; Jennett et al. 2003; 2004; 2005 ; Keppell et al. 2001; Khoja et al. 2007; Wickramasinghe et al. 2005)
To propose solutions to practical issues not yet studied in a research stream	● To provide framework for E-Health evaluation by redefining the scope, developing a methodology and so on (Barber et al. 2007; Buccoliero et al. 2007; Campbell et al. 2001; Jennett et al. 2003; 2004; 2005; Khoja et al. 2007; Winkelman et al. 2005) ● To provide framework to solve practical problems in E-Health applications (Baynon et al. 1998; Blobel et al. 2007; Di Giacomo et al. 2006; Jian et al. 2007; Jirjis et al. 2005; Croll et al. 2007; Kluge, 2000; Orfanidis et al. 2004; Pyarali et al. 1996; Smith et al. 2005; Thompson, 2006) ● To propose a framework to solve practical issues in healthcare industry (Floca et al. 2007; Sharma et al. 2005)
To facilitate future research	● To facilitate future evaluation research (Ammenwerth et al. 2003； Barber et al. 2007; Brennan, 1995; Keppell et al. 2001; Sellitto et al. 2005) ● To facilitate the design, implementation, and evaluation of future projects (Clamp et al. 2003; Kalra et al. 2005; Karras et al. 2006; Miscione, 2007)