DOCTOR OF PHILOSOPHY

An Integrated and Distributed Framework for a Malaysian Telemedicine System (MyTel)

Abd Ghani, Mohammad

Award date:
2008

Awarding institution:
Coventry University

AN INTEGRATED AND DISTRIBUTED FRAMEWORK FOR A MALAYSIAN TELEMEDICINE SYSTEM (*My*Tel)

MOHD KHANAPI ABD GHANI

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE UNIVERSITY'S REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

OCTOBER 2008

COVENTRY UNIVERSITY

Abstract

The overall aim of the research was to produce a validated framework for a Malaysian integrated and distributed telemedicine system. The framework was constructed so that it was capable of being useful in retrieving and storing a patient's lifetime health record continuously and seamlessly during the downtime of the computer system and the unavailability of a landline telecommunication network.

The research methodology suitable for this research was identified including the verification and validation strategies. A case study approach was selected for facilitating the processes and development of this research. The empirical data regarding the Malaysian health system and telemedicine context were gathered through a case study carried out at the Ministry of Health Malaysia (MOHM). The telemedicine approach in other countries was also analysed through a literature review and was compared and contrasted with that in the Malaysian context. A critical appraisal of the collated data resulted in the development of the proposed framework (*My*Tel) — a flexible telemedicine framework for the continuous upkeep of patients' lifetime health records.

Further data were collected through another case study (by way of a structured interview in the outpatient clinics/departments of MOHM) for developing and proposing a lifetime health record (LHR) dataset for supporting the implementation of the *My*Tel framework. The LHR dataset was developed after having conducted a critical analysis of the findings of the clinical consultation workflow and the usage of patients' demographic and clinical records in the outpatient clinics. At the end of the analysis, the LHR components, LHR structures and LHR messages were created and proposed. A common LHR dataset may assist in making the proposed framework more flexible and interoperable.

The first draft of the framework was validated in the three divisions of MOHM that were involved directly in the development of the National Health ICT project. The division includes the Telehealth Division, Public and Family Health Division and Planning and Development Division. The three divisions are directly involved in managing and developing the telehealth application, the teleprimary care application and the total hospital information system respectively. The feedback and responses from the validation process were analysed. The observations and suggestions made and experiences gained advocated that some modifications were essential for making the *My*Tel framework more functional, resulting in a revised/final framework.

The proposed framework may assist in achieving continual access to a patient's lifetime health record and for the provision of seamless and continuous care. The lifetime health record, which correlates each episode of care of an individual into a continuous health record, is the central key to delivery of the Malaysian integrated telehealth application. The important consideration, however, is that the lifetime health record should contain not only longitudinal health summary information but also the possibility of on-line retrieval of all of the patient's health history whenever required, even during the computer system's downtime and the unavailability of the landline telecommunication network.

Table of contents

Acknowledgements

Firstly, I am most grateful to my supervisors: Dr. Rajeev Bali for believing in me and for his common-sense, knowledge and wittiness — thank you, Raj, for the invaluable professional and emotional support and the inspirational simple facts of life; Professor Raouf Naguib for his great encouragement, shrewd guidance and immense assistance; and Professor Ian Marshall for his critical thoughts and advice. I would also like to say thank you to all academic and support staff at the Faculty of Engineering and Computing and the rest of the staff at Coventry University, who have provided full assistance and support.

I would like to thank both examiners, Dr. Alan Eardley and Professor Brian Lehaney, for reading this thesis and for contributing to a stimulating academic discussion.

I am thankful to all staff at the Ministry of Health Malaysia involved in this study for welcoming me in their practice and participating in the empirical part of this research. Their cooperation has provided a valuable insight into the study.

I gratefully acknowledge the funding received from the Public Services Department of Malaysia, Ministry of Higher Education of Malaysia and Universiti Teknikal Malaysia Melaka (Technical University of Malaysia), who helped sponsor this study.

Finally, I am most indebted to my family, especially my wife, Suzana, my son, Mohd Tirmizi, my daughter, Rabiatul Adawiyah, my daughter, Khairul Bariyah, my son Imam Baihaqi, my son Imam Hambaly, my Mum and Dad and my siblings for being there to give me emotional comfort and putting up with me.

Dedication

To my wife, Suzana, my children, Tirmizi, Rabiatul, Bariyah, Imam and Hambaly, and my parents, Azizah and Abd Ghani.

List of figures

List of tables

Abbreviations

CCR	Continual care records
CCTV	Closed-circuit television
CIS	Clinical information system
CME	Continuing medical education
CPD	Continuing professional development
CPG	clinical practice guidelines
CPOE	Computerised practitioner order entry
CRS	Clinical Record Services
CSS	Clinical support system
CUHK	Chinese University of Hong Kong
EHR	Electronic health records
EJB	Enterprise Java Bean
EMR	Electronic medical records
EMRX	EMR exchange
EPR	Electronic patient record
EU	European Union
GDP	Gross domestic product
GDS	Group Data Services
GSM	Global system mobile
HIMS	Health information and management support
HIS	Health information system
HKHA	Hong Kong Hospital Authority
HKL	Kuala Lumpur Hospital
HRA	Health risk assessment
ICT	Information and communication technology
IS	Information system
ISDN	Integrated service digital network
ITV	Interactive televideoconferencing
J2EE	Java™ 2 Platform Enterprise Edition
JIT	Just-in-time
JSP	Java Server Page
LHR	Lifetime health records
LIS	Laboratory information system
MCPHIE	Mass Customised Personalised Health Information and Education
MOHM	Ministry of Health Malaysia
MSC	Multimedia Super Corridor
MyTel	Malaysian integrated and distributed telemedicine system
NASA	National Aeronautics and Space Administration
NHG	National Healthcare Group
NHI-IC	National Health Insurance Smart Cards
NHIMAC	National Health Information Management Advisory Council
NHS	National Health Services

NPfIT	National Programme for IT
NST	Norwegian Centre for Telemedicine
PCT	Primary care trust
PDA	Personal digital assistant
PIS	Pharmacy information system
PLHP	Personalised Lifetime Health Plan
PMS	Patient management system
RIS	Radiology information system
RUP	Rational Unified Process
SingHealth	Singapore Health Services
SMS	Short message services
TBNHI	Taiwan's Bureau National Health Insurance
TS	Teleconsultation
VPN	Virtual private network
SOP	Standard operating procedures
CRFP	Concept requests for proposal
TPC	Teleprimary care
THIS	Total hospital information system
ITCD	Information Technology and Communication Division
ISDU	Information System and Documentation Unit of Ministry of Health

Research papers published

Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Shibghatullah, A. S. (2007) "The Design of Flexible Front End Framework for Accessing Patient Health Records Through Short Message Service"**,** *IEEE Asia-Pacific Conference on Applied Electromagnetics***,** Melaka, Malaysia**,** 4-6 December 2007**,** pp.1-5

Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Wickramasinghe, N. S. (2008) "Electronic Health Records Approaches and Challenges: A Comparison Between Malaysia and 4-East-Asian-Country", *International Journal of Electronic Healthcare*, Vol.4, No.1, pp.78-104.

Nguyen, Q. T., Naguib, R. N. G., Abd Ghani, M. K., Bali, R. K., Marshall, I. M., Phuong, N. H., Culaba, A. B., Wickramasinghe, N. S., Shaker, M. H. & Lee, R. V. (2008) "An Analysis of Healthcare Informatics and Systems in South East Asia: A Current Perspective from Seven Countries", *International Journal of Electronic Healthcare*, Vol.4, No.2, pp.184-207.

Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. M., Baskaran, V., Wickramasinghe, N. & Puentes, J. (2008) "A Flexible Telemedicine Framework for the Continuous Upkeep of Patient Health Record", *Proceedings of the Fourteenth Americas Conference on Information Systems*, Toronto, Canada, August 14th-17th 2008.

Nguyen, Q. T., Abd Ghani, M. K., Naguib, R. N. G., Bali, R. K., Marshall, I. M. & Phuong, N. H. (2008) "Issues and Challenges in the Development of Electronic Health Records in Malaysia and Vietnam", *Conference on Applications of Medical Informatics in Hospital Management (VN-HISMANAG'08)*, Hanoi, Vietnam, 9th January 2008.

Wickramasinghe, N., Bali, R.K., Lehaney, B., Jonathan S., M. Chris G. (2009) "Healthcare Knowledge Management Primer", In Abd Ghani M.K, ed. (2009) Case Exercise: KM and Personal Health Records – A Malaysian Perspective, Routledge, ISBN: 978-0-415-99443-9.

Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Wickramasinghe, N. S. (xxxx) "An integrated and distributed framework for Malaysia telemedicine system - *My*Tel", *International Journal of Healthcare Technology and Management*, to be submitted.

Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Wickramasinghe, N. S. (xxxx) "Critical Analysis on the Usage of Patient Demographic and Clinical Record during Doctor-Patient Consultation – A Malaysian Perspective", *International Journal of Healthcare Technology and Management,* to be submitted.

Chapter 1 Introduction

1.1 Overview

The overall aim of the research is to produce a validated, flexible, integrated and distributed framework for a Malaysian Telemedicine system. The system would provide for distributed sites and multiple storage devices for the upkeep of the lifetime health records (LHRs) of patients and would incorporate high accessibility and availability across different healthcare service levels.

This research is sponsored by the Ministry of Health Malaysia (MOHM), which is keen to receive a validated framework to assist in the nation's effort to implement telemedicine efficiently and effectively throughout Malaysia.

The framework will provide a mechanism to store and retrieve the LHRs using portable devices during possible disasters. This mechanism will allow for the continuous and seamless flow of patient information and knowledge and timely access to a patient's LHR during a doctor-patient encounter (anywhere in the country regardless of the healthcare centre of his/her previous visit). By utilising front-end computing capabilities (such as mobile phones, smart cards and PDA), the LHR would be located close to the patient and will expand the telemedicine system into an integrated and distributed system.

1.2 Research Objectives

This section presents the research objectives of the research programme. The objectives of the research are summarised as follows.

1.2.1 Provide a Literature Review

The first objective in this research is to appraise the current state of knowledge and practice and the existing telemedicine approaches therein that may help in achieving the primary aim of the research. For this reason, the literature dealing with telemedicine approaches in Malaysia shall be reviewed, compared and contrasted with those of other countries. If no suitable approach is found, it will be possible to elicit the most relevant approach and best practice and to learn from any possible weaknesses. The pilot implementation of the Malaysian Integrated Telehealth Project and the ICT infrastructure of various healthcare facilities under the Ministry of Health (Malaysia) would be investigated with regards to their capability to aid in understanding the problem.

1.2.2 Investigate Patients' Demographic and Clinical Record Usage in Outpatient Clinics

The second objective is to investigate the existing demographic and clinical patient data for creating standardised LHR datasets. The proposed LHR datasets will be used as a standard LHR data dictionary for creating and generating the LHR repository. The LHR data dictionary is used as a standard requirement for integration, especially for creating and accessing a patient's lifetime health summary in a seamless manner. At the end of this level, the initial component, structure and message of LHR datasets should be identified and defined.

1.2.3 Establish Initial Flexible Framework

The research hypothesis represents the gap between the existing framework and the research aim. This third objective is about identifying the means to close this gap. This objective is to design a suitable framework that achieves our research aims; at this level, we assume that the basic architecture of the framework has be identified and constructed.

1.2.4 Validating the Framework

After the proposed framework is established, it is important to validate it and identify the main gaps and discrepancies that may discourage the framework from achieving the aim of the research. The validation will be conducted through close collaboration with the Malaysian Ministry of Health. The identified gaps would be rectified through the process of the refinement and improvement of the framework.

1.3 Research Questions

After a series of reviews and discussions on telemedicine approaches between Malaysia and other countries (see chapter 2), there are crucial questions that can be elicited from the literature. The approaches of other countries could be used as a reference for Malaysia to implement the telemedicine applications. However, not all approaches and methods can be followed because every country has a different healthcare system and policies for providing and delivering the healthcare services. The main hypothesis revealed is that the flexible framework of a telemedicine system could be implemented more usefully if it is employed in the distributed set-up of healthcare facilities and during possible system disasters (inadequacy of telecommunication infrastructure) for the seamless and continuous upkeep of patient health records.

Based on this hypothesis, the fundamental question for this research is, could a flexible framework enhance and/or overcome the integration and issues concerning continuity and seamlessness in accessing, creating and storing patient health records across application systems and healthcare facilities? It is important to submit a direct question that could be addressed from detailed research. More precisely, the key research questions can be described as follows:

<u>Key research question 1</u>

What are the most critical aspects for a framework to implement a Malaysian integrated telemedicine system that ensures that patient LHRs can be maintained continuously and seamlessly?

This question is related to the development of a flexible framework that focuses on the provision of a systematic flow of processes with regards to how the LHR can be co-located with patients during doctor–patient encounters. Can ICTs such as servers and Internet technology ensure the high accessibility and availability of patient health records? Technology and the telecommunication infrastructure differ significantly across the world. For example, the Internet dial-up and broadband penetration rate for Malaysia was around 13.9% and 1.9% in 2005 (Malaysian Communications and Multimedia Commission, 2005). This shows that the broadband infrastructure in Malaysia is still in its infancy. The use of normal narrowband in a telemedicine system for transporting the patients' health records across healthcare facilities nationwide does not make sense due to issues of telecommunication reliability, speed and responsiveness.

Hence, the continuum of care and timely access to patient health records is always inadequate and inconsistent. This research will look into this issue by exploring the telemedicine context in Malaysia and validating the proposed framework based on the Malaysian health system in the Ministry of Health Malaysia.

Key research question 2

What is the crucial LHR dataset to be used for supporting the framework?

The framework should be supported by the common LHR structures for tackling system integration and interoperability issues. The meaning of interoperability here is the integration of the patient's LHR across application systems and healthcare facilities. It is difficult to force all healthcare providers to change or use the new applications. This research will explore the key attributes of health records to be used for creating, retrieving and storing the LHRs and for helping healthcare professionals to diagnose patient problems during doctor–patient encounters.

1.4 Introduction to the Problem

The availability, accuracy and completeness of health records will be of great help to clinicians in treating patients (Roman et al., 2006). The completeness of patients' lifetime health records (LHRs) should not only be present chronologically in a single application system or health institution but also across different applications and in institutions.

Only when health records are integrated along a timeline (and independently of sources) would all relevant and necessary patient information be available and could it form the basis for formulating proper and accurate advice, diagnosis and treatment wherever a patient may seek such care or services. Such a longitudinal (and hence seamless) view of a patient's health record would lead to much better planning for clinicians so that it would be possible to provide a continuum of care throughout a person's lifetime (Whitten and Sypher, 2006).

However, the above characteristics would not be achieved if health ICT applications (for example, telehealth, telemedicine and hospital information systems) developed for supporting the clinical process are rigid and inflexible. These scenarios become much worse when dealing with the inadequacy of telecommunication infrastructures and system interoperability limitations (such as disparate set-ups of hospital information systems).

Evidently, the healthcare system is complex and the telemedicine system under development should be able to mitigate the complexity by giving more attention to its flexibility for accessing, creating and storing patients' lifetime health records continuously and seamlessly.

1.5 The Problem and its Context

The impact due to the system limitation (inflexibility of health ICT applications) to maintain LHRs has brought many consequences for patients' health records. Firstly, it results in incompleteness of the contents of patients' health records. This means that the patients' health records for certain encounters will not be captured and stored accordingly and may be lost. Manual data entry will bring issues of reliability and validity for medical records normally captured by non-clinical staff. This is supported by many studies that questioned the variable quality of existing patient records (Barnett, 1984). There are also criticisms that the patients' medical records are often missing, illegible or inaccurate (Hsia et al., 1988).

Secondly, it results in the problem of continuity and seamlessness of health record information. The fragmented health records may result in issues to do with the accessing, availability and retrieving of patients' health records seamlessly and continuously. In the United States, in 2005, approximately 80% of healthcare providers were still using paper-based medical records in their day-to-day consultations and, from the systems that did exist, few were interoperable and the physicians found great difficulty in accessing patients' records at the right time (IAB, 2006).

The third consequence is related to issues of database linkages and integration. The LHR is normally stored in a database system which has linkages between information and record-specific data types. In the case of the inconsistency of a telecommunication network or system downtime during updating of the linkages, some of the saved data will be incomplete and data integrity will be an issue that requires data maintenance. Incompleteness of the micro level of medical data will result in issues to do with the integration and seamlessness of patients' LHRs. This hampers the optimal use of LHRs in providing patient care in a distributed environment of a telemedicine system and hospital information system (Lua et al., 2005).

It may be important to develop a flexible framework in order to integrate the LHR system and to ensure that it can be accessed, viewed and stored seamlessly and continuously across healthcare premises. Recent mobile technology, such as PDA, smart phone and smart cards, would enable a LHR to be located close to a patient, and the doctor may retrieve a given patient's medical history seamlessly through these devices (Liu et al., 2006).

Good care is dependent on flexible access to previous LHRs which should be a feature of the health system of the future. Care should not be episodic or fragmented but should take into account the patient's entire health history providing a long-term outlook (Suleiman, 2001).

1.6 Rationale and Significance of the Study

The research project is expected to produce a validated flexible framework for an integrated and distributed Malaysian telemedicine system. The framework will be presented to the Ministry of Health (Malaysia) for the deployment or further development of a telemedicine system in Malaysia. The data and findings from the research can aid in the benchmarking of the current Malaysian telemedicine concept and in measuring the practicality of the existing approach.

In terms of a broader contribution, especially in the healthcare perspective, the framework provides an important tool to improve healthcare services to patients by co-locating the LHR with the patient. In addition, the patient's LHR can be accessed and stored seamlessly and continuously during a doctor-patient encounter regardless of the location of his/her visits. By having this characteristic of a health system/record, medical mistakes would be reduced and avoided during the delivery of the healthcare services.

1.7 Organisation of the Report

The structure of this report is as follows. *Chapter One* starts with the research objectives and continues with the research questions in sections 1.1 and 1.2. The chapter continues with the introduction of the research problem and the description of the problem area and its context in sections 1.3 and 1.4 respectively. Section 1.5 describes the rationale and significance of the study. Finally, section 1.6 outlines the organisation of the report.

Chapter Two expands the problems highlighted in *Chapter One* by reviewing the telemedicine literature and approaches of ten countries (Singapore, Taiwan, Hong Kong, Japan, China, Australia, New Zealand, Canada, Norway and the UK). The approaches and concepts are compared and contrasted with those in the Malaysian telemedicine context. At the end of the chapter, the summary of the reviews are discussed and concluded.

Chapter Three describes and presents the research methodology undertaken in this research. The chapter starts by summarising the methodology and continues with the research design and process in sections 3.1 and 3.2. Section 3.3 describes the case study approach and section 3.4 elaborates on the data collection methodology. Section 3.5 describes the sources of information and section 3.6 presents the category and types of data to be collected in this research project. Section 3.7 summarises and concludes the chapter.

Chapter Four presents the background of the organisation for performing the case study and the findings from the data collection.

Chapter Five expands the case under study in chapter four by performing a critical analysis of patient demographic and clinical data in the outpatient clinics. The chapter also presents the findings from the data collection and proposes the lifetime health record dataset.

Chapter Six presents a proposed draft framework for an integrated and distributed Malaysian telemedicine system — a flexible framework for the continuous upkeep of patients' lifetime health record.

Chapter Seven describes the framework validation feedback and presents the findings from the three cases through cross-case analysis.

Chapter Eight summarises the research accomplishment; it also concludes the research observations and highlights future research work.

Chapter 2 Literature Review

2.1 Introduction

This chapter reviews and examines the telemedicine literature relevant to the aims and objectives of the research. The chapter starts with a general review of telemedicine and its context in healthcare services. The chapter continues by reviewing, comparing and contrasting the existing literature in terms of the different approaches to and concepts of telemedicine systems in other countries. It examines the abilities of the approaches of their frameworks in providing seamless and integrated patients' lifetime health records (LHRs) across different healthcare service levels.

This chapter also examines the background to Malaysia's healthcare system and the telemedicine context in Malaysia, and the rationale for why Malaysia needs a flexible framework for an integrated telemedicine system. Finally, some assumptions are made on what can be done to utilise the flexible framework in an alternative way that may help the upkeep of patients' health records continuously across different healthcare levels. These assumptions are used as research questions to be answered throughout the remainder of the thesis.

2.2 Telemedicine and the Evolution of Medical Services

There are great differences between the developing and developed worlds in terms of issues to do with health and healthcare services. The emphasis of the developing world is on basic survival (such as providing better access to healthcare and increasing the quality of health) whilst in the developed world the emphasis is on reducing public funding for healthcare. Indeed, the rapid increases in healthcare costs and finding ways to control them have become the most important health policy issues for the developed world in the past few decades (Industry Canada, 2006). Table 2.1 shows an increasing total cost (% GDP) of health expenditure among the G-7 countries from 2000 to 2004.

Table 2.1: Total Health Expenditure of the G-7 Countries
Source : (WHO, 2008b; WHOSIS, 2006)

An increase in healthcare expenditure also took place in Asian countries; most of them also gradually increased their expenditure on health every year. Table 2.2 shows the total health expenditure between 2000 and 2004.

Table 2.2: Total Health Expenditure of the Asian Countries
Source : (WHO, 2008b; WHOSIS, 2006)

Many factors contribute to the rapid rise of healthcare costs. One is the demographic changes such as population ageing with its associated increased rates of chronic diseases and disabling conditions as well as changing disease patterns from communicable diseases to non-communicable diseases. Non-communicable diseases are also known as lifestyle diseases, such as heart attacks, depression, diabetes, high blood pressure, strokes, etc. These scenarios have been taking place in developing countries such as Singapore, Malaysia and Thailand where the percentage of population aged 60 and over has increased (WHOSIS, 2006).

Chronic and lifestyle diseases are expensive to treat because they often require lifelong management. A study shows that, over a 30-year period, the disease burden has shifted from communicable diseases to mainly lifestyle related diseases where ischaemic heart problems have become the highest disease burden suffered globally as depicted in Table 2.3.

1990	2020 (Projection)
1. Lower respiratory infection	1. Ischaemic heart disease
2. Diarrhoeal diseases	2. Depression
3. Perinatal conditions	3. Traffic accidents
4. Depression	4. Cerebrovascular disease
5. Ischaemic heart disease	5. Chronic obstructive airways disease (COPD)
6. Stroke	

Table 2.3: Change in Global Disease Burden

Source: adapted from (Schutz et al., 2006)

Due to the new trend in diseases that are suffered globally, governments and national health financing authorities seek new and different ways to provide adequate levels of services at lower costs. This is where telemedicine and telehealth initiatives come into prominence. Studies have clearly demonstrated that telemedicine and telehealth initiatives can realise savings while at the same time broadening the reach of healthcare systems (Frances et al., 2007; Koch, 2006; Moehr et al., 2006).

2.3 Telemedicine, Telehealth and the Internet

Telemedicine literally means “medicine at a distance” and it can be used to deliver a range of services: information, education, consultation, diagnosis, treatment, support and governance

(Ministry of Health Malaysia, 1997e; Richard et al., 2006). According to Mohan and Yaacob (2004), telehealth refers to the integration of information, telecommunication, human–machine interface technologies and health technologies to deliver healthcare, to promote the health status of the people and to create health. Telemedicine and telehealth initiatives are essentially about providing communication links between medical experts and remote locations. They also act as an electronic vehicle to transport patients' health records across healthcare levels and services by the use of information and communication technologies (ICT) such as the Internet.

Internet-based technologies represent the most powerful instruments for the creation and dissemination of health knowledge in healthcare organisations (Dwivedi et al., 2007). The Internet is used as a low-cost vehicle for telemedicine services, best suited to services that are transactional in nature and that do not have a strong synchronous requirement (Whitten and Sypher, 2006). However, the Internet remains a poor vehicle for viewing large images and files in real time (Coiera, 2003). Telemedicine services might be disrupted or fail when the Internet connection is intermittent or unavailable. Therefore, whilst the design of any telemedicine system should not be wholly dependent on the availability of the telecommunication network, the system should have the flexible capability to handle such limitations (for example, the inconsistency and unavailability of a telecommunication network) (Martinez et al., 2004).

2.4 Telemedicine Technologies and Approaches

This section will discuss the evolution of telemedicine technology and its approaches and limitations. The limitations are related to the flexibility for creating, displaying and storing patients' health records continuously and seamlessly.

2.4.1 An Early Telemedicine System

The first telemedicine technology introduced in 1900 used television as its communication instrument for providing medical services to rural area in Antarctica (Sullivan and Lugg, 1995). In the late 1950s, interactive video communication technology was introduced for transmitting radiological images and providing telepsychiatry consultations via coaxial cable in the Nebraska Psychiatric Institute (Puentes et al., 2007). The telemedicine technology evolved using satellite-based communications pioneered by the National Aeronautics and Space Administration (NASA) to provide disaster medical assistance to people who suffered from the devastating earthquake in Mexico City in 1985 (Bashshur and Lovett, 1997; Garshnek and Burkle, 1999a; Garshnek and Burkle, 1999b).

In 1985, NASA changed its interest from disaster assistance to international telehealth service provision. The projects developed included the Space Bridge Project for providing medical consultation to earthquake victims in Armenia and the SatelLife/HealthNet to provide health communication information and services in developing countries (Garshnek, 1991; Ferguson et al., 1995). These various approaches of telemedicine demonstrated many benefits for mankind. However, the technology used at that time was not cost-effective and failed to sustain itself financially (Maheu et al., 2001). The most important remark from the previous literature is that the early telemedicine framework did not give due attention to the efficacy of integrated health records in delivering healthcare services.

2.4.2 Recent Telemedicine Systems

The most common types of telemedicine technologies used recently are interactive televideoconferencing and store-and-forward technology (Norris, 2002). Interactive televideoconferencing (ITV) used synchronous connections while store-and-forward technology utilised asynchronous connections (Whitten and Sypher, 2006).

The problems with ITV were that it was too dependent on the availability of healthcare professionals, it required a high network bandwidth and the downtime of computer systems and telecommunication networks was zero (Maheu et al., 2001). For example, by using ITV, the telemedicine centre and the remote centre have to establish a network connection and a proper schedule in order to conduct the consultation session and both parties need to be physically present in front of the video equipment (Jankharia, 2001; Gomez et al., 1998). Without a proper administrative set-up (readiness of doctor and patient) and an adequate bandwidth telecommunication, the consultation service through ITV cannot proceed effectively (Hailey, 2001). This approach has not provided alternatives for continuing the consultation session when the telecommunication network and system downtime are inadequate, and this leads to discontinuity of care and the medical record cannot be created, displayed and stored seamlessly (Takahashi, 2001; Oakley and Rennie, 2004).

Generally, the recent telemedicine system framework does not pay attention to the integration and sharing of patients' medical records across telemedicine services, healthcare levels and healthcare facilities (Warren et al., 1999). By way of example, in New Zealand, the research on telemedicine system diffusion found that the majority of medical records are fragmentally stored in individual hospital information systems within health facility centres (Al-Qirim, 2006). This scenario resulted in a lack of continuity and the lack of a seamless integration of patient medical information.

By way of another example, the Canadian government — in order to mitigate these issues — has placed high priority on the convergence of electronic health records (EHR) and telehealth as critical and integrated components of Canada's health infostructure (Canada Health Infoway, 2006a). This demonstrates that telemedicine programmes in Canada, which have received investment since 1991, still require improvement in terms of the integration and continuation of medical records.

The same scenario has occurred with the Malaysian Integrated Telehealth Project. However, due to a lack of focus in collecting and integrating EMRs for generating centralised patient LHRs, the project suffered from significant drawbacks; this led to suspension of the full nationwide implementation (Harun, 2007). The Malaysian telehealth framework leverages the Internet as its main transport for a communication network (Ministry of Health Malaysia, 1997a).

Unfortunately, the telehealth framework provides less consideration of the issues of inconsistency and inadequacy of the telecommunication infrastructure across health facility centres. The system strictly depends on network availability and only works well in big cities such as Kuala Lumpur, Johore Bahru and Penang (Government of Malaysia, 2007). The framework should take into consideration the situation associated with the inconsistency and inadequacy of the telecommunication infrastructure during unpredictable system disasters.

2.4.3 Current Telemedicine Systems

The Internet has been instrumental in propagating and disseminating revolutionary technologies as and when they developed. Technologies currently deployed in telemedicine and telehealth applications have moved to an Internet-based platform as their main communication transport for carrying medical information across healthcare providers and healthcare professionals (Wua et al., 2007).

The Internet has two basic and essential features for telemedicine and telehealth: firstly, its ability to disseminate knowledge rapidly and without boundaries; and, secondly, the ability of the Internet to bring down interaction costs (Whitten and Sypher, 2006; Richard et al., 2006). In the twenty-first century, the confluence of mobile computing and the medical sector was heightened with mobile and wireless applications being widely used for healthcare services (Linhoff, 2002). Mobile applications being used in telemedicine or the telehealth environment include the following: telehomecare, disease management, the emergency ambulance patient service (Anantharaman and Han, 2001), clinical triage systems, remote vital sign readings (Rasid and Woodward, 2005) and accessing patient health summaries in wards and at emergency outpatient locations.

However these applications are often still not effectively integrated in the overall organisation process and patient health records reside, in most cases, in "silos". This has implications for healthcare professionals who require complete, accurate and timely access to health records in order to provide quality care. Inadequate healthcare services account for the majority of deaths in developing countries (Harun, 2002).

To discuss further the ideas of current healthcare delivery systems and telemedicine/telehealth systems (and hospital information systems), the founder of *Malaysian Integrated Telehealth* was interviewed (Harun, 2007); he provided a scenario to illustrate some limitations:

> Suppose we are on a holiday somewhere and suddenly develop stomach discomfort. We decide to go to the nearest GP clinic. On registering and seeing the doctor, we find that some time will have to spent by the doctor in getting some background information about our medical history because that doctor does not have access to our past medical records. This is a major disadvantage because the doctor would have to rely merely upon our words to make a sound medical judgment, while we would have to recount and recall repeatedly details of past medical encounters, clouded perhaps, by the deficiencies of poor memory recall and inaccuracies.

The implication of this is that the current telemedicine/telehealth/HIS systems have been operating in a fragmented manner. If current telemedicine systems have been designed to cater for the continuous and seamless flow of patient, health and medical information (especially across the public–private sector divide), it would very much assist the above scenario. It is vital that the design of a telemedicine system should be flexible for the seamless and continuous upkeep of patients' health records.

2.5 The Need for Integrated Lifetime Health Records for Continuing Care

In an typical episodic encounter, a substantial portion of the healthcare provider's time is spent in obtaining the patient's medical history and subsequently recording, dictating, transcribing and arranging the information in an organised manner before a diagnosis can be made or before an appropriate treatment can be prescribed and administered (Coiera, 2003).

Furthermore, if it is required that the patient be referred to another medical provider for an expert opinion or a second opinion, the entire procedure of information collection may have to be repeated; any necessary pathological (and perhaps radiological) data collection process is a laborious task, one which cannot be delegated to another professional (Maheu et al., 2001). What is crucial here is that the absence or incompleteness of such data may lead to an inappropriate diagnosis and treatment or one that contradicts with the person's physiological condition such as allergies (Chaudhry et al., 2006).

According to a study conducted by the Institute of Medicine (Williams and Moore, 1995), the situation is quite worrying as 30% of physicians find great difficulty in accessing patients' records at the right time and 70% of hospital records are found to be incomplete. An integrated LHR is critical for continuing care and these efforts are currently progressing in many countries such as Canada, the UK and mainland Europe (Ingeborg and Volker, 2001).

The government of Canada is committed to the development of an interoperable enterprise health records solution by integrating approximately 40,000 existing health information systems in use across the country (Canada Health Infoway, 2006b). Similar efforts are also being undertaken in the UK's NHS through its extensive health ICT project, Connecting for Health (National Health Services, 2006a). EHR services are the most integral component among the applications and an important backbone of NHS health infostructure (National Health Services, 2007).

Both Canada and the UK have acknowledged that disparate health information systems and independent telemedicine systems will not be sustained in the long term. Healthcare services will not be improved if the services are still episodic and access to health records is always restricted within a healthcare facility and an application system. Good care is dependent on access to the previous medical records, which should be a feature of healthcare systems in the future.

2.6 The Need for Flexible Frameworks for the Continuous Upkeep of LHRs

As healthcare organisations have grown and obtained new health information systems, the need has arisen to integrate these systems with older (legacy) systems that continue to function in parts of the organisation (Mykkanen et al., 2003; Warren et al., 1999; Coiera, 2003). The integration of existing and forthcoming information systems represents one of the crucial challenges, as it is both technically challenging and expensive (Berler et al., 2004). It is clear that new ICTs have integration problems in healthcare because of the way that this sector is organised for meeting the increasing clinical, organisational and managerial needs.

A survey conducted in the Ministry of Health Malaysia on the category of the information system implemented in the organisation (refer to Figure 2.1) provides an example to illustrate the scenario. Approximately, seven categories of information systems were implemented in the organisation and the systems were installed with various application specific technologies and platforms (operating systems, hardware, databases and applications). In this context, integration represents one of the most urgent priorities in order to implement an integrated telemedicine system.

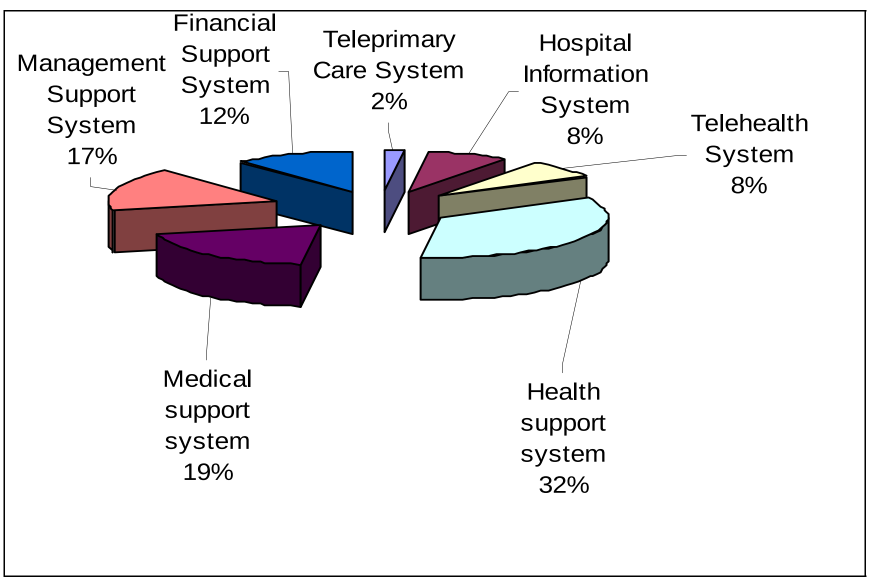

Figure 2.1: Categories of Health ICT Projects in Public Healthcare Facilities

Source: adapted from (Ministry of Health Malaysia, 2006a)

The efforts of collecting, integrating and generating centralised patients' health records from the existing disparate HISs are the major challenges faced by stakeholders. In 2005 in Canada, approximately 20% of physicians were using electronic medical records or technologies in clinical care in their day-to-day consultations; from the systems that did exist, few were interoperable (Canadian Medical Association, 2005). Different technologies, the fragmented set-up of the ICT infrastructure and solutions led to challenges with regards to achieving solution integrity between applications and services and, finally, to gathering and generating the LHRs centrally.

Malaysian public healthcare facilities are also faced with the same situation where the information systems operate independently: there is a variety of technology platforms (refer to Table 2.4) and it is not possible to share patients' medical records with one another (Abd Ghani et al., 2007). Uncoordinated planning, legacy and proprietary systems with limited or no networking capabilities present major challenges to systems integration (Norris, 2002). It is, therefore, of critical importance that the design of the telemedicine system should be flexible for interoperability, scalability and reusability. This is to ensure that the LHRs can be synchronised across healthcare facilities and HIS applications and that they can be maintained seamlessly and continuously.

Application Name	Programming language	Operating system	Database	Application Networking	Web/Application Server
Teleprimary Care	VB .Net	Windows	MS SQL Server	Client Server	N/A
Total Hospital Information System	PHP	LINUX	MySql	Web-based	Apache Tomcat
Intermediate Hospital Information System	PHP/MS VB	Windows/Linux	MySql/Ms SQL Server	Client Server/Web-based	Apache Tomcat
Basic Hospital Information System	Informix	Informix/Unix	Informix	PC/Dump Terminal	N/A
HIS (legacy system)	Informix	Informix/Unix	Informix	Dump Terminal	N/A
Telehealth					
MyHealth	Java 2 - JSP	Windows	My SQL	Web-based	Apache Tomcat
Teleconsultation	MS Visual C++	Windows	MS SQL Server	Client Server	N/A
LHP	Java 2EE	Solaris/Unix	Oracle	Web-based	Sun Application server

Table 2.4: Software and Middleware Used in Health ICT Projects

2.7 Evaluating the Telemedicine/Telehealth Framework

In order to develop a suitable telemedicine framework for certain organisations, an evaluation of past and existing systems or models is needed (Miller, 2002). Evaluation serves a number of purposes. The evaluation is undertaken to understand system performance, improve clinical performance and patient outcomes, and understand the unpredictable characteristics of health information systems (HISs) in general (Van Bemmel and Musen, 1997). Potentially, the evaluation of health informatics applications (telemedicine in particular) can help improve the quality of care and its costs and help determine the safety and effectiveness of HISs (Van Bemmel and Musen, 1997; Giuse and Kuhn, 2003). Evaluation can be used to improve HISs through using past experience to identify more effective techniques or methods, investigate failures and learn from previous mistakes (Friedman and Wyatt, 2006).

This section highlights how this research project derived the proposed framework through the review of the existing telemedicine framework and model. The evaluation starts with early approaches to the telemedicine framework and continues with a review of the telemedicine framework.

2.7.1 Early Approach to the Telemedicine/Telehealth Framework

The review of the telemedicine framework seeks to answer the questions of *what*, *where* and *how* in regard to the flexibility (integration and continuous access) issues in accessing patients' lifetime health records. A discussion of early studies on telemedicine/telehealth frameworks is presented based on these evaluation questions. The summary of this discussion is presented in Table 2.5.

The "what": the question "what" relates to the aspect of the evaluation that needs to be focused on. There are many aspects of telemedicine/telehealth frameworks that can be evaluated. Evaluation normally involves technology, humans, organisations and the interactions between them (Ammenwerth and de Keizer, 2005; Wyatt and Wyatt, 2003). Evaluation can also cover technical, professional, organisational, economic, ethical and legal domains (Stoop and Berg, 2004). Brender (1997) compared evaluation studies between the field of health informatics and the field of information systems and observed that the focus of empirical evaluation studies in health informatics was on the aspects of correctness. The evaluation trend of health informatics has been increasingly shifting towards the organisational and human factors. By way of example, Kaplan and Shaw (2004) presented a number of evaluation studies that concentrated on the following human and organisational issues: organisational readiness, diffusion of innovation, workflow, change management, human factors, clinical context, cognitive factors and methods of development and dissemination in determining the system's success.

In this research, however, the "what" question will only focus on and discuss the functionality and medical data that need to be shared among different applications, healthcare levels and services. The human and organisational aspects will be discussed in the telemedicine approach in section 2.8.

The "where": the question "where" relates to the locations of the integration points in the framework of integrated systems for the continuing access to and maintenance of the patient's LHR. The integration points should cover technical and business functionality aspects that ensure the transferability and accessibility of the necessary medical data (Esser and Goossens, 2009). Different types of integration requirements cannot be satisfied by one integration approach only; selecting appropriate standards or approaches for each integration need is a complex task (Mykkanen et al., 2003). The integration points of this evaluation will be focused at the functional level.

The "how": the question "how" relates to the identification of the most suitable telemedicine model and the selection of the concrete integration technologies and standards to be implemented in the proposed framework. The evaluation also includes the technical infrastructure needed to support the framework solution (for example, clinical code sets, integration standard, architectural standard and types of telecommunication network).

Reference	Theme	Findings
Doolittle G.C and Spaulding R.J, 2006	Defining the needs of a telemedicine service.	Doolittle and Spaulding have reflected that there is a generic model to define a telemedicine service, which is assessed from a clinical, economic and technical perspective. The framework outlines six generic steps that should be used as a guide for planning new telemedicine programmes. It is a high-level framework that does not touch on technical aspects. A detailed description regarding the technical profile is needed.
Mykkanen J. et al., 2003	A process for specifying integration for multi-tier applications in healthcare.	This is a seven-layer interoperability model (technical interface, technical infrastructure, application infrastructure, functional interface, semantics, functional reference model and development lifecycle) rigorously used in specifying the integration framework process. The use of a seven-layer interoperability model can potentially enhance integration issues in healthcare software.
Esser P.E. and Goossens R.HM., 2009	A framework for the design of user-centred teleconsulting systems	The framework uses the user-centred design approach to develop the telemedicine system. The framework has the potential to contribute to design methodology by providing a practical tool that can be used by design professionals to consider the user at every stage of the design process, even when the context is complex and unfamiliar to the designer. Little information is provided for the system interoperability.
Rasid M.F.A. and Woodward B., 2005	Mobile telemedicine system for transmitting biomedical signals from a patient to a hospital.	The research produces a system to transmit a patient's biomedical signals wirelessly to a hospital for monitoring or diagnosis, using a mobile telephone. The system mainly focuses on designing a processor. The system has the potential to be used as an alternative telecommunication network during a system disaster for transmitting patient health records to the central system. Other types of medical data are expected to be incorporated.
Warren S. et al., 1999	Information architecture for telehealth system interoperability.	This is a technology-based framework that focuses on the information architecture that specifies a common integration gateway from one application to another system.
Lin C.C. et al., 2007	Ubiquitous HIS network architecture	This technology framework, which focuses on the telecommunication network, defines a flexible gateway to transmit patient health records from a remote system to a central system. The framework has the potential to mitigate an inadequate landline telecommunication infrastructure across healthcare centres.
Chronaki C.E. et al., 2001	An HL7/CDA framework for the design and deployment of telemedicine services.	The framework assists the iterative design and deployment of telemedicine services that are efficient and effective, promoting reusability of a clinical document template. The framework is a valuable tool for working groups that are interested in the rapid prototyping and continuous evolution of telemedicine services.
Gonzalez C., 2002	Integrated telemedicine system in Andalusia	The system is a care-centred provider where the remote site and participating site should be established and scheduled accordingly. A patient-centred approach/paradigm is preferable in providing convenient services.
Kyriacou E. et al., 2001	Multipurpose healthcare telemedicine system.	The framework focuses on designing a flexible telecommunication network for transmitting bio medical data. The system framework uses a client-server model and flexible telecommunication network for handling different telecommunication means (GSM, satellite and POTS). Further work is required in integrating the system with the hospital information system.
Ganguly P. and Ray P., 2000	Software interoperability of telemedicine systems : a CSCW perspective	A software framework is based on a distributed object model. Four interoperability issues (physical, data-type, specification-level and semantic) are used as a basis to develop the framework. A generic framework for other healthcare services is expected.
Tsiknakis M. et al., 2002	An open, component-based information infrastructure for integrated health information networks	This is the development of an interoperable framework for the regional health telematics network of Crete (HYGEIAnet). The purpose of the framework is for integrating health information systems and patient health records across healthcare services and levels.
Canada Health Inforway Inc., 2006	An interoperable EHR framework	This is an interoperable framework for integrating health information systems, services and longitudinal patient health records. The EHR is used as a backbone for providing healthcare services and sharing health information across HIS applications and healthcare levels.

Table 2.5: Early Studies on the Selected Telemedicine/Telehealth Framework

2.7.2 Review of the Telemedicine/Telehealth Framework

Based on the above findings, it can be learnt that the domain of telemedicine in the information age is potentially unlimited. The distance and remoteness suggested by the prefix "tele" and the illness or clinical connotation of the word "medicine" are, however, misleading (Suleiman, 2001; Ministry of Health Malaysia, 1997e). The distance involved may be vast, or just a few feet, and the service involved may well be non-medical, focusing on wellness not illness, and delivered in a domestic rather than a clinical setting (Whitten and Sypher, 2006; Harun, 2002). Progressive recognition of this new understanding of telemedicine will lead to the increasing development and creative application of healthcare solutions and frameworks that can be implemented as "telemedicine" in the future (Horsch and Balbach, 1999; Heinzelmann et al., 2005). However, this raises an important question for a provider and healthcare professional: does the telemedicine application provide adequate access to patients' health records at the right time and place? Moreover, what is the most important aspect of telemedicine solutions that ensures patients' health records can be maintained seamlessly and continuously?

Such questions probably require telemedicine technologies to be evolved by a new generation of developers and practitioners that shift toward a data bias. EMRs exploded onto the telemedicine scene and a wide array of health ICT projects have emerged to integrate some form of EMR into the telemedicine equation (Whitten and Sypher, 2006; Dahle and Callahan, 2002). Thus, any essential ingredient of a telemedicine system framework should integrate with the EMR system for enhancing decision support in managing patient problems.

In the next section, a number of frameworks are reviewed to identify various dimensions in a healthcare setting that, together, are used to develop the proposed framework. Based on three aspects (that is, what, where and how), the selected telemedicine frameworks are grouped into three categories, namely generic, specialty-based and EMR-based models. The descriptions and discussions of each framework are offered in the following section.

2.7.2.1 Generic telemedicine framework

2.7.2.1.1 Doolittle and Spaulding framework

Doolittle and Spaulding (2006) reflected that there is a generic model to define a telemedicine service that can be assessed from clinical, economic and technical perspective. The framework emphasises processes that entail six sequential steps.

1. Defining the need for a telemedicine service
2. Planning a service
3. Conducting a needs assessment
4. Developing a healthcare team
5. Marketing
6. Evaluating the programme.

The framework outlines areas that must be addressed when considering whether telemedicine has anything to offer in a particular area of health service delivery. The approach involves defining the needs of a telemedicine application, which is a fundamental requirement for developing a successful and sustainable service. Doolittle and Spaulding's (2006) recommendations are based on 14-years' experience of providing telemedicine services from the Kansas University Center for Telemedicine and Telehealth (KUCTT).

This high-level framework does not include technical and implementation aspects. It is geared more towards processes involved in defining telemedicine services at the planning stage. However, the framework provides invaluable input in defining important telemedicine services that relate to the essential functionalities in supporting my proposed telemedicine framework.

2.7.2.1.2 Mykkanen et al. framework

Mykkanen et al. (2003) formulated a process for specifying integration for multi-tier HIS applications in the healthcare domain. The process is part of an integration method that is validated in the *PlugIT* project in Finland. This integration framework mitigates the integration issues of the heterogeneous HIS applications in a healthcare setting and is based on the seven-layer interoperability model, which consists of the technical interface, technical infrastructure, application infrastructure, functional interface, functional reference model and development lifecycle. They used four important questions (that is, what, where, how and when) in each situation to address the integration issues (Mykkanen et al., 2003).

1. What: what are the data and functionality that needs to be shared among different applications?
2. Where: where are the integration points located in the architecture of interoperable systems?
3. How: what is the most suitable interoperability model and what are the concrete integration technologies and standards for implementing the interoperability?

4. When: can the interoperability be supported during the development and acquisition of systems and the overall system's infrastructure, or is it a separate process from the development?

I believe that this validated integration framework is an ideal generic model, which can be adopted to mitigate a fragmented set-up of telemedicine services and hospital information systems. It is my contention that the framework is very useful to this research project in the area of positioning integration points in the intended framework. I would say the framework approach is similar to Doolittle and Spaulding's method, which emphasises *processes*. A flexible framework is sought that is able to maintain patients' health records continuously during the potential downtime of the telecommunication network and computer system. Hence, a more detailed model of the telemedicine system needs to be examined.

2.7.2.1.3 Warren et al. framework

Warren et al. (1999) proposed an object-oriented information architecture for telemedicine systems that promotes "plug-and-play" interaction between system components through standardised interfaces, communication protocols, messaging formats and data definitions. Each of the component functions of the architecture acts jointly as a black box and a component plugs in a "lego-like" fashion to achieve the desired device or system functionality (Warren et al., 1999). The component functions are services that specify a common integration gateway from one service to another.

There are seven main sets of interrelated services that act as a single system that acquires state-of-health information about a patient. The seven services can be described as follows:

Figure 2.2: Seven Services Represented in Warren's Telemedicine Architecture
Source: (Warren et al., 1999)

- ***User Interface*** service represents hardware and software interactions with the user including mechanisms that support telemedicine device controls (for example, buttons and lights on the front panel of an instrument) and person-to-person interactions.
- ***Medical Devices*** service represents mechanisms for acquiring patient data, delivering therapy to a patient or analysing specimens collected from a patient.
- ***Patient Records*** service represents a device's ability to store and retrieve the information for a patient that the device has collected.
- ***Processing*** service consists of specialised routines to manipulate data. Examples of these include statistical routines to analyse trends in datasets, filtering routines to manipulate waveforms and images, and "intelligent agents" that aid in diagnosis and care planning.
- ***Communications*** service represents (1) mechanisms a telemedicine device uses to communicate with other devices and (2) the services that support these communications (for example, address books that contain e-mail addresses or directories that indicate where to find specific services).

- ***Protocols*** service constitutes the brain of a telemedicine device. The “programs” or “scripts” in this service area accomplish specific medical objectives by utilising resources acquired from the other services. A simple protocol might, for example, direct a medical instrument to take a reading, tell the patient record to store the reading and tell the user interface to display the reading. Protocols can deliver sophisticated functionality through command nesting.
- ***Backplane*** service represents mechanisms that tie the other six services together. It provides intra-device communications as well as profile information needed for a device’s “self-awareness”. This self-awareness is essential in creating devices that work with one another in a plug-and-play fashion.

Besides the seven components offered in the framework, Warren et al. also stressed the importance of methodologies used for the construction of the system and concluded that object-oriented methodologies will result in a wide array of software components that can be employed in telemedicine applications. Furthermore, according to Falas et al.(2003), the methodology must take into account the burgeoning trend in health towards distributed computing and component-based software development. It is my contention that the use of component-based methodology is one of the most important principles in developing a telemedicine system.

At this point generic frameworks for HISs (telemedicine, in particular) have been described, discussed and presented. I will now look at a specific telemedicine service that is provided in depth in a telemedicine system for the specific clinical service.

2.7.2.2 Specialty-based framework

2.7.2.2.1 Esser and Goossens framework

Esser and Goossens (2009) proposed a framework for the design of user-centred teleconsulting systems. The framework described the theoretical dimensions relevant to teleconsultations, based on the framework previously proposed by Miller (Miller, 2002). The framework would contribute to the design methodology by providing a practical tool that can be used by design professionals and it also considers the user at every stage of the design process. The framework is developed by focusing on three perspectives as follows.

1. Doctor–patient communication
2. Technology-mediated communication
3. Technology acceptance.

Figure 2.3: Framework for the Design of User-centred Teleconsulting Systems
Source: (Esser and Goossens, 2009)

By providing design guidelines (the user-centred design approach) for a developing telemedicine system, the weaknesses found in the development stages could be predicted and reduced beforehand. From the above discussion, it can be learnt that the collaboration between technology and humans is an ongoing process that takes place as processes engage in the iterative process of knowledge development (Nonaka and Takeuchi, 1995). I am of the opinion that this factor is the essence in designing a user-centred teleconsultation application, thus increasing suitability for this research.

2.7.2.2.2 Rasid and Woodward model

Rasid and Woodward (2005) formulated a mobile telemedicine system for transmitting basic biomedical signals from a patient’s mobile phone to a hospital. The framework provides mechanisms to transmit biomedical data wirelessly by focusing on the designing of a processor. It is my contention that this mobile telemedicine model would be a suitable model for incorporation into my intended telemedicine system as an alternative telecommunication network. A global system for mobile (GSM) communication could be used for transmitting patient biomedical data to a central system during the downtime of landline telecommunication network (Abd Ghani et al., 2007).

Although the mobile telemedicine model developed by Rasid and Woodward is mainly for telehomecare services with limited types of data, the model can be enhanced for accepting other types of medical data and services.

2.7.2.2.3 Lin et al. framework

Lin et al. (2008) proposed and implemented a long-term healthcare system integrating a wireless local area network (WLAN) and cable television (CATV) networks in the form of a ubiquitous network providing a service platform for physiological monitoring. This system is a telehomecare system for an ageing society in Chiayi City of Taiwan. The framework is technology based and concentrates on healthcare network infrastructures that focus on the telecommunication network, devices and data transmission. The framework defines a flexible gateway to receive and transmit patient physiological data (for example, vital signs) from where the patients might be able to access data at the central system (Lin et al., 2008).

The framework can be described through the following methods concerning each key technology and system process.

1. *Establish a cable access point (CAP), a CAP-based ubiquitous network architecture*: this step concentrates on the construction of network integration (for example, cable modems with WLAN) for providing users with easy access in public places and at home.
2. *Establish a authentication, authorisation and accounting (AAA) security certification mechanism*: this step manages the security portion that processes user identification verification and grants permission to access the database.
3. *Establish health monitoring devices*: this step integrates the different kinds of sensors (for example, vital signs sensor, LCD display, microprocessor and wireless transmission devices) and constructs data conversion and transmission.
4. *Establish health gateway*: this step mainly establishes and manages the patients' health records database, which receives data from or transmits it to various locations. There are three types of health gateways with different roles, namely medical gateway, home gateway and public gateway. The medical gateway is a middleware server at the hospital for storing patients' health records uploaded from the home gateway and public gateway. The home gateway and public gateway are responsible for storing all types of data uploaded from wireless health-monitoring devices at home and in public areas respectively.

I believe this pilot model, after suitable adaptation, would be an ideal model for Taiwan's health system and community set-up. However, I would say that some of the ideas, especially the use of mobile telecommunication and portable devices, could be adopted into my proposed framework for mitigating inadequate access to patients' lifetime health records.

2.7.2.2.4 Chronaki et al. framework

Chronaki et al. (2001) formulated a framework for the iterative design and deployment of telemedicine services based on medical open standards including the health-level-seven clinical document architecture (HL7/CDA) for clinical documents, digital imaging and communications in medicine (DICOM) for imaging and a standard communications protocol for computer assisted electrocardiography (SCP-ECG) for the electrocardiogram (ECG). The framework was developed based on the approach of HL7 CDA standards and interoperability with middleware services of the health information infrastructure (Chronaki et al., 2001).

I would say that this framework focuses on the design of health communication protocols and clinical document templates that facilitate structured data entry for teleconsultation services. The approach might be beneficial for system interoperability and provides guidelines for defining the necessary medical records to be captured for creating life-long electronic health records.

2.7.2.2.5 Kyriacou et al. framework

Kyriacou et al. (2001) formulated a telemedicine system framework that used a client-server model and a flexible network for handling different telecommunication means (a global system for mobile — GSM, satellite and plain old telephony system — POTS). The system is used for emergencies or patient monitoring cases during emergency events for transmitting bio signals and still images of the patient from the place of the incident to the base unit. The system is divided into three components.

1. *Telemedicine unit*: this component is responsible for bio signal acquisition, image capturing and processing, and the collection and transmission of images of the patient to the base unit.
2. *Base unit (doctor unit)*: this component is responsible for the interchange of data, and the displaying and monitoring of bio signals or still images coming from the telemedicine unit.
3. *Hospital database unit*: this component is responsible for managing the data storage of the patient's medical record.

Kyriacou et al. (2001) adapted the above system and tested it in four pilot sites in Greece, Italy, Sweden and Cyprus. I am of the opinion that this pilot system is a flexible telemedicine system as it provides an alternative telecommunication network for transmitting the patient's medical record.

2.7.2.2.6 Bai et al. framework

As discussed earlier, telemedicine activities depend on the telecommunication technologies and transmission speeds employed. Telemedicine is meant to provide support in the areas of long-distance clinical care, patient and healthcare professional health-related education, public health and health administration (Bonnardot and Rainis, 2009; Seung Jae Huh et al., 2000). The use of telecommunication technologies for clinical diagnosis and education has traditionally involved the use of interactive-video for the synchronous delivery of healthcare (Whitten and Sypher, 2006).

Bai et al. (1998) demonstrated the use of the World Wide Web (WWW) for telemedicine and interactive medical information exchange. The framework provides a hardware-independent platform for teleconsultation services where physicians could interact with one another as well as access medical information over the Internet. The system provides several medical applications including the following.

1. *File manager* to manage the medical images stored in the web server
2. *Data tool* to manage cooperative operations on the medical data between participating physicians (for example, image or ECG waveforms)
3. *Bulletin board* to enable the users to discuss special cases by writing text on the board
4. *Digital audio system* to use a point-to-point structure to enable two physicians to communicate directly through voice.

It is my contention that Bai et al.'s system is very useful for establishing interactive communication among physicians. It is, however, very specific to teleconsultation services in its nature. A suitable aspect for the proposed framework has yet to be found. I, therefore, examined another category of the framework that is a medical-record-based framework as described in the next section.

2.7.2.3 Medical-record-based framework

2.7.2.3.1 Canada Health Inforway framework

Canada Health Inforway (2006b) formulated the electronic health record solution (EHRS) framework to provide the enterprise system architecture. The EHRS framework guides the overall development of the whole and the individual parts of the health information system into an integrated one where the electronic health record (EHR) is used as a base for integration. The desired end result of the EHRS framework is to have information available for health-related decisions in one view regardless of the source of the information (for example, system, location or time) (Canada Health Infoway, 2006a). The framework is made up of five key components as follows.

1. **Point of Service (PoS) Applications** – these are information systems being used at the points of service, providing critical healthcare information to inform clinical decision making. This may be the electronic medical record (EMR) in a physician's office or primary care clinic, the information system in a hospital emergency department or the system in the local pharmacy.

2. **EHR Repository –** this component provides information containing a significant subset of the overall EHR data available for sharing with other domain repositories and jurisdictions. The framework has identified four logical clinical domain repositories, namely a shared health record, drug information, diagnostic imaging and the laboratory. By integrating this information from one domain to another, the clinical decision making for a patient would be enhanced.

3. **Longitudinal Record Services (LRS) –** this LRS component performs the functions of collecting and bringing together all the data for a given patient from birth to the present date and from whatever source holds this information into a single longitudinal record. LRS will provide the necessary knowledge about the EHR data when requested by physicians or PoS

systems across healthcare levels and services. The longitudinal records are useful to clinicians when making clinical decisions.

4. **Health Information Access Layer (HIAL) –** this component is responsible for connecting possibly hundreds of PoS systems with multiple repositories and registries. Its job is to act as a gateway that is a critical sharing point for making it possible for information in different languages and forms to be shared with the full range of EHRs. It provides a single standardised way for PoS systems to connect to the EHR infostructure, regardless of how a particular jurisdiction has partitioned EHR information domains and services.

5. **EHR Viewer** – this component provides a patient EHR summary, to be viewed or used by the healthcare professional in supporting real-time day-to-day care delivery for different types of caregivers. The EHR viewer is generated or obtained from a patient's longitudinal record of EHR. It will be included along with PoS applications or it could be executed by itself for providing a window for the user into the EHR.

The interrelated EHR solution framework formulated by Canada Health Infoway is illustrated in Figure 2.4.

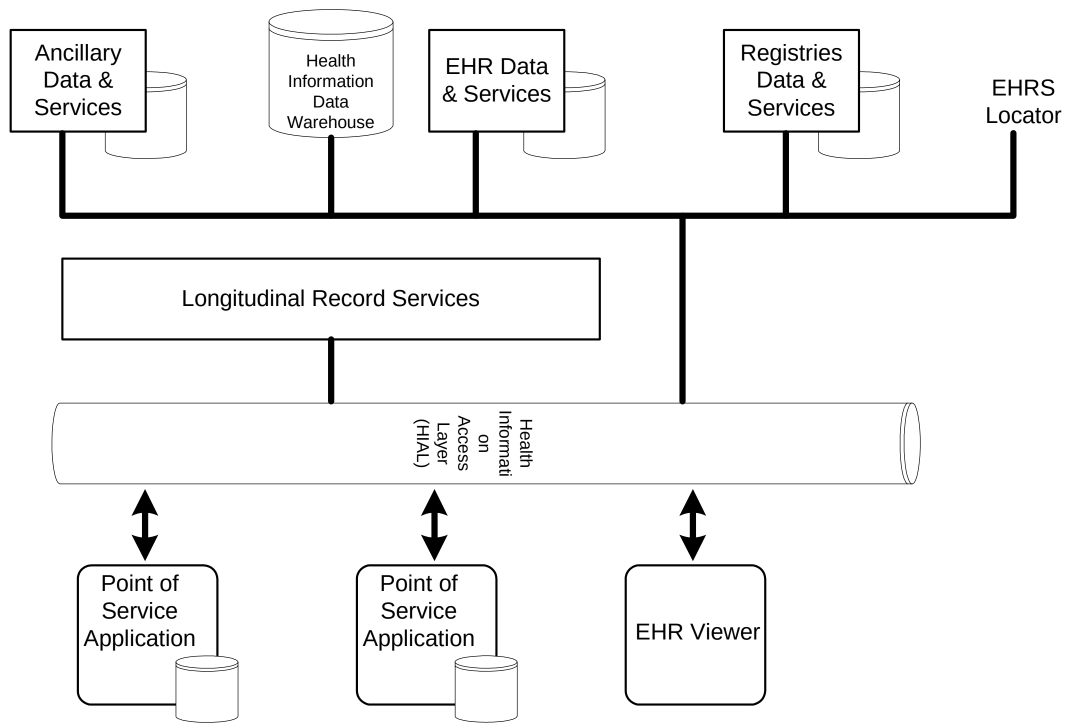

Figure 2.4: EHR Solution Framework.

Source: adapted from (Canada Health Infoway, 2006b)

What is unique about the framework is that the five components defined in the EHRS framework allow new HISs to inter-operate with the old HIS across healthcare levels through the sharing of EHRs. It is my contention that although the framework was mainly for EHR interoperability, the framework could be used in telemedicine services for providing access to the patient's health record (EHR) continuously.

2.7.2.3.2 Tsiknakis et al. framework

Tsiknakis et al. (2002) formulated an integrated health information network (HYGEIAnet) framework for the region of Crete. The development of HYGEIAnet is a long-term effort to provide an integrated environment for healthcare delivery and medical training across the island of Crete. The system provides seamless access to EHR in providing seamless care during a doctor–patient encounter. Thus, the I-EHR service is an integral part of the framework which consists of several components as follow (Tsiknakis et al., 2002).

1. Patient identification service (PIDS) – this service allows for the unique association of distributed patient record segments to a master patient index.
2. Health resource service (HRS) – this service provides resource information across healthcare services and levels through a common reference point. By way of example, the health worker can share and view information about the available equipment/devices at each facility as well as information on the doctors or pharmacists on-duty.
3. I-EHR indexing service (IS) – this is the software used to index and manage data, and it is determined by the selected federated schema. The service indexes the clinical findings captured by the physician that are relevant to the particular encounter or visit. The information will then be summarised for future reference and care.
4. I-EHR update broker (UB) – this service is responsible for the prompt and consistent propagation of information from the feeder systems to the I-EHR indexing server.
5. Clinical observation access service (COAS). – this service implements the standardised, public interfaces in all feeder systems.
6. Terminology service (TS) – the service is used for assisting in the process of entering coded data, transforming messages or data elements from one form to another, inquiring about associations that may not pertain to the various data elements and aiding in the entry, validation, translation and simplification of composite concepts.

Tsiknakis et al. (2002) elaborated that the above framework is based upon an ongoing experience in developing HYGEIAnet that shares a number of similarities with the generic software engineering process, namely the emphasis on requirement analysis and design of the product being proposed.

Although there are a number of HIS frameworks that focus on how to provide healthcare services in an integrated manner, there has been a marked preference for frameworks that provide links or pairs with EMRs/EHRs (Maheu et al., 2001; Whitten and Sypher, 2006). I concur with the viewpoint that, in the near future, the HIS framework (telemedicine, in particular) would move towards pairing or integration with EMRs/EHRs for continuous and seamless care.

Framework/authors	Evaluation aspects			
	Focus area	What	Where	How
Generic frameworks				
Defining the needs of a telemedicine service. (Doolittle G.C and Spaulding R.J, 2006)	• Method • Interoperability	• Generic function of healthcare services	• Analysis design stage	Emphasise on: • Clinical • Economic • Technical
Information architecture for telehealth system interoperability. (Warren S. et al., 1999)	• Interoperability.	• Generic function of healthcare services	• Application service level	Standard of: • Information protocol • Common integration gateway
A process for specifying integration for multi-tier applications in healthcare. (Mykkanen J. et al., 2003)	• Processes • Interoperability	Generic function of: • Clinical • Administrative	Application tier: • User • Workspace • Enterprise • Resource	• Interaction modes • Messages standard • Telecommunication network Technology
Specialty-based frameworks				
A framework for the design of user-centred teleconsulting systems. (Esser P.E. and Goossens R.HM., 2009)	• Methodology	• Teleconsultation services	• Design stage	
Mobile telemedicine system for transmitting biomedical signals from a patient to a hospital. (Rasid M.F.A. and Woodward B., 2005)	• Design of processor	• Telehomecare services	• Device level • Data level	• Wireless/mobile network (GSM) • Mobile phone • Device and • Data comm.

Software interoperability of telemedicine systems: A CSCW Perspective. (Ganguly P. and Ray P., 2000)	• Interoperability and data comm.	• Telecardiology	• Application level	Standardisation of • Data type • Specification – level • Semantic
Ubiquitous HIS network architecture. (Lin C.C. et al., 2007)	• Flexible network architecture	• Teleconsultation – pervasive healthcare	• Connectivity • Data comm.	• Wireless local area network (WLAN) • Cable television (CATV) • Devices
An HL7/CDA framework for the design and deployment of telemedicine services. (Chronaki C.E. et al., 2001)	• Interoperability • Methodology	• Teleconsultation.	• Application level • Communicat-ion protocol	Medical open standards: • HL7/CDA • DICOM • SCP-ECG
Multipurpose healthcare telemedicine system. (Kyriacou E. et al., 2001)	• Telecommunicati on network interoperability.	• Emergency healthcare and telehomecare.	• Application level	• Telecommunica-tion network, devices and data communication.
EHR-based frameworks				
An open, component-based information infrastructure for integrated health information networks (Tsiknakis et al., 2002)	• Interoperability • EHR • Software engineering process	• Generic healthcare services. • EHR services	• Design stage • Application level	• Centralised EHR • EHR infrastructure
An interoperable EHR framework. (Canada Health Inforway Inc., 2006b)	• Interoperability • EHR	• EHR services	• Application level • Data level	• Centralised EHR services • Standard clinical protocol. • Common gateway for integration

Table 2.6: Selected Telemedicine Framework Categorised by Evaluation Aspects

2.7.2.4. Summary of telemedicine framework review

From the above discussions, there are three categories of telemedicine frameworks: the first one is from a general context of healthcare services, while the second and third are from a specific clinical discipline and system (that is, paediatric and general medicine) and EMR-based context respectively. What emerges is that a generic framework of telemedicine is looking at the services integration from the providers' perspective and efforts are carried out in developing frameworks for building an integrated telemedicine service. On the other hand, the specialty-based framework and EMR-based framework are looking at this from the viewpoints of both the customers and the patients (that is, a people-based perspective) and providers. What can emerge from the three perspectives (that is, a technology-based perspective) of the frameworks is that the combination of these three viewpoints could provide a holistic telemedicine framework for improving healthcare services through seamless and continuous access to patients' health records. Based on the aforementioned discussion, it becomes clearer that the integration between telemedicine services and EMRs/EHRs is needed for a continuum of care, which is the essence of this research.

In order to maintain a seamless access to patients' health records, a flexible solution to maintain the data should be addressed in the framework or system. The proposed solution to these issues is often addressed through multi-channels of the telecommunication network as formulated in frameworks by Mykkanen et al. and Lin et al. Unfortunately, the above frameworks do nothing to address alternative storage for maintaining the patients' health records during unpredictable system disasters. The wide adoption of portable device technology (for example, mobile phones and PDA) in healthcare services can potentially improve information access and promote evidence-based practice to make informed and effective decisions at the point of care (Abd Ghani et al., 2007; Lu et al., 2005). It is my contention that the portable device technology could be utilised further for health record storage purposes and this could address the flexibility requirements of the intended framework.

The next section will now look at how the divergence between telemedicine services from the three categories could be fed with the specific organisational needs (a Malaysian health perspective). The review of other countries' approaches in implementing telemedicine systems would reveal the suitable aspects of the framework for the Malaysian telemedicine system.

2.8 Review of Telemedicine Approaches in Other Countries

This section reviews the telemedicine approaches of several selected countries. The most suitable approaches, experiences and best practices therein could be used as part of the proposed framework and theory building.

2.8.1 Taiwanese Context

a) Demographic Statistics

Taiwan has a total land size of 36,188 km^2 and had a population of 22.978 million in March 2008 (Taiwan Directorate General of Budget Accounting and Statistics, 2007). The main economic activities of Taiwan are centred on industrial activities such as semiconductors and electronic products.

In 2003, Taiwan spent approximately 5.3% of GDP on healthcare. The average life expectancy of its citizens stands at 73 years and 79 years for males and females respectively (Department of Health Taiwan, 2008). The social insurance systems were the main schemes for covering healthcare financially; and the healthcare provision remains private-sector driven. However, the state government still has authority for performing a chiefly regulatory role (Holliday and Tam, 2004).

b) Health Informatics Initiatives and Approach

Telemedicine development in Taiwan has proliferated since 1990 and was officially launched in 1995 under the National Information Infrastructure (NII) project (Hu et al., 2002). The mission of the project was to provide a wide array of services nationwide for remote diagnosis and patient management in primary, secondary and tertiary sectors. The mission also included support for clinical training and continuing medical education (CME) for healthcare professionals and medical assistants such as nurses and paramedics (Luh et al., 2005; Liu et al., 2001). The CME programme is a prominent telemedicine application in Taiwan.

The implementation approach of telemedicine in Taiwan was carried out in three stages: initiation (such as reliability, availability, performance and data voluminosity), promotion research (tested or piloted) and evolution (obtained data and assessment) (Chen et al., 2001). Taiwan's telemedicine approach is predominantly focused on clinical services and CME services but less attention is given to linking and integrating the services with the patient's EHR.

This "bottom-up" orientation is its current approach to promoting telemedicine services but it lacks the effort devoted to an overall strategy for linking and sharing EHRs across healthcare facilities and levels. The EHR strategy development so far has started with bottom-up field projects followed by a realisation that a strategic EHR framework is needed to maximise benefits. Among the approaches for implementing the EHR in Taiwan's healthcare facilities is the national health insurance smart cards, known as "NHI-IC" cards (Liu et al., 2006). The NHI-IC replaces the existing paper-based health insurance cards with a card capable of updating patients' critical health records. The implementation of NHI-IC cards in hospital medical services demands both information technology and financial support for building up the information infrastructure and enhancing the existing health information system in Taiwan (Tsai and Kuo, 2007).

Three-fourths of the land area of Taiwan is mountainous and there are several small isolated islands around the major island. The use of intranet and Internet connections using the integrated service digital network (ISDN) and broadband network is common in telemedicine and EHR applications with a bandwidth range of between 128 kbps to 2 mbps (Chen et al., 2001). A widespread telecommunications network infrastructure capability provides many advantages (infrastructure cost and implementation duration) for implementing telemedicine and EHR systems across healthcare facilities and levels in Taiwan.

The greatest challenge to implementing telemedicine and EHR systems in healthcare facilities and levels in Taiwan is to integrate the existing disparate systems and legacy health information systems for collecting and mining the centralised EHRs. To cite an example, the legacy computer system IBM/SNA (System Network Architecture) OS390 introduced over 25 years ago is still in use at National Taiwan University Hospital (Hsieh et al., 2006). Other legacy systems, such as the HIS (laboratory, radiology, pharmacy, admit, discharge and transfer information system) and other support systems, are new challenges to integrate with recent health information systems and technologies like telemedicine, telehealth and e-health systems. This needs further research in order to have a smooth integration and to maintain the asset of the legacy system in Taiwan.

2.8.2 Singaporean Context

a) Demographic Statistics

Singapore has a land size of 697.1 km^2 and had a total population of 4.588 million in 2007 (Singapore Department of Statistics, 2008). The main economic activities are based on the semiconductor industry where, at present, the country stands as the third largest silicon manufacturer in the world (Holliday and Tam, 2004; Mathews and Cho, 2000).

The healthcare expenditure of Singapore in 2005 was 3.7% of GDP and the average life expectancy of its citizens is 77 years for males and 81 years for females (Ministry of Health Singapore, 2007a).

The majority of healthcare provisions for Singapore are through healthcare consortiums or private-driven organisations. Healthcare funding is generated from compulsory savings systems such as the Central Provident Fund scheme. Two healthcare clusters, namely National Healthcare Group (NHG) and Singapore Health Services (SingHealth), manage the healthcare delivery system of Singapore, which include networks of hospitals, speciality centres and polyclinics (Ministry of Health Singapore, 2007b).

b) Health Informatics Initiatives and Approach

The objective of the telemedicine initiative in Singapore is to curb ever-escalating healthcare costs, increase efficiency in medical care, promote health (HPBonline, 2007) and empower Singaporeans to manage their health. A store-and-forward method (through the Internet) is the main approach to delivering telemedicine services in Singapore. The *OphthWeb* is a pioneer telemedicine system for delivering optometric treatment services and a testing ground for generating electronic medical records (EMRs) for Singaporeans before other clinical specialties are applied to (Chew et al., 1998).

The use of web-based telemedicine applications reduces telecommunication costs and telemedicine equipment (such as videoconferencing) costs. The use of the Internet in healthcare delivery enables people to have easy access to telemedicine applications at a low cost and in a convenient manner (Chew et al., 1998). There are specialist areas that utilise telemedicine technologies, such as teleophthalmology (which is considered to have less risk compared to other specialties). Teleophthalmology does not require a high degree of computer literacy and there is less data entry for healthcare professionals to capture the diagnosis and medical findings.

Singapore's health portal becomes an essential medium to promote healthy lifestyles or wellness programmes for the citizens (Health-4-U, 2007). On the other hand, continuing medical education (CME) plays an important role in keeping medical professionals up to date with changes in medicine generally and in areas relevant to their speciality (SingHealth, 2007). The geography and the population size require proportionately little investment in the required telecommunication infrastructure.

The majority of telemedicine services and e-health applications in Singapore use the high-speed broadband backbone (Singapore ONE) with a bandwidth range up to 622mbps (Tay-Yap and Al-Hawamdeh, 2001). As such, the Internet is a suitable piece of technology for implementing telemedicine applications in Singapore and this makes it possible to share patients' health records across and between healthcare stakeholders and they are accessible by patients anytime and anywhere via the Internet.

Telecommunications charges, service charges and integration with legacy systems are among the main challenges for the long-term sustainability of telemedicine and EHR initiatives in Singapore.

Year	Name of the project	Application orientation	Health network & users	Content delivery medium	Project description
1997	OpthWeb	TeleOphtalmology	Xiamen Eye Centre in China and Singapore National Eye Centre	Internet browser, Store-and-forward, e-mail	Web-based ophthalmic provides multimedia patient data and educational information and answers frequently answered questions for doctors, patients and healthcare providers anytime and any place around the world
1998	CyberCure	Teleconsultation	Hospital, consumers	Internet, store-and-forward	The system is an interactive multimedia application for children and it was produced by KK Women's & Children's Hospital.
1999	Health & Environment @ eCitizen	Health Portal	Consumers	Internet, store-and-forward	The portal provides health promotion as well as health information resources for citizens through an eCitizen portal.
2001	Health ONE	CME, Health Information Portal	National University of Singapore/ Home users	Audio and video	The project provides a multimedia health information resource that caters for both public as well as health professionals. The health professionals are able to continue their medical education through distance learning programmes using audio and video aids.
2001	Health-4-U	Health Portal	Consumers	Internet browser	This is patient education website of the Singapore General Hospital. This site provides credible information in layman's terms about disease conditions and the associated treatment and procedures.
2001	e-pharmacy	Prescription Services	Consumers and pharmacist	Internet	The service allows patients to be prescribed medication online and delivered the order throughout the island.

2001	CARES	TeleAppointment	Health providers/consumers	Internet browser	An interactive appointment scheduling through the web
2001	HPBOnline	Health Portal	Contents providers/consumers	Internet browser	Health Promotion Board (HPB) is a website that promotes a healthy lifestyle for citizens through health guides and information for the public.
2005	Telecare for Chronic diseases	Obstetrics and Gynaecology, Nephrology, Cardiology	Hospital, home users	Internet, GSM-SMS	This project involves Singhealth outpatients sending in their vital signs and symptom health status from home or away to Singhealth facilities and networks through the Internet of SMS.
2006	3-D High Definition (HD) telemedicine transmission in ophthalmology	TeleOphtalmology	Hospitals	Internet browser	The real-time vitreo-retinal surgery that is transmitted using the 3-D HD format via the Asia Broadband (a new high-speed 155Mbps R&D link between Singapore and Japan) live to the audience in Singapore

Table 2.7: Telemedicine and E-health Applications in Singapore

Source: adapted from (Lun, 1999; Chew et al., 1998; Tay-Yap and Al-Hawamdeh, 2001; SingHealth, 2007; HPBonline, 2007)

2.8.3 Hong Kong Context

a) Demographic Statistics

Hong Kong is an industrially-based economy and one of the five leading economies of East Asia (Holliday and Tam, 2004). The population of Hong Kong stood at 6.97 million in 2005 and its land area is 1,092 km^2 (Yahoo Education, 2005d).

The Hong Kong Hospital Authority (HKHA) is responsible for providing healthcare provision and funding. The provision of a healthcare system focuses mainly on secondary care rather than primary care (Cheung et al., 2001). In 2002, Hong Kong spent approximately 5.5% of GDP on health expenditure and the average life expectancy of the citizens is 79 years for males and 84 years for females (Hong Kong's Domestic Health Accounts (HKDHA), 2005; WHOSIS, 2006). This indicates that Hong Kong is facing significant changes in its demographic pattern where the ageing population has increased over the years.

b) Health Informatics Initiatives and Approach

The mission of telemedicine initiatives in Hong Kong is to both improve healthcare delivery and make better health information available for healthcare professionals and for patients (Lun, 1999). The Hong Kong Hospital Authority (HKHA) has strongly supported the development and implementation of information systems and telemedicine initiatives in the healthcare facilities of Hong Kong (Holliday and Tam, 2004; Cheung et al., 2001).

The approach to telemedicine in Hong Kong is to start with medical informatics initiatives where the computerisation of the Hospital Authority is a focus. By way of an example, after the Hospital Authority (HA) was established in 1991, there were three phases of information system projects developed. These were the establishment of a patients' database, the development of clinical systems for generating central electronic patient records (EPRs) and the integration of healthcare information systems (Hjelm et al., 2001).

The establishment of a wide area network then took place linking all hospitals and clinics together for information sharing. This integration provides seamless access to the results in the clinic workstations or wards (Hjelm et al., 2001). Most of the telemedicine technology is based on a store-and-forward approach using broadband Internet access with a bandwidth size of 384kbps and above (Holliday and Tam, 2004).

The barriers to the long-term sustainability of the telemedicine initiative in Hong Kong include the integration of telemedicine services into the existing healthcare delivery system. The use of a single system and Internet connections across the healthcare facility of HKHA would reduce a lot of the implementation cost. These might be suitable for Hong Kong, which has a relatively small population and geographical area, which means, therefore, it would not be too costly to install an adequate broadband telecommunication infrastructure. It would be very costly for countries like Malaysia, however, to provide such an infrastructure and a flexible solution has to be found to connect all healthcare centres seamlessly.

2.8.4 Japanese Context

a) Demographic Statistics

Japan is one of East Asia's leading economies and one of the world's leading countries in the ICT industry. The total land size of Japan is about 377,835 km^2 and the total population stood at 127.771 million in October 2007 (Statistics Bureau of Japan, 2008; Yahoo Education, 2005e).

In the year 2004, the life expectancy of Japanese males and females was 79 years and 86 years respectively and the healthcare expenditure stood at 7.7% of GDP (WHOSIS, 2006). Healthcare claims are fully covered by healthcare schemes such as health insurance and the social insurance system. The health provision of Japan remains private-sector driven, but the Government has authority in the regulatory and policy matters (Holliday and Tam, 2004).

b) Health Informatics Initiatives and Approach

Efforts to develop telemedicine, telehealth and the EHR system started when the first Japanese telemedicine system went through an experimental stage in Wakayama Prefecture in 1971. The Wakayama Medical Association, with the collaboration of Osaka University and Wakayama Medical College, carried out a project to provide medical care for rural mountain areas via closed-circuit television (CCTV) (Holliday and Tam, 2004). This was the best connectivity at that time. The electronic health records (EHRs), including images, sounds and documents, were transmitted via a telephone circuit and facsimile. In 1994, Japan's EHR aim through "Health Information Strategy 21" was launched with the mission to provide quality and efficient healthcare services for the citizens (Toyoda, 1998).

The implementation of the EHR system was delivered through a multitude of channels for health information applications. Hospital information and management systems, telemedicine systems, telehealth systems and decision support systems were among the common healthcare information applications used in the EHR efforts.

The bottom-up approach of telemedicine, telehealth and EHR development in Japan mainly comes from higher medical institutions, medical associations and private sectors (Takahashi, 2001). Japan does not currently have a government-centred EHR system. However, some local, regional and single hospitals have installed digital patient records and share data between hospitals, clinics and patients (Arnold et al., 2007).

The majority of telemedicine, telehealth and EHR system developments were initiated by the medical institutions and medical schools in universities. This approach serves to lessen the risks, such as inadequate buying-in by physicians to use the applications.

The use of Internet technologies is the most popular approach to delivering EHR services to consumers or healthcare professionals in Japan. The Internet and broadband telecommunications are the main transports for transporting the patients' health records across different healthcare facilities and levels and to healthcare professionals and consumers (Tsuji et al., 2003).

The challenges to the long-term sustainability of telemedicine, telehealth and EHR initiatives in Japan include excessive regulation and issues of integration with the existing healthcare delivery. One example of excessive regulation is that physicians in Japan are prohibited from answering specific questions about healthcare or diseases by e-mail or telephone (Holliday and Tam, 2004). Although the health informatics standard organisation have been established in Japan, integration is still a critical issue that needs to be resolved and this is still in progress today (Inamura and Lemke, 2007).

It has to be noted that healthcare services deal with human beings and this is why change management becomes a critical challenge in implementing telemedicine, telehealth and the EHR system in Japan. The technologies and standards cannot guarantee the buy-in and the succession of health information systems without considering the re-engineering process of the existing business processes (Masuda et al., 2005).

2.8.5 Chinese Context

a) Demographic Statistics

China is a vast country area with a total land area of 9,596,960 km^2. It is the world's most populous country and had a population of 1.3 billion in 2005. The average life expectancy of its population was 70 years for males and 73 for females in 2003. Overall, in 2002, approximately 5.8% of GDP was spent on healthcare services (WHOSIS, 2006). The main economic activities of China are agriculture and industrial product manufacturing (Yahoo Education, 2005c).

There is a big difference between the coastal areas and the rural areas in western China in terms of the development of the country. This difference affects the healthcare delivery services where healthcare facilities in the coastal areas are relatively easy to access compared to those in rural and poor areas (Hsieh et al., 2001). The inadequate distribution of healthcare services between coastal areas and rural areas forms the major problem. The Government of China is looking at alternative approaches to overcome the situation by using telemedicine technology. Telemedicine would give hope to improving access to healthcare services and can result in significant savings for the patients and China's healthcare system.

b) Health Informatics Initiatives and Approach

In 1995, China embarked on its first telemedicine initiative, which was based mainly at the Chinese University of Hong Kong (CUHK) in Hong Kong mainland. Continuing from the first attempt, a task force on telemedicine was established at the Faculty of Medicine of CUHK in April 1996. Seven months later, the Telemedicine Society was inaugurated in November 1996.

This society formed a discussion and research group among healthcare professionals and academics (Hsieh et al., 2001).

The objective of telemedicine in China is to ensure equal distribution of healthcare services to those living in rural and underserved areas. It is also meant to lower healthcare costs and travel time by providing a remote access facility for the healthcare services through telecommunication technology.

The key supporters in developing the telemedicine project include higher medical institutions and universities. The collaboration arrangement with external institutions (such as the United States National Library of Medicine (NLM) in Bethesda, Maryland, USA) also contributes towards the development of telemedicine in China (Hjelm et al., 2001).

In order to synchronise the telemedicine initiative between institutions and healthcare professionals, the Government of China has established the Telemedicine Task Force and Telemedicine Society. These institutions are used for strategic meetings and formulating policies and setting up procedures and standards.

The Government of China has also created a policy to encourage international collaboration for her modernisation initiatives. One of them is the telemedicine effort through direct collaboration between a Chinese medical institution and a Western medical institution, Xiamen Eye Centre in Fujian province in southern China and Singapore and a Medical Faculty of the CUHK and its teaching hospital. With this collaboration, the telemedicine programmes can be adequately tested. The participating hospitals would benefit in terms of it being a test-bed platform for getting feedback and improvement (Noseworthy, 2004; Chew et al., 1998).

China faces the same issues in that the telecommunication infrastructure is still inadequate. For this reason, through the authority of China Post, Telephone and Telegraph (PTT), the bandwidth infrastructure is upgraded to support the telemedicine implementation. The selection of the connectivity type and the bandwidth size depends on the programmes, the services provided or the approach of the contents to be delivered. Most of the telemedicine programmes require a high telecommunication bandwidth between 384 Kbps to 2 Mbps (Noseworthy, 2004; Hsieh et al., 2001).

The emphasis in the telemedicine initiative in China is still on illness and emergency treatments and the focus is still not on EHR-based mediation. Thus, it has failed to bring about a long-term health promotion (wellness), health community and participation from patients in terms of taking care of their health conditions. There is an absence of a standard solution framework for national telemedicine implementation in China. Because of this, there are redundant telemedicine programmes developed among the healthcare providers and medical research institutions (such as universities). In fact, the systems developed are customised according to dedicated requirements for each healthcare provider and university. This would bring issues of integrating the systems and sharing the EHR system across healthcare facilities and levels. Inadequate integration among telemedicine system components in China will lead to a lack of continuity of care across different episodes and setting up of clinics or hospitals (Leung et al., 2003; Varghese and Scott, 2004).

2.8.6 Australian Context

a) Demographic Statistics

Australia is a large region with a total land size of 7,686,850 km^2. The country is divided into seven states and two territories and its main economic activities are the export of raw materials and agricultural products (Yahoo Education, 2005b). ,Its population stood at approximately 21 million in 2007 and 80% of them live in cities (Australian Department of Health and Ageing, 2005; Australian Bureau of Statistics, 2008).

Australia spent about 9.5% of GDP on healthcare services. The average life expectancy of its citizens is 78 years for males and 83 years for females (WHOSIS, 2006). The delivery and management of public health services are primarily the responsibility of the state and territory governments. The Government directly funds a broad range of health services. The public sector also plays a significant role in delivering the health services to all Australians. Service charges are normally paid or claimed through private health insurance schemes and the National Healthcare Funding System, known as Medicare (Australian Department of Health and Ageing, 2005).

b) Health Informatics Initiatives and Approach

The first telemedicine project in Australia began in 1992 and the project started with teleconsultation services for remote indigenous communities in the Northern Territory (Australian Department of Health and Ageing, 2001). At this time, the majority of telemedicine applications were focused on certain specialties using interactive video and point-to-point communication and the applications were set up in a fragmented manner. Due to this limitation, the telehealth initiatives. which include telemedicine and e-health, were embarked on in all Australian states and territories in early 1996. The objective of telehealth is to provide lower cost healthcare services to rural areas as well as urban areas. It is also a means to optimise the quality of healthcare services and enables the healthcare services to be delivered in an integrated manner rather than being an end in themselves (National Telehealth Plan for Australia and New Zealand, 2001) (see Table 2.7 for some of the telehealth and telemedicine services and applications implemented in Australia).

Australia's telehealth approaches not only focus on clinical aspects but also include other crucial non-clinical aspects (see Table 2.7). Table 2.6 summarises the action plan for the sustainability and expansion of Australia's telehealth services. The action plan shows that the telecommunication requirement and widely accepted standards are critical elements for implementing telehealth applications.

Action plan	Description
Infrastructure	establishing an appropriate telecommunication infrastructure nationwide for equitable access to healthcare services
Standards	developing widely-accepted standards such as a health informatics standard
Research and development	identifying new areas for research and development in telehealth applications
Funding and financing	establishing funding and financing options that can be listed in the health insurance schemes
Communication, education and training	continuing the promotion and training of telehealth is essential to health service providers, managers, health practitioners, consumers and the general community

Table 2.8: Telehealth Action Plan

Source: adapted from (Australian Department of Health and Ageing, 2001)

At the beginning of the telehealth initiatives, telehealth services were developed in a staggered manner; they focused on certain specialties and services. It started with the telepsychiatry services, which provide a link between rural health centres and tertiary hospitals (Lessing K. and

Blignault I., 2001). The implementation of telehealth services was by state starting with rural and remote areas and continuing to urban areas.

In terms of the content delivery type, *interactive videoconferencing* and *store-and-forward* are the main technologies used in delivering the telehealth contents and services (Mahncke and Williams, 2006). Broadband connectivity is the primary communication service used in telehealth services and the primary transmission speed is between 256 kbps and 2mbps. Telephone lines and dedicated connectivity are used as the primary transmission medium and primary connection type. Some of the telehealth services use satellite for their primary communication service (Australian Department of Health and Ageing, 2007; Lovell and Celler, 1999). This is for rural and remote areas where it is impossible to install a normal telephone line due to costs and geographical barriers.

The Government, through the National Health Information Management Advisory Council (NHIMAC), realised that the telehealth services should be incorporated with electronic health records for providing integrated services. Looking at this requirement, the Health*Connect* Board was formed to take the responsibility of ensuring that the national health ICT project including telehealth progressed accordingly (Australian Department of Health and Ageing, 2003; Australian Department of Health and Ageing, 2001). Health*Connect* is Australia's health information network and it aims to improve the delivery of healthcare services, provide a better quality of care, increase patient safety and improve health outcomes through a seamless, secure, integrated system of electronic health records. It is anticipated that Health*Connect* will have a broad and significant impact on the Australian health sector (Australian Department of Health and Ageing, 2003; HealthConnect, 2004).

In summary, Australia's telehealth approach is trying to integrate the services and applications of other health online initiatives and change from a fragmented approach to an integrated one. This is because the main challenge to long-term sustainability of telehealth services in Australia is the integration of telehealth services into the existing healthcare delivery system (Yellowlees, 2001; Dillon et al., 2005). The development of national electronic health records through Health*Connect* is the backbone of an integration process where the patients' health records can be accessed seamlessly via telehealth services across healthcare providers. It looks as if the approach has been widely effective in terms of implementation and practice in sustaining telehealth services in Australia or other countries.

Category	**Application**	**Service**	**Technology**
Clinical	Mental Health (Telepsychiatry)	• managing patient's condition • patient's case review • medical management	• videoconferencing • interactive w/still image
	Primary care	• managing patient's condition	• videoconferencing
	Multi-disciplinary	• managing patient's condition	• videoconferencing
	Pain management	• pain management • managing patient's condition	• videoconferencing
	Paediatrics (Telepaediatrics)	• patient consultations • managing patient's condition • patient referral	• videoconferencing • e-mail • telephone
	Obstetric and Gynocology (TeleObstetrics)	• managing patient's condition	• store and forward
	Radiology (Teleradiology)	• diagnostic exam interpretation	• interactive w/still image
	Ophthalmology (Teleophtalmology)	• managing patient's condition • diagnostic exam interpretation	• videoconferencing • store and forward
	Speech Pathology	• diagnostic exam interpretation • managing patient's condition	• videoconferencing • audiographic
	Rehabilitation Therapy	• managing patient's condition • patient's case review	• videoconferencing
	Dialysis	• medical/surgical follow-up	• videoconferencing

Non-clinical	Continuing Medical Education (CME)	• providing medical module and online examination.	• videoconferencing
	Patient education	• providing health information	• Internet, videoconferencing
	Community education	• providing health information	• Internet, videoconferencing
	Training	• providing medical module and online examination	• videoconferencing
	Conferences Demonstrations Patient scheduling	• providing support and administration functions	• Internet

Table 2.9: Telehealth/telemedicine Services and Application

Source: adapted from (NSWHEALTH, 2003; NSWHEALTH, 2004; Australian Department of Health and Ageing, 2001; Lovell and Celler, 1999; Williams and Smith, 2004; Lessing K. and Blignault I., 2001)

2.8.7 New Zealand Context

a) Demographic Statistics

New Zealand had a population of 3.8 million in 2003 (WHOSIS, 2006). The total land size of the country is 268,680 km^2 and the main economic activities are agriculture and the manufacturing of industrial products (Yahoo Education, 2005f).

The model of the health delivery system of New Zealand is more community oriented and is structured into three levels of health services. They are the district health boards, primary healthcare and primary health organisations. The district health boards are responsible for providing and funding the provision of health and disability services in their districts. They are supported by the Ministry of Health, which provides national policy advice, regulation, funding and monitoring of the performance of its agencies. Primary healthcare and primary health organisations, on the other hand, cover a broad range of out-of-hospital services for people in the communities (Ministry of Health New Zealand, 2008).

With a comprehensive network set-up of healthcare facilities in each district and community area, the healthcare delivery services of New Zealand are considered to be relatively good. The healthcare status has also improved since 2003 when the average life expectancy of the citizens stood at 77 years for males and 82 years for females. However, the health expenditures are still considered high at 8.5% of GDP (WHOSIS, 2006).

b) Health Informatics Initiatives and Approach

The first telemedicine project in New Zealand began in 1993 in North Island. It involved transmitting radiology images between two hospitals using a leased lined network. In 1994, a pilot implementation of teledermatology and telepsychiatry programmes began in North Island and the programme was developed by the Institute of Telemedicine at Queen's University, Belfast (Australian Department of Health and Ageing, 2001; Oakley and Rennie, 2004). The telemedicine vision emphasises the principle of providing a possible solution for health providers to reach out to rural areas to integrate with one another, increase limited healthcare delivery services, promote disease prevention and monitor the health conditions of patients. The telemedicine projects are funded directly by the Commonwealth Government and through research grants. The key supporter is the Government and the project is normally led by the Health and Hospital Services (HHS) and Higher Institutions of Schools of Medicine (Al-Qirim, 2006).

Most of the telemedicine services developed in New Zealand focus on clinical areas such as dermatology, psychiatry, and paediatrics. For non-clinical areas, there are also various services developed for continuing medical education (CME) and administrative (meetings and discussions) functions (Al-Qirim, 2007; Oakley et al., 2000). The approach to implementing them normally starts with a specific clinical discipline; and they have been developed in a staggered manner. Telemedicine in New Zealand began with research projects (such as a university and medical research projects) and a pilot implementation project in government hospitals.

The health networks for telemedicine or telehealth services are between hospitals, university hospitals and health centres. This indicates that telemedicine or telehealth services are appropriate for being implemented in healthcare facilities before they can be implemented directly for the consumers. The primary communication service used for transporting the data is ISDN with a transmission speed between 128 kbps and 384 kbps. Almost all networks use broadband lines and dedicated connections for the transmission medium and connection type (Al-Qirim, 2005; Oakley and Rennie, 2004).

The research carried-out by Al-Qirim (2007) on telemedicine adoption in New Zealand found that there are twenty-three health information systems running in different health facilities in New Zealand. This has led to integration issues between different systems and has posed a major barrier for a seamless care system across healthcare facilities. Hence, telemedicine technology is one of the best solutions for integrating the health organisations and services in New Zealand.

Realising that the continuum of care would be achieved through the continuous and seamless access to electronic health records (EHRs), the Health Information Strategy for New Zealand (HIS-NZ) was formed in 2005. The HIS-NZ committee foresaw that the more successful overseas models were adopting "distributed" EHRs where information may be spread throughout many different physical information systems (Ministry of Health New Zealand, 2005). Information is linked and can be referenced electronically, so that when a clinician is making a decision about care, relevant and appropriate information about the patient, and what has been done in the past, is readily available during doctor–patient encounters (Whiddett et al., 2006).
HIS-NZ envisions that an EHR will be distributed at local, regional and national levels, with the richest and most detailed information about a consumer being kept locally. HIS-NZ has discounted a single national repository EHR for all an individual's identifiable health information (Ministry of Health New Zealand, 2005).

New Zealand has long had experience in two telemedicine specialties, namely telepsychiatry and teledermatology (Al-Qirim, 2003). The other programmes such as telepaediatry and teleradiology have also increased in their usage and have been implemented in various districts and rural areas (Ministry of Health New Zealand, 2003). The telemedicine development approach is based on telemedicine specialties or clinical areas such as mental health, radiology and paediatrics. Without agreement on how these programmes relate to and communicate with one another, the current developed approach for telemedicine could lead to further divisions among the various parties involved in the implementation of telemedicine and integration issues will prevail in future. Due to a lack of coordination between them, the systems do not interact with one another (Al-Qirim, 2004).

Now, the Ministry of Health New Zealand realises that the development of a shareable EHR system is seen as an important element of the strategy to link the existing disparate health information system into an integrated one. An integrated EHR system would improve the telemedicine services provided; by way of example, it would reduce the number of multiple tests that are often carried out on patients in New Zealand's HHS (Al-Qirim, 2005). This is a major challenge for HIS-NZ to integrate different information systems implemented in the existing HHS. In summary, the integration of a telemedicine system into the existing healthcare information system is the main barrier to the long-term sustainability of the telemedicine initiative in New Zealand.

2.8.8 Canadian Context

a) Demographic Statistics

Canada has a total land area of 9,984,670 km^2 and its population stood at 32.27 million in July 2005. The main economic activities are manufacturing, services and mining. Canada is also a high-tech industrial society that has recently entered into the trillion-dollar class (Statistics Canada, 2005; Yahoo Education, 2005a). Although it has produced a trillion-dollar-class economy, a debate on how to manage the rising cost of a publicly funded healthcare system will linger on.

The roles and responsibilities for Canada's healthcare system are shared between federal and provincial-territorial governments. The health insurance plans, namely Medicare, take the major roles in Canada's health insurance programme, which is managed by thirteen provincial and territorial governments nationwide. In other words, the territorial and provincial governments take the major role in the management, organisation and delivery of health services for their residents (Health Canada, 2006).

The healthcare delivery system in Canada includes community care, primary care and tertiary care. Primary healthcare is the foundation of the healthcare system. Sometimes, in certain conditions, the patients may be referred for tertiary or specialist care at a hospital or long-term care facility or in community care (primary health community). The services are normally given free of charge to the patients and the cost of services are publicly funded by the general tax revenues and insurance (Health Canada, 2006; Industry Canada, 2006).

Through a wide network of healthcare centres and hospitals developed in each province and territory, the Government spent approximately 9.7% of GDP on its healthcare expenditure in 2003 and it is expected to increase every year. In fact, the health status has also improved in that the average life expectancy of its citizens was 78 years for males and 82 years for females in 2003 (WHOSIS, 2006). The increase in healthcare expenditure and the improvement of life expectancy of Canadians at birth would require a new paradigm and technology in delivering the healthcare system such as a telehealth system.

b) Health Informatics Initiatives and Approach

In 1997, *Health Canada* made the convergence of electronic health records (EHRs) and telehealth a high priority as both are critical and integrated components of Canada's health infostructure (Canada Health Infoway, 2006c). Since 1998, more than 100 hospitals have subscribed to the telehealth services and telehealth has performed over 10,000 consultations in over 70 specialties or clinical disciplines (Canada Health Infoway, 2006a).

According to Canada Health Infoway (2006a), telehealth services provided today are typically poorly integrated with the existing organisational structure, governance, processes and information system infrastructure. As a result, telehealth events are not being scheduled within existing physician or organisational applications; in turn, this creates all sorts of complications and ultimately limits the usage and accessibility of telehealth-based services for people who really need them (Hailey, 2001). Most importantly, the contextual clinical data relating to patients are not captured electronically as part of telehealth encounters (Noseworthy, 2004).

Hence, Canada's telehealth applications have moved towards total integration with EHR-based solutions (interoperable EHRs) so that telehealth can share consistent and comprehensive EHR information across its geographical territory (Moehr et al., 2006; Canada Health Infoway, 2006b). The majority of telecommunication technologies used in telehealth applications are ISDN lines with a bandwidth range from 128mbps to 2mbps (Industry Canada, 2006). The use of Internet communication in telehealth applications is still low and the efforts in terms of web-based applications are becoming a major approach especially for realising the national EHR solution initiative (Canada Health Infoway, 2006b).

The Canadian effort and approach to gathering, integrating and sharing relevant patient health information between health services across care setting and disciplines is a piece of proactive action. However, this bottom-up approach, which will integrate the 40,000 existing clinical information systems (Canada Health Infoway, 2006a), is a tremendous challenge to face.

2.8.9 United Kingdom Context

a) Demographic Statistics

The UK is a developed country and a leading trading power and one of the quartet of trillion-dollar economies of Western Europe. Its population stands at approximately 59 million with 244,820 km^2 of total land area (WHOSIS, 2006).

The Department of Health is responsible for the health and social care policy in each town or county in England through the National Health Service (NHS) and primary care trusts (PCTs). The healthcare delivery system in the UK includes primary and secondary care. Primary care is the first point of encounter for receiving treatment for routine illnesses and injuries as well as for preventive care. On the other hand, secondary care provides elective care and emergency care, which usually follows a referral from a primary health professional such as a GP (National Health Services, 2006b).

The Government funds the provision of healthcare facilities and services in the UK. The Government spent approximately 7.7% of GDP on its healthcare in 2003 and this expected to increase every year. Increasing life expectancies for males and females from 73 years and 80 years respectively in the 1995s to 78 years and 81 years respectively in 2003 has caused chronic age-related diseases and conditions (WHOSIS, 2006). With this scenario, the UK Government launched the National Programme for Information Technology (NPfIT) in 2000 for handling the current and future challenges in providing high-quality healthcare services through the convergence of ICT and telemedicine (TEIS, 2006; National Health Services, 2006c).

b) Health Informatics Initiatives and Approach

The UK's telemedicine services started in 1992 at the Royal Victoria in Belfast and was for managing minor injuries through an ISDN 128 Kbps line (Ferrer-Roca and Sosa-Iudicissa, 2002). Before 1998, telemedicine was developed according to specialist clinical areas using a fragmented approach where there were no champions for leading and controlling the initiatives at a national level (Norris, 2002).

The telemedicine services were not able to integrate into the existing healthcare delivery system and this led to integration issues. From 1999 onwards, the National Programme for IT (NPfIT) initiative was established for the NHS and a strategic plan was developed for the effective use of information and communication technologies to create and share long-life electronic health records for everyone (National Health Services, 2007; TEIS, 2006; Norris, 2002). The lessons learned from previous experiences suggest that telemedicine services could not be developed separately from the existing processes of the healthcare delivery system.

NPfIT components were, therefore, designed by taking into account the integration and sharing of patients' life-long clinical records. The patients' clinical records (Brenan, 2007; NHS, 2007) were a main component of NPfIT and they integrated other NPfIT components (such as electronic booking and electronic transmission of prescriptions) and all GPs locally and nationally, enabling mining of clinical records (NHS, 2006a). The NHS Clinical Record

Services (CRS) became a framework for validating the patients' demographic and clinical histories before patients were treated (NHS, 2006a).

The fast and large bandwidth (up to 2mbps) of broadband telecommunication (by way of an N3 Network) was used for linking and transmitting the health information of patients across health facilities in the UK (NHS, 2006d). Looking at its systematic approach in implementing the NPfIT/telehealth programmes across health services in the UK, it appeared that the vision and mission for mining and sharing clinical records might finally be achieved. However, the UK approach might not be suitable for Malaysia due to differences in cultural identity, the health system, the stakeholder organisation and the readiness of the broadband infrastructure across healthcare facilities. The total cost of 12 billion pounds (NHS, 2006) spent for the project (although telehealth was part of the project) was far too costly. The flexible system solution should be considered for mitigating the implementation challenges and for a cost effective solution.

2.8.10 Norwegian Context

a) Demographic Statistics

Norway is one of the Baltic countries situated in the Baltic Sea Region. It is a member of the European Union (EU). Norway is a small country of 324,220 km^2 and it had a population of 4.6 million in 2005 (Yahoo Education, 2005g; WHOSIS, 2006).

The healthcare delivery system of Norway is fully funded and provided by the Government. In 2004, the Government spent approximately 9.7% of its GDP on healthcare expenditures. The healthcare status of its citizens is considered to be among the best in the world. This claim is supported by its citizens' life expectancy: 77 years for males and 82 years for females (WHOSIS, 2006).

The Ministry of Health and Care Services of Norway is largely responsible for setting the direction in health policy, public health, healthcare services and health legislation. The healthcare delivery system is covered by the primary health and secondary health systems. The primary health services provide the first point of contact for treatment for the population; and the secondary health services provide specialised medical treatment as well as in-patient and outpatient services (Norwegian Ministry of Health and Care Services, 2007).

b) Health Informatics Initiatives and Approach

Telemedicine developments in Norway started in 1980 in the University Hospital of Trømso. The following year, the Ministry of Health and Social Affairs designed the University Hospital of Trømso as the national reference centre for telemedicine. Videoconferencing technology was first used for medical purposes in 1986 and the work on electronic patient medical records (EPMRs) for GPs commenced in 1992. On the 1 August 1996, Norway became the first country to implement a nationwide telemedicine reimbursement schedule for telemedicine services (Norwegian Centre for Telemedicine, 2007).

The telemedicine services and applications developed in Norway include clinical specialties (such as teleradiology, teledermatology, telecardiology, telepsychiatry) and distance education. These services are well developed and employ minimal resources in the long-term implementation of telemedicine services in Norway (Norum et al., 2007a; Bergmo, 1996; Elford, 1997).

Real-time and store-and-forward telemedicine technologies are used in providing the telemedicine services. The broadband telecommunication technology range from 384kbps up to 10mbps is a means for sharing health information across healthcare levels. The physical geography of Norway poses fewer barriers to installing the telecommunication infrastructure nationwide (Norum et al., 2007a).

From the beginning of telemedicine initiatives, the Norwegian Centre for Telemedicine (NST) has played a role in streamlining telemedicine initiatives in Norway (Norwegian Centre for Telemedicine, 2006). The early development of telemedicine is based on research efforts that take place in the form of both projects commissioned by the authorities and NST's own initiatives. Most of the applications have been developed based on an ad-hoc approach (Norwegian Centre for Telemedicine, 2007; Norum et al., 2007b).

In 2004, the national agenda for computerising the healthcare system and integrating patients' longitudinal electronic health records was initiated through a National ICT strategy, namely Te@mwork2007. Te@mwork 2007 was the national strategy for ICT development in the health and social sector for the period 2004 to 2007. The strategy was to give direction and continuity to ICT development in the healthcare sector. The vision for the project is that patients and clients shall experience continuity of care when using the services (Norwegian Centre for Telemedicine, 2004).

There are not many barriers to implementing telemedicine services in Norway. There is no restriction to the practice of telemedicine; the only extra training for providing telemedicine consultations is to learn how to use the system. However, the most crucial barriers are related to security, integration, technology and organisational aspects. The integration of the telemedicine system into the existing healthcare delivery system is the major challenge in the telemedicine initiative in Norway (Uldal, 1999; Larsen et al., 2003). However, the top-bottom approach and systematic plan through the Te@mwork2007 strategy focus on collecting and integrating the EHR applications across healthcare facilities; Norway's approach in implementing telemedicine could be the relevant model for Malaysia and other countries to learn from.

2.9 Review of Telemedicine Initiatives and Approach in Malaysia

This section reviews the Malaysian context in developing and implementing the telemedicine system and health ICT initiatives in public healthcare facilities. The section starts with the background to the Malaysia healthcare system. It is meant to present general ideas on the current and future healthcare status and development in the country. The section also highlights the current and future ICT agendas and initiatives nationwide. Finally, the accomplishment and the lesson learnt from the pilot implementation of Malaysia's integrated telehealth will be presented and discussed.

2.9.1 Background to the Malaysia Healthcare System

2.9.1.1 Health vision

Malaysia's vision 2020 sets a visionary and achievable agenda that sees Malaysia in 2020 as an advanced and socially cohesive society with a standard of living and quality of life comparable to the leading economies of the world (Vision 2020, 1996).

In line with this vision, Malaysia's healthcare system is to be transformed. Health status is one of the key pillars of national advancement and is considered fundamental to Malaysia's social and economic well-being. The national health vision states, "Malaysia is to be a nation of healthy individuals, families and communities" (MOH Telemedicine Blueprint, 1997). The future healthcare system of Malaysia emphasises quality, innovation, health promotion, respect for human dignity, the promotion of individual responsibility and the promotion of community participation (Ministry of Health Malaysia, 2006b). In other words, Malaysia's future healthcare system is focused on people and services, with technology playing a key enabling role. The vision is the inspiration for the development of health services in the nation and provides the framework for the development and the use of health ICT in delivering healthcare services.

2.9.1.2 Demographic statistics and health indicator

With its total land size of 329.847 km^2, the population of Malaysia in 2007 stood at approximately 27.17 million (Department of Statistics Malaysia, 2006). Malaysia has achieved remarkable advances in healthcare. Life expectancy increased from 69 years for males and 74 years for females, in 1995, to 71 years for males and 76 years for females, in 2005 (see Table

2.10). The infant mortality rate (per thousand) decreased from 10.4% in 1995 to 5.1% in 2005. Overall, approximately 3.8% of GDP is spent on healthcare services (WHOSIS, 2006).

Indicator	1995	2002	2003	2004	2005
Life expectancy (Number of years)					
Males	69.4	70.7	71.0	70.4	70.6
Females	74.2	75.3	75.5	76.2	76.4
Crude birth rate	25.9	22.2	21.9	21.3	19.6
Crude death rate	4.6	4.6	4.7	4.6	4.4
Infant mortality rate	10.4	6.6	6.3	5.9	5.1

Table 2.10: Malaysian Quality of Life Indicator 1995–2005

Source: adapted from (Ministry of Health Malaysia, 2005; Ministry of Health Malaysia, 1995; Ministry of Health Malaysia, 2002; Ministry of Health Malaysia, 2003c; Ministry of Health Malaysia, 2004)

2.9.1.3 Healthcare status and healthcare services

The Government has expanded the number of healthcare facility centres and the scope of health services nationwide. For example, the rural, or primary care, clinics have expanded their services to general outpatient services or stand-alone polyclinics (Ministry of Health Malaysia, 2005).

On the other hand, the health manpower population ratio shows that the workload and the shortage of human resources in healthcare services will become critical issues in the future. For example, it is estimated that one doctor will manage 1300 patients; even worse is the ratio of pharmacists to the population, which is 1:6512 (Ministry of Health Malaysia, 2005).

The future plan regarding the healthcare system in Malaysia requires extensive changes by converging ICT, medical contents and health knowledge. By incorporating effective telemedicine, telehealth and e-health, it is envisaged that the demand for healthcare services in health facility centres would be reduced, the shortage of health manpower would be addressed accordingly and, finally, the cost of services provided through clinics and hospitals would decrease.

2.9.1.4 Current healthcare delivery system and physical set-up

The Malaysian public healthcare system is structured according to a hierarchical pyramid-based concept as shown in Figure 2.5. At the base of the pyramid is a broad array of primary healthcare services (such as health centres, polyclinics, mobile clinics and maternal and child clinics) spread throughout the country. The next level is the district hospitals in every one of 120 districts, which feed into state general hospitals in each state capital. At the top of the pyramid lies the Hospital Kuala Lumpur, which is the national tertiary reference centre that provides specialist and super-specialist services for the nation (Abu Bakar, 2007).

There are problems related to the distribution and delivery of healthcare services. For example, the healthcare information has been delivered through a pyramid-style healthcare system where the providers control and distribute the information. Resources are concentrated in the very expensive hospital sector although services can be more cost-effectively and conveniently delivered at the primary care level (Ariff et al., 2002). The above scenario has limited the citizens in accessing healthcare information and has created a mal-distribution of healthcare manpower. Hence, it imposes a high level of demand upon healthcare professionals to provide information.

In terms of the physical healthcare facility set-up, the healthcare premises are normally developed within the area where most of the population is living. Since 1998, 95% of the population has been living within a five-kilometre radius of the nearest healthcare facility (Suleiman, 2001). This set-up make it possible for patients from anywhere in the country to be referred to the appropriate hospital and to access and visit several healthcare facilities through a nationwide network of clinics, hospitals and other health programmes in a convenient manner.

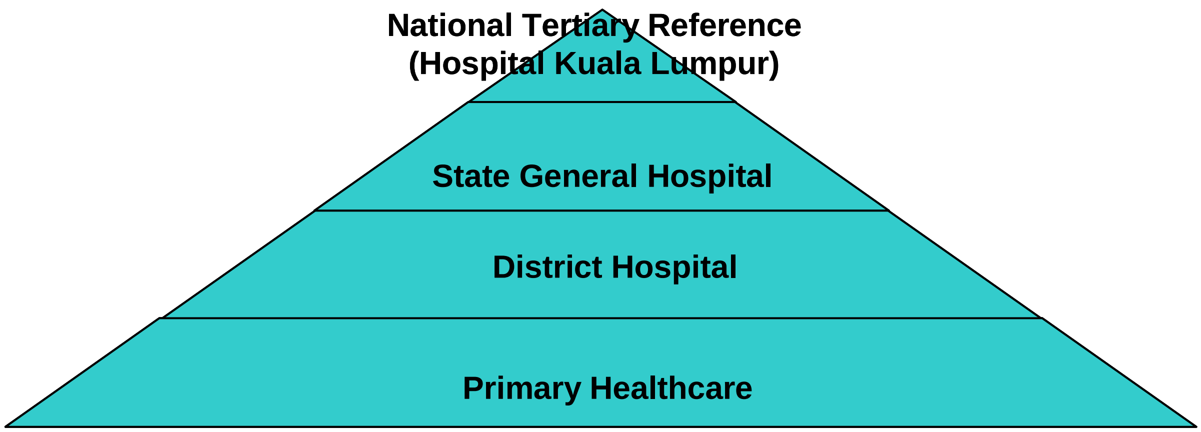

Figure 2.5: Malaysian Hierarchical Healthcare Structure

Source: adapted from (Nguyen et al., 2008; Suleiman, 2001)

2.9.2 Background to Malaysia Information and Communication Technology (ICT)

2.9.2.1 General ICT background

Malaysia has a vision of moving towards a knowledge-based society and economy. In this vision, ICT is seen as the driver for the restructuring of the economy and employment in the country. In order to achieve the vision, the Government took an initiative by endorsing the National ICT Agenda in 1996. The components focused on in the agenda include the development of people (such as education and skill-development), providing access to the info/infrastructure (such as national broadband, policy and regulation and affordable devices) and the development of home-grown applications (Ministry of Science Technology and Innovation of Malaysia, 2008).

In 1996, another step was taken by the Government to boost the development of ICT in the country through the official launch of the Multimedia Super Corridor (MSC). The MSC initiative was to drive the economy towards higher productivity through technology and value-added economic activities and to be a tool for Malaysia to leapfrog into the information age and knowledge-based economy (MSC Malaysia, 2007).

In addition, the Malaysian Government is leading the goal of turning Malaysia into a knowledge-based economy by building up its contents and development infrastructure. Among the future plans are those to set up a content development fund, to set up an agency specifically for international filmmaking, to maintain current intellectual property rights, to encourage impartial and widely distributed content and to establish a local content growth quota (Mohan et al., 2002).

In fact, the Government has made an initiative to set up the important facets of a knowledge economy (k-economy) such as legislations (soft infrastructure) and telecommunications (physical infrastructure). For legislation, there are numerous “cyber laws”, such as the Communication & Multimedia Act 1998, Digital Signatures Act 1997, Copyright Amendment Act 1997 and Computer Crimes Act 1997, already enacted in Malaysia (Ministry of Energy Water and Communications Malaysia, 2008b).

Telecommunications is one factor that casts a “bearish” sentiment on Malaysia’s goal of a k-economy. Mobility and affordability are the two principal setbacks that need to be looked into. With respect to mobility, Malaysia’s physical infrastructure is mainly concentrated in urban areas. In the rural areas, on the other hand, it is difficult to get access to telecommunications. In terms of the affordability issue, the ISDN and broadband lines in Malaysia are being leased out at a much more expensive rate.

In order to narrow the gap in basic telecommunications access between the socioeconomic groups, the Government is currently propagating key initiatives. These include the following: a) formulating programmes to bridge the digital divide by developing “Rural Community Internet Centres” and decreasing costs of devices to make PCs more affordable; and b) providing all schools, health centres and other government agencies with adequate Internet access (Ministry of Energy Water and Communications Malaysia, 2008a). Table 2.11 shows the number of broadband subscribers using communication technology in Malaysia from 2002 until 2005.

Year	Number of subscriptions				Penetration rate
	ADSL	SDSL	Others	Total	
2002	18,511	542	249	19,302	0.08
2003	108,173	1,931	302	110,406	0.45
2004	247,802	2,834	1,885	252,501	0.98
2005	477,685	3,712	9,233	490,630	1.86

Table 2.11: Malaysia Broadband Subscribers by Telecommunication Technology
Source: adapted from (Malaysian Communications and Multimedia Commission, 2005)

With regard to the ICT initiatives carried out by the Government since 1996, the digital divide issues have declined and the number of Internet users, both in the urban as well as the rural areas, has increased dramatically. The Internet and web technologies will be used to enable the public to access Multimedia Super Corridor (MSC) flagship applications such as telehealth, smart schools, electronic government and others. In other words, the ICT initiative in Malaysia is very much in line with the vision of the MSC platform, in particular, and Malaysia's Vision 2020, in general.

2.9.2.3 Telecommunication infrastructure, Internet and cellular

Based on a survey carried out by the Malaysian Communication and Multimedia Commission (2006), the Internet dial-up subscriber penetration rate rose from 7.1 per 100 population in 2000 to 14 per 100 population in 2006 (see *I1* in Table 2.12). Similarly, the penetration rate for broadband subscriptions rose from 0.08 per 100 population in 2002 to 3.3 per 100 population in 2006 (see *I2* in Table 2.12). It was estimated that, in 2006, there were 12.5 million Internet users in Malaysia.

On the other hand, mobile telecommunications have also had an impact on the telecommunication industry in Malaysia. The penetration rate for cellular phones increased from 21.8 per 100 population in 2000 to 74.1 per 100 population in 2005 (see *I3* in Table 2.12). However, it declined marginally by 2.4 percent to 72.3 per 100 population in 2006. Meanwhile, the total number of short message services (SMS) increased to 9.9 billion in 2006 as compared with 3.6 billion in 2002 (see *I4* in Table 2.12).

Having cellular phones has become a trend and everyone carries them anytime and anywhere. There is a possibility that these cellular phones will be used as one of the multitudes of channels for storing and accessing the health records of patients during doctor–patient encounters. Table 2.12 illustrates the cellular phone users and the penetration rate from 2000 until 2006.

Year	Penetration rate (*per 100 population*)			Total (*million*)
	Internet dial-up subscriptions (*I1*)	Broadband subscriptions (*I2*)	Cellular phones (*I3*)	Short message services (*I4*)
2000	7.1	-	21.8	-
2001	8.8	-	30.8	-
2002	10.5	0.08	36.9	3,605.9
2003	11.4	0.45	43.9	6,163.5
2004	12.7	0.98	56.5	9,532.1
2005	13.9	1.86	74.1	7,553.6
2006	14.0	3.3	72.3	9,979.2

Table 2.12: Malaysia ICT Indicators from 2000 until 2006
Source: adapted from (Malaysian Communication and Multimedia Commission, 2007; Department of Statistics Malaysia, 2006)

2.9.2.4 Health information systems initiatives in the public health facility

The majority of Malaysian doctors do not use computers in delivering healthcare services to the patients. The patients' medical records are recorded on paper-based medical records and kept in the records office at each health facility premises. Computer use is greatest for general administrative work, less for patient-oriented administration and least for clinical use.

The results of a survey on computer use carried out with the ICT division of MOHM are depicted in Figure 2.6 and summarise the categories of information systems implemented in the Public Healthcare Facility for 2006. Approximately, more than half (51%) of the applications that have been implemented in various health facilities are for facilitating the administration functions of medical practice services and public health services. The management and financial support systems contribute around 29% of the total projects.

Whilst the core clinical applications for generating the electronic medical records (EMRs) and lifetime health records (LHRs), such as Teleprimary Care (TPC), Hospital Information System and telehealth (Ministry of Health Malaysia, 1997e), contribute around 18% of the total projects, the majority of the systems are still under trial/pilot implementation in certain healthcare centres and hospitals in various states. This percentage shows that the EMR/clinical application system has been given less attention and focus for collecting and generating the LHRs.

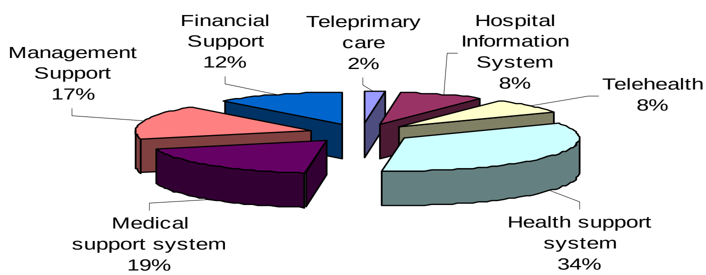

Figure 2.6: The Categories of Health ICT Projects in a Public Health Facility
Source: adapted from (Ministry of Health Malaysia, 2006a; Ministry of Health Malaysia, 2007)

2.9.3 Pilot Implementation of the Malaysia Integrated Telehealth Project

2.9.3.1 History

In 1997, the expert panel, consisting of the proponents of both the health and ICT domains, produced the following documents: Malaysia's Telemedicine Blueprint, Telemedicine Standards and Four Concept Requests for Proposals for Lifetime Health Plan, Mass Customised Personalised Health Information and Education, Continuing Medical Education and Teleconsultation. After a long period of consideration, in 1998, the Government awarded the contract for the telehealth project to Medical Online Sdn Bhd and World Care Sdn Bhd. Medical Online Sdn Bhd was responsible for developing three components — the Lifetime Health Plan, Mass Customised Personalised Health Information and Education and Continuing Medical Education — and World Care Sdn Bhd was responsible for developing the teleconsultation component (Harun, 2007).

The first deliverables of telehealth services, Mass Customised Personalised Health Information and Education Portal and Continuing Medical Education Portal, were deployed in November 2000. The portals provided health information and advice as well as health education for both consumers and healthcare professionals.

Subsequently, the first deliverable of Lifetime Health Plan, Clinical Support System, was deployed in three hospitals, namely Kajang Hospital, followed by Seremban Hospital and Kuala Lumpur Hospital (HKL) in April, July and August 2001 respectively. The deployment of CSS also provided links to 24 health centres using a dedicated ISDN leased line (Harun, 2001).

2.9.3.2 Telehealth components and applications

The Malaysian Integrated Telehealth Project was conceived to fulfil the vision of the Malaysian Government, specifically the Ministry of Health, for a more proactive and efficient healthcare delivery to the public. Conceptually, the Malaysian telehealth project consists of four applications built around the premise of a series of patient-health provider appointments (Mohan and Raja Yaacob, 2004). These meetings comprise a series of wellness visits (by way of example, immunisation events, medical screening events, ante-natal and post-natal events and other health preventive programmes) and some illness visits (by way of example, cough, fever and other related health problems) as illness conditions arise (Suleiman, 2001; Billie, 2003; Harun, 2002).

The focus of the system will be on people and services, using ICTs as the key enablers to provide an accessible, integrated, high-quality and affordable healthcare system. The Malaysian Integrated Telehealth pilot projects involve four components (Ministry of Health Malaysia, 1997e; Harun, 2001):

- Lifetime Health Plan
- Mass Customised Personalised Health Information and Education — subsequently renamed *MyHealth*
- Continuing Medical Education — subsequently renamed *Continuing Professional Development (CPD)*
- Teleconsultation.

Lifetime Health Plan (LHP)

The LHP is a backbone of the Malaysian Integrated Telehealth system, which consists of three main components, namely Clinical Support System (CSS), Personalised Lifetime Health Plan (PLHP) and Group Data Services (GDS). CSS is an administrative tool for supporting healthcare facilities to create the EMRs and finally collate and generate a summary lifespan of EMRs called LHRs. PLHP is a service to deliver health plans and care plans generated from the LHRs. GDS is a data mart for delivering data-mining services and generating relevant reports (Ministry of Health Malaysia, 1997d; Mohan and Raja Yaacob, 2004; Harun, 2002).

Mass Customised Personalised Health Information and Education (MCPHIE)

MCPHIE offers a selection of relevant patient information about the disease that can be further personalised by the doctor and home consumers. A MCPHIE component involves creating and delivering health content using the Internet, multimedia technologies and mass communications. The application has access to the PLHP component of LHP and will include a health risk assessment (HRA) component. This component will assess an individual's risk of getting certain diseases and generate reports that can advise him/her on prevention and lifestyle habits (Harun, 2002).

Continue Medical Education (CME)

CME has been developed to drive the medical and health practices. Beside providing services on education and learning activities, it is aimed at giving just-in-time (JIT) valuable relevant information based on clinical practice guidelines (CPGs) and other scientifically proven evidence. It is executed mostly in the work place, during a doctor–patient encounter (supporting decision making relating to the patient being treated), which is a specific response to a specific situation at specific point in time of the care process (Ministry of Health Malaysia, 1997e; Harun, 2001).

Teleconsultation (TS)

The TS services could be called upon if an expert opinion needs to be obtained. The TS provides the platform whereby referrals can be done without having to send the patient anywhere physically. The EMR-based patient referrals will be sent electronically to the referring centres. The x-ray film as well as the pathology test will be transmitted via Internet telecommunication using encrypt and decrypt mechanisms (Ministry of Health Malaysia, 1997e).

A simple scenario will be elaborated thereafter on how the applications interact with each other. As the patient walks in to see the attending healthcare provider, the attending doctor will access the CSS. All this data under the CSS will be compiled in the EMR of the patient. Upon the patient checking into the LHP system, his EMR at the point of care is generated. Similarly, the patient's LHR and PLHP will be generated and kept within the database.

Upon subsequent visits to the healthcare providers, the LHR and the PLHP of the patient will be called upon and added onto accordingly. In this respect, the patient's records are shared amongst the healthcare providers to ensure a continuity of care. The LHR of the individual will be processed and will generate a PLHP, which can be accessed through MCPHIE via the Internet (for those with Internet access) and through call centres or through the attending healthcare provider (for those without Iternet access). Figure 2.7 illustrates the interplay between components within the telehealth applications to form an integrated solution.

It was noted that the Malaysian integrated telehealth components are mainly based on the LHR system for delivering services. Therefore, the integrity of the LHR has to be established first. The Malaysia's approach towards integrated services of telehealth should be focused on developing the scalable and flexible application for collecting the EMR and generating the LHR continuously. Prioritising and focusing on critical components such as LHR is critical for the success of the project.

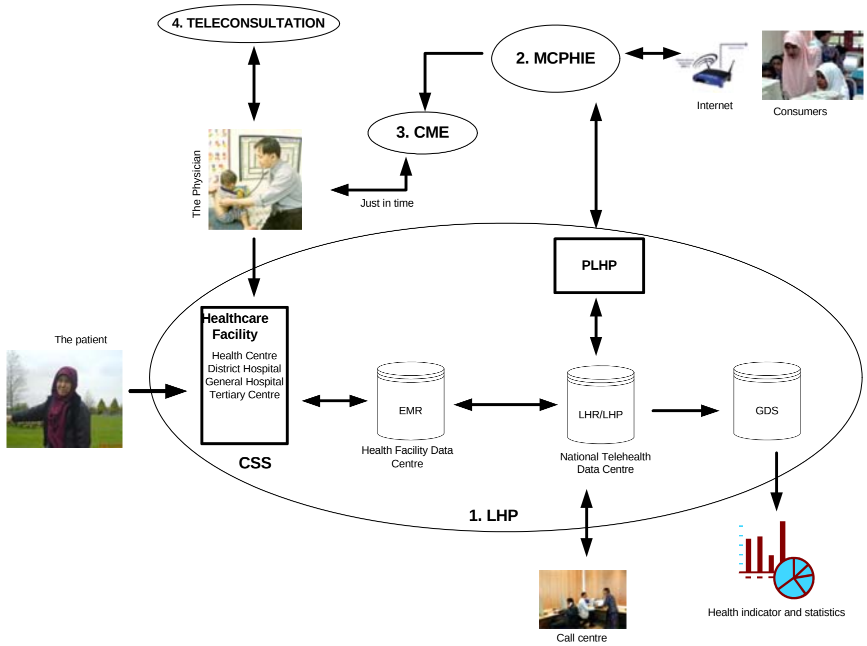

Figure 2.7: The Four Components of the Pilot Telehealth Application

Source: adapted from (Ministry of Health Malaysia, 1997e; Ministry of Health Malaysia, 1997d)

2.9.3.3 Implementation approach

Introduction

Malaysia's implementation approach to the integrated telehealth project aims at redesigning the work processes of the present healthcare system. This is to facilitate the design and delivery of an innovative healthcare system by shifting towards the wellness paradigm. The approaches taken, of course, involve interdependent components comprising people, organisation, process and technology. However, this section will only discuss the technology aspect, which could have a direct impact on the main research questions of the research.

The review regarding pilot implementation approaches to the Malaysian integrated telehealth project was gathered through an initial case study at MOHM and Medical Online Sdn Bhd by way of an open-ended interview (personal interview with MOHM's staff and the president of Medical Online Sdn Bhd, who was responsible for and pioneered the integrated telehealth project in Malaysia), archival records, documents and observation. This was the best way to acquire the information due to a lack of published documents and reasons that are confidential in nature. The approaches, issues and challenges concerning the Malaysian integrated telehealth project are summarised as follows.

Health Content Development

The development of the telehealth project started initially with the development of the contents for MCPHIE and CME. The acquisition of the contents started initially with academics from the local universities who were willing to spend some time writing according to the templates designed for the project. The project then went to the development phase whereby both components were developed from scratch and it was customised to the dedicated requirements of the Ministry of Health Malaysia. The first milestone of the telehealth services was the launch of the MCPHIE and CME website in November 2000 with a small number of contents within four selected programme areas. However, the EMR under the LHP component was still not established. Thus, the integration between medical records and medical contents was not only difficult to conceptualise but also had no precedent elsewhere in the extent and reach of its integration (Ministry of Health Malaysia, 1997d).

Software Application Development

The development process: the integrated telehealth project is a custom development approach where the Rational Unified Process (RUP) methodology was adopted for helping the project team manage the development of the software applications iteratively. The reason this approach was used is that the basic functions of the applications can be easily maintained in the initial phase. They can then grow into more sophisticated and complex systems in later phases (Police et al., 2004). Integrated telehealth software is developed iteratively and it can continuously verify software quality and control changes done to the software.

Application technology: the application technology of the integrated telehealth project opted for the n-tier and open-system architecture based on the Java™ 2 Platform Enterprise Edition (J2EE). The server side applications of telehealth used extensively the Java's back-end API components such as Enterprise Java Bean (EJB). Java Server Page (JSP) was used as a standard front-end page for managing the user input (Ministry of Health Malaysia, 1997c). The aim of this selected technology was to make the project affordable with low initial capital investment. For example, the advantages of n-tier applications include cost and time savings at deployment because software updates and maintenance are kept automated, existing ICT infrastructure can be used and, finally, intranets can be easily incorporated.

Unfortunately, the downside of this choice were performance issues such as the response time to access the patients' medical records took more than the agreed standard requirements of the stakeholder. The server side applications required an adequate network bandwidth size and totally depended on the server's uptime. A flexible framework to access and store patients' medical records using portable devices would mitigate these issues and would ensure continuity of medical records in any possible situations.

Application Infrastructure

Connectivity: the telehealth system components used a virtual private network (VPN) or intranet networking for linking all healthcare centres, hospitals and a central telehealth data centre. The spectrum of bandwidth requirements ranged from 2 mbps from the hospitals to the central data centre, to 64 kbps from health centres to hospitals, and 100 mbps for the local area network (LAN) of the hospitals (Ministry of Health Malaysia, 1997a). These bandwidth requirements are interrelated to the complexities of levels of care: primary, secondary or tertiary care. The scope and complexity of the interconnectivity requirements are the major challenges in implementing the integrated telehealth project, especially for the continuous upkeep of the LHR in any possible disaster.

The network bandwidth size becomes critical once the number of users increases at healthcare centres. This will bring a performance issue and require high-level costs to upgrade the network bandwidth size. These issues could be resolved by utilising portable storage devices to access and store the patient's LHR through global system mobile (GSM) communication and short messaging services (SMS) or personal communication media such as Bluetooth (Lu et al., 2005; Hall et al., 2003). This could ensure the high availability of the LHR and marginal reduction of the network costs.

Databases: the implementation of telehealth databases were presented two fold. One centralised database was located at the data centre, and another linked to the many distributed databases at the various hospitals. The distributed databases carried in them detailed patients' medical records stored in a decentralised manner at every individual hospital's data centre (Ministry of Health Malaysia, 1997b). All distributed databases were then linked up to the centralised telehealth data centre. The purpose of the centralised database was to ensure the accessibility for the public and healthcare providers. This was also for ensuring a continuum of care for the public where health records were retrievable at one central point.

However, the existing central database and distributed database frameworks depend on the availability of a telecommunication network and computer system. If a possible disaster (the computer system is down or telecommunication is unavailable) happens, there is no alternative medium of storage for accessing and storing the patients' health records. Thus, the requirement to have a flexible framework for accessing and storing the LHRs from/to portable storage devices is essential. The integration of the various components of the telehealth system and capability for a continuous retrieval of health records of patients during a possible disaster are still the main issues that remain as major research questions.

2.9.3.4 Discussion on pilot implementation issues and challenges

The implementation of telehealth applications would naturally necessitate the development of national repositories for LHRs, the former for storing integrated medical records of individuals to date. Such a huge collection of critical data would certainly allow for various forms of statistical studies and data mining (referred to as GDS), which would result in better health planning at the national and state levels. Such a collection of services, including GDS and LHR together with PLHP, may be collectively classed under the generic title of HIMSS.

The development of national repositories for LHRs would in turn necessitate a nationwide effort in terms of the collection of EMRs at various health centres or institutions (general practitioner, health centre, district hospital, general hospital and tertiary centre). The EMRs not only have to be integrated in terms of chronology but also across health centres to form corresponding LHRs. This entails the development and deployment of various CSS at the participating health centres, where the CSS would come in the form of a set of integrated clinical applications comprising of various systems such as the hospital information system, the laboratory information system, the radiology information system, the picture archiving and communication system, etc. (Mohd Yusof et al., 2007).

An overall view of the telehealth project given above shows the ultimate telehealth service that requires the use of the LHR repositories, which are generated via the HIMSS and also shows that LHRs are built from EMRs that are collected via CSS. The point here is how to make sure the collection and the generation of patients' health records could be continued during the unavailability of landline networks and the downtime of the computer system. Obviously CSS and HIMSS need to be active at all times because LHR contents need to be updated with every new encounter at various healthcare centres. Therefore, it was critically important to have a flexible framework for ensuring that the health records of patients could be captured, viewed and stored continuously and seamlessly.

The barriers and challenges in developing and implementing the pilot integrated telehealth services are dependent on many factors and there are many risks that need to be considered. Based on the finding from the initial case study conducted at MOHM, below are some of the issues and challenges faced during the pilot implementation of the telehealth application.

Continuity and Seamlessness of Health Records

The continuity and seamlessness of patients' medical information is a major problem in the Malaysian public and private healthcare facilities and is also a critical issue in other countries such as the UK, the USA, Australia, Canada and others in mainland Europe (Mahncke and Williams, 2006; Brennan, 2007; Scott, 2006). It has been demonstrated that access to paper records is generally problematic and resource intensive (Liaw, 1993). A study carried out on cervical cancer patients in Malaysia (Hashim, 2000) found that only 30% of patients' records were sufficiently complete and accessible, with another 30% of records being available but not complete and the remainder of records being lost or not retrievable at all. This would relate to the need for generating EMRs that can be shared across different healthcare facilities. Although the information system has been implemented and used as a means to support the medical practice in day-to-day operations, the continuous and seamless access to patients' medical records is still inadequate. The three major information system projects in Malaysian public healthcare facilities, namely Teleprimary Care, Total Hospital Information System and Telehealth, are still unable to share and link the patients' health records from one facility to another (Ministry of Health Malaysia, 2003d; Selayang Hospital, 2002). The different technologies, the fragmented set-up of the ICT infrastructure and the fragmented solutions lead to very difficult challenges for achieving solution integrity between applications and services and, finally, for gathering and generating the LHRs centrally.

Telecommunication Infrastructure

Telehealth or e-health systems involve geographical information and the use of telecommunication technologies when providing healthcare services for the patients. Telehealth applications can be implemented in healthcare facilities or can provide patients with services directly through the Internet. In Malaysia, the network infrastructure may not be consistent across the country and among healthcare facilities. For example, in 2005, the average Internet penetration in Malaysia was around 14% (Malaysian Communications and Multimedia Commission, 2005). Internet penetration in large cities such as Kuala Lumpur is around 50%. These issues and challenges need to be addressed before the telehealth or e-health system is fully implemented in healthcare facilities nationwide. An inadequate telecommunication infrastructure would jeopardise the availability, accessibility and the continuous upkeep of the patients' medical records.

System Integration

The integration issues of health information systems (HIS) are well known throughout the healthcare industry. In 2005, approximately 80% of healthcare providers in the US were still using paper-based medical records in their day-to-day consultations; for the systems that do exist, few are interoperable (IAB, 2006). The Malaysian public healthcare facilities are also facing the same situation where systems operate independently and are unable to share patient medical records with one another. Uncoordinated planning and legacy and proprietary systems with limited or no networking capabilities present major challenges for system integration (Norris, 2002). These integration challenges include formulating and developing *health informatics standards* (such as a clinical code set — for example, patient identifier, clinical terminology, drug code, disease code classification and administration code set), *information system architectural standards* (such as software, hardware, operating system, middleware, network communication protocol, database system, data model and information communication protocol) and *standard operating procedures* (such as care pathways, clinical professional guidelines and operational policies). It is, therefore, of critical importance that existing systems are upgraded and the future HIS adopts standard solutions and integrity models for interoperability, scalability and reusability. Malaysia's telemedicine blueprint, consisting of four integrated application components, provides a comprehensive framework and a road map for the building and provision of a future healthcare information system. It is critical that the MOHM should coordinate and enforce the development of the existing and the future information systems to adopt that framework. This is to ensure that medical information is synchronised between the systems and that LHRs can be accessed seamlessly and continuously.

Health Informatics Standard

In order to enable the various information systems to accept each other's data (and to share the patients' medical information from one healthcare context to another) the information model, terminology, connectivity and policies need to be standardised (Nelson, 1997). The lack of standards in collecting and sharing health information reduces efficiency and hinders collaboration as healthcare organisations expand. The standards form the framework for integration between the various healthcare systems in delivering the healthcare services. In the context of IS projects in a Malaysian healthcare facility, the health informatics standard, especially the health vocabulary standard, is still inadequate. The health vocabulary standard includes clinical terminology, disease classification, a drug classification code, a procedure code, a test classification code, the national code standard, such as the Public Sector Data Dictionary, and the Ministry of Health Code Standard (Hisan, 2006). These standards are crucial for the various systems to exchange information, for the achievement of MOHM's goal to have integrated LHRs and for seamless and continuous access to the patients' LHRs. The importance of standards for ensuring interoperability of clinical information in the LHRs is broadly recognised. Without standards, the initiatives and the efforts to integrate the heterogonous IS set-up and fragmented IS solutions into an integrated whole will not succeed. This is due to the fact that the standards are a key foundation element of the solution integrity and integrated LHRs.

Changing Mind-sets

Various individuals are involved in providing the delivery of healthcare services, including physicians, specialists, nurses, pharmacists, medical assistants, administrators and other related healthcare staff. They are the users who will use the ICT in their daily routines in dealing with patients. The majority of them still have limited computer-related skills. Many may well be set in their existing ways and existing work processes may well have been ingrained into their daily lives for decades. Thus, any purported change in their routine daily workflow is bound to be viewed with some degree of hostility and resistance. In addition, inadequate awareness about ICT projects has further compounded the problems and challenges for implementing information systems at healthcare facilities. Proactive initiatives, such as providing training and short courses on ICT and medical informatics knowledge, are important. Healthcare professionals need to embrace ICT as a mainstream tool for the future evolution of the healthcare system, especially via the adoption of telehealth and telemedicine in improving healthcare delivery to citizens (Wootton and Craig, 1999; Maheu et al., 2001).

Business Process Reengineering

Another challenge to be faced in implementing the integrated telehealth services is the requirement for business process reengineering. In the design of new service delivery models, the normal routine business process of healthcare providers requires re-engineering to suit the telehealth services. This is essential for achieving best practice outcomes, and it will be the basis for applying information technology solutions (Abd Ghani et al., 2008a). The success of the project is critically dependent on wholesale adoption and usage by the healthcare professionals and providers of the Clinical Support System (CSS) sub-system, which assists in the collection of EMRs and then forms the LHRs. The reluctance of healthcare professionals to use the system and to change the way their legacy style of work will hamper the implementation of the telehealth project. Hence, a simple and flexible approach for capturing patients' EMRs is essential for encouraging the healthcare professionals to use the system. Nevertheless, this issue will not be the main focus in this research and will be included in future research.

2.10 Summary of Telemedicine Approaches in Malaysia and Ten Countries

It was noted from the literature that telemedicine approaches vary among countries. The variation is due to the different cultures, socioeconomic conditions and politics of these countries. However, the healthcare scenarios and the development of a telemedicine system might be similar and the experiences and lessons could be learned and shared by other countries.

Recommendations for the implementation approach to guide a future LHR system in the Malaysian context of telemedicine in both the short and medium time frames are discussed below:

2.10.1 Broadband for Health Network

Malaysia should provide a dedicated telecommunication network infrastructure for a health network across healthcare facility centres. It was noted that the broadband telecommunication technology has been used in most telemedicine systems of the five countries for linking and transmitting the health information of patients across health facilities. The dedicated National Network for health network services/programmes is an effective approach for providing a fast and large bandwidth (between 128 Kbps and 2 Mbps) of networking for the implementation of telemedicine systems. By way of example, the N3 Network is a suitable approach for providing and supplying the telecommunication infrastructure to mitigate both the current and future requirements of the UK's health ICT initiatives (National Health Services, 2006a). SingTel in Singapore, NII in Taiwan and Health Infoway in Canada provide dedicated broadband services and requirements for telehealth and e-health programmes of the five countries respectively (see Table 2.13).

The telecommunication network for the Malaysian telemedicine system was one step behind in that the narrow bandwidth was still in use for transporting the medical information. In addition, the network infrastructure set-up was provided and maintained by various vendors, which led to network integration and maintenance issues. The Ministry of Health Malaysia, through its information technology strategic planning (ISP – 2006–2010), aimed to provide a network link to all hospitals across the country by the year 2006 (Ministry of Health Malaysia, 2007). The aim was also that this telecommunication infrastructure would be provided for all health centres as well due to the fact that the health centres provide primary care to the patients and are an important source for generating LHRs (see Table G4 in Appendix G for various transmission channel types used for telemedicine applications in ten countries).

Type	Bandwidth size	Singapore	Hong Kong	Taiwan	UK	Canada	Malaysia
POTS	64 Kbps	x					
Switched 56	56 or 64 Kbps						X
ISDN	64 Kbps - 2 Mbps		x	x	x	x	X
T-1	1.544 Mbps						
Cable	10 to 30 Mbps downstream & 128 Kbps to 10 Mbps upstream						
DSL	1.5 to 8 Mbps downstream & 1.544 Mbps upstream				x		
ATM	155 to 622 Mbps	x	x	x			
Satellite	16 Kbps to 92 Mbps downlink					x	

Table 2.13: A Variety of Telecommunication Networks Used in the Telemedicine System

Source: adapted from (Tay-Yap and Al-Hawamdeh, 2001; Holliday and Tam, 2004; Chen et al., 2001; National Health Services, 2006a; Industry Canada, 2006; Ministry of Health Malaysia, 1997a)

2.10.2 Focus on the Development of EMRs and LHRs

We learned from the Canadian and UK approach to electronic healthcare where the EMR-based medication is their current approach to achieving a seamless access to patient information and health records. On the other hand, the Hong Kong approach to developing and implementing a telemedicine system incrementally nationwide started with the establishment of the ICT infrastructure. The computerisation of the hospital authorities to generate centralised patient medical records that can be accessed and shared by healthcare providers and healthcare professionals seamlessly was another effective lesson to be learned from the Hong Kong approach. These three examples could be emulated to develop the LHR system in Malaysia by implementing the crucial EMR systems in all healthcare centres for collecting the EMRs and finally generating the LHR repository.

The LHR collator, which might be a critical component of the LHR repository, should be given priority in terms of development and implementation. The LHR collator should be scalable and interoperable enough to collate a patient's episodes from various systems and healthcare facilities. The establishment of a standard integration framework for collecting EMRs and generating LHRs is important for the success of the telemedicine system (see Table 2.14 for a comparison of telemedicine development approaches).

Development approach	Singapore	Hong Kong	Taiwan	U.K.	Canada	Malaysia
National agenda and initiated by the Government	No	No	No	Yes	Yes	Yes
Support and drive by National Telemedicine policy and strategy	No	No	No	Yes	Yes	Yes
Starts and initiates from research and development project by research organisations/institutions	Yes	Yes	Yes	No	Yes	No
Implementation approach through pilot run and transformed into production	Yes	Yes	Yes	Yes	Yes	Yes
The programmes/services are developed by specialties independently	Yes	Yes	Yes	No	Yes	No
Consolidate and integrate from fragmented services/programmes into an integrated one	No	Yes	No	Yes	Yes	Yes
Integrate with Electronic Health Record Infostructure for sharing the health information	Yes	Yes	No	Yes	Yes	Yes
Provide a dedicated telecommunication infrastructure for health network services/programmes	Yes	No	No	Yes	Yes	No

Wellness paradigm (WP) or illness paradigm (IP)	IP & WP	IP	IP	WP & IP	IP	WP & IP
Funded by the Government	No	Yes	Yes	Yes	Yes	*30%
System development approach - Custom Development (CD) or Package Integration (PI)	CD	CD	CD	PI	CD	CD
Telemedicine/Telehealth Technology - Realtime (RT) or store and forward (SF) or both (BT)	SF	BT	BT	SF	BT	SF

Table 2.14: Comparison of Telemedicine Development Approaches

Source: adapted from (Chew et al., 1998; HPBonline, 2007; Tay-Yap and Al-Hawamdeh, 2001; Holliday and Tam, 2004; Cheung et al., 2001; Hjelm et al., 2001; Chen et al., 2001; Hsieh et al., 2006; Liu et al., 2006; National Health Services, 2006c; National Health Services, 2007; Brennan, 2007; Health Canada, 2006; Canada Health Infoway, 2006a; Hailey, 2001)

2.10.3 Focus on Crucial Functions

The healthcare sector is complex and involves various clinical specialties and disciplines. To computerise and include all specialties in one short telemedicine implementation is impossible and highly unachievable. We already know that the implementation of an ICT application involves a series of processes and requires resources and time. Incremental approaches in developing and implementing the telemedicine applications mitigate the resources and time constraints. However, choosing the wrong crucial functions to be included in the telemedicine system would result in issues to do with user acceptance and integration.

The Malaysian telemedicine system should focus on crucial functions for collecting as many EMRs as possible for generating patient LHRs. The greatest amount of clinical workflow that patients went through every time they visited the healthcare provider was registration and clinical consultation and diagnosis. These two business functions (administrative and clinical) exist in all healthcare levels — primary, secondary, tertiary and reference centres. The two crucial functions were proposed: a patient registration system and a clinical information system should be the focus and should be included in the Malaysian telemedicine system for maintaining LHRs seamlessly and continuously. We learned from other countries' experiences that the development of disparate systems in "silos" would bring integration issues and would not sustain the telemedicine system in the long term (see Table 2.15 for a comparison of integration characteristics between the five selected countries and Malaysia).

Integration characteristics	Singapore	Hong Kong	Taiwan	U.K.	Canada	Malaysia
Use of central EMR as a basis for integrating/sharing the patient health information in delivering telemedicine services?	Yes	No	No	Plan	Plan	Plan
Integrate telemedicine delivery services into existing healthcare delivery services? E.g. expand telemedicine services in the existing healthcare facility instead of creating a new telemedicine centre separately.	No	No	No	Plan	Plan	Plan
Service Integration? E.g. teleprimarycare integrated with teleradiology or other telemedicine specialties and components.	No	No	No	Plan	Plan	Plan
System/Application Integration? Applications can be integrated with the existing application system such as the healthcare information system, etc.	No	No	No	Yes	No	Plan
Network integration? Use one network platform.	Yes	Yes	No	Yes	Yes	No
Integrate with legacy system?	No	No	No	No	No	Plan
Use of portable devices as a means for integrating patient health records across healthcare levels. E.g. smart cards	No	Yes	No	No	No	Yes

Table 2.15: Telemedicine Integration Characteristics between Five Countries and Malaysia

Source: adapted from (Chew et al., 1998; HPBonline, 2007; Tay-Yap and Al-Hawamdeh, 2001; Holliday and Tam, 2004; Cheung et al., 2001; Hjelm et al., 2001; Chen et al., 2001; Hsieh et al., 2006; Liu et al., 2006; National Health Services, 2006c; National Health Services, 2007; Brennan, 2007; Health Canada, 2006; Canada Health Infoway, 2006a; Hailey, 2001)

2.11 Summary of Electronic Health Record Approaches and Challenges between Malaysia and Four East Asian Countries

This section will discuss the EHR approaches and challenges of Malaysia and four East Asian Countries including Singapore, Taiwan, Hong Kong and Japan. When compared to these four countries, Malaysia seems to fall behind in a few distinct areas and is at a par in terms of many important approaches and challenges in implementing EHR systems. It would be summarised from the literature that there are five common major challenges in implementing EHR systems in four East Asian countries. These include integration efforts, process reengineering, people, funding and law and regulations. The integration efforts are categorised as a major challenge in implementing the EHR systems in all four East Asian countries. The criticality of the challenges differs from one to another country depending on their health policies, socioeconomics, cultures and politics (see Figure 2.8 — Five Major Challenges in Implementing an EHR system).

Figure 2.8: Five Major challenges in Implementing an EHR System

2.11.1 Integration Efforts

Japan, Taiwan, Hong Kong and Malaysia faced the same issues with regards to a lack of system integration capability. This might also be happening in other countries around the globe. All four East-Asian countries have been inventing and implementing hospital information systems in the healthcare facilities for more than twenty years. The application technologies are already obsolete and a majority of the legacy systems are still implemented in “silos” and the integration efforts have significant challenges.

Japan has faced critical challenges in making its existing EHR system an integrated one and in its inability to share medical records across healthcare facilities and levels. By way of example, the data between hospitals and clinics in Japan are still not easily shared although the computerised practitioner order entry (CPOE) system was implemented in the 1980s (Arnold et al., 2007). The variety of health information systems and technologies that were implemented previously present peculiar challenges to integration. As a further example, most of the telemedicine systems and services in Japan are implemented in a fragmented manner and these would also contribute significant challenges to integrating the telemedicine services into existing healthcare services where EHRs are used as a basis for diagnosing patients’ problems (Takahashi, 2001; Varghese and Scott, 2004).

The integration efforts in Taiwan are also complex. The many types of health information systems (hospital information system, telemedicine system and e-health) deployed through the bottom-up and research approaches, most of which have been implemented in a fragmented manner, have led to crucial issues in sharing the EHRs. To cite an example, there were major upgrades and integration efforts in the existing hospital information systems (HISs) when Taiwan's Bureau of National Health Insurance (TBNHI) introduced national health insurance smart cards, known as "NHI-IC" cards into Taiwan's health system (Liu et al., 2006). The variety of HISs and technology platforms will require major amendments and maintenance to the existing system for communicating with the NHI-IC card reader and NHI-IC data centre and to integrate with telemedicine services.

Hong Kong has fewer challenges with regards to integration efforts due to its small geographical size and the small number of healthcare facilities and the EHR system deployed is still at the beginning stage. According to a survey carried out by Leung (2003), 70% of the community-based clinics have yet to computerise any clinical functions. This should be an advantage in implementing an integrated EHR system across healthcare facilities and levels from scratch where data conversion and integration work with existing systems will not be involved during the implementation.

Singapore is one of the leading countries in EHR initiatives where the geographical size and effective ICT implementation planning provide great advantages to implement a standard EHR system across healthcare facilities and levels. The standardised system and technology used in all healthcare facilities has reduced the integration issues. By way of example, the implementation of the EMR Exchange (EMRX) in all levels of healthcare facilities made it possible for patients' health records to be accessed by the patients and healthcare professionals via the Internet (Health-4-U, 2007).

Where does Malaysia stand on this issue? It is likely that it is similar to other countries (Japan, Taiwan and Hong Kong), as it still looking for the best solution for linking all EHRs into an integrated one. Malaysia has many steps to go to achieve this vision since the health informatics standards and healthcare infostructure have yet to be established and are still in progress. Clinical standards such as clinical code sets and communication protocols and the architecture for clinical document standards are still under development and these are crucial for integration (see the severity of challenges faced by five East Asian countries in Table 2.16).

Table 2.16: Challenges Faced by Five East-Asian Countries
Source : (Abd Ghani et al., 2008a)

2.11.2 Process Reengineering

The integration issues cannot be resolved through technologies alone. A comprehensive change-management approach that integrates a number of enabling strategies and activities will be required at system, enterprise and project levels to ensure the effective implementation of EHR systems. This includes the service model design and process reengineering. Service delivery models will need to be redesigned and processes re-engineered to maximise the benefits of investments in health ICT and multimedia technologies (Al-Qirim, 2006). EHR projects should utilise service models designed for achieving best and accepted practice performance in terms of access, quality and cost and, finally, healthcare delivery services could be improved. To cite an example, Malaysia's telehealth projects that aim to focus on the wellness approach in its services require lots of process reengineering of its existing healthcare services model — shifting from an illness to a wellness paradigm (Ministry of Health Malaysia, 1997e). This has also happened in Singapore where the Health ONE project is aimed at empowering the citizens to manage their health status themselves and of course the healthcare delivery process needs to be changed (HPBonline, 2007).

To cite a further example, in Taiwan, with the introduction of NHI-IC cards, a healthcare provider is responsible for writing the specified data onto a card and transferring the data to TBNHI within 24 hours. Therefore, hospitals are likely to face more obstacles in the adoption of the NHI-IC cards as an integral part of their hospital information systems. The existing processes have to be reengineered to accommodate the functionality features of the NHI-IC.

To summarise the complexity in the five countries, Singapore has less challenges compared to Japan, Taiwan, Hong Kong and Malaysia. This is due to the fact that the EHR implementation approach in Singapore is through a standard platform of applications that are hosted centrally and accessed by all healthcare facilities through the web. By way of an example, Singapore Health Service (SingHealth) has deployed a standard system (namely Eclipsys' Sunrise(TM) suite of healthcare information solutions) in all SingHealth's healthcare organisations (HCOs) for minimising changes to the existing workflow and reducing change-management efforts during the implementation of EHR (Business Wire, 2001).

2.11.3 People Issues

People issues relate to change management, communication, training and development. Addressing the attitudes, habits and cultures or behaviours focused on present healthcare delivery practices and preparing the general population and healthcare professionals for the major changes linked to health ICT–EHR will require comprehensive communication and education/training strategies, particularly for people and healthcare professionals, who will need to operate in the new environment (changing from paper-based to computer-based medical records) (Bali and Wickramasinghe, 2008). Furthermore, this will entail training and developing personnel to operate effectively in a team-based, information-rich and multimedia-enabled working environment (Edward, 2005; Yang et al., 2007).

As knowledge workers, health professionals will increasingly interact with each other and their patients through multimedia networks (electronic health information and e-workflow). This alone will require a significant investment in training and technology. By way of example, in Taiwan, on average there is approximately one physician per 800 people and the largest medical centre sometimes treats over 10 000 outpatients a day, and the number of inpatients is nearly 3000 (Chen et al., 2001). This situation (the patient workload and the fact that it is time consuming) may not allow the physician to be involved in computerisation efforts and use a computer system in providing healthcare services to the patients.

To cite a further example, the survey carried out by Leung (2003) found a wide spectrum of potential barriers that may impede the adoption of computers in clinical practice in Hong Kong and it includes a lack of physical skills to implement and use technology and attitudinal or behavioural issues.

2.11.4 Funding

The widespread reshaping of the healthcare services and the rollout of EHR systems must take into account the potential impact on the cost of services delivered. Malaysia is determined to extract the maximum value out of current and planned healthcare expenditures, including investments in health ICT and EHR initiatives.

In this technologically expanding world, healthcare expenditure has been steadily increasing in both the developed and developing nations. Major causes of death and morbidity such as heart diseases, cancer and trauma are being caused by lifestyle changes (Schutz et al., 2006). Thus, a paradigm shift from an illness-focused health industry to a wellness-focused one through health information systems (telemedicine, telehealth and e-health) is of prime importance to cut down costs and improve the healthcare delivery system as well as to improve the quality of life of the people (Harun, 2007). It is envisaged that the EHR project will be the enabler in ensuring a cost effective and improved healthcare delivery service for the nation.

However, as this is a national project, and a complex one at that, challenges are to be anticipated, including the funding sources. The existing funding source for the EHR project depends largely on the Government. This has happened in Malaysia, Hong Kong, Singapore and Taiwan. Approximately, 75% of the healthcare infrastructure expenditure in Singapore has been provided by the Government (HPBonline, 2007; Business Wire, 2001) and even more in Malaysia at approximately 90% (Ministry of Health Malaysia, 2005).

Japan currently does not have a government-centred EHR system although some local and regional hospitals have installed telemedicine and EMR systems and shared them between healthcare facilities (Tsuji et al., 2003). The healthcare services and infrastructure are largely supported by private sectors.

The widespread reshaping of the healthcare system and rollout of the EHR system must take into account the potential impact on the cost of the services delivered and the source of funding. The five East Asian countries face similar challenges in providing continuous funding for the projects. The government has to balance its financial contribution to health ICT projects and evidently the private sectors are trying to maximise revenues from the investment they have made. This might be slow down the development of the EHR initiatives in the five regions and also in some other countries. Table 2.17 shows the health ICT initiatives in the five East Asian countries.

Country	Ministry of Health Website	National ICT project for Health	Electronic Health Record initiatives
Malaysia	moh.gov.my and dph.gov.my	Integrated Telehealth, Teleprimary Care, Total Hospital Information System	Lifetime health record (LHR)
Singapore	moh.gov.sg	Health ONE, telemedicine	EMR exchange (EMRX)
Taiwan	doh.gov.tw	Telemedicine, national health insurance smart-cards	NHI-IC cards
Hong Kong	hwfb.gov.hk	Telemedicine, patient-held medical record system	Patient card
Japan	mhlw.gov.jp	e-Japan, telemedicine, telehealth	Computerised patient medical records (CPRM)

Table 2.17: Health ICT and EHR Initiatives in Five East Asian Countries

2.11.5 Laws and Regulations

The appropriate laws, policies regulations and standards strategy will be required to ensure the effective operation of a virtual healthcare delivery through an electronic health record system while protecting the rights of individuals/patients (Sucurovic, 2007). In order for a patient's healthcare provider to have an accurate diagnosis and proper care management of the disease, the patient will have to reveal his medical history. In this respect, the healthcare providers will be bound by law and ethics in terms of the duty of confidentiality. The code of ethics in a doctor–patient relationship shall apply in the EHR environment as much as it does in conventional practice (paper-based medical records).

As far as personal data are concerned, it is a private matter between the physician and the patient. It is only the medium in which the medical data are kept which is different. In this respect, the patient would be required to sign the consent form before the personal data can be incorporated into the database. In practice people will think this is difficult. What if there is an emergency; does the patient need to sign the consent form? What if the patient is unconscious or is in grave need of medical attention? So what will happen in such a situation? As far as the healthcare professionals are concerned, they may use their judgement and training and attend to the necessary actions based on the situation at hand (Harun, 2007). When the situation has been stabilised and when conditions are permitting they may then procure their patient's consent or the person needs to sign the consent form only once in his lifetime (National Health Services, 2007).

The excessive policy regulation regarding the confidentiality and privacy of patients' medical records will hamper the implementation of EHRs nationwide. One example of excessive regulation is that the physicians in Japan are prohibited from answering specific questions about healthcare or disease by e-mail or telephone (Holliday and Tam, 2004). In Singapore, a prescription can be repeated online without seeing the physician for six months. Taiwan and Hong Kong face significant challenges in term of data privacy and confidential. The Malaysia Government has also taken the initiative to come up with a set of Cyberlaws to govern EHR initiatives (Ministry of Health Malaysia, 2000). Finally, law and regulation are crucial for keeping patients' health records confidential and private. However, there is a need for a balance of information revealed by the patient and the need to keep the medical information private. Table 2.18 depicts some of the EHRs captured through the clinical support systems that may possibly have an impact on the patient's confidentiality and privacy.

Table 2.18: Application, Electronic Health Records and Possible Impact on a Person's Confidentiality and Privacy

Source: (Harun, 2001)

2.12 Summary

This chapter began with an overview of telemedicine and the evolution of medical services and described the challenges faced by medical services. Based on the aforementioned discussion, it is clear that medical services faced substantial challenges in providing better healthcare services. This was due to rapid changes in demography, disease patterns and demand for better healthcare services. It can be learnt from the discussion that a convergence between ICT and medical services is needed to respond to these challenges. This is where health-ICT (such as telemedicine) initiatives come into prominence and can realise savings while at the same time broadening the reach of healthcare systems.

Thereafter, the HIS framework or model was evaluated for building research theories and used for developing a research conceptual framework. The role of the frameworks or models was described in the "what, where and how" questions of interoperability. From the discussion, it can be learnt that there are three types of frameworks commonly used in implementing the telemedicine system: firstly, the generic framework that provides a general guideline to develop and implement the system; secondly, the speciality-based framework that provides specific telemedicine services; and thirdly, the EMR-based framework that provides integration between telemedicine services and is paired with EMR/EHR. At this point, the EMR-based framework is considered suitable for this research.

The organisational aspect needed to be explored for finding suitable approaches, best practices and experiences. The ten country-specific examples of telemedicine approaches that were briefly described have all commenced with a “bottom-up” perspective and field projects followed by a realisation that a strategic framework is needed to maximise benefits. The Malaysian approach was almost the complete reverse to these approaches as it has elected to start a “top-down” strategy through its national agenda and vision — Malaysia’s *Vision 2020*; telemedicine was one of the important key areas for developing a knowledge-based society by way of the *Vision 2020* mission (Mohamad, 1996; MSC Malaysia, 2007).

Three unique factors were concluded from the literature search and the case study conducted at the Ministry of Health Malaysia. Firstly, it was noted that the Malaysian telemedicine strategy was derived through the *National Agenda of Vision 2020* that has been initiated and committed to by the Government of Malaysia. Secondly, the Malaysian integrated telehealth components were mainly based on EMR and LHR repositories for delivering the services. Thirdly, and uniquely, Malaysia’s telehealth was designed and customised to suit Malaysian circumstances and consisted of an integrated system made up of four major components.

It must be borne in mind that each of these components, although in existence in other countries, was often incorporated in an isolated and stand-alone manner. For example, teleconsultation services were already available elsewhere, as were CME and MCPHIE (albeit referred to by different names) and even LHP. However, it was evident that none of the countries used an integrated system that comprised the four components of LHP, MCPHIE, CME and TS.

The uniqueness of the Malaysian approach was designed to manage and integrate the disparate EMRs into an integrated LHR as well as ensuring that the LHR can be maintained (seamlessly and continuously) and shared by the four components. The EMR was critical because it was the source of information for other health record structures such as the LHR and LHS. Therefore, the integrity and the continuous upkeep of the LHR have to be established first. Malaysia's approach towards integrated services of telehealth should be focused on developing the scalable and flexible application for accessing, creating and storing the LHR seamlessly and continuously. Prioritising and focusing on critical components such as an integrated LHR and developing a suitable framework are needed both for the progress and success of the project.

The next chapter details how an appropriate research methodology was identified and developed to collect the data necessary for this research.

Chapter 3 Research Methodology

3.1 Introduction

This chapter describes the research methodology chosen and undertaken for this research. After due consideration, it was decided that a case study based approach was the most suitable for this project. Case study research uses a systemised way of observing (Yin, 2003b). This strategy is characterised by the following two features, which are valid for conducting this research. Firstly, there is its ability to not explicitly control or manipulate variables.

Secondly, there is the ability to study a phenomena in its natural context (Yin, 2003a). These two features are appropriate for research into identifying a suitable telemedicine framework where the aim is to study within realistic settings. The following section will briefly discuss the research design, the case study based approach, source of information and the types of data collected.

3.2 Overview of Research Methodology

This section discusses the appropriate research method to be used in this research. The discussion commences with a brief overview of the research strategy, research design and research classification. Thereafter, the research paradigm, research methodologies and circumstances for the selection methodologies are presented and discussed.

3.2.1 Research Strategy

A research strategy comprises an all-encompassing method, covering the logic of the design, data collection techniques and specific approaches to data analysis (Yin, 2003b). This section overviews and discusses the research strategy commonly used in performing research activities. If suitable, it would be used to facilitate the research project from inception to conclusion.

3.2.2 Research Design

According to Miles and Huberman (1994), research design is an action plan to help a researcher to perform the research from the inception stage to the conclusion. This is achieved by providing the researcher with the initial set of questions to be answered with the initial set of conclusions about these questions. A good research design also states the degree to which the results of the research can be generalised.

3.2.3 Research Processes and Classification

According to Hussey and Hussey (1997), based on the aim of the research process, research can be classified into four main categories. Each category of classification entails a different type of approach, as listed in Table 3.1.

Table 3.1: Research Classification

Source: (Hussey and Hussey, 1997)

Exploratory, descriptive, analytical or predictive research

Exploratory research is often characterised by an extensive collection of data with the objective of identifying patterns, ideas or hypotheses rather than testing or confirming a hypothesis. Exploratory research is frequently used in research studies that look at problems in which few previous studies are present. It should also be noted that exploratory research seldom offers conclusive answers to research issues and generally gives guidance on what future research, if any, should be conducted (Hussey and Hussey, 1997).

Descriptive research expresses phenomena as they exist. It is usually used to identify and acquire information on the characteristics of a particular problem. The data collected are often quantitative in nature and statistical techniques can be applied to them in order to summarise information (Collis and Hussey, 2003; Cooper and Schindler, 2003).

Analytical or explanatory research is basically a continuation of descriptive research conducted at an in-depth level. Predictive research, however, forecasts the likelihood of a similar situation occurring elsewhere (Hussey and Hussey, 1997).

Deductive or inductive research

Deductive research refers to the development of a conceptual and theoretical structure that is later tested by empirical observation. In deductive research, particular instances are deduced from general inferences (Hussey and Hussey, 1997).

Inductive research refers to a study where theory is extended from the real world and is based upon observation of empirical reality. In inductive research, general inferences are deduced from particular instances (Saunders et al., 2003; Hussey and Hussey, 1997).

Applied or basic research

Basic research is also known as fundamental or pure research. In general, the objective of basic research is to bring about a contribution to the body of knowledge; applied research focuses on trying to solve a specific existing problem (Cooper and Schindler, 2003; Hussey and Hussey, 1997).

Quantitative or qualitative research

Research can be differentiated by examining the approach adopted by the researcher. The quantitative approach to research is basically objective in nature and concentrates on measuring phenomena; the qualitative approach is more subjective and involves examining and reflecting on perceptions in order to gain an understanding of social and human activities (Hussey and Hussey, 1997).

Based on the aforementioned discussion, it becomes apparent that each research classification has relevance purposes and objectives. The discussion regarding the research methodology continues with research paradigms in the next section.

3.2.4 Research Paradigms

This section provides an overview and compares a research paradigm that is commonly used in the research processes. A paradigm has been defined as the progress of science practice based on people's philosophies and assumptions about the world and the nature of knowledge (Hussey and Hussey, 1997). The research paradigm for this research presents a framework for an accepted set of theories, methods and ways of defining data. As a result, they assist in providing basic beliefs and guidelines on the research issues and in presenting alternative research methods and techniques to be adopted for the research process (ibid).

There are two research paradigms — the positivist paradigm and the phenomenological paradigm — and they form the structure of any research process (Collis and Hussey, 2003). The discussion will be focused on these two paradigms in the next section.

3.2.4.1 Positivist paradigm

The positivist or quantitative paradigm focuses on those research issues that are observable and measurable and can be validated. Researchers try to maintain an independent and objective stance as they believe that their interactions with the research problem will not affect the parties connected with the research problem (Hussey and Hussey, 1997).

The positivist paradigm maintains the position that the researcher should remain distant from, and independent of, the research issues as this would allow an objective evaluation of the research problem. In terms of the data collected, using the positivist paradigm tends to free them from the researcher's bias (Creswell, 1994).

Positivist or quantitative research tends to use impersonal and formal language as compared to qualitative research, which uses more informal words such as "like", "understanding", "discover" and "meaning". Quantitative research methodologies use a deductive form of logic wherein theories and hypotheses are tested in a cause-and-effect order. On the other hand, in a qualitative methodology, inductive logic prevails (Creswell, 1994).

3.2.4.2 Phenomenological paradigm

The phenomenological paradigm has often been described as the science of phenomena as it pertains to understanding human behaviour from the participant's own frame of reference (Hussey and Hussey, 1997). A qualitative approach incorporates much more of a literary form of writing as the rules and procedures are not fixed, but rather open and emerging. This implies that phenomenologists have to bear inherent risks resulting from imprecise procedures (Hussey and Hussey, 1997; Creswell, 1994).

The adoption of a qualitative research methodology tends to lead to the identification of categories that provide rich context-bound information leading to patterns or theories that help explain a phenomenon. In addition, the phenomenologist always aims to identify patterns which may be repeated in other similar situations, unlike the positivist researcher who aims for measures that can replicate the same pattern under exactly the same conditions (Hussey and Hussey, 1997).

In terms of study variables, the research phenomenon is largely unknown and the problem needs to be explored because little information exists on the case under study. In fact, in many qualitative studies, a theory base does not guide the study because the variables are incomplete, inadequate or missing (Creswell, 1994).

According to Hussey and Hussey (1997), positivist and phenomenological paradigms represent two extremes, and very few researchers actually perform the research using one paradigm in its totality. They also noted that the phenomenological paradigm arose primarily to overcome some of the main criticisms of the positivist paradigm.

3.2.4.3 Differences between the positivistic paradigm and the phenomenological paradigm

The research paradigm discussed in the previous section is about how the research should be conducted. The issue of the paradigm is about choosing an appropriate model for this research for the acquisition of knowledge that reflects a belief in how the knowledge can be most effectively represented by the research process and findings. In order to determine the model that could be suitable with this research nature, Collis and Hussey (2003) summarise the main differences between the two paradigms.

Positivist	Different in terms of	Phenomenological
Objective and empirical	Nature of research	Subjective and exploratory
How your research fits into existing framework	Literature review	Notion of what to explore
Define hypotheses	What you are trying to establish?	Generate knowledge
Structure research	Research objectives (what you are intending to do)	Generate theories
Pre-determined research structure and data	Outcome	Process and data collection are flexible

Table 3.2: Differences between the Positivistic and Phenomenological Paradigms

In a positivistic paradigm, the nature of research is objective and empirical in nature. In contrast, the phenomenological paradigm is typically subjective and exploratory, where the case under study is normally not familiar to the researchers.

The phenomenological paradigm uses a literature review to explore the case under study for generating and establishing knowledge that provides openness, as new theories can be generated and phenomena ignored by previous researchers, and literature is recognised (Patton, 1987). In the literature reviews in the positivistic paradigm, the focus is on how the research fits into the existing scenario where the findings are used to define the hypotheses.

In addition, the phenomenological paradigm places an emphasis on processes and meanings that are not rigorously examined or measured, in terms of quantity, amount, intensity or frequency that existed in the positivistic paradigm.

Based on the aforementioned discussions, the phenomenological paradigm is considered appropriate for this research. This is because it can assist in capturing the essence of the findings and evidence of the aspects that are crucial for implementing the Malaysian telemedicine system. Whilst this subsection discusses the research paradigms, the next subsection will offer descriptions and definitions of the research methodologies.

3.2.5 Research Methodologies

A research method is a strategy of inquiry that includes the research design and data collection (Avison and Myers, 2002). The choice of research method influences the way a researcher collects data. Specific research methods also imply different skills, assumptions and research practices. The definition and description of these two methods (positivistic and phenomenological) are dealt with in the following two subsections.

3.2.5.1 Overview of positivistic methodologies

In this subsection, I shall describe two examples of positivistic methodologies that might be relevant for comparison purposes. The methodologies include longitudinal studies and cross-sectional studies.

Longitudinal Studies

Longitudinal studies have been associated with a positivistic methodology that involves repeated observations of the same items over long periods of time. This research is categorised as an observational study. The aim of the study is to research the dynamic of the problem by investigating the same situation or people several times or continuously (often many decades), over the period in which the problem runs its course (David 1993; Hair et al., 2003).

Longitudinal study is a broad term. It can be defined as the research in which "data are collected for each item or variable for two or more distinct periods; the analysed subjects or cases are the same, or at least comparable, from one period to the next, and the analysis involves some comparison of data between or amongst periods" (Menard, 1991).

In this research, the empirical data would be collected and compared from various cases. However, the predetermined periods are not involved and measured in the research due to the innovative and exploratory nature of this research. From this research point of view, the predetermined time points are rendered inappropriate for studying the appropriate aspects for: 1) developing a framework for Malaysian telemedicine system; and 2) studying the need analysis of an integrated LHR system. Hence, this methodology was not suitable for this research project.

Cross-sectional Studies

Cross-sectional studies form a class of research methods that involve observation that takes place at a single point in time. It will be carried out when the objective of the study is to have a holistic overview of the research issue (Hair et al., 2003; William, 2006). The cross-sectional studies have the following features: 1) the data are collected once; 2) there are constraints of resources; and 3) they do not explain why a correlation exists (Hussey and Hussey, 1997; Collis and Hussey, 2003).

Cross-sectional observations are the form of data most commonly used for assessing the determinants of behaviour in the social sciences (Coleman, 1981 ; Blossfeld and Rohwer, 1995). Generally, cross-sectional data are recorded in a succession of surveys at two or more points in time, with a new sample on each occasion (ibid). These samples either contain entirely different sets of cases for each period, or the overlap is so small that it is considered to be negligible (ibid). From this research point of view, the principal limitations of the cross-sectional survey is that it is conducted at just one point in time; it was not suitable for this research as the essence of this research had more to do with theory building, conceptual framework development and validation.

3.2.5.2 Overview of phenomenological methodologies

The overview of the phenomenological methodologies includes ethnography, action research, grounded theory and the case study. The subsequent sections show that due consideration was given to various methods in carrying out the research design and processes.

Ethnography

The ethnography method is an approach in which the researcher uses socially acquired and shared knowledge to understand the observed patterns of human activity (focus on a community). The informants selected are known to have an overview of the activities of the community. Such informants are interviewed a number of times, using information from previous informants to obtain clarification and deeper responses when re-interviewed (Fetterman and David, 1998). The aim of this methodology is to enable the interpretation of the social world in the same way that the members of that particular world interpret it. Participant observation is the main method of collecting data where the researcher becomes a working member of the group being studied (O'Reilly, 2005).

There are six levels or outlines of abstraction on how to carry out an ethnographic research study. They are as follows: 1) the culture under study and that of the researchers are linked; 2) cross-cultural differences are identified; 3) the environment surrounding the culture is looked into; 4) general statements about the culture are formulated; 5) a comprehensive description of events and activities to delineate the practices within a cultural domain is carried out; 6) the occurrence of activities is documented (Gbrich, 1999).

From this research point of view, it can be learnt that the principal limitation of ethnography was that it would be applied in environments quite familiar to that of the participants. Hence, it was not suited for the research as the essence of this research had more to do with theory building, conceptual framework development and validation. In addition, the case under study in this research was unfamiliar to the researcher and has to be explored intensively.

Action Research

Action research is a type of applied research. It is a reflective process of progressive problem solving led by individuals working with others in a team or as part of a "community of practice" to improve the way they address issues and solve problems (Reason and Bradbury, 2001.). According to Hussey and Hussey (1997), the objective of action research is to enter into a situation, attempt to bring about "change" and "monitor the results". Hence, the research type requires a close collaboration between the researcher and the respondent's organisation in which the research is being carried out, and this can be a challenge.

Based on the aforementioned descriptions, action research was considered inappropriate for this research project. This was due to the fact that this research dealt more with theory building, conceptual framework development and validation in understanding the "how" and "why" questions. In addition, this research project aimed to explore the following questions. "What are the critical factors for a framework to implement a Malaysian integrated telemedicine system that ensures that the patient LHRs can be maintained continuously and seamlessly? What is the crucial LHR dataset to be used to support the framework?" In contrast, action research has to do more with revealing the changes and monitoring the results.

Grounded Theory

Glaser and Strauss (1967) defined a grounded theory as being one that will be readily applicable to and indicated by the data and be meaningfully relevant and be able to explain the behaviour under study. In other words, this research method emphasises the generation of theory from data in the process of conducting research. The grounded theory research method is a reverse of traditional research where a variety of data collection methods are the first step rather than starting the project by researching and developing a hypothesis (Glaser and Strauss, 1967). According to Gbrich (1999), grounded theory is based on the conception that all researchers are capable of generating a theory and that it has the potential to enable researchers to develop theoretical propositions or even theories of the middle range that may explain the empirical world.

Despite having a capability to explain the empirical world effectively, grounded theory has the biggest limitations from the perspective of its applicability in a healthcare context. The researchers with a minimum theoretical knowledge have often used this method to produce theories that are little more than a reaffirmation of their own biases (Gbrich, 1999). Due to this limitation, it was not suitable for the study of healthcare organisation processes, which was the essence of this research. Additionally, since grounded theory starts with minimum theoretical knowledge, it was difficult for the researcher to choose the appropriate respondents, and to explore and focus on the case under study.

Case Study

According to Yin (2003b), the case study is one of several ways of doing social science research; it is a method of choice when the phenomenon under study is not readily distinguishable from its context. Case studies typically carry a lot of ethnographic descriptions and normally result in theory generation. Yin (2003b) observed that a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly defined. Hence, it would be appropriate to highlight the fact that a case study is an extensive examination of a single instance of a phenomenon of interest (Ellram, 1996).

In fact, Benbasat et al. (1987) also observed that a case study is often portrayed as being similar to exploratory research as it is used to tackle research issues that have little theory or a deficient body of knowledge. In addition, a case study could also provide a powerful description to illustrate particular social contexts in the case under study (Gbrich, 1999). The significant advantages to be gained by adopting a case study approach is that it is dynamic and the research carried out can be made both generalised and representative by taking a case unit or study focus (individual, case group, organisation or culture) and observing it (Miles and Huberman, 1994; Yin, 2003b).

Although the case study is a distinctive form of empirical inquiry, its major drawback is that, whilst defining a case, the researcher has to choose among alternative theoretical options and, as such, the researcher's bias might be seen in the case study. Nevertheless, once the drawback is overcome, the adoption of a case study approach could result in a holistic approach that supports the observation and grounding of a particular phenomenon (Yin, 2003a).

From this research point of view, it became clearer that the case study research method was particularly well-suited to this research since the object of this discipline was the study of IS in organisations and "interest has shifted to organisational rather than technical issues" (Benbasat et al., 1987). In addition, the case study method was applicable to this research due to the nature of the subject of study in this research, which was subjective in nature. It is hard to measure internal elements such as confidence, awareness, experiences, knowledge and project requirements. In order to understand these elements, the researcher needed to immerse himself in the respondents' activities and build a good relationship with the respondents. By having a good relationship, trust could then be established (Karhu, 2002) and, consequently, the respondents were encouraged to become actively involved in this research. To capture all these complexities, the case study method was most suitable for this research.

3.3 Circumstances of Selection Methodologies

At this stage some of the quantitative and qualitative research methodologies have been described that provided a clear picture for selecting relevant research approaches into this research project. The researcher's decision to select a qualitative research (case study) for *My*Tel was guided by the research aims and objectives, which were tied to healthcare specific contexts. In order to accomplish this challenge, the researcher required access to an organisation associated with the healthcare sector. Access to the organisation's empirical data was essential for allowing the researcher to analyse a real-life context, the technological, sociological and organisational aspects for theory building as well as developing and validating the framework for a Malaysian telemedicine system.

As this research objective would have involved building and extending theory (by creating a flexible framework for a Malaysian telemedicine system), it became evident that the empirical data required would be qualitative in nature. Adoption of the qualitative research method offered support in resolving some of the difficulties in the research process:

1. The aim behind this research was innovative and exploratory, where a proposition of a flexible framework for a Malaysian telemedicine system would be developed. Positivistic methodologies that include longitudinal studies and cross-sectional studies are often used in psychology to study developmental trends across the life span. The studies form a class of research methods that involve observation and well-known variables to be analysed and measured (Irani et al., 1999; Yin, 2003b; Hussey and Hussey, 1997). This research project was both innovative and exploratory (was a conceptual framework) dealing with contextual multidisciplinary data, up-to-date inputs and empirical data that needed to be explored and analysed before the intended framework is proposed. Due to these factors, the positivistic methodologies seemed to be irrelevant to this research compared to phenomenological methodologies.

2. The primary aim of the research was to develop a validated framework for a Malaysian telemedicine system that could ensure that the patients' LHRs could be maintained continuously. This required identifying, understanding, building and extending the

applicability of best practices from both practical and theoretical standpoints. This research had more to do with theory building, conceptual framework development and validation than statistically carrying out hypothesis testing and substantiation. Hence, the precondition of validation could not be achieved by positivistic methodologies as compared to phenomenological methodologies.

The phenomenological methodologies, ethnography, grounded theory and action research are among research methodologies similar to the case study approach (Yin, 2003a). Nevertheless, the three research approaches (ethnography, grounded theory and action research) are noted because they are relevant to the situation where the research phenomena have maximum control over the investigation process (Yin, 2003b).

On the other hand, the case study approach is more preferable and has a distinct advantage over other research strategies when the researcher desires little or no control over the investigation process of contemporary events (Yin, 2003b; Miles and Huberman, 1994). Yin (2003b) observed that the research questions focus mainly on "what" questions that are exploratory, such as "what are the crucial aspects…?". This type of question is justifiable in conducting an exploratory study. Looking back at this research question ("what are the most critical aspects for a framework to implement a Malaysian telemedicine system that ensures patient LHRs can be maintained continuously and seamlessly?"), it was a justifiable rationale for conducting an exploratory case study for analysing the real-life events of the phenomena of Malaysian telemedicine initiatives at MOHM.

Another reason associated with applying the case study method to this research was a need to understand the “how” and “why” questions. Yin (2003b) argues that the emphasis on the “how” and “why” questions demarcates case study research from other approaches such as ethnography, action research and grounded theory. As mentioned in Chapter 2, this research aimed to explore the following questions: “How is it possible to ensure patients’ LHRs are maintained continuously and seamlessly? How doe the LHR summary support the implementation of the proposed framework? Why is the integrated LHR needed for a continuum of care?” These questions illustrate that the emphasis of this research was on “how” and “why” questions. Therefore, as suggested by Yin (2003b), the case study approach needed to be adopted in this research.

The binding feature of the ethnography (Fetterman and David, 1998) and action research (Altrichter et al., 1996) methodologies is the emphasis on comprehensive in-depth descriptions. Such descriptions are aimed at either the cultural behaviour of a group, at capturing the essence of an experience or at understanding the complexity of a bounded case. However, both methodologies do not really emphasise the “how” and “why” questions, which were central to this research.

Contrastingly, the binding feature of grounded theory is the emphasis on the building of a theory that is grounded in systematically gathered and analysed data to conceptualise one process inherent within a certain contextual environment (Martin and Turner, 1986). However, the objective of this research was not to build a theory based on empirical observations or data. Rather, this research sought to develop theory that was based on the understanding of the “how” and “why” questions. It is the emphasis on the “how” and “why” questions that demarcates case study research from other approaches such as ethnography, action research and grounded theory (Yin, 2003b). As this research emphasised the “how” and “why” questions, as stated above, the case study method was appropriate to this research.

An additional reason for using the case study method was that it is the most widely used research method or strategy in the IS area (Myers and Haase, 1999; Irani et al., 1999). Overall, these researchers agree that the case study research is appropriate where the predominant research questions are those of “how” and “why”, which was the case with this research. In this instance, case study research allowed the incorporation of a range of materials that may have suggested different stories and the collection of data was done right away without already having determined the answer or even the form of the answer.

3.3.1 Overview of Selected Research Design

This research was conducted in two stages as depicted in Figure 3.1. Stage 1 of the research commenced with the literature review of the state of the current telemedicine approaches in other countries including Asia Pacific (Singapore, Japan, Taiwan, Hong Kong, China, Australia and New Zealand), Europe (the UK and Norway) and Canada. The review was carried out over six months using secondary data from various sources. The decision to conduct this review (telemedicine approaches in other countries) was taken on the basis that it can provide a wider perspective for the approaches and issues in implementing the telemedicine system. The telemedicine approaches of other countries were discussed, compared and contrasted with the Malaysian context of the Integrated Telehealth Project. The relevant approach was used as an input for developing the basic proposed framework.

The research proceeded with the field (case study) visit where the real situation of the case was explored, investigated and analysed. These processes were carried out through interviews and accessing to archival documents. Interviews are one of the most important sources of case study information (Friedman and Wyatt, 2006; Yin, 2003b). For this research, the key respondents were asked to comment on and inquire about certain events.

Archival documents served to corroborate the evidence and were useful for making inferences about the events. The archival documents included such items as mission documents, standard operating procedures (SOP), concept requests for proposal (CRFP), telemedicine blueprint, technical documents and other associated documents. In order to access this information, the ICT division of MOHM was the contact point for accessing the related data and the information related to the Malaysian telehealth project.

The inputs and the requirements from the case study were analysed, compared and contrasted with other countries' approaches. The first version of the proposed framework was developed and its validity was evaluated in collaboration with the MOHM. An evaluation form (regarding the proposed framework) was designed to check and test its validity at different health centre locations under the remit of the MOHM. The response report was reconciled and the comments and discrepancies from the validation were analysed and used to refine and improve the proposed framework. Finally, the final framework would be produced and areas for future research identified.

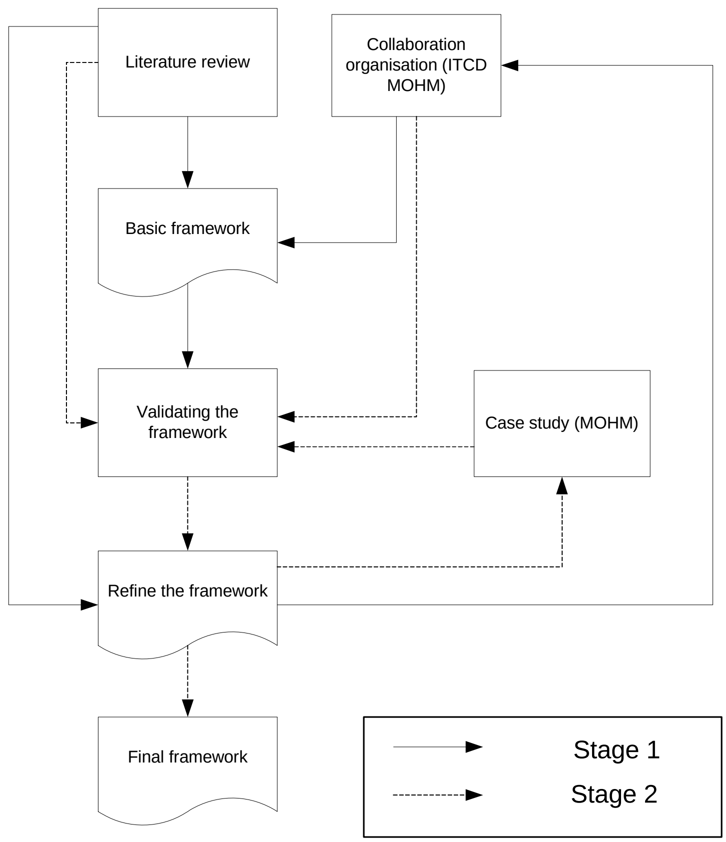

Figure 3.1: The Research Design and Process

3.4 Case Study Approach

This section will describe the approach and discuss the processes involved in the case study conducted at the Ministry of Health Malaysia.

3.4.1 Background of the Location for Performing a Case Study

A case study was conducted in the Ministry of Health Malaysia (MOHM) that involved four administration divisions and a clinical services section (outpatient departments of polyclinics and healthcare centres). The administration division consisted of an Information Technology and Communication Division (ITCD), which managed the Ministry's ICT requirements, a Family Health Development Division, which managed the Teleprimary Care project (TPC), a Health

Planning and Development Division, which looked after the new Total Hospital Information System project (THIS) and a Telehealth Division, which was responsible for managing the telehealth project. This case study explored the major application systems developed in the Ministry and evaluated and tested the applicability of the framework in outpatient clinics.

3.4.2 Sampling

A snowball sampling method (Patton, 2002) was used to gain in-depth information from key informants about the development of the telemedicine project and the related health ICT projects. Respondents were identified from initial contacts made with individuals known to staff members. A network was then built up by asking the initial group of respondents to suggest additional respondents for interview. In total, 40 respondents were found amongst directors, managers, domains and clinicians who were involved and associated with the telemedicine and health ICT initiatives in MOHM. Table 3.2 lists the job titles of the respondents who participated in the case study.

Respondent	Total (N =)
Director of Telehealth Division	1
Chief Information Officer of MOHM	1
ICT/Technical Manager	4
Medical Officer	30
Project/Domain Manager of TPC Project	1
Project/Domain Manager of THIS Project	1
Former Telehealth Founder/Company CEO	1
Former Telehealth Solution Architect	1
Total	**40**

Table 3.2: List of Respondents

3.4.3 Data Collection

According to Yin (2003a) and Stake (1995), there are at least six sources of evidence for collecting data in case studies: they are interviews, archival records, documents, direct observation, participant observation and physical artefacts. During the evaluation of the case, observations of daily outpatient clinical routines, interviews, meetings, discussions and social events took place in different organisations, divisions, departments and healthcare centres. A good rapport between the researcher and participants was established at both formal and informal occasions.

In this research, interviews are one of the most important sources of case study information. Open-ended and structured interviews methods were used to obtained the primary data. The interviews were conducted at two organisations: the Ministry of Health and a former responding organisation (AIH Group). A group of personnel from the Ministry (directly involved in the health ICT project — ITCD — and the Telehealth Division team) were identified and a contact person established to create a close working relationship and rapport (see section 3.4.2).

The AIH Group consisted of the president of the company and various former groups of the project team that included a solution architect and a software development manager. The interviews were informal and unstructured in order to make the respondents feel natural and encourage them to talk freely on areas of interests to this research (Yin, 2003b). However, I devised a set of questions as a guide for the interviewer (which acted as a framework). The set of questions was divided into sections according to the objectives and themes.

Archival documents such as mission documents, telemedicine blueprints, a concept request for a proposal report (CRFP), a requirement analysis report and technical documents provided useful evidence for making inferences about the case. Documents were acquired from the ITCD, health centres, polyclinics and hospitals. The artefacts of the ICT project were maintained by the ITCD and, based on the collaboration arrangement between ITCD and this project, data collection and access to project documents had been established and resolved. This high level access lifted the normal severe restrictions to existing data with an official letter being produced when requesting the related documents. This is one of the standard operating procedures (SOP) established by MOHM regarding research protocol.

3.4.4 Data Analysis

Based on the specified case (unit of analysis) being studied, three techniques were used to analyse the results: coding, and contextual and narrative analysis. Narrative explanation is one of the most powerful forms for expressing experiences (Rice and Ezzy, 1999). In this research, the data were analysed through data analysis processes including data reduction, data display and conclusion drawing and verification (Miles and Huberman, 1994).

Open-ended interview data (noted in the interview form and audiotape) were transformed into word tables that displayed the data from the individual cases according to some uniform framework (Yin, 2003b; Miles and Huberman, 1994). Structured interview data were also categorised and captured onto a spreadsheet format for creating data displays. These activities were refined through a series of analyses until the complexity was simplified and the structured evidence presented for addressing the research questions.

3.4.5 Case Study Quality

In this case study, two tests were used to establish the quality of the empirical research (Yin, 2003a). Firstly, there was a construct validity test for establishing and reducing subjectivity by linking the data collection questions and measures to research questions (Rowley, 2002). The evaluation measures in the interview questions were identified based on the proposed framework and linked to the research objectives. The result would demonstrate that the interview questions addressed the research questions adequately.

Secondly, reliability was tested by demonstrating the operation of the study. By way of example, the data collection procedures were repeated with the same results being produced. This was achieved through detailed documentation of procedures and systematic record keeping (such as the design of structured and pre-defined questions forms) (Rowley, 2002).

Based on the above tests, the potential bias that might be an issue when conducting qualitative research could be overcome by effective data triangulation. Triangulation was carried out by using multiple evidence from different sources to confirm the same findings and facts (Miles and Huberman, 1994; Yin, 2003a; Yin, 2003b). For example, certain facts obtained from a domain manager were confirmed with a different domain manager as well as via the project documentation and observation.

3.5 Data Collection Methodology

The case study methodology supports the collection of empirical data from multiple sources of data such as documents, archival reports, observations and interview (Yin, 2003b). This research focused on gathering empirical data that were qualitative in nature and the data were collected using different methods. For example, secondary data were gathered from the literature review and organisation documents that formed the theoretical and initial proposed framework.

The primary data (of the main case) were collected using semi-structured and open-ended interviews and were combined with observation and an analysis of the organisation's documents. These data were obtained from the participating respondents mentioned in section 3.4.2. Primary data have two purposes: first, they are to corroborate understanding of an actual phenomenon and to identify crucial requirements for developing the proposed framework. Secondly, the primary data were also used to validate the proposed framework using data obtained from the telehealth project of MOHM.

Data collection methods do suffer some inherent limitations, especially with the use of semi-structured and open-ended interviews. The limitations include difficulties in generalisability; the data may have inherent consistencies and reflect the researcher's biases and perceptions. In order to safeguard against this, due caution was exercised whilst gathering empirical data and the quality of the case study was ensured (see section 3.4.6) by constructing validity and reliability tests.

3.6 Sources of Information

The search for articles that applied to the research questions (other countries telemedicine approaches) was conducted using electronic and hand searches from a number of databases ranging from medical, medical informatics, information systems and ICT. The sources of evidence collected during the case study included documentation, archival records, interviews and direct observations from the case study organisation (Yin, 2003b). Some related sources are listed in Table 3.3.

Sources	Databases /documentation
Major subject focus databases	• IEEE
Selected journal for hand search	The following journals were manually examined for the relevancy of titles and abstracts regarding telemedicine approaches for the specified countries. • International Journal of Medical Informatics (IJMI) • International Journal of Electronic Healthcare (IJEH) • International Journal of Telemedicine and Telecare (IJTT) • International Journal of Healthcare Technology and Management (IJHTM) • Journal of the American Medical Association (JAMA) • Telemedicine and E-Health • IEEE EMBS
Specialist databases	• American Telemedicine Association (ATA). http://www.atmeda.org/ • Healthcare Information and Management System Society (HIMSS). http://www.himss.org/ • Canada Health Infoway. http://www.infoway-inforoute.ca/. • NHS Connecting for Health. http://www.connectingforhealth.nhs.uk. • Health Level 7 (HL7). http://www.hl7.org
Online Government web site (Ministry of Health)	The following web sites were manually examined for the relevancy of the overview of their health system. • Ministry of Health Malaysia (MOHM). http://www.moh.gov.my. • Ministry of Health Singapore (MOHS). http://www.moh.gov.sg/ • Ministry of Health Taiwan. http://www.doh.gov.tw • Ministry of Health HongKong. http://www.hwfb.gov.hk • Ministry of Health South Korea. http://www.mohw.go.kr • Ministry of Health Japan. http://www.mhlw.gov.jp • Ministry of Health Australia. http://www.health.gov.au • Ministry of Health New Zealand. http://www.moh.govt.nz • Ministry of Health UK. http://www.dg.gov.uk • Ministry of Health Canada. http://www.hc-sc.gc.ca • Ministry of Health Norway. http://www.odin.dep.no/hod/english/bn.html
Malaysian Government Agency	• ICT Division of MOHM – the agency provides documentations, archived reports and articles regarding health ICT projects in Malaysia's health system • Information and Documentation Unit (ISDU), Department of Planning and Development of MOHM – the agency provides health facts and statistics for Malaysia's health system. • Department of Statistics Malaysia (http://www.statistic.gov.my) – provides Malaysian population and other vital statistics. • Malaysian Communication and Multimedia Commission (MCMC) [http://www.skmm.gov.my] – provides statistical information and facts regarding telecommunication consumers.

Table 3.3: Sources of Information

Internet search engines were used at the beginning of the search for identifying related terms, articles, databases and website addresses. The hand search then proceeded to the selected databases/journals.

3.7 Categories and Types of Data

3.7.1 Telemedicine Approach in Other Countries

The telemedicine approaches and concepts of other countries were collected from secondary sources such as journals, government documents, proceeding papers, books and government websites. The information about telemedicine initiatives and telemedicine frameworks in certain countries was considered confidential. Normally, the reports were published in the governments' official reports with journals, books and proceeding paper reporting in detail on other countries' telemedicine activities and initiatives.

Referring to non-government sources of documents required a longer period of time for obtaining the appropriate and the right information. For this reason, the Ministry of Health's (MOH) website was used as the main source of reference during the review process. This website provided information on the healthcare vision and mission, health system, healthcare delivery system and related topics. The website provided useful information on the country's approach and concepts in telemedicine and e-health initiatives.

Websites provided links to related important information such as health indicators, the current situation and the project's progress with regards to telemedicine or the telehealth project. The Ministry of Health Canada (Health Canada, 2006) provided a special link to the Canada Health Infoway website (Canada Health Infoway, 2006c), which is involved in telemedicine and telehealth initiatives for the country. The website provided comprehensive electronic information regarding the project and granted visitors permission to access and download the documents.

It was important to understand the healthcare system of the countries that were involved in the review. Implementing telemedicine services required an understanding of healthcare organisations and their business processes. By knowing the healthcare systems of the countries being reviewed, the time taken for reading and capturing the information could be reduced.

The information collected included the background of the country, the background of the healthcare system, telemedicine history, telemedicine/telehealth services and applications, telemedicine/telehealth approaches, telecommunication technology and the barriers and challenges to implementing and sustaining the telemedicine services.

There would be a limit to the number of countries to be reviewed. Uncertainty in the number of countries in the reviewing process might have resulted in a lack of objectivity for the research and the inclusion of irrelevant information (Yin, 2003b; Yin, 2003a). The selection criteria included a similarity in terms of social and cultural situations, economy and politics. However, experience was the main factor for the selection. In general, the countries involved in the review were divided based on various continents.

For example, these were Asia Pacific (Singapore, Hong-Kong, China, Taiwan, Japan, Australia and New Zealand), the Americas (Canada) and Europe (UK and Norway). Norway, Australia, Canada and the UK are amongst the developed countries that are very active in developing and implementing telemedicine/telehealth services across government healthcare facilities in and integrating the national health records of patients into telemedicine services nationwide. The Asian countries were chosen due to their similarities in social structure, culture and economy.

3.7.2 Internet Penetration and Mobile Phone Users Survey

Maheu (2001) pointed out that a qualitative approach is one of the more effective choices to view behaviour in a natural setting and to increase understanding of a phenomenon under study (particularly for one which has not previously been studied). The survey on the usage of portable devices among Malaysians was to evaluate the potential storage devices for storing the lifetime health record of citizens.

The main purpose of this survey was to understand the current state of usage of portable storage devices among Malaysians in general and the usage trend of mobile phones in particular. The approach to obtaining this information was through secondary data from the Malaysian Communications and Multimedia Commission (MCMC). MCMC is a government agency responsible for implementing and promoting the Government's national policy objectives for the communications and multimedia sector and overseeing the new regulatory framework for the converging industries of telecommunications, broadcasting and online activities (Malaysian Communication and Multimedia Commission, 2006).

Secondary data from MCMC were chosen as the data were both reliable and highly comprehensive (had a response rate of 79%) and provided enough parameters to support aspects of the research questions (that is, could mobile phones provide alternative storage to store patients' lifetime health records?)

A proforma (data extraction form) was designed using Microsoft Word. The form displays the vital parameters that include year of survey, geographical area, percentage and number and categories of analysis (technology type, gender, age, employment, period of time used and service types). All relevant data were extracted to avoid referring back to the paper.

The analysis method applied to this data was similar to that of primary qualitative research as described in section 3.4.4 of this chapter. A combination of textual commentary and summary tables was used to present the studies identified and conclusion drawn.

3.7.3 ICT Infrastructure in Public Healthcare Facilities

Information regarding ICT infrastructures at all healthcare centres were to be gathered by way of secondary data sources (obtained from the Information Technology and Communication Division (ITCD) of MOHM). The information variables included the telecommunication network (such as LAN, WAN, dial-up, broadband, wireless and bandwidth size), application software (hospital information system, teleprimary care system, telehealth system, clinical support system and administration and financial information system), system software (such as the operating system and firmware) and hardware (such as personal computer, server, printer, scanner and modem). The weaknesses of the data were that they might not have been up to date, might have been unreliable due to improper prior survey techniques and might have involved third parties maintaining the ICT equipment. If the up-to-date information was absent, a collaborative survey was to be conducted with ITCD.

3.7.4 Patient Demographics and Clinical Records

The objectives of acquiring this data were to identify and analyse the attributes and the patterns of the actual patients' medical records. It was also to identify what type of medical information was accessed, reviewed and recorded by the doctors during patient–doctor encounters. Patients' medical records can be obtained in two ways. First, they can be obtained from the Information System and Documentation Unit of the Ministry of Health (ISDU). The information provided by the ISDU was converted from the manual form (clinical notes written by the healthcare professional) into an International Coding for Disease Revision 10 (ICD-10) coding system. The conversion was carried out manually by the medical record personnel (medical assistants and senior medical record officer). The information contained disease categories according to gender, age group, ethnic group, district and state. The information was then used to produce a monthly report regarding disease patterns encountered in each area or state.

The weaknesses of this data were that the actual patterns of the patients' medical records recorded by the doctors could not be analysed in detail. The ICD-10 is a system of categories of diseases that are appropriate for statistical classification of diseases (WHO, 2007). As such, the detailed clinical findings (for example, demographic information — name, address, age, sex, blood type, allergies and clinical records — medication, medical history, diagnosis, test results and procedures) during patient–doctor encounters are not included in the ICD-10 format.

Secondly, the patients' records could also be obtained from the registration department (medical record unit) of every healthcare facility. The majority of healthcare facilities in MOHM use a manual system and each one of them contains patient records that are still kept in a paper-based format. The patient records strive to be the single data access point for healthcare professionals managing a patient.

All observations, test results, medications, patient clinical notes and so forth are recorded on paper. Once an episode of care has been completed, the clinical notes form part of the patient's file from which all clinical data are archived. The paper-based patient medical record is ultimately a suitable source for analysing the existing pattern of the patient's demographic and clinical records. The result from the analysis is then used for creating the basic structure of LHR datasets.

For every patient file, the routine processes of data analysis and data abstraction were carried out as follows. The research assistant would obtain at random any five patients' names and patients' registration numbers from the list provided by the registration clerk. The analysis process started by identifying and extracting the demographic data and clinical data especially with regards to clinical terms: for example, symptoms (fever, flu, dry cough and swelling), permanent diagnosis (high blood pressure, diabetes mellitus and asthma) and allergies (seafood and penicillin) that were manually written down by the doctors.

The demographic data attributes to be extracted included the patient's identification number, name, address, age, ethnic group, religion, sex, occupation and gender. Common clinical record attributes included symptoms, diagnosis, family history, vital signs and medication. One of the difficulties encountered during the analysis process included non-standardisation of clinical terms/notes recorded by the doctors, incomplete information and unreadable handwriting by the doctors. The data analysis was then transformed into a data model and conceptual design that will be covered in chapter five.

3.7.5 Forms and Templates

Forms and templates provide a consistent and structured format for patient data. They are easy to analyse and provide an easy way to extract the attributes of the information. In fact, they do not involve a patient's privacy and confidentiality requirements, which are totally absent from the actual data.

The processes involved in analysing and capturing the information were as follows. The research assistant would write an official letter to the director of the selected healthcare facilities. The letter would request permission to acquire the related clinical forms and templates that were used for recording the patients' clinical notes or recording discharge summaries for the episode. Once permission was received, the forms and templates would be analysed by the research assistant.

The essential attributes would be transferred into a logical database model, which will be described in detail in Chapter five. The weakness of these data is that the actual patterns of a patient's clinical notes cannot be visualised. However, it provides comprehensive information regarding a patient's medical records that should be recorded by the healthcare professional during the doctor–patient encounter.

3.8 Triangulation Strategy

Denzin (1970) defined triangulation as the use of more than one approach to the investigation of a research question for enhancing confidence in the ensuing evidence and findings. Yin (2003b) observed that some studies have used, or relied upon, a single research method but may suffer from limitations associated with this method or from the specific application of it. As an example, in conducting their research, should researchers choose the single most appropriate source or the one with which they are most familiar? Triangulation offers the prospect of enhanced confidence and corroborates a wealth of evidence.

Patton (1987) discussed and distinguished four types of triangulation for evaluating the evidence:

1. the *triangulation of data sources* (data triangulation), which entails gathering data through several sampling strategies, so that slices of data at different times and social situations, as well as on a variety of people, are gathered;
2. the *triangulation among different evaluators* (investigator triangulation), which refers to the use of more than one researcher in the field to gather and interpret data;
3. the *triangulation of perspectives to the same dataset* (theoretical triangulation), which refers to the use of more than one theoretical position in interpreting data;
4. the *triangulation of methods* (methodological triangulation), which refers to the use of more than one method for gathering data.

A researcher can carry out triangulation using different methods, theories, investigators or data sources to study the same phenomenon. Denzin (1970) elaborated that, if researchers have used different methods to investigate the same phenomena and if their findings and conclusions are the same, their results would have greater validity and reliability compared to results obtained by using a single research approach. In addition, triangulation would also assist in: 1) the converging of results; and 2) merging the overlapping and different facets of the phenomenon (Creswell, 1994). The rationale for using triangulation is explained in the next section.

3.8.1 Rationale for Using Multiple Sources of Evidence

The research approach adopted in this research was qualitative in nature where the case studies were employed for acquiring empirical phenomena and data. The research involved two main activities: 1) understanding the organisation's operational background; 2) data collection for the research analysis and validating the proposed framework. In order to obtain and gather this information the research activities would be built into the data collection by way of personal interviews and archival records. However, Miles and Huberman (1994) mentioned that case study research may contain important issues of personal bias due to the dependence upon a researcher's personal attributes and skills. Patton (2002) also mentioned that one of the important disadvantages associated with this type of research was personal bias.

As this research was qualitative in nature, the issue of personal bias was also associated with this research. The triangulation of methods and data sources was employed in this research for mitigating a systematic bias in a research study. Furthermore, as argued by Krieger (1991), people cannot avoid a bias because the outer world or people's "external reality" is inseparable from what people already know based on their lives and experiences — people's "inner reality".

The rationale of triangulating data sources (multiple sources of evidence) was further elaborated by Yin (2003b). Some studies may rely only on participant observation but may not examine a single document. Similarly, numerous studies have relied on archival records but have not involved a single interview. This isolated use of sources may be a function of the independent way that sources have typically been conceived. Thus, on many an occasion, investigators have announced the design of a new study by identifying both the problem to be studied and the prior selection of a single piece of evidence such as “interviews” (Yin, 2003b).

In addition, in the context of the case study research approach, the use of an individual source of evidence is not recommended (Yin, 2003a). The use of multiple sources of evidence allows an investigator to address a broader range of historical, attitudinal and behavioural issues (Yin, 2003b; Denzin, 1978). In fact, the evidence gathered from different sources would enhance the applicability of the findings and confidence. According to Webb et al. (1966), once a proposition has been confirmed by two or more independent measurement processes, the uncertainty of its interpretation is greatly reduced and the most persuasive evidence comes through a triangulation of measurement processes.

Furthermore, the most important advantage presented by using multiple sources of evidence is the development of a converging line of inquiry (Yin, 2003b). Hence, the findings and conclusions obtained are likely to be more convincing and accurate if they are based on different sources of information.

In this research project, the data triangulation would be used to analyse the findings that were obtained from different sources of information. By way of example, the proposition of the *My*Tel framework involved acquiring evidence from several sources of information including archival records, documents and 40 samplings of respondents with three different specialisations of domains and divisions. The multiple sets of data were "mutually confirming" in that they potentially showed a consistent answer as evidence or pattern of requirements and lessons learned. All sets of data were triangulating on the same set of research questions that resulted in multiple sources of evidence and methods converging. The approaches towards triangulation strategy will be discussed in detail below.

3.8.2 Approaches to the Triangulation Strategy

As mentioned above, qualitative data were gathered from personal interviews and document materials. During the research, direct observation was carried out to some extent. All these approaches to data collection were intended to put into practice the concept of triangulation to reduce personal bias in the research work. Miles and Huberman (1994) mentioned that triangulation is supposed to support a finding by illustrating that the independent measures agree with it or, at least, do not contradict it.

The triangulation strategy started when the respondents from different divisions were invited so that multiple sources of evidence could be collected. It commenced when (during the first stage of this research) the researcher contacted the key informants of MOHM. The aims behind contacting key informants were to establish relationships and identify related respondents. A network was then built by asking the initial group of respondents to suggest additional respondents for the purposes of interviewing, acquiring documents and carrying out observations. All of these processes were done through the induction period of the case study visit to the MOHM premises. After the induction period, the process of collecting the data commenced. The means of collecting qualitative data within this research consisted of interviews, document reviews and observation. The data collection using the triangulation strategy is described below.

Triangulation of methods for gathering data

According to Patton (2002), personal bias is one of the important issues in qualitative research. This issue is also associated with this research. In order to mitigate this issue, the case study interview was carried out with different research participants in order to add details and richness to the understanding of the Malaysian health system and Malaysian telehealth perspectives.

To understand an organisation's operational background, mission and vision of the Malaysian healthcare system and health ICT programmes, senior management members were interviewed. During this stage, semi-structured interviews were employed. This approach allowed a great deal of flexibility in asking a pre-determined set of questions or issues that were related to the organisation's operations and its mission and vision (Gubrium and Holstein, 2002). In this process, the researcher was free to pursue certain in-depth questions. By way of example, the managers were asked about the functions of their divisions in MOHM, their objectives in developing health ICT projects and their opinions regarding the proposition of the *My*Tel framework. A description of this interview will be given in chapters 4, 5 and 7.

Another approach employed in collecting evidence during the case study was the structured-interview. This approach was used for acquiring evidence regarding the health ICT infrastructure across the healthcare facilities of MOHM. This approach was also employed in analysing the usage of patients' demographic and clinical data during doctor–patient consultations (the description of this analysis will be given in Chapter 5). The structured-interview was used to corroborate certain facts that the researcher had established.

During a field visit to the case study site, direct observation was employed for corroborating evidence and understanding. This was to increase confidence and to confirm the evidence gathered from the archival records and documents. A description of the analysis and observation on the outpatient clinic and clinical diagnosis workflow will be given in Chapter 5.

Triangulation of data sources

Personal interviews

Interviews are considered to be the favoured tool used by the qualitative researcher for data collection (Denzin, 1978) and it is one of the frequently used data collection tools utilised for this research. However, the interview conducted from a single source will lead to personal bias. In this research, the interviews were conducted with different categories of respondents. The respondents included a group of senior management members, project managers, domain managers, technical managers and doctors. All respondents were selected from different divisions and different health ICT projects under MOHM. The same questions for the specific objective were asked of all groups of respondents.

As an example, to understand an organisation's operational background as well as the mission and vision of the Malaysian healthcare system, senior management members from the three different divisions (the Telehealth Division, Public Health Division and Planning and Development Division) were interviewed. For exploring and collecting specific evidence on the need for standardising a solution architecture framework and the need for an integrated LHR system, the head of the ICT division, project managers and domain managers from three health ICT projects were interviewed respectively. Thirty doctors from outpatient clinics were also interviewed for corroborating evidence regarding the usage of patient demographic and clinical data during doctor–patient consultations. The definitions and descriptions of the case study are provided in chapters 4 and 5.

By way of another example, for validating the proposition for the framework, open-ended interviews were employed in the three different health ICT projects (Telehealth, TPC and THIS). Open-ended interviews were useful in this research because they were desirable when obtaining the same information from each interviewee at several points in time where there were time constraints for data collection and analysis (Gubrium and Holstein, 2002). The description of validating the framework will be described in Chapter 7.

The above discussion presented the data triangulation strategy used in this research in obtaining and confirming case study findings. It was noted that the use of multiple sources of evidence could corroborate the confidence in and validity of the research findings. Hence, data triangulation was established in this research where personal bias would be addressed accordingly.

Document review

In addition to the above techniques, data collection involved an intensive document review. Yin (2003b) found that researchers supplement observational fieldwork and interviewing with gathering and analysing documentary materials, such as those detailing laws, regulations, contracts, correspondence, memoranda and routine records on services and clients. These kinds of documents are useful sources of information on activities and processes and can generate ideas for questions that can be pursued through observation and interviewing (Yin, 2003b).

Archival record and document reviews were undertaken intensively during the stage of understanding the operational background of the organisation used for this research and the development of the proposition for the framework. To understand the operational background of the organisation, the researcher gathered and analysed the documentary materials such as the ministry profile and background, management summary, analysis reports, strategic planning reports, organisational structure, departmental functionality, job description and an overview of the MOHM. In order to develop the proposed telemedicine framework, archival records such as research reports, a telemedicine blueprint report, a request for proposal reports, a telemedicine standard and policies, user requirements reports and architectural reports were gathered and analysed in depth, and in an intensive manner.

The document review used in this research had major advantages because the documents were generated contemporaneously with the events they referred to. Hence, they were less likely to be subject to memory decay or memory distortion compared to data obtained from an interview (Miles and Huberman, 1994). Nevertheless, there was an important disadvantage: they may have been subject to selective-survival or selective-deposit (Webb et al., 1966). Bearing in mind the strengths and weaknesses of the document review, this approach would be used to establish data triangulation in this research.

Conduct observation

First-hand observation of a phenomenon is another important source of qualitative data for evaluation (Yin, 2003b; Miles and Huberman, 1994). The main purpose of observational evaluation is to obtain a thorough description of the research including research activities, participants and the meaning participants attach to the research. It involves careful identification and an accurate description of relevant human interactions and processes (Miles and Huberman, 1994).

In this research, the observation involved the systematic noting and recording of activities, behaviours and physical objects in the evaluation setting, with the researcher acting as an unobtrusive observer. The aim of the observations during the case study visit was to ensure that the level of understanding of the researcher with regards to the outpatient workflow and clinical diagnosis processes was at a satisfactory level. This was also to cross-check with the workflow described in the archival records and information given during interviews.

Besides observing the physical workflow of outpatient clinics, the existing ICT applications used in the clinics were also observed. This was carried out for the teleprimary care application and pilot implementation of the first version of the telehealth system. The description of this observation and analysis will be described in Chapter 4.

Bearing in mind the benefits of observations that provide empirical evidence, this approach was employed in this research to establish data triangulation.

3.9 Collaborating Establishment

As mentioned in the previous section, this research utilised the case study research method. This was due to the nature of this research, which was subjective and innovative. In addition, the research aim was to have a deep understanding of the requirements of the proposed conceptual framework for a Malaysian telemedicine perspective. Therefore, close collaboration with MOHM was needed. The purpose of the collaboration was to gain access to the existing data, allowing the investigation of the problem area and collection of essential data, and validating the conceptual framework.

The selection criteria for the collaboration organisation in this research were guided by the research's aims and objectives, which, in turn, were tied to a specific context, that is the Malaysian healthcare system. In order to accomplish the research target, the researcher required access to an organisation associated with the healthcare sector, MOHM in particular. From the above discussion, it became clear that through the collaboration arrangement, the researcher would be able to access and analyse the empirical data in a real-life context (Yin, 2003b; Irani et al., 1999). It was widely agreed that people in the organisation had knowledge and talent (Wickramasinghe et al., 2006).

Bearing in mind the strength and richness of experiences of MOHM in providing healthcare services in Malaysia, it was then selected as a research collaborator. A close collaboration with MOHM through its ICT division, namely the Information Technology and Communication Division (ITCD), commenced in January 2006. Contact was made and updates communicated (on an ad hoc basis) by way of various communication channels (including e-mail, telephone, mail and field visits). ITCD was also used to facilitate networking with other related divisions and projects in MOHM, especially telehealth and other health ICT projects (Patton, 2002). The project office and the personnel in charge were contacted for acquiring and accessing the sources of information.

In addition, ITCD has extensive experience in managing ICT projects in MOHM and its choice as the organisation collaborator provided a considerable advantage to this research. In fact, the organisation could provide empirical information and strong evidence in supporting the research question. The division has direct access to the needs and requirements of healthcare organisations regarding health ICT requirements and experiences. ITCD will also make available, on a confidential basis, MOHM's documents relating to the development, implementation and post-implementation of telehealth applications and hospital information application systems that are deployed across healthcare facilities nationwide.

In order to streamline the scope of work during the research activities, collaboration guidelines were outlined and consent was obtained from the collaborator. This consent was important for this type of research as it was longitudinal in nature and involved many research activities. Therefore, there were five collaboration guidelines involved, which included the following.

1. Allowing access to existing data and information
2. Allowing an investigation of the case under study to be performed at certain healthcare premises and conducting primary data collection
3. Providing feedback for validating the proposition of the conceptual framework

4. Acting as a contact point to establish a relationship with other divisions in MOHM if required
5. Being willing to adopt the solution framework if it would fit or was applicable to Malaysian telemedicine requirements.

In summary, the use of ITCD as a collaborating organisation would ensure a more complete approach to empirical research. Empirical data would be collected in a time sequence that clarified the direction as well as the magnitude of change in framework requirements. This was the characteristic that was needed by this research. Therefore, the collaboration strategy was employed in this research and it formed an important part of the research work

3.10 Summary

This chapter began with the overview of appropriate research methodologies that were to be adopted in this research. The research methods involved in this overview included longitudinal studies, cross-sectional studies, ethnography, action research, grounded theory and case studies. Bearing the strengths and weaknesses of each method in mind, the case study method was considered most suitable in this research. This was because the predominant research questions were those of "how" and "why". The case involved in this research was tailored for analysing the real-life events of the phenomena and to validate a proposed framework. Contrastingly, other methods such as action research, grounded theory and ethnography do not really emphasise "how" and "why" — questions, which were central to this research.

MOHM was selected for the case study. The first step in establishing case study research is that the researcher identifies suitable respondents for gathering evidence and collecting data. Thirty doctors from thirty outpatient clinics and three health ICT projects from three different divisions were selected. Qualitative data were gathered from personal interviews and document materials. During the research, direct observation was also carried out.

These data collection approaches were intended to put into practice the concept of triangulation in order to reduce a systematic bias in the research work. The issue of personal bias was dealt with by using two strategies, which were triangulation of data sources (personal interviews, document materials and observation) and triangulation of methods for gathering the data (interviews, documents and questionnaires).

This research also used secondary data. This was due to the fact that pertinent and rich data were already available and highly significant for finding evidence. The secondary data could have resolved some of the primary data collection issues such as recall bias, no response and interviewer bias. However, secondary data also have several weaknesses. One such weakness is that the researcher has no control over the selection, quality and method of collecting the data and sometimes his or her reliability can be questioned. For this reason, official government documents were used in this research for acquiring reliable sources of information.

By and large, a case study method (qualitative data) was most appropriate for investigating and identifying the critical aspects for a framework to implement a Malaysian telemedicine system. This was because it recognised the "how" and "why" questions for generating the theory and used them to develop a conceptual framework. The following chapter will draw the implementation of the case study in MOHM, the outcome of which will be presented in the chapter.

Chapter 4 Telemedicine System in the Malaysian Context: A Case Study

4.1 Introduction

This chapter presents the main research strategy used in this research, which is a case study. The case study had two objectives: firstly, to evaluate and explore the approaches and experiences of the pilot implementation of the Malaysian integrated telemedicine system as well as other related systems (such as TPC and THIS) that are employed in the Malaysian health system; and secondly, to evaluate the validity of the proposed framework at different levels of healthcare services. We took the advantages from this case study to help in answering the research questions, and as a tool to validate the applicability of the proposed framework. In order to demonstrate the applicability of the proposed framework, the case study was conducted at the Ministry of Health Malaysia (MOHM), which included the ICT division, the Telehealth Division, outpatient clinics and two other divisions that were responsible for implementing major health ICT projects (the TPC project and THIS project) in MOHM.

4.1.1 Objective of the Chapter

The main objective of this chapter is to report the case study's results and findings to closure. The findings and the results from the interviews provided invaluable evidence and answers for designing the proposed framework. By the end of the chapter it is hoped that the research questions will be answered and a solution for a flexible framework can be produced.

4.1.2 Outline of the Chapter

The chapter starts with a brief introduction to what it is intending to address. This is followed by section 4.2, which discusses the background to and rationale for the selected organisation for performing the case study. Section 4.3 describes the organisational background for performing the case study. The findings from the data collection are discussed in section 4.4 and, finally, section 4.6 summarises the chapter.

4.2 Background to the Case Study

The case study of this research was conducted in two stages in two organisations; the Ministry of Health Malaysia (MOHM) as the main case study and Avicenna International Holding (AIH) Company as the secondary case study. The case study started in a close collaboration with MOHM through its ICT division in January 2006. Relationships were made and communicated informally as required through various communication channels including e-mail, telephone and mail. This division was also used to leapfrog establishing a networking with other related divisions and projects in MOHM, especially telehealth and other health ICT projects such as TPC and THIS, which are indirectly involved in the implementation of an integrated telehealth system. The project office and the personnel in charge were contacted for the purposes of acquiring and accessing the sources of information. Yin (2003b) mentioned that a good case study requires various sources of evidence and they are highly complementary. Hence, beside MOHM, the former telehealth solution company (AIH), which was awarded for the development of the project, was also contacted and a relationship was established. With these two organisations, it was enough to evaluate the Malaysian telemedicine approach and collect the appropriate evidence for answering the research questions.

The first stage of the case study was mainly to collect information and evidence regarding the background of the Malaysian health system and health status, and the state of telemedicine initiatives and other ICT initiatives in the public healthcare system. Evidence was obtained from various sources such as archival records, documentations, observation and informal interviews and questions (refer to Chapter 3 for how the interviews were undertaken).

After gathering the responses from the first part of the case study, the case study preceded with the preparation of a specific questionnaire, which verified the results obtained from the literature review process and the secondary data obtained from MOHM and AIH Company. The interviews and observations were conducted at the respective divisions (ICT division, Telehealth Division, TPC, THIS and outpatient clinics) of MOHM from April until June 2007. The interviews were conducted using structured, semi-structured and open-ended interview approaches with the involvement of three categories of groups of respondents: IT managers, domain managers, top management and medical officers/GPs. The interviews were focused around the need for a flexible framework and an integrated LHR system for maintaining patients' health records seamlessly and continuously. Each of the interviews lasted approximately two to three hours.

The final stage of the case study was to validate the proposed framework. The applicability of the proposed framework was tested in three divisions of MOHM, namely the Telehealth Division (telehealth project), the Family Health Development Division (TPC project) and the Health Planning and Development Division (THIS project). The first cut of the framework report was documented and submitted to each case study respondent. The report was packed with the response forms that would be used by the respondents to indicate the feedback and comments. The feedback and comments were analysed and the final framework was refined.

4.3 Organisational Environment for Performing the Case Study

This sub-section presents the background to and functionality of the organisations involved in this case study research. There were two organisations involved in this research: MOHM and the AIH company.

The main case study was conducted in the Ministry of Health Malaysia (MOHM) involving four administration divisions and one clinical services section. The clinical services section focused on the consultation and medical diagnosis workflow in general outpatient clinics of polyclinics and health centres. The administration divisions consisted of the ICT division, which managed the development and maintenance of MOHM's overall ICT requirements, a Family Health Development Division, which managed and acted as the owner of the Teleprimary Care project (TPC), a Health Planning and Development Division, which managed the implementation of the new Total Hospital Information System project (THIS) and a Telehealth Division, which was responsible for managing the development and implementation of the telehealth project. The telehealth project was investigated, evaluated, explored and observed in terms of its need for flexibility to maintain LHRs continuously and seamlessly. The applicability of the proposed framework was evaluated and tested through these three projects. The medical officers in outpatient clinics were interviewed with regards to the usage of patients' health records and demography during doctor-patient encounters.

4.3.1 Ministry of Health Malaysia

The healthcare system in Malaysia is divided into private and public sectors. The public health sector is led by the Ministry of Health Malaysia (MOHM); it is the main healthcare service provider for the Malaysian population as well as for foreign residents. The comprehensive range of health services are provided through a nationwide network of clinics, hospitals and healthcare programmes. The MOHM's vision (Ministry of Health Malaysia, 2006b) is described by the following.

> *Malaysia is to be a nation of healthy individuals, families and communities through a health system that is equitable, affordable, efficient, technologically appropriate, environmentally adaptable and consumer friendly, with emphasis on quality, innovation, health promotion and respect for human dignity and which promotes individual responsibility and community participation towards an enhanced quality of life.*

MOHM is divided into several divisions and departments as depicted in the diagram below (Figure 4.1). The diagram shows the basic relationship between divisions within headquarters and between headquarters and state health departments. The green box shows the correspondence divisions/departments involved in my case study.

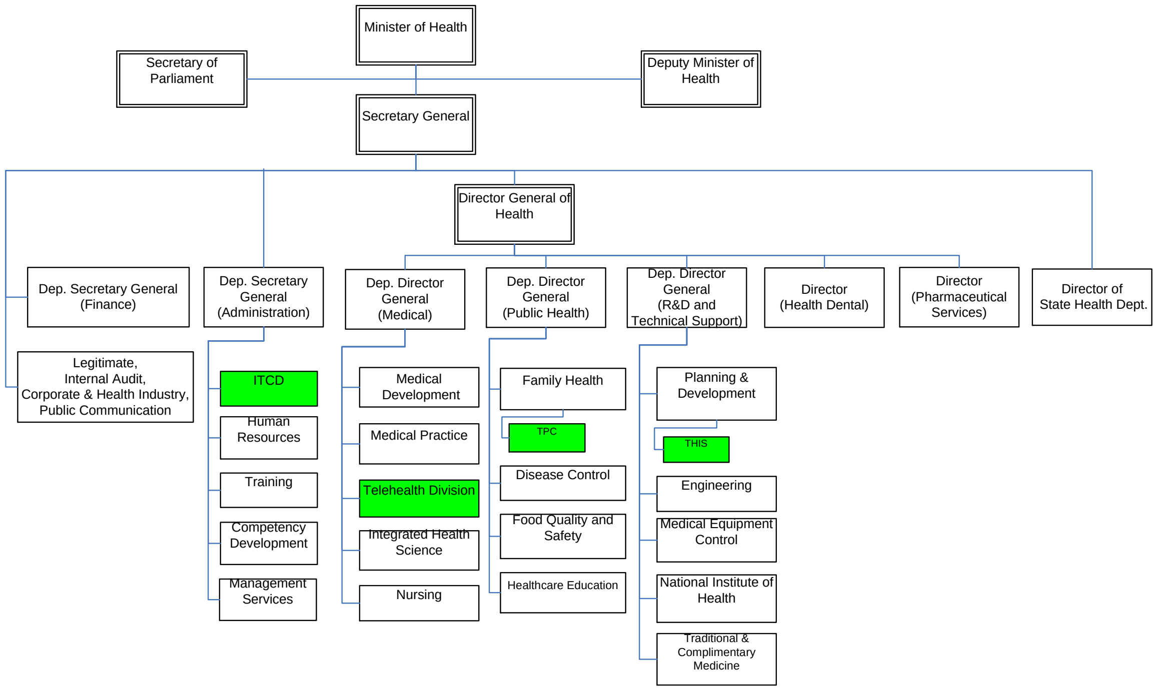

Figure 4.1: MOHM's Organisational Structure

Source: adapted from (Ministry of Health Malaysia, 2008b)

Figure 4.2 below gives the organisational structure of medical and public health at the state and district level.

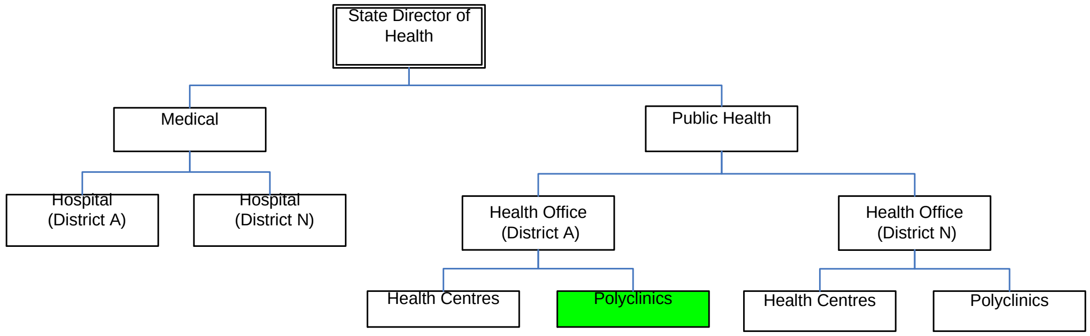

Figure 4.2: State Health Organisational Structure

Source: adapted from (Ministry of Health Malaysia, 2008b)

The health office in a district will be headed by a medical officer of health. At the district health office level, the services provided are quite varied. Healthcare is provided via the various health centres and polyclinics strategically located in the most populated areas in the district and is considered the first point of contact for patients with the healthcare system. If the need for healthcare services arises, patients are then referred to a higher level of care at hospitals without specialists and, if the clinical need arises, they will then receive treatment at hospitals with specialists. This referral system is adhered to throughout the system. The general principle of these processes is that a patient needs to be physically present at the corresponding healthcare facilities depending on the level of care required.

The organisational structure at each hospital varies depending on the classification of the hospital. Currently, hospitals are divided into those with specialists and those without specialists. A hospital is usually administratively located within a district and is headed by a hospital director. Figure 4.3 depicts the general organisational structure at each hospital.

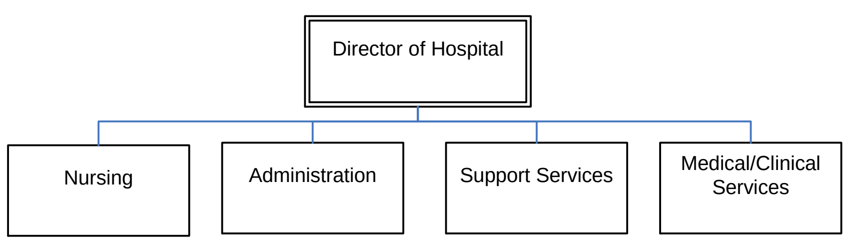

Figure 4.3: Hospital Organisational Structure

Source: adapted from (Ministry of Health Malaysia, 2007)

At this point we should clearly understand the organisational and service structure of MOHM in managing the health system in Malaysia. The structure is complex and it is impossible to describe the functions of every division and department. In order to find the research answers and to collect as much evidence as possible, a snowball method was used to extend the relationship and contact other related divisions within MOHM with regards to the research project (Patton, 2002). With the help of and close collaboration with the ICT division of MOHM, the additional location or related division/department/projects were identified for conducting the case study. The additional case study organisations included the Telehealth Division, the TPC project under the Family Health Development Division and the THIS project under the Health Planning and Development Division. The background to the individual case study organisation will be described in the next section.

4.3.1.1 Information Technology and Communication Division

The Information Technology and Communication Division (ITCD) is the main case study and the first contact in dealing with MOHM. ITCD is responsible for planning, managing, technically advising and consulting, developing, implementing, maintaining and coordinating the ICT's requirements and initiatives in MOHM. The division has extensive experience in managing ICT projects in MOHM and its choice as the main case study provides a considerable advantage for the case study. ITCD has direct access to the needs and requirements of healthcare organisations regarding the status of ICT initiatives and the requirements, challenges and lessons learned. ITCD will also make available, on a confidential basis, MOHM's documents relating to the development, implementation and post-implementation of telehealth applications and hospital information application systems that are deployed across healthcare facilities nationwide. This significantly enhanced the researcher's understanding and knowledge of (1) the state of health of ICT initiatives in MOHM, especially the telehealth project, and (2) the state of the ICT infrastructure in the healthcare facilities of MOHM and its challenges.

4.3.1.1.1 ITCD's organisational structure

The ITCD is divided into two subdivisions (management and planning and technical and operation) and eight units (research and development and quality assurance, the service management sector, the project management sector, the training and document sector, the operation and network sector, the public health project sector, the medical project sector and the technical support sector). The management and planning subdivision is responsible for providing project management, service management and research and development and quality assurance functions. The technical and operation subdivision is responsible for providing support for project development and training and for providing an adequate ICT infrastructure in all healthcare facilities. The ITCD is led by the chief information officer, who reports directly to the deputy chief general secretary of MOHM. Figure 4.4 depicts the organisational structure of ITCD.

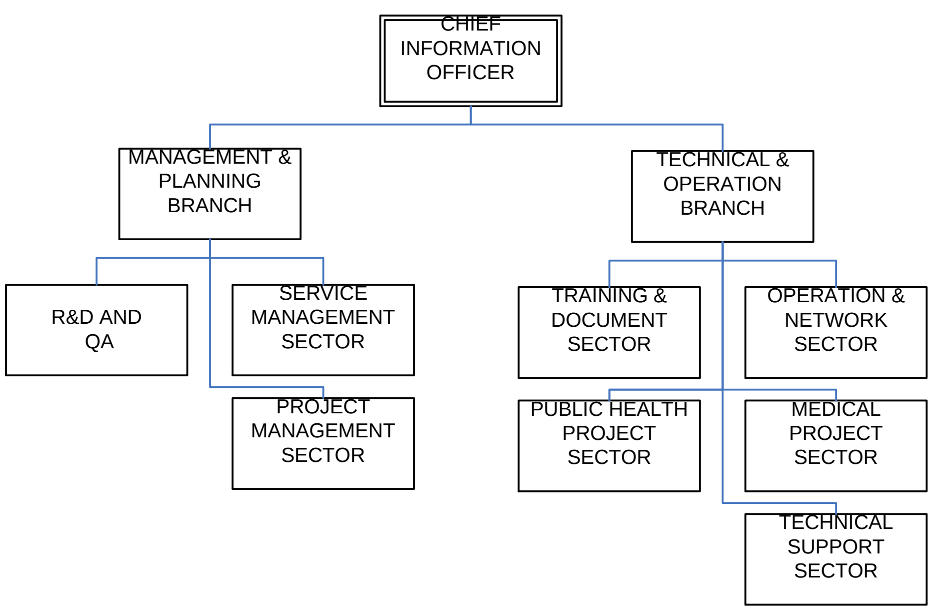

Figure 4.4: ITCD's Organisational Structure

Source: adapted from (Ministry of Health Malaysia, 2008a)

4.3.1.1.2 Examples of relevant health ICT experience in MOHM

1) Legacy Application Systems

There are various existing main application systems maintained by the ITCD across healthcare facilities nationwide including the following:

i) *SPPL – Sistem Pengurusan Pesakit Luar (Outpatient Management System)*

ii) *SPPD – Sistem Pengurusan Pesakit Dalam (Inpatient Management System)*

iii) *HMIS – Health Management Information System*

iv) *LIS – Laboratory Information System*

v) *OTS – Operating Theatre System*

vi) *CCMS – ICU Critical Case Monitoring System*

Application system	Description
SPPL	SPPL was developed for supporting the outpatient administration system. Two of its objectives are to improve staff efficiency and to decrease the patient waiting time. The functionality of this system includes patient registration and patient appointments. The system manages the registration of and appointments for outpatients that are conducted at clinics within the hospitals such as pharmacies, laboratories, dialysis and physiology. Among the hospitals using the system are Hospital Seremban, Hospital Batu Pahat and Hospital Kuala Lumpur. There is a step being taken to integrate the SPPL and SPPD. By integrating these systems, the clinical episodes captured in the outpatient clinics can be transferred and shared by the doctors in inpatient clinics or wards.
SPPD	SPPD was implemented as a step to improve the billing system of the hospitals as well as to improve the management of patients in the wards. The system aims to reduce the amount of hospital bills being overdue, increase staff productivity/efficiency and increase the quality of healthcare service for the public. This system has been implemented in 12 hospitals including Hospital Besar Kuala Lumpur (HKL), Hospital Seremban,Hospital Johor Bharu, Hospital Kota Kinabalu, Hospital Alor Setar, Hospital Penang, Hospital Klang, Hospital Kajang, Hospital Kuantan, Hospital Kuala Terengganu, Hospital Seberang Jaya and Hospital Ipoh.
HMIS	The Health Management Information System (HMIS) acts as a management tool to generate and provide statistical reports and statistical analysis for policy makers and research institutions on the health status of Malaysia. The system is maintained centrally at MOHM's head office.
LIS	The purpose of LIS is to provide the functions needed to manage the test order information flow within laboratories as well as between different departments within hospitals. It includes work processes ranging from receiving the test orders, collecting the specimens, receiving the specimens and producing the test results and the necessary reports.
OTS	OTS was developed for the operation theatre unit, which assists in the functioning of the operation theatres.
CCMS	The CCMS was implemented at Paediatrics Institute Hospital Kuala Lumpur and the system was purchased from the vendor using dedicated proprietary software and hardware. The system was at the time under maintenance and the integration to the existing system such as SPPD was still in the planning stage.

Table 4.1 : MOHM's Legacy Application System

2) Recent Application Systems

The recent health application system projects involved in and maintained by the ITCD include:

i) Telehealth (Health Online Portal)

ii) THIS – Total Hospital Information System

iii) TPC – Teleprimary Care System

Application system	Description
Health Online Portal	The telehealth system consists of four components and one of its components, namely the health online portal, was deployed and could be accessed by the consumers through the Internet connection. The objective of this component is to provide online information and education for the public consumers relating to their health concerns and enquiries. The application was developed using Java technology and hosted and centralised at the head office of MOHM.
THIS	THIS is one of the health ICT initiatives approved by the Government of Malaysia (under the Nine Malaysian Planning; 2006–2010) to computerise the work flow processes of all new developed hospitals with ICT to facilitate in the process of providing best care for every patient. The development approach of THIS was through package customisation and integration. The project was outsourced to awarded vendors where the ready-made software of THIS was customised and tailored according to the needs of the MOHM. By way of example, CERNA, MEDICOM and KOMPAKAR software were customised and implemented in Selayang Hospital, Pandan Hospital and thirteen other new hospitals and Putrajaya Hospital respectively. ITCD is extensively involved in providing technical advisory (ICT infrastructures) as well as policy and procedure (change management and security policy) for implementing the applications. As of now, there are 16 hospitals implementing THIS (including the intermediate and basic version of THIS). Currently, the technology transfer process from awarded vendors to MOHM is still in progress (see Chapter 2 for a detailed description of THIS).
TPC	TPC is another of MOHM's health ICT initiative projects and it focuses on public health services (health clinics) by utilising the convenience of ICT in providing primary care services for the patients. ITCD is involved intensively in the project by way of providing technical consultation and advice, policies and ICT infrastructure. The system was implemented in pilot sites in the three states of Johor, Sarawak and Perlis, which involved two hospitals, 45 health clinics, four district health office, two state health office and five divisions of the public health department. The system was developed by the awarded vendors and is currently maintained by the ITCD (see Chapter 2 for a detailed description of TPC).

Table 4. 2: MOHM's Recent Application System

4.3.1.2 Telehealth division

The Telehealth Division is another main case study of my research project. The Telehealth Division is responsible for planning, conceptualising, managing, developing and implementing the Multimedia Super Corridor (MSC) Telehealth Project of Malaysia. The name has been changed from Integrated Telemedicine to Integrated Telehealth due to a change in its concept and scope as described in Chapter 2.

The Telehealth Division has extensive sources of information regarding the telemedicine/telehealth project and it gives an unprecedented opportunity to explore, access and acquire the sources of evidence and validate the applicability of the proposed framework. The true experience and source of evidence are the main reasons for adopting the Telehealth Division as another main case study. At the beginning of the case study, this division has been contacted and communicated informally through e-mail, phone and in writing. A good relationship has been established especially with the deputy director of the telehealth application, the deputy director of telehealth content programmes and key project team members. The documentation and archival records were obtained (with the utmost confidentiality) and analysed to advance the knowledge of Malaysia’s telehealth concept and approach, and validated the evidence obtained from the initial case study. Detailed questionnaires for collecting primary data were prepared. The questionnaires were developed based on the responses given from the initial case study and evidence was obtained from the documentation and archival records. The interview questions were centred on the research questions, which were used for designing a suitable framework for maintaining patients’ LHRs continuously and seamlessly and the appropriate LHR structure to support the framework.

The case study conducted at the Telehealth Division significantly enhanced the researcher's knowledge and understanding of (1) the objectives, concept and approach of Malaysian Integrated Telemedicine/Telehealth System, (2) the crucial components of the telehealth system to be developed, (3) the crucial challenges for implementing the telehealth system in the Malaysian health system.

4.3.1.3 Teleprimary Care Project

The Teleprimary Care (TPC) project is one of the telemedicine initiatives that focus on the computerisation of the primary healthcare system in Malaysia. The project started in February 2003 and has been piloted from 2004 until now in the three states of Johor, Sarawak and Perlis. The total healthcare facilities (sites) involved in the pilot project included two reference hospitals, 46 health clinics, two state health offices, four district health offices and five divisions in the public health department.

The TPC project was intended to overcome the existing inefficient methods of consultation and the workflow process between primary care centres and secondary centres. Examples of limitations include episodic care, the physical distance that leads to patients incurring travel costs and insufficient specialist care as well as the sheer volume of paper-based medical records, which need to be digitised and shared across healthcare facilities. The TPC project was designed to computerise all the functions (clinical and administrative) in the health clinics with the exception of the dental health service. Documenting accurately the healthcare provided in health clinics would be provided through the TPC project and, as a result, data from different parts of the health clinic are made available in a seamless manner across health clinics.

The TPC project is headed by the Family Health Development Division (primary care) The development of the TPC application system is through smart collaboration between MOHM and the ICT company awarded the contract. The genuine experience and knowledge of project team members in developing and implementing the TPC project for the country and the significance of the TPC project itself made it suitable for selection in my additional case study.

The TPC project was involved in the validation process of the proposed framework. The questions were centred on the following: (1) the need for a flexible framework for the continuous upkeep of patients' LHRs; (2) the crucial patient demographic and health records required by the doctors during doctor–patient consultations; and (3) the applicability of the proposed framework. Responses to questions 1 and 2 were obtained through the structured and open-ended interviews conducted with various levels of TPC project team members while responses to question 3 (accepted, modified, rejected) were obtained through the assessment and reviewed process carried out by the TPC's key project personnel. The comments and suggestions would be analysed for presenting the applicability of the proposed framework.

4.3.1.4 Total Hospital Information System project

The Total Hospital Information System (THIS) project is another national health ICT project that has been embarked on by the government since 1996 in Selayang Hospital. The role of the project is to computerise new hospitals. THIS was designed to provide in-depth information on services in an individual hospital by automating and managing the total processes in the hospital including clinical, financial and administrative systems. Documenting accurately the care given in hospitals will be provided through the THIS project. As a result, data from different parts of the hospital are made available in a seamless fashion within the hospitals. Then, the individual THIS application system will be integrated with the telehealth application for generating the lifelong health record services.

The THIS project is headed by the Health Planning and Development Division of MOHM and technically advised by the ITCD. As of now, five new hospitals (Selayang Hospital in Selangor state, Putra Jaya Hospital in Putra Jaya Territory, Pandan Hospital in Johor state, Lahad Datu Hospitals in Sabah state, Hospital Kepala Batas in Penang state and Serdang Hospital in Selangor state) have been installed with the THIS application and another 13 new hospitals will be installed with THIS by the year 2010. The development approach of the THIS application is through the outsourcing and integration of software packages. Although the applications in each hospital use different software technology and platforms, a minimum critical requirement for all these facility-based systems is that they must contribute to generating the EMRs and building up the LHRs of patients.

The crucial role of the THIS project in establishing EMRs for building the LHR services in telehealth applications provides significant justification for adopting the THIS project as an additional case study for collecting evidence and validating the proposed framework (Ministry of Health Malaysia, 2007). The questionnaire was centred on the following: (1) the need for a flexible framework for updating LHRs continuously and seamlessly; (2) the need for integrated LHRs for seamless and continuous care; and (3) to validate the applicability of the proposed framework. Questions 1 and 2 were obtained through the structured and open-ended interviews carried out with various levels of the THIS project team members. Meanwhile, the answers to question 3 (accepted, modified and rejected) were obtained through the assessment and reviewed process carried out by THIS's key project personnel. The comments and suggestions would be analysed to present the applicability of the proposed framework.

4.3.1.5 Outpatient clinics

The outpatient clinic service reports administratively to the Family Health Development Division The outpatient clinics within a state and district are best described using Figure 4.2 and Figure 4.3. The diagrams give the organisational structure of medical and public health at the state and district levels. The health office in a district (district health office) will be headed by a medical officer of health. At the district health office level, the services provided are quite varied. Healthcare is provided via the various health centres/polyclinics strategically located in the most populated areas in the district. In this research, a case study will be based at community polyclinics in the state of Malacca.

The community polyclinics comprise the first level of services that are made available to the community. The services provided are comprehensive at this level, essentially comprising maternal health, child health, acute care of diseases, chronic care of diseases, mental health, geriatric care, community-based rehabilitation, well-person services and health promotion. These services are provided as outpatient treatment. In order to support such services, there are also laboratory services and radiological services. The pharmaceutical services are also provided in-house.

With these comprehensive services and workflows, it was significant that the outpatient clinic was selected for advancing knowledge on the case under study. The selected locations would cover most processes of consultation and medical diagnosis workflow in outpatient clinic and the healthcare setting provided extensive relevant evidences for answering the research questions.

Referring back to the research questions of the thesis, the first question was centred on the question of what is the crucial framework for the Malaysian Integrated Telemedicine System for updating LHRs continuously and seamlessly (refer research questions of Chapter 1). The answers to and evidence for the first question were obtained from the main case study and three additional organisations (the Telehealth Division, the Family Health Development Division and the Health Planning and Development Division) for validating the proposed framework. However, this case study was mainly for exploring and finding the answers for the second question: what are the crucial LHR datasets for supporting the framework?

The crucial patient demographic and health records were identified and obtained initially through the collection of secondary data from various sources of evidence such as documents and archival records (paper-based consultation templates and administrative and clinical forms). The outpatient clinic personnel were contacted for accessing and obtaining the source of evidence. The outpatient consultation and medical diagnosis workflow in outpatient clinics became the main unit of analysis of the case under study.

Based on the initial study and responses, detailed questionnaires were created for collecting the primary evidence and data. Through the main personnel contact of the case study organisation and ITCD, the 30 respondents in different health clinics and polyclinics under MOHM were identified for carrying out the interviews with using structured and open-ended interviews. The interview sessions were conducted informally and lasted approximately 60 to 85 minutes (refer to Chapter 5 for the critical analysis of patients' demographic and clinical data).

4.3.2 Avicenna International Holding Group

In 1999, the Government of Malaysia awarded Avicenna International Holding (AIH) Group with the task of developing and implementing the Multimedia Super Corridor (MSC) telehealth application. AIH's involvement in business is broken down into three main divisions: medical services, technology and health informatics. For the development of the telehealth project, Medical Online Sdn Bhd (MOL) was assigned to manage the project.

The MOL is a sister company of AIH and responsible for managing the development of the MSC telehealth project. MOL is a concessionaire appointed by the Government of Malaysia in developing and implementing the MSC telehealth project in its piloted sites. It covers the period from the inception of the project until 30 April 2002.

MOL started the project with an internal staff strength of 40 people. As of 30 April 2002, the staff strength increased to 260 people, out of which 180 people were involved directly in this project. The people, comprised of domain expert, technical staff, a designer and management, are further divided into more specific groups of application developers, software researchers, application implementers, system engineers, etc.

MOL, being the special purpose company to operate telehealth, has engaged two prime contractors, namely Planet Connections (M) Sdn. Bhd. and Millennium Integra (M) Sdn. Bhd., to develop, implement and provide maintenance and enhancements of the telehealth application.

For the purpose of the MSC telehealth project, a special structure was created and established to form the MSC telehealth project organisation as a vehicle to lead such a complex project for MOHM (see Figure 4.5).

As of then, the above project organisation no longer existed due to the fact that the concessionaire period of the telehealth project between MOL and MOHM had finished. The MSC telehealth project was no longer managed by the MOL. However, the wealth of experience and the in-depth lessons learnt by MOL (in developing and implementing the pilot telehealth project in various hospitals and health clinics) should be acquired by the researcher for the future development of the telemedicine system in the whole country.

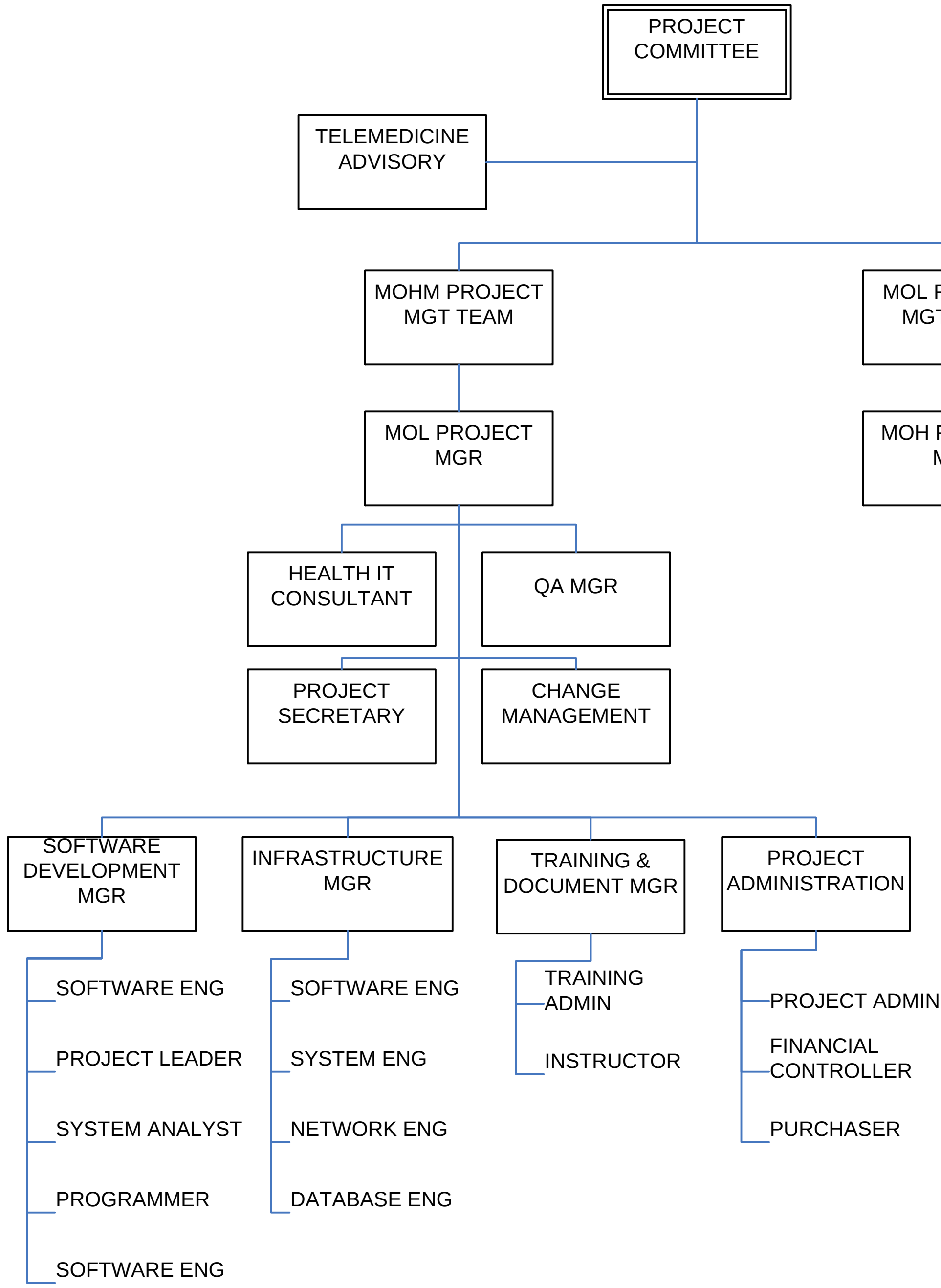

Figure 4.5: Telehealth Project Organisation

Source: adapted from the Ministry of Health Malaysia (1997d)

The researcher had several options for acquiring and documenting the MOL experiences, challenges and lessons with regards to the national telehealth pilot implementation. The researcher thought that the best way to get first-hand information was through interviews with the people who were thoroughly involved in the project. Finally, two key personnel from AIH were identified and they were the president and CEO of the company and the solution architects of the project were contacted and engaged for the interview session. The information obtained from the interviews was recorded using audio tapes and converted into textual documentation manually.

4.4 Discussions of the Findings from the Data Collection

This section discusses the findings from the data collection exercise conducted in various divisions and departments in MOHM. The answers and responses were transformed into a graphical format using a Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree). Based on observations and interviews that took place during the initial study, a number of emerging themes were revealed as follows:

1. the importance of ICT infrastructure (telecommunication network infrastructure) for implementing the telemedicine system across healthcare centres
2. the role of portable storage devices in providing alternative storage for the upkeep of patient health records continuously
3. the need for a flexible information system for maintaining and accessing health records continuously and seamlessly
4. the role of EMR as a source for generating the LHRs
5. the importance of standardised LHR datasets for enabling the integration of LHRs across healthcare facilities
6. the role of a clinical support system for capturing and generating EMRs at the facility base

7. the role of a central health management system for managing a health records repository and aggregating a data pool.

The objective of the above themes was to ensure that the analysis and studies undertaken would be reflected in the making of the proposed framework.

The analysis and discussion of research results will be divided into the following four sections: 1) the current state of the ICT infrastructure and general use of ICT in the public healthcare facilities (hospitals/clinics); 2) the analysis of patients' demographic and clinical information in outpatient clinics (this will be discussed in Chapter 5); 3) a flexible framework needing analysis; and 4) the integrated LHRs needing analysis.

4.4.1 Current State of the ICT Infrastructure and General Use of ICT in the Public Healthcare Facilities of MOHM

The interviews and analysis were conducted at the ICT infrastructure and network section office of ITCD. This section is responsible for managing and providing the ICT infrastructure across health facilities nationwide under MOHM. The scope of the ICT infrastructure includes the provision of a telecommunication network infrastructure (WAN and LAN), a data centre facility, computer hardware (PCs and servers) and computer software (operating system, database system, middleware software, etc.).

The manager and her assistant mentioned that the development of the ICT infrastructure was in line with the development of the health ICT initiatives in MOHM. When the question was asked about the health ICT and health informatics, they responded that they had heard about health ICT and health informatics before. The manager said that the health ICT scope was very broad compared to health informatics. The manager also mentioned that she had heard about the telehealth, telemedicine and e-health systems before and most of her section's responsibilities were providing the ICT infrastructure to these projects/initiatives. She also mentioned that the ICT infrastructure was crucial and was regarded as one of the critical success factors for implementing the health ICT project.

The percentage (%) of healthcare facilities having an ICT infrastructure (software, hardware and network) varied depending on its levels. Almost all hospitals (100%) had installed and been provided with the ICT infrastructure. The majority of community polyclinics, rural clinics and maternal and child clinics were still using a manual system and were not equipped with a crucial ICT infrastructure.

The level of the ICT infrastructure at healthcare facilities also varied. The types and levels of ICT technologies deployed at the healthcare facilities are shown in Figure 4.6. Although the hospitals were equipped with an ICT infrastructure, the most modern infrastructures were only fitted for newly developed hospitals. The existing hospitals had yet to be equipped with these latest facilities although some had been installed with the basic ICT infrastructure. By way of example, the workgroup servers would be deployed only at the healthcare facilities that are involved in the health ICT project (THIS, TPC, HIS and telehealth (TH)). Those healthcare facilities involved in the health ICT project would be provided with dedicated rooms (server rooms) for allocating the computer equipment.

ICT Infrastructure	Hospitals		Community Polyclinics	Rural clinics	Maternal & child clinics
	New	Existing			
Internet	/	*	!	!	!
Intranet	/	*	!	!	!
LAN	/	*	!	!	!
PCs	/	/	/	/	!
Server	/	*	!	!	!
Server room	/	*	!	!	!
Telephone	/	/	/	/	/
Fax	/	/	/	/	/

Note: / – provided in most of the healthcare facilities
* – depending on the health ICT project that it involves
! – not provided in most of the healthcare facilities

Figure 4.6: Level of ICT Infrastructure at Healthcare Facilities

Internet access was not provided at all healthcare facilities unless the healthcare facility participates/is involved in the health ICT project. The staff who worked in the ICT healthcare facility would be able to access the Internet; but those not involved in the project would not be able to use the facility. With this scenario, evidently there existed a digital divide among health workers.

The type and size of the telecommunication network deployed in the healthcare facilities also varied depending on the usages (for example, the number of users, type of applications, size of the healthcare facility — number of disciplines and departments). The healthcare facilities that were involved in the health ICT project would be provided with fixed-lined telecommunication using virtual private network (VPN) connectivity. The rural healthcare facilities that were involved in the TPC project used very small aperture terminals (VSAT) for transporting the data to a central data centre located at the Ministry of Health office in Putrajaya. Some of the healthcare centres might have decided to have their own telecommunication networks by using dial-up and broadband connectivity from the Internet service provider (ISP) for accessing the Internet applications. Figure 4.7 depicts the connectivity types in the healthcare facilities of MOHM.

Connectivity	Bandwidth
Virtual private network (VPN)	64kbps – 2mbps
Integrated service digital network (ISDN)	64 kbps – 128kbps
Very small aperture terminal (VSAT)	512kbps – 2mbps
Asymmetric digital subscriber line (ADSL)	128kbps – 2mbps
Dial-up	56kbps

Figure 4.7: Overview of Connectivity Type in Healthcare Facilities

According to the respondents, the e-mail application was an important mechanism and tool to distribute health information around the organisation. The office web mail application and e-mail accounts were provided for all health workers to assist in communication around healthcare facilities. However, this facility was only available for certain healthcare facility premises and this depended on the availability of the telecommunication network installed in the healthcare premises.

Laptops and PCs are common micro-computing devices provided for the healthcare professionals and other health workers in delivering healthcare services. Other devices such as mobile computing (for example, smart phone and PDA) are still not implemented at the moment. Figure 4.3 shows the category of health workers that had been provided with the computer facility in providing healthcare services.

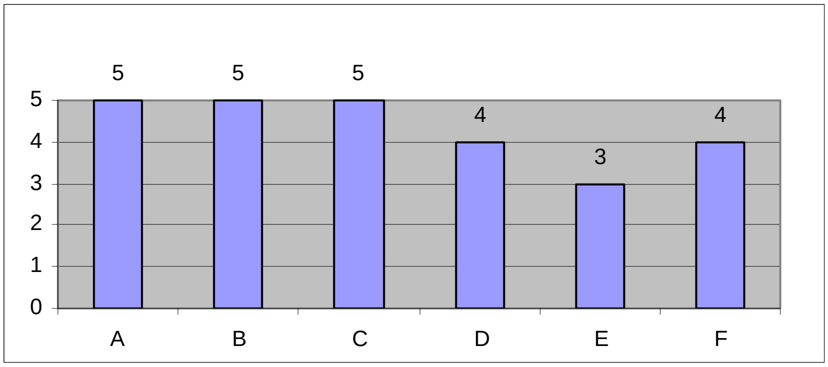

Figure legend

A	Healthcare professional
B	Medical assistants
C	Nurses
D	Registration clerks
E	Medical attendances
F	Administrators

Figure 4.8: Category of Health Workers Provided with Computer Facilities

Figure 4.8 shows that healthcare professionals, medical assistants and nurses were the groups of health workers that had constantly been provided with computers to be used in providing daily healthcare services. The registration clerks and administrators were also provided with computers to help them in performing administrative work (such as registration, finances, billing and human resources), while medical attendances were identified as the group who used computers less due to the nature of their work in dealing with patients and maintaining a physical healthcare facility.

The ICT infrastructure manager pointed out that the registration department, laboratory department, radiology department and administration departments had a high ranking in terms of their use of computers in their daily operations in providing healthcare services for the patient (refer Figure 4.9). This was due to the fact that these departments were very crucial in providing support for the clinical and administrative function of the healthcare centres. The consultation room, pharmacy department and operation theatres were given less attention with regards to using computers in their daily operations. This was due to the fact that the computerisation of the clinical functions was still incomplete.

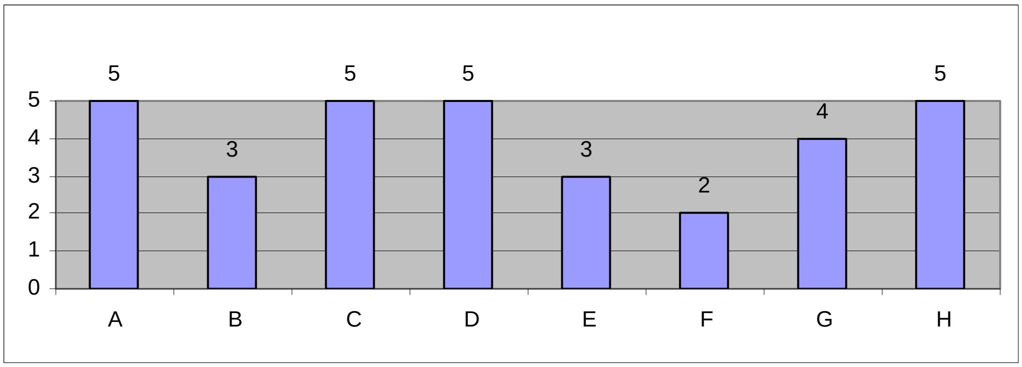

Figure legend

A	Registration counter
B	Consultation room
C	Laboratory department
D	Radiology department
E	Pharmacy department
F	Operation theatres
G	Ward service
H	Admin office

Figure 4.9: Departments that Used Computers the Most in Delivering Healthcare Services

In terms of the application software used in healthcare facilities, Figure 4.10 shows how the ICT infrastructure manager ranked the existence of the application software in the healthcare facilities. The patient management system, laboratory information system and administration system were among the most available application pieces of software in the healthcare facilities. However, the applications were still implemented independently and disparately across disciplines/departments within the healthcare facilities. The clinical information system, radiology information system and pharmacy information system were not constantly used across the healthcare facilities and were only used as compulsory applications in new hospitals that were implementing the THIS project and the healthcare centres that were involved in the TPC project.

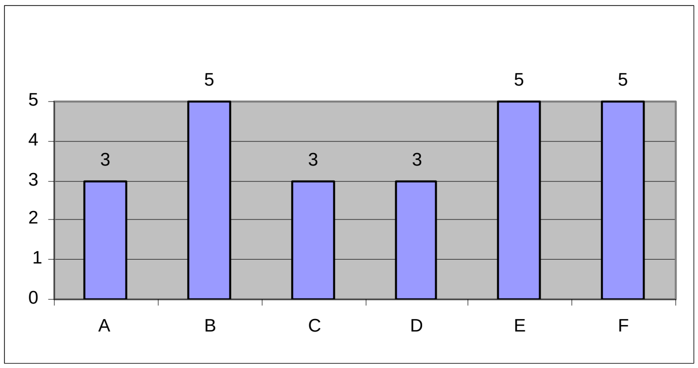

Figure legend

A	Clinical information system
B	Patient management system
C	Radiology information system
D	Pharmacy information system
E	Laboratory information system
F	Administration information system (e.g. Personnel system)

Figure 4.10: The Most Application Software that Exist in Healthcare Facility

The ICT infrastructure manager pointed out that the ICT skills among health workers were still at the entry level. She agreed that the health workers needed continuous ICT training in order to implement health ICT in the clinical workflow and administrative processes of healthcare services across healthcare facilities. She also mentioned that it was stated in the MOHM's Information Strategic Planning (ISP) for the year 2006 to the year 2010 that ICT training was one of the critical success factors for implementing health ICT in the healthcare sector nationwide.

4.4.2 Evaluation of the Need for Incorporating a Flexible Framework and an Integrated LHR System in the Malaysian Telemedicine System: a Cross-Case Analysis

This section presents the results of the study carried out to examine the need for incorporating a flexible framework and integrated LHR system in the Malaysian telemedicine system for accessing, creating and generating patients' health records seamlessly and continuously

The objective of this study was to corroborate understanding on actual phenomena and identify crucial requirements for developing the proposed framework. The study was also used to validate the assertions gained from the main case study by elucidating the background, goals, objectives, development and implementation approach and lessons learned from the three existing health ICT projects (TPC, THIS and TH) in MOHM.

Interviews were conducted at MOHM and data were collected from personnel involved in the three cases by way of semi-structured and open-ended interviews. The interviews lasted 120 minutes. Responses were transformed into a field form (a graphical format using an opinion scale (Y – "Yes" and N – "No")) and at the same time recorded on audio tape, which would be converted into descriptive text (Avison and Myers, 2002; Miles and Huberman, 1994).

This section also summarises the results obtained from data collected from the three cases in two major sections (refer to sections C and D in Appendix A).

1. Section C: Flexible Framework Needs Analysis

   Respondents: team leaders of three (the TH project, TPC project and THIS project) major health ICT projects in the Ministry of Health Malaysia

   Method: structured interview

2. Section D: An Integrated LHR Needs Analysis

   Respondents: the management group (the TH project, TPC project, THIS project and Information and Technology Communication Division) of the health ICT project in the Ministry of Health Malaysia

   Method: open-ended interview

Finally, the study produced a prioritised and crucial list of requirements (technologies and applications) and lessons learned that MOHM should focus on, if the LHRs are to be successfully maintained (created, generated, integrated and available) continuously and seamlessly.

4.4.2.1 Flexible framework needs analysis

The first key question (can you explain in brief the background of the project?) that was put to the three divisions was to ascertain insight into the background of the three major health ICT projects under MOHM that were implemented across healthcare facilities nationwide. All personnel from three projects explained in detail about the project background, including the project implementation chronology, goals and objectives. Figure 4.11 shows the implementation chronology of the three projects, which varied from one to another.

Year	TPC	Year	THIS	Year	TH
1995	☒ Feasibility study	Oct’96	☒ Project kick-off	Nov’99	☒ Project kick-off
2000	☒ Call for tendering	Aug’96	☒ 1st THIS live in Selayang Hospital	Nov’00	☒ 1st deliverable of MCPHIE portal
Aug’02	☒ Project awarded to vendor	2000	☒ 2nd THIS live in Putra Jaya Hospital	Nov’00	☒ 1st deliverable of CME portal
Feb’03	☒ Kick-off in February 2003	2004	☒ Live in Pandan Hospital, Johor state	Jun’01	☒ 1st version of LHP (CSS) - pilot in Kajang hospital & 6 health centres
Mar’03-Dec’04	☒ Infrastructure and system development and testing	2007	☒ Live in Serdang Hospital, Selangor state	Jul’01	☒ 1st version of LHP (CSS) - pilot in Seremban hospital & 7 health centres
2004	☒ Pilot implementation in 2004 in three states of Johor, Sarawak and Perlis			Sep’01-Apr’02	☒ 1st version of LHP (CSS) - pilot in HKL hospital & 13 health centres
2005	☒ 2 hospitals, 45 health clinics, 4 district health office, 2 state health office and 5 divisions in the Public Health Department			Jul’04	☒ The project is suspended
				2006	☒ Restructuring telehealth project
				2006	☒ Redevelop of telehealth project

Figure 4.11: Project Chronology

Although the date of the implementation varied among the projects, the project goals (see Figure 4.12) were nearly the same; to provide high quality healthcare through the merging of ICT and the health system. The respondents also highlighted the fact that Malaysia’s health vision is a critical component of the national agenda and was created to achieve Malaysia’s Vision 2020 as the health status of the nation is fundamental to its advancement in economic and social well being. They further mentioned that, in order to achieve this, it is critical that the Government (MOHM) implements the merge between the healthcare system and ICT immediately.

TPC	THIS	TH
☒ To provide quality healthcare ☒ To ensure prompt access to specialist care for every citizen ☒ To enable the creation of a knowledge infrastructure — contribute towards healthcare policy formulation and continuous professional development	☒ Patient safety ☒ Efficiency ☒ Quality service ☒ Health data mining	☒ Wellness focus ☒ Person focus ☒ Self-help ☒ Care provided at home or close to home ☒ Seamless and continuous care ☒ Services tailored as much as possible ☒ Effective, efficient and affordable services

Figure 4.12: Project Goals

The objectives of the projects (see Figure 4.13) were slightly different due to the specific purpose of each project. By way of example, the TPC project under the Family Health Development Division was developed mainly for primary care services. The THIS project under the Health Planning and Development Division was developed mainly for tertiary care and new hospitals' business functions. The TH project, which was under the Telehealth Division, was developed for integrating all levels of healthcare services (primary and tertiary) so that the LHRs could be accessed seamlessly and continuously.

TPC	THIS	TH
☒ To automate the day-to-day operations of health clinics and the specialist clinics in the hospitals, thus allowing care providers more time to focus on the patients ☒ To provide a systematic data collection and analysis structure in the health clinics, hospitals and health	☒ To provide accurate medical treatment and medication for the patients ☒ To provide an efficient and effective service for the patients ☒ To provide quality services for every patients	☒ To promote wellness throughout life through network-based services and health management tools ☒ To provide user-friendly virtual services when and where required ☒ To increase the ability of individuals to manage health through knowledge transfer

offices to allow for real-time patient management ☒ To facilitate effective teleconsultation by making the EMRs of the patients available to the care providers on both sides ☒ To allow sharing of patient management protocols between health clinics and hospitals to achieve seamless, borderless and continuous care ☒ To enable easy data collection and an analysis of health data that which will help managers at various levels to determine the status of the population at any time ☒ To provide for an efficient disease surveillance system that will help prevent epidemics in the long term	☒ To facilitate in collecting and generating electronic medical records and lifetime health records.	and interactive network-based health ☒ To provide distributed multimedia network to deliver virtual services into rural areas, community centres and health settings ☒ To integrate personal health and medical information across episodes of care throughout life through computerised health records and plans. ☒ To customise and integrate services and information for individual and group needs ☒ To provide enhanced access, integration and timely delivery of high quality services at a reasonable cost

Figure 4.13: Project Objectives

With regards to the question of the application development approach and methodology (refer to Figure 4.14) used across the projects, TPC and TH were outsourced to the preferred vendors and the projects implemented a custom development approach using object-oriented application development methodology. The THIS project was also outsourced to the preferred vendors and the project was implemented using package integration and the customisation approach.

It was noted from the survey that two out of three divisions answered in the affirmative by way of using a custom development approach but only the THIS project used a package integration approach. This scenario provided considerable challenges for MOHM to implement a standardised solution framework across health ICT projects that were already or were to be implemented in MOHM.

Case	System development approach	Methodology used
TPC	Custom development (outsource)	OOAD
THIS	Package integration & customisation	None
TH	Custom development (outsource)	OOAD

Figure 4.14: Which One of the Following Development Approaches and Methodologies Is Used in your Project?

In terms of the technology (software, hardware, firmware, telecommunication network and database system) and deployment approaches that were implemented in the projects, TPC and TH were similar in that the web-based and enterprise-wide application deployment was their selected solution (see Figure 4.15). Only THIS used the client server and workgroup deployment solution, which was focused within the facility on which it was based. It was noted that the software technologies used varied between each project. In fact, THIS had a variety of software technologies used in its projects and this was to bring critical challenges for standardising the framework solution across the projects.

Case	Application Technology	Application Approach	Deployment type
TPC	.Net	Web-based	Enterprise wide
THIS	Varies	Workgroup client server	Within facility
TH	J2EE	Web-based	Enterprise wide

Figure 4.15: Can you Explain in Brief the Technology Used in the Projects?

With regards to the question of what type of telecommunication technology and bandwidth size were used in the projects (refer to Figure 4.16), the answers given by the respondents varied. The TPC used a very small access terminal (VSAT with a bandwidth size ranging up to 2mbps) as its main telecommunication transport across healthcare centres nationwide. This was due to the fact that some of the participating health centres were located in rural areas and the telecommunication infrastructure was inadequate.

The TH pilot project used a virtual private network (VPN with a bandwidth size range between 64kbps and 2mbps) for linking and transporting health data across healthcare facility centres. Only the THIS project used a local area network (LAN) as the nature of its implementation was independently deployed within the healthcare provider.

It was noted that the application response times for the three projects were regarded as moderate. All projects said that the performance in terms of response time would decrease once the number of users increased as the current implementation was still at the pilot stage. The current telecommunication network infrastructures installed in the three projects should be standardised to cater for the future needs of the application systems. In line with this scenario, the respondents pointed out that the MOHM had at that time embarked on a special project, namely "MOHM*Net" for providing and standardising the network requirements across healthcare facilities nationwide. This shows that the government had committed towards health ICT in providing healthcare services for the citizens.

Case	Type of network technology	Bandwidth size	Application response time
TPC	VSAT	256 Kbps - 2 Mbps	moderate
THIS	LAN	100 Mbps	moderate
TH	VPN	64 Kbps - 2 Mbps	moderate

Figure 4.16: The Varieties of Telecommunication Network Technologies Used in the Projects

To the question (does your project implement health informatics standard — for instance, standard clinical codes, a messages standard and a national code standard?), with regards to whether the project implemented the health informatics standard, TPC and TH answered that they had implemented the health informatics standard but THIS said it planned to implement it (see Figure 4.17). Although TPC and TH had implemented the health informatics standard, it had actually been carried out individually at a project level and not at national level.

Case	Used health informatics standard?
TPC	Yes
THIS	No
TH	Yes

Figure 4.17: Does your Project Implement a Health Informatics Standard?

When the respondents were asked if they have heard about the solution framework before (have you heard about framework before — for instance, solution framework, application framework, software/system framework and architectural framework?), all gave affirmative answers. They pointed out that the standard solution framework was a critical element for system interoperability and for integrating the disparate applications across healthcare facilities.

When asked the next question (do you agree that the healthcare information system, telehealth system, telemedicine system and e-health system are complex systems?), they also agreed that the health ICT project was complex as the medical services involved multi-disciplines and the development of the health ICT applications should be developed incrementally using a proper system development process (see Figure 4.18). TPC and TH said that they had implemented a proper system development process (SDP) in managing the development of the application system. However, this had not happened in the development of the THIS application system.

Case	Is health ICT complex?	Do you practice a proper SDP?
TPC	Yes	Yes
THIS	Yes	No
TH	Yes	Yes

Figure 4.18: Is Health ICT Complex and Did you Practise a Proper System Development Process?

With regards to the question of whether the projects had a standard architecture framework for developing and implementing the health ICT project, only the TH mentioned that its project had started with the definition and the development of a standard architecture framework for the entire system solution (see Figure 4.19). Apart from TH, TPC's and THIS's responses were in the affirmative in that the development of the systems was based on the creativity of the individual system designers (such as designer A designed sub-system A and designer B designed sub-system B).

It is, therefore, of critical importance that existing systems need to be upgraded and the future health ICT project should adopt a standard architecture framework and integrity models for interoperability, scalability and reusability. This is why it was still not possible to integrate the three projects and Figure 4.20 shows a common feature in that none of the projects used the same standard architecture framework in developing the system for collecting and generating the health records.

Case	Have a standard architecture framework?
TPC	No
THIS	No
TH	Yes

Figure 4.19: Does your Organisation Have a Standard Architecture Framework for Developing and Implementing Health ICT Projects?

Case	Use the same standard architecture framework?
TPC	No
THIS	No
TH	No

Figure 4.20: Do All Projects Use a Same Standard Architecture Framework?

A standard architecture framework is important in ensuring that medical information is synchronised between the systems and that LHRs can be accessed seamlessly and continuously. All projects responded affirmatively that the standard architecture framework is crucial for the integration and information exchange across healthcare facilities and levels (see Figure 4.21).

Case	Architecture framework is crucial?
TPC	Yes
THIS	Yes
TH	Yes

Figure 4.21: Do you Agree with the Statement that a Standard Architecture Framework Is Crucial for System Integration and Information Exchange?

There was a common response to the question regarding the frequency of system downtime (see Figure 4.22). All projects said that the system downtime was very rare in that it was estimated that the occurrence was less than three times per month. This is due to the fact that the system was still at the pilot stage in selected healthcare facilities and the number of transactions was still small in number.

Case	Frequency of system downtime (monthly)
TPC	Less than 3 times
THIS	Less than 3 times
TH	Less than 3 times

Figure 4.22: Have you Experienced System Downtime?

There was a mixed response to the question of the causes of system downtime. A common point that emerged from all projects was that application bugs (see column E in Figure 4.23) were common causes of system downtime. All three projects also responded with affirmative answers that system downtime was not due to the operating system crashing or hanging (see column B in Figure 4.23). The two respondents (the TPC and TH cases) gave affirmative answers regarding the most frequent reason that causes system down (see column A and E in Figure 4.23). The

TPC and TH cases also had a common point in that they were not clear whether the database server (see column C in Figure 4.23) could be the main reason affecting system downtime. They pointed out that the database system had a close dependency on the operating system and application system. The THIS project differed from others in terms of the its opinion about the telecommunication network factor (see column A in Figure 4.23), which could be contributed to system downtime. This was due to the fact that the THIS project was a client–server workgroup solution and the local area network was its means of communication between users and departments within the healthcare facility.

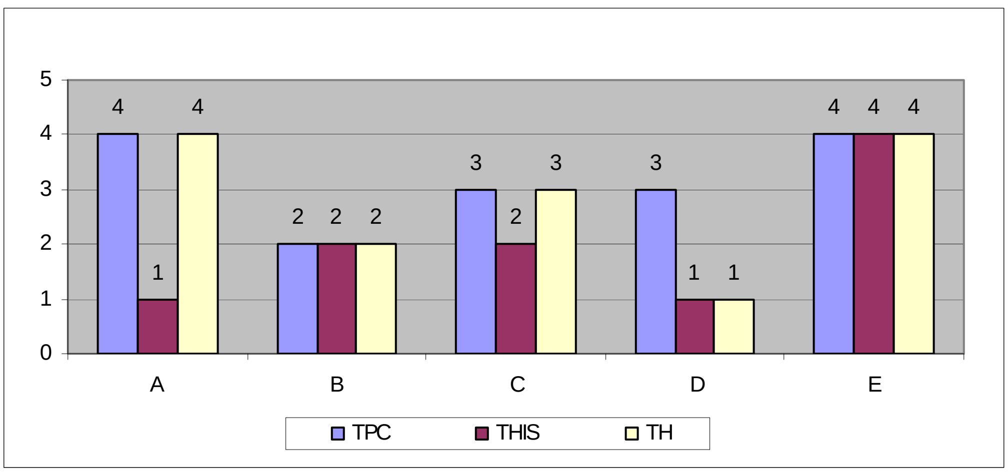

Figure legend

A	Telecommunication network fails or operates intermittently
B	Operating system server crashes or hangs
C	Database server crashes or hangs
D	Power failure
E	Application bugs

Figure 4.23: Have you Experienced System Downtime?

With regards to the question of the turnaround time for recovering from system problems (see Figure 4.24), two cases (THIS and TH) felt that the system problems should be resolved within an hour. The TPC case felt that the problems had to be resolved within 24 hours. The divergence of answers was due to the different services provided by the healthcare facilities and the different functionalities designed for each system. These varieties of healthcare services and application functionalities trigger the demand for a flexible and stable framework for ensuring the telemedicine system will be reliable most of the time.

Case	Turnaround time of recovery
TPC	Within 24 hours
THIS	Within an hour
TH	Within an hour

Figure 4.24: What Was the Turnaround Time for Recovering from the Problems?

With regards to the question of whether all three projects had any disaster recovery plan for maintaining the services during the downtime of the computer systems, all of them said that they had a disaster recovery plan for mitigating the downtime of computer system. However, the only recovery option that they had during the disaster was to go back to the manual system (see Figure 4.25). One of the respondents pointed out that reverting to manual procedures is a normal backup plan for ICT services and it has been demonstrated on many occasions that access to paper records is generally problematic and resource intensive. This concern should trigger the management of MOHM to initiate a course of action for developing a flexible system solution for mitigating the system disaster and for the upkeep of patient health records continuously.

Case	Has disaster recovery plan?	Disaster recovery technology
TPC	Yes	Manual system
THIS	Yes	Manual system
TH	Yes	Manual system

Figure 4.25: Do you Have Any Disaster Recovery Plan for Maintaining the Services during the Downtime of the Computer System?

There was an affirmative response to the question of whether mobile technology could provide a high level of system flexibility, economic benefits and educational value in maintaining patients' lifetime health records (see Figure 4.26).

Case	Mobile technology can provide		
	High system flexibility	Economic benefits	Educational value
TPC	Yes	Yes	Yes
THIS	Yes	Yes	Yes
TH	Yes	Yes	Yes

Figure 4.26: Do you Foresee that Mobile Technology Can Provide a High Level of Flexibility for Accessing and Storing Patients' LHRs during Any Possible System's Downtime?

Mobile technology (by way of example, portable devices and wireless technology applications) in healthcare can be recognised as both emerging and enabling technologies that have been applied in various countries for improving patients' care services. In the case of MOHM, the three projects gave various responses to the possible obstacles in the use of a mobile technology in healthcare services (see Figure 4.27).

A common point that emerged was that all projects felt that the confidentiality and privacy of patients' LHRs were not the main obstacles to implementing mobile technology in healthcare services (see column B in Figure 4.27). It was also agreed by all projects that the users' training (see column C in Figure 4.27) would be a crucial challenge as the users were the critical success factor for the success of system implementation. All projects responded that mobile technology was reliable (see column F in Figure 4.27).

The TPC and TH projects strongly agreed that there would be critical challenges for integrating mobile technology into the existing healthcare information system. In fact, the change management process is one of the critical success factors for ensuring the success of the new system to be implemented. The change management process will lead to a change in work process issues and the response from the three projects was affirmative (see column D in Figure 4.27).

On the people factor (see column E in Figure 4.27) that could hinder the implementation of mobile technology, two cases (THIS and TH) strongly agreed that people's attitudes were the challenge that most needed to be managed and resolved. This was due to the fact that the majority of the doctors had still ingrained in them their legacy working styles and they were ICT-illiterate.

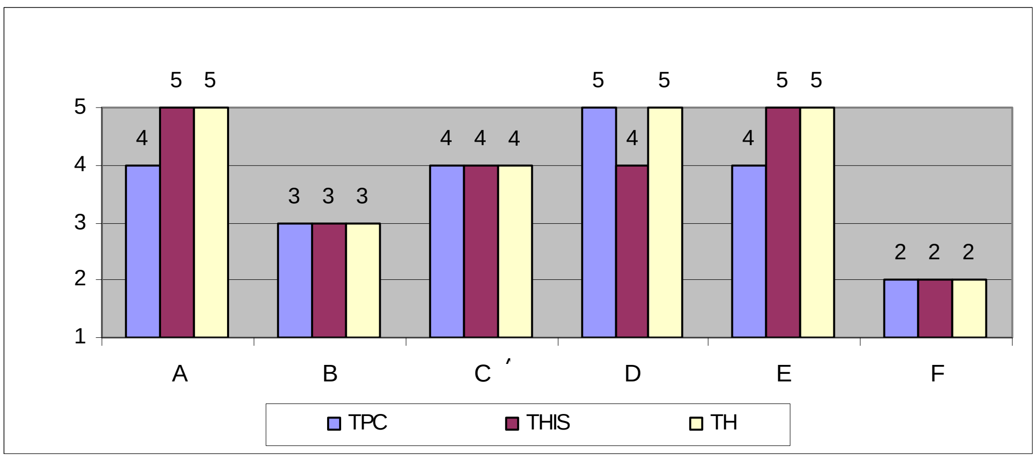

Figure legend

A	Integration into existing healthcare information system
B	Convincing the patients that the confidentiality and privacy of their LHRs will be assured
C	Training issues for users
D	Change of work process issues
E	People factors such as attitudes, knowledge, roles and habits
F	Reliability of the technology

Figure 4.27: What, in your Opinion, May Be the Possible Obstacles in the Use of Mobile Technology in the Healthcare System?

With regards to the question about the essential factors that should be provided in order to integrate the LHR system across healthcare facilities (see column F in Figure 4.28), all projects strongly agreed that the business functional solution had to be standardised across healthcare services. Two cases (THIS and TH) also responded with affirmative answers that the standardisation of the code set and communication protocol were crucial (see column B and C in Figure 4.28). According to the TPC project, it was also very critical to standardise and improve best practice change management and effective project management (see column G and H in Figure 4.28) for ensuring the LHRs were integrated and shared across healthcare facilities and healthcare levels.

On the design of open system standards, all projects agreed that the design of the application system should be interoperable (see column E in Figure 4.28). Two cases (TPC and THIS) pointed out that the standardisation of the system architectural framework is crucial for system interoperability.

System interoperability requires an adequate telecommunication network infrastructure in every participating healthcare centre. This is why two cases (THIS and TH) felt that the telecommunication network should be available across healthcare facilities and there should be critical components for sharing the LHRs among healthcare professionals and healthcare providers (see column D in Figure 4.28).

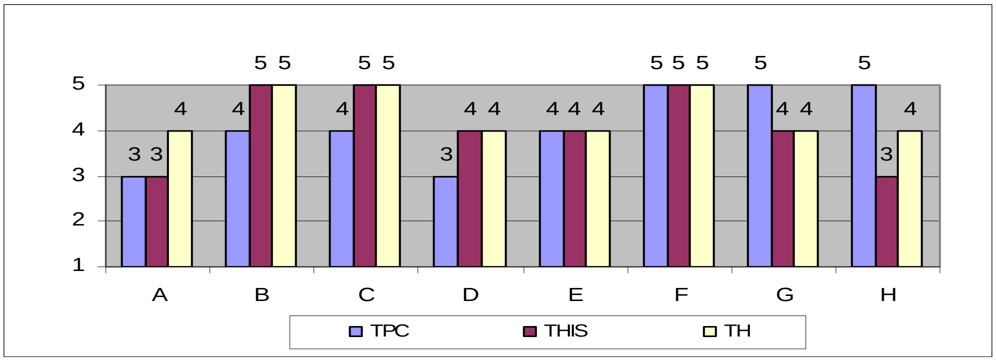

Figure legend

A	Standardisation of technology used
B	Standardisation of code set (e.g. clinical term, ICD-10 etc.)
C	Standardisation of communication protocol (e.g. HL7)
D	Establishing telecommunication infrastructure availability
E	Design an open system standard
F	Standardisation of business functional solution
G	Establishing and standardising a best practice change management
H	Establishing a collaborative project management

Figure 4.28: Which of the Following do you Think are Essential for Information System Interoperability, if it Has to Integrate and Share Patients' Medical Records across Systems/Healthcare Levels?

4.4.2.1.1 Section summary

In this section the responses from the three case studies were gathered in terms of the generic issues relating to the needs for standardising the architectural framework for maintaining the LHRs continuously and seamlessly. The conclusion drawn from the key findings was that the three case studies had their own styles in developing the application system and they used a dedicated architecture framework solution. It was also noted that some of the projects had never implemented a standard architecture framework and this would lead to problems in system interoperability. In fact, all the projects were under the same ministry — MOHM.

Another finding noted was that the three projects were developed with specific purposes and goals depending on health service functions. By way of example, the TPC project was mainly for serving the primary care service functions and the THIS project was for serving tertiary care service functions in hospitals.

The ICT infrastructures provided across healthcare facilities were also inconsistent. By way of example, the telecommunication network and PCs were still inadequate in healthcare centres compared to those in hospitals. All case studies agreed that an architectural framework solution should be standardised across projects and it should be designed in a flexible manner for maintaining LHRs continuously and seamlessly.

4.4.2.2 Needs analysis of the integrated lifetime health record

This case study was conducted at MOHM, where the deputy director of each project (TPC, THIS and TH) was interviewed by way of using an open-ended interview with pre-defined questions. The objective of the study was to identify the main issues pertaining to the existing patient health records and the critical requirements for maintaining health records continuously and seamlessly. The data collected from the personnel of MOHM were also used to validate the information retrieved from the main case study (archived records, documents and observations) of the research study.

The first interview was conducted with the deputy director of THIS, the project under the Development and Planning Division of MOHM. As mentioned earlier, the THIS project was developed purposely for supporting the administration and clinical functions of new developed hospitals across the country. The THIS project was under the Ninth Malaysian Planning Budget from 2006 until 2010. Doctor F welcomed us to her office. She had been a doctor but had given up clinical practice five years previously.

The second respondent was a deputy director of the TPC project, Dr G. The TPC project was under the Family Health Development Division of MOHM and had been developed for computerising the administrative and clinical functions of health clinics and polyclinics nationwide. At that time, the project was being implemented in a pilot form in various health centres in the three states. Dr G invited us to a small party held by her department where there were plenty of delicacies to appease the appetite. Just after 20 minutes, we started the discussion, during which Dr G fully cooperated in answering the questions comprehensively.

The third respondent was a director of the telehealth project. Dr H was in quite a rush for a meeting at nine that morning. Although our session lasted for only 30 minutes, he gave his full cooperation in responding to all the questions.

To the first question (can you explain briefly the background of the project?), the three respondents explained fully in terms of the motivation for and reasons why their projects were developed. All cases mentioned that one of the reasons the project was developed was due to the shortage of human resources. It is hoped that, with the emergence of ICT in the healthcare system, the human resource issues (especially for healthcare professionals) will be minimised and addressed accordingly (see row 1 in Figure 4.29).

The three also responded with a common reason for the inability of the existing healthcare system to share and provide adequate access to health records continuously. Hence, these projects were developed as the means to provide seamless access to health records through the collection of EMRs and the generation of an LHR repository. They also mentioned that the LHR repository provided prospective health information for healthcare institutions and researchers through statistical analysis and trend analysis reports (see row 2 in Figure 4.29)

It was also stressed in the threes cases that the increase in consumer expectations and the expansion of the business functions of healthcare services were some of the reasons the projects were developed and required by all healthcare levels (see row 3 in Figure 4.29). The three cases also responded with affirmative answers that the projects were developed for facilitating the rapid changes in patient demographic patterns as the recent diagnoses were almost related to the lifestyle of patients.

The THIS and TH projects highlighted the fact that the motivation to develop the projects was due to the fact that the existing health information system and the healthcare services were set up in a fragmented and episodic manner (see row 5 in Figure 4.29). Finally, the TH project mentioned that the project facilitated the process of reshaping the future healthcare system from one that largely focused on illness, facilities and healthcare providers to one that focused on wellness, people and the capacity to deliver services directly into people's homes.

It was shown that the goals and the objectives of the three projects were based on electronic LHRs. As such, it is crucial for MOHM that integrated LHRs are developed and focused on and it would be considered to be a critical success factor for achieving the goals and objectives of the projects.

TPC	THIS	TH
☒ Shortage of human resources	☒ Shortage of human resources	☒ Limited resources of healthcare professionals
☒ To provide health data collection for reporting, statistical analysis and research	☒ Inadequate health record sharing and to provide health data collection for reporting, statistical analysis and research.	☒ To provide a group data service to policy makers in formulating policies and healthcare plans at the national level through electronic reports such as statistical analysis, trend analysis and data mining.
☒ Expansion of business functions/healthcare services	☒ Rising consumer expectation — facilitate this through enhancement of decision-making processes	☒ Rising consumer expectation — TH acts as a tool to lead the country's healthcare system into the information age
☒ Changes in demographic patterns	☒ To facilitate in the process of providing the best care for every patient.	☒ Demographic and lifestyle changes
	☒ Existing care is fragmented and episodic.	☒ Inadequate integration of healthcare delivery and continuity of care
		☒ To facilitate the process of reshaping the future healthcare system from one that currently largely focuses on illness, facilities and healthcare providers to one that focuses on wellness, people and the capacity to deliver services directly into people’s homes.

Figure 4.29: Can you Explain Briefly the Background to the Project?

When asked about the projects' goals and objectives, all cases were explained in detail as depicted in Figure 4.30. In summary, all projects responded that the main goal of the health ICT initiatives that were currently embarked upon across healthcare facilities was to provide quality healthcare services through the merger of ICT and the healthcare system.

The TPC and THIS projects mainly focused on the primary care services and tertiary care services respectively. This was done by computerising the day-to-day operations of health clinics and hospitals.

On the other hand, the main aim of the TH project was to integrate all EMRs that are created from the TPC and the THIS systems into integrated LHRs that were hosted centrally for continuous and seamless access across healthcare levels. With this feature (integrated LHRs), it would promote a wellness paradigm throughout life through network (Internet) based services and health management tools such as LHR data mining. It also aimed to make the LHR services personalised according to an individual's and group's needs. By way of example, the TH application would provide virtual access and the ability for individuals to manage health through knowledge transfer and interactive network-based health.

Case	Goals	Objective
TPC	☒ To provide quality healthcare through the convenience of ICT	☒ To automate the day-to-day operations of health clinics and the specialist clinics in the hospitals, thus enabling care providers to have more time to focus on the patients
	☒ To ensure prompt access to specialist care for every citizen regardless of physical distance from hospitals	☒ To provide systematic data collection and analysis structure in the health clinics, hospitals and health offices to allow for real-time patient management

Case	Goals	Objective
	☒ To enable the creation of a knowledge infrastructure that would contribute towards healthcare policy formulation and the continuous professional development of MOHM staff	☒ To facilitate effective teleconsultation by making the EMRs of the patients available to the care providers on both sides
		☒ To allow sharing of patient management protocols between health clinics and hospital to achieve seamless, borderless and continuous care
		☒ To enable easy data collection and analysis of health data that will help managers at various levels to determine the status of the population at any time
		☒ To provide an efficient disease surveillance system which will help prevent epidemics in the long term
THIS	☒ Patient safety	☒ To provide accurate medical treatment and medication for the patients
	☒ Efficiency	☒ To provide efficient and effective service for the patients
	☒ Quality service	☒ To provide quality services for every patients
	☒ Health data mining	☒ To facilitate in the collection and generation of electronic medical records and lifetime health records.
TH	☒ Wellness focus	☒ To promote wellness throughout life through network-based services and health management tools
	☒ Person focus	☒ To provide user-friendly virtual services when and where required
	☒ Self-help	☒ To increase the ability of individuals to manage health through knowledge transfer and interactive network-based health
	☒ Care provided at home or close to home	☒ To provide a distributed multimedia network to deliver virtual services into rural areas, community centres and health settings
	☒ Seamless and continuous care	☒ To integrate personal health and medical information across episodes of care throughout life through computerised health records and plans.

Case	Goals	Objective
	☒ Services tailored as much as possible	☒ To customise and integrate services and information for individual and group needs
	☒ Effective, efficient and affordable services	☒ To provide enhanced access, integration and timely delivery of high quality services at a reasonable cost

Figure 4.30: Can you Explain in Brief the Objectives of the Projects?

Regarding the status, progress and milestones of the projects, all cases replied that the projects were still at the trial and pilot implementation stage in various healthcare facilities. The TPC project responded that the applications that were already implemented in the two states of Johor and Sarawak (involving two hospitals, 45 health clinics, four district health offices, two state health offices and five divisions in public health division) were still at the trial stage of implementation. The national rollout implementation (across healthcare centres nationwide) was still pending and awaiting a decision from the top management of MOHM as well as approval from the Government.

The implementation of THIS progressed accordingly in that the new hospital (Serdang Hospital in Selangor state) was being tested in terms of the system and for user acceptance. Four other hospitals (Hospital Sungai Petani, Hospital Alor Star, Hospital Sungai.Buluh and Hospital Ampang Kuala Lumpur) would be deployed with the THIS application in 2008. The intermediate version of THIS, namely IHIS, would be deployed in two new hospitals in 2009. Another version of THIS, namely the Basic Hospital Information System (BHIS), would also be deployed in six new hospitals in 2010.

The TH project gradually progressed in that the less critical components such as Health Online had been launched and were already in production and Continuing Professional Development (CPD) was still at the conceptual design stage. The major component of TH, the LHR services, was still at the conceptual design stage and it was expected that it would be materialised in the middle of the year 2008.

Looking back at the progress of the three cases, the development of the projects looked unfocused in that inadequate priority was given to the development of the integrated lifetime health records (LHR repository). The development of LHR services should have been made the priority to achieve continuous and seamless access to patient health records.

The interview proceeded to the question about the scope of the projects. TPC and THIS had a similar scope in that the clinical information system and patient management system became the integral components for supporting the administrative and clinical functions of healthcare facilities. There were three components (LHR, PLHP and GDS) identified in the TH project that were integral to the national healthcare services. It was noted that the LHR component was very critical compared to the GDS and PLHP components. The respondents pointed out that these three components were crucial for the national health system for integrating and improving the accessing and sharing of health information across applications and healthcare levels (see Figure 4.31).

TPC	Integral	THIS	Integral	TH	Integral
Clinical management system (CMS).	High	Patient management system	High	Lifetime Health Record (LHR)	Very High
Clinical support system (CSS).	High	Clinical information system	High	Personalised Lifetime Health Plan (PLHP)	High
Wellness module.	Moderate	Radiology information system	Moderate	Group Data Services (GDS)	High
Epidemiology module	Moderate	Laboratory information system	Moderate	Health Online (MyHealth)	Moderate
Security and administration modules.	Moderate	Pharmacy information system	Moderate	Continuing Professional Development (CPD)	Moderate
		Financial accounting & human resources system	Moderate	Call centre	Moderate
		Ward management system	Moderate	Teleconsultation	Moderate

Figure 4.31: What are the Components of the System involved in the Project and which One is Integral to National Healthcare Services?

The many applications as depicted in Figure 4.31 led to critical challenges for integrating the varieties of systems into an integrated one. The respondents were asked whether the many systems had the capability of being integrated with each other; all cases responded that the integration process would require a lot of effort, time and resources. In fact, they also pointed out that it was critical to prioritise the integration and that all parties involved in the health ICT projects should work on it. They further pointed out with an affirmative answer that the solution for integrating the disparate system and health records should be done through a standard integration framework that could create and collect patient health records for generating an integrated LHR system centrally (see the opinions of all cases in Figure 4.32).

TPC	THIS	TH
TPC uses the standard International Classification of Diseases Revision 10 (ICD10). Integration can be achieved but requires a huge amount of effort and time. The only way to integrate is through the sharing of integrated lifetime health records (LHRs)	The new version of the THIS application is incorporated with health informatics standards and is ready to integrate with LHRs. However, the existing application does not implement health informatics standards and requires lots of amendment if it is required to integrate with other systems. The solution for integrating the system and health records across healthcare levels should be done through the collection and generation of centralised LHRs.	The development of health ICT projects should be given a priority in establishing the health informatics standards. The LHR component should have a common integration framework for integrating all electronic medical records from disparate systems across healthcare facilities.

Figure 4.32: MOHM Has a variety of Information Systems in the Various Healthcare Facilities; Some Have Been Implemented and Some Are Still under Development. How do you See this Situation (Varieties of Systems and Vendors) in Terms of the Capability of the Systems to be Integrated with One Another?

Another point that was agreed on by all of the cases was that the health informatics standards, technology standards and change management were the most probable obstacles to face when integrating these disparate systems (see obstacles 1, 2 and 3 in Figure 4.33). All cases pointed out that these factors posed the biggest challenges due to the fact that every project was managed disparately and in isolation.

The TPC project added that the people factors (negative attitude towards innovation, ingrained legacy work style, reluctance to adapt to the changes, etc.) also contributed to the integration complexity (see obstacle 4 of the TPC case in Figure 4.33). THIS further added that the project management and the user acceptance processes (see obstacles 4 and 5 of the THIS case in Figure 4.33) were also critical challenges that needed to be considered and managed effectively.

Case Obstacle	TPC	THIS	TH
1.	Health informatics standards	Health informatics standards	Health informatics standards
2.	Change management	Change management	Change management
3.	Technology standards	Technology standards	Technology standards
4.	People — negative attitudes	User acceptance — to get an acceptance from the doctors will be the hindrance	Functional standards
5.	-	Project management — have to deal with multi-vendors and multi-systems	-

Figure 4.33: What are the Most Probable Obstacles and Challenges to Integrating these Disparate Systems?

An interesting point that emerged from the interviews was that all three projects stated that, although the projects were developed disparately, a lot of effort was made in integrating and sharing the health records across healthcare centres. Examples were the standardisation and installation of a virtual private network (namely MOHM*Net) across healthcare facilities, the establishment of a health informatics standards committee, the development of a standard for code sets and the business process reengineering (BPR) establishment (see Figure 4.34). In the researcher's personal opinion, this scenario showed that all projects were very keen to have an integrated solution for the LHR repository. However, the projects were lagging behind in terms of setting up the priority and managing the overall requirements of the systems.

TPC	THIS	TH
The respondent informed the researcher that there were efforts for integrating and collecting the LHRs across the disparate system. But the LHR component was still not ready.	The respondent explained that there were efforts towards integrating all clinical systems for collecting LHRs. Among the efforts was setting up the virtual private network across health facilities, namely MOHM*Net. The health informatics standards committee was also established to facilitate the development of the standards.	The respondent reported that the LHR component was still in the design stage. The development of health informatics standards (such as clinical code sets, and administration code and national code standards) was also in the way of completion. The BPR was actively worked on by the project team across the projects.

Figure 4.34: At Present, Are There Any Efforts Being Made to Integrate All the Clinical Systems for Collecting and Generating the Electronic Medical Records and Lifetime Health Records?

With regards to the question on the system components that is crucial to be integrated, the TPC mentioned that it was crucial to create and integrate health records. The TH case added that the use of a standard discharge summary was important for creating and collecting EMRs and finally generating individual LHRs. All cases agreed that it was crucial to integrate the clinical information system through the sharing of LHRs (see Figure 4.35). As such, they felt all projects needed to focus more on creating and collecting EMRs for generating an integrated LHR repository.

TPC	THIS	TH
The crucial components to be integrated were health records of patients, which will be created and generated through the clinical information system module	The EMR should be created through the clinical information system for generating the summary of patients' health records, namely LHRs	The LHR component, especially a standard discharge summary, should be used by all disparate systems for collecting the health records centrally.

Figure 4.35: Which of the System Components do you Think it Is Crucial to Integrate?

Another point that emerged was that all the cases described that the primary care services (provided through the network of health clinics and polyclinics) should be given a focus and priority in implementing the health information system and generating the patients' EMRs (see Figure 4.36). The TH case added that every healthcare facility that had been computerised with the EMR system should be able to create and generate the EMRs through a standard discharge summary agreed by MOHM. As such, they felt that there was a need for MOHM to focus more on computerising health centres and polyclinics with the information system (IS — for example, the clinical information system and patient management system) and telemedicine system. This was due to the fact that these types of healthcare facilities were sources for generating the EMRs.

TPC	THIS	TH
The respondent strongly agreed that the health centres and polyclinics should be given priority in implementing the IS and sources for creating the EMRs.	The respondent mentioned that the implementation of HIS should be based on the workflow of healthcare system/processes (by way of example, from primary to secondary and finally to treasury level). As such, the THIS implementation should start from health centres and be incrementally deployed at the hospital level.	The respondent highlighted the fact that all the EMR system should be integrated into the LHR repository regardless of what types of healthcare level they are. The generation of LHR should be given priority/focus on the individual health records/episodes (such as medication, allergy and important diseases suffered by the patient), which could ensure the continuity of care. As such, there was no specific healthcare level to be prioritised as long as the computerised healthcare facility could create and generate the EMRs.

Figure 4.36: What Type of Healthcare Level Do you Think it Is Crucial to Focus on and Prioritise for Implementing the IS and Generating the EMRs/LHRs?

All projects also agreed that it was important for all healthcare facilities to have access to a telecommunication network (Internet) so as to create, collect, store and share the LHRs (see Figure 4.37). They pointed out that adequate PCs also played an important role as a means for the doctors to use the application to capture the clinical episodes continuously. The TH case pointed out further that the patient management system (PMS) and clinical information system (CIS) were among the application infrastructures crucial to all healthcare facilities in generating the LHR repository. THIS believed that it was crucial to make the health infostructure (such as health informatics standards) ready for ensuring the smooth implementation of LHR collection and generation.

TPC	THIS	TH
The respondent suggested that it was crucial provide the telecommunication network and PCs for making sure the LHRs can be collected and generated continuously.	The respondent mentioned that it is crucial to provide the telecommunication infrastructure, hardware infrastructure and health informatics standards for submitting and collecting the LHRs from various systems and health facilities nationwide.	The respondent stressed that the three crucial infrastructures to be deployed were: i) application infrastructure — basic system such as PMS and CIS — should be in place; ii) a telecommunication network infrastructure should be established — MOHM*Net; and iii) computers — all healthcare professionals should be equipped with dedicated PCs.

Figure 4.37: What Infrastructures Is it Crucial to Deploy at Each Healthcare Facility for the Purpose of Integrating the Systems, Collecting the EMRs and Generating and Sharing the LHRs?

Another point which all of the cases agreed on was that MOHM should have a flexible system framework for capturing, displaying and storing the EMRs/LHRs continuously. They believed that the flexible system could mitigate unpredictable system downtime and the implementation of the system should not depend solely on telecommunication network (see Figure 4.38).

TPC	THIS	TH
The respondent agreed that MOHM should have a flexible system framework for mitigating the emergency case such as system downtime and the inconsistency of the telecommunication network	The respondent agreed that MOHM should have a flexible system framework for continuing access to and the upkeep of patients' health records across systems and health facilities.	The respondent agreed that MOHM should have a flexible system framework for handling unpredicted events such as an inconsistent telecommunication network, a variety of healthcare information systems and system downtime.

Figure 4.38: Looking at the Telecommunication Infrastructure Scenario (Inconsistent) across Healthcare Facilities and the Country in General, we Should Have a Flexible System Framework for Capturing, Displaying and Storing the EMRs/LHRs Continuously. Do you Agree with this Idea?

When asked to comment on the possibility of using mobile technology to store and access patient LHRs during any possible system downtime, the answers were affirmative (see Figure 4.39). The three cases believed that mobile technology provided lots of flexibility as the technology enabled the data to be stored and accessed remotely at the patients' possession. However, TH pointed out that it was tough to implement it in the healthcare system. This was due to the fact that the existing workflow process required changes and the healthcare professionals needed to be trained extensively.

TPC	THIS	TH
The respondent agreed that mobile technology could provide flexibility for accessing, storing and displaying health records of patients.	The respondent agreed that mobile technology could provide high flexibility in accessing and storing patients' health records during system downtime.	The respondent agreed with the idea of using mobile technology for providing high flexibility in accessing and storing patients' health records during any possible system downtime. However, it would take time and pose challenges for implementing in MOHM. She mentioned that the CM was the main challenge due to the fact that the main users were clinicians/doctors who had basic computer skills.

Figure 4.39: Taking into Account the Criticality of Patients' Medical Records, which Need to Be Seen Continuously by the Doctors during Patient–doctor Encounters, Do you Foresee that Mobile Technology (such as the Mobile Phone, PDA, Smart Card and MP3) Can Provide a High Level of Flexibility in Accessing and Storing Patients' LHRs during Any Possible System's Downtime?

There was an affirmative viewpoint with regards to the question of whether mobile technology would have economic benefits for the health system of the country (see Figure 4.40). THIS stressed that the mobile technology usage could be applied in the healthcare system of Malaysia due to a rapid increase in hand-phone ownership among Malaysians. TH added that the portable devices such as PDA and mobile phones could be used to access and store patients' health records through a global mobile system (GSM) and short message service (SMS) application. TH further pointed out that the MOHM should do more research on the usage of portable devices in Malaysia's healthcare system due to the fact that this technology was affordable and could reduce the cost of landline telecommunication. TPC added that the implementation of mobile technology required further research and development and approval from the top management of MOHM as the health records required a high degree of confidentiality and privacy.

TPC	THIS	TH
Mobile technology has economic benefits in the healthcare system. However, the MOHM needs further research and development for identifying the areas that really require the technology and the impact for the existing business process. In fact, the usage of that technology requires approval from the top management of MOHM and the Government.	The respondent agreed that mobile technology has economic value. Looking at the amount of hand-phone ownership among Malaysians, she believed that one day mobile technology would become an important device in Malaysia's healthcare services.	The respondent said that mobile technology devices such as PDA and mobile phones could be used for storing and accessing health records through GSM and SMS applications. They have economic benefits and MOHM should research its usage in the healthcare system.

Figure 4.40: Do you Consider that Mobile Technology Has Economic Benefits for the Health System of the Country?

With regards to the question of whether mobile technology would have educational value, all three cases said they strongly agreed. TPC and TH had no further comments on the question. However, THIS was concerned about security vulnerability and policy changes that would have an impact due to the use of the technology (see Figure 4.41).

TPC	THIS	TH
Yes agreed	The respondent agreed that mobile technology has educational value. However, the need is still in vague at the moment. She also mentioned the security concern and policy changes that need to be incorporated.	Yes agreed

Figure 4.41: Do you Consider that Mobile Technology Has an Educational Value?

With regards to the final question (could you please describe key lessons to be highlighted and used for moving forward) (see Figure 4.42), all cases were willing to share their lessons learned, which could be used for the future development of health ICT projects, especially the telemedicine/telehealth system. Surprisingly, all cases mentioned that change management would provide critical challenges for implementing telemedicine and IS in the healthcare system. This was due to the fact that various individuals were involved in providing healthcare service delivery, including physicians, specialists, nurses, pharmacists, medical assistants, administrators and other related healthcare staff. All cases added that they (individuals involved in healthcare delivery) were the users who would use the ICT in their daily routine in dealing with patients. TPC pointed out that the majority of health workers still had limited computer-related skills. THIS also mentioned that many of them would be set in their existing ways and existing work processes might well have been ingrained into their daily lives for decades. Thus, any purported change in their routine daily workflow was bound to be viewed with some degree of hostility and resistance (Abd Ghani et al., 2007).

THIS and TM mentioned that it was critically important that all projects should work together to focus on developing the system that would have a high impact on the public's needs and benefits. They pointed out that this could be done through project scoping and prioritising by way of developing the critical components — the LHR repository.

TPC highlighted the fact that the variety of application systems implemented in the healthcare facilities would undoubtedly lead to maintenance issues. Maintenance issues included the need for multiple skills to support multiple systems that used different technologies and many vendors were involved in providing the support.

All cases believed that leadership through effective project management contributed to the success of the projects, especially when health ICT was a complex system. They pointed out that the project needed strong leadership and effective project organisation for moving forward.

TPC further pointed out that it was critical to provide continuous ICT training for health workers. She said that this was to ensure that the healthcare professionals, especially, were updated with the latest technology and were aware of the progress of MOHM's health ICT project.

THIS and TM further highlighted the fact that in line with the development of the telemedicine system and other health information systems, MOHM should also give priority to establishing the health informatics standard for integrating the LHRs across applications and healthcare facilities and, finally, the LHRs could be maintained continuously and seamlessly.

TPC	THIS	TH
☒ Change management — the business process reengineering has to be established before the system is implemented	☒ The change management and business process reengineering should be established and standardised across healthcare levels	☒ The change management and business process reengineering should be established and standardised across healthcare levels
☒ User acceptance — the project team should work together with clinicians and domains for getting user's buy-in to the system.	☒ Focus on developing a system that can have benefits for patient safety and efficiency in delivering healthcare services.	☒ Focus on the functions/services that would have a big impact on the public needs and benefits
☒ System maintenance — award for the capable vendor and avoid giving to many parties/vendors	☒ Focus on important deliverables that have a great impact on the business needs and reduce the nice-to-have functions.	☒ Scope of the project deliverables and prioritise the business needs

☒ Project management structure — cut through the red tape.	☒ Leadership and organisation — health ICT project needs strong leadership and strong organisational structure for moving forward.	☒ Leadership and organisation — the telehealth project requires strong leadership for moving forward.
☒ Continuous training — the training and ICT awareness should be carried out periodically and continuously for all health workers	☒ The health informatics standards should be established especially for integrating and sharing the LHRs across systems and health facilities.	☒ The health informatics standards should be established and given a priority for sharing the LHRs across systems and health facilities

Figure 4.42: Finally, Could you Please Describe Key Lessons to be Highlighted and Used for Moving Forward.

4.4.2.2.1 Section summary

This section discussed the integrated LHR needs analysis of the three major health ICT projects of MOHM — TPC, THIS and TH. It was noted that all projects had affirmative aims in that, at the end of the day, the patients' clinical episodes or electronic medical records needed essentially to be created and collected for generating integrated LHRs in LHR repository.

In order to achieve this aim, they agreed that all projects should have a standard architecture framework for sharing the LHRs across healthcare facilities. It was noted that the framework should also be flexible to cater for an existing scenario in which healthcare facilities were ill-equipped with a telecommunication infrastructure and might not be ready for any possible system disaster.

Finally, all cases shared the important key lessons in that it was urged that the change management, component prioritisation, leadership and health informatics standard factors should be established and resolved accordingly.

4.5 Summary

This chapter provided a detailed description of the various organisational functions of MOHM (including its various divisions), which were selected for conducting the case study. The selected divisions were suitable and relevant for providing practical evidence and references for this research. Thereafter, details of the case research process were provided.

The chapter also discussed findings from the primary data collection at MOHM by way of structured and open-ended interviews. The feedback from the interviews showed that the health-ICT infrastructure across public healthcare facilities is still inadequate. This has motivated MOHM management to provide an adequate health-ICT infrastructure for enabling LHRs to be shared across healthcare facilities. The responses from high-level management interviews showed that the integrated LHRs and a flexible framework also needed to be incorporated into the Malaysian telemedicine system.

The case study assisted in examining the critical aspects of the proposed framework in practical situations. The following chapter will draw on another case study's findings and utilise that to examine the suitable components and LHR datasets for the proposed conceptual framework of this research.

Chapter 5 Analysis of Patient Demographic and Clinical Records

5.1 Introduction

This chapter presents an analysis of the clinical consultation workflow and the usage of patient demographic and clinical records in outpatient clinics. The analysis was carried out through a case-study approach conducted at the Ministry of Health Malaysia (MOHM) in six months starting in January 2007 and ending in June 2007. The data obtained from the case study (by structured interviews and accessing archived records) would be used to develop standard datasets of lifetime health record (LHR) and would support the implementation of the proposed framework. This case study would also provide support in answering the second research question: "What is the crucial LHR dataset to be used for supporting the framework?" It is already known that the patients' health records, including demographic and clinical records, are crucial for supporting a physician in making an accurate decision in providing treatment and medication for the respective patient (Scott, 2006). In this research, a common LHR is important for making the proposed framework more flexible and interoperable.

The chapter starts with a brief introduction and continues by presenting the background to the organisation for conducting the case study. The chapter then presents and elaborates on the findings from the case study investigation including details of the system analysis and discussion of the findings from the primary data collection (analysis of patient demographic and clinical data in outpatient clinics). The chapter continues with further discussions from the case study investigations. The proposition of an LHR dataset including LHR components and structure will be described and elaborated on. Finally, the chapter ends with the summary of the chapter.

5.2 Introduction to the Case Study

According to Yin (2003b), the case study organisation should be selected based on the relevancy and appropriateness of the case being studied. In this case study, the outpatient clinics department of MOHM was selected for conducting and exploring the case under study — analysis of patient health records in outpatient clinics. The next section will elaborate on the background to and the undertaking of the case study in the outpatient clinics.

5.2.1 Background to Outpatient Clinics

The outpatient clinics department reports, in an administrative sense, to the Family Health Development Division of Public Health Services of MOHM (see Figure 4.2 and Figure 4.3 of Chapter 4 for MOHM's organisational structure). Healthcare services are provided through various health centres and community polyclinics strategically located in the most populated areas in the district. The health centres and community polyclinics comprise the first level of service made available to the community. The services provided are comprehensive at this level, essentially comprising maternal health, child health, acute care of diseases, chronic care of diseases, mental health, geriatric care, community-based rehabilitation, well person services and health promotion. These services are provided as outpatient treatments. In order to support such services, there are laboratory services and also radiological services. The pharmaceutical services are also provided in-house. With these comprehensive services and workflows, it was a significant reason for the outpatient clinic department being selected as a case study organisation for advancing knowledge on the case under study. The selected organisation will cover most of the processes of consultation and medical diagnosis workflow in outpatient clinics. The healthcare setting provides relevant evidence for and extensive information about patient demographic and clinical data that would contribute in developing the LHR components and structure.

5.2.2 Methods of Undertaking the Analysis

There were two methods that contributed to the proposition for the LHR components and structure:

1) conduct a system analysis
2) conduct an analysis of patient demographic and clinical data.

The first method was conducting a system analysis — where the case being studied was explored through case study analysis (system analysis) by way of accessing archival records, discussions and interviews. The crucial patient demographic and health records were identified and obtained initially through the collection of secondary data from various sources of evidence such as documents and archival records (paper-based consultation templates and administrative and clinical forms). The pilot telemedicine application was also investigated and analysed extensively by way of open-ended interviews, discussions and reviews of the archived records. The former telemedicine contractor was also contacted for accessing crucial information and data (such as technical reports and application implementation experiences), which could provide invaluable input and a clear understanding of the pilot telemedicine application blueprint.

The second method was an analysis of patient demographic and clinical data. The outpatient clinic personnel were contacted for accessing and obtaining the primary source of evidence (analysis of patient demographic and clinical data through structured interviews). Based upon responses and feedback from the initial case study, detailed questionnaires were created for collecting the primary evidence and data collection. Through the main personnel contact of the case study organisation, 30 respondents (medical officers or GPs) from different health clinics and polyclinics were identified for the interview. According to Naiburg and Maksimchuk (2001), the best way to understand the business process and information obtained from the many players and sources are to begin modelling their descriptions. In this research it was done through an analysis of an outpatient clinic business model, which described the activities, users and stakeholders involved in the workflow.

The interviews were carried out by the ten assistant researchers who were appointed to conduct the interviews with the 30 doctors in outpatient clinics. The assistant researchers were selected out of the medical graduates who had extensive knowledge in the medical domain. By doing this, the discussion between interviewer and respondent was conducted smoothly.

5.3 Discussion of the Findings from the Case Study Investigations

The case study investigations will be presented in two subsections, namely an analysis of the current system and a discussion of the findings from the primary data collection. The system analysis section will explore and elaborate the background to the current system (manual and computer system) and the workflow of consultation and medical diagnosis in outpatient clinics. The findings from the primary data collection section and outcomes of the investigation from the primary data collection will be discussed.

5.3.1 System Analysis

The aim of the system analysis was to come out with a minimal number of application systems and data/objects that needed to be manipulated, captured and stored for creating the LHR dataset.

For this purpose, the consultation and medical consultation workflow (in which the medical records were viewed, captured and generated) in outpatient clinics were analysed and examined.

The analysis started with the description of the workflow and continued on to examine the basic definitions of the application system, at which point we should be able to map the relevant part of the workflow to the corresponding application systems. This would provide an idea of how the application systems would support or contribute towards enhancing the continuous and seamless access to the patient health records. From this mapping the minimal functions required for the applications will be derived as well as the data-objects that it was critical to manipulate, capture and store for forming the LHR structure.

5.3.1.1 Architectural overview of the Malaysian telemedicine application (revisit)

In order to recall the entire scope of the project and fully appreciate the functional requirements of the Malaysian telemedicine application, it is perhaps best to take another look at the overall view of the pilot telemedicine project. Figure 5.1 below depicts precisely this picture.

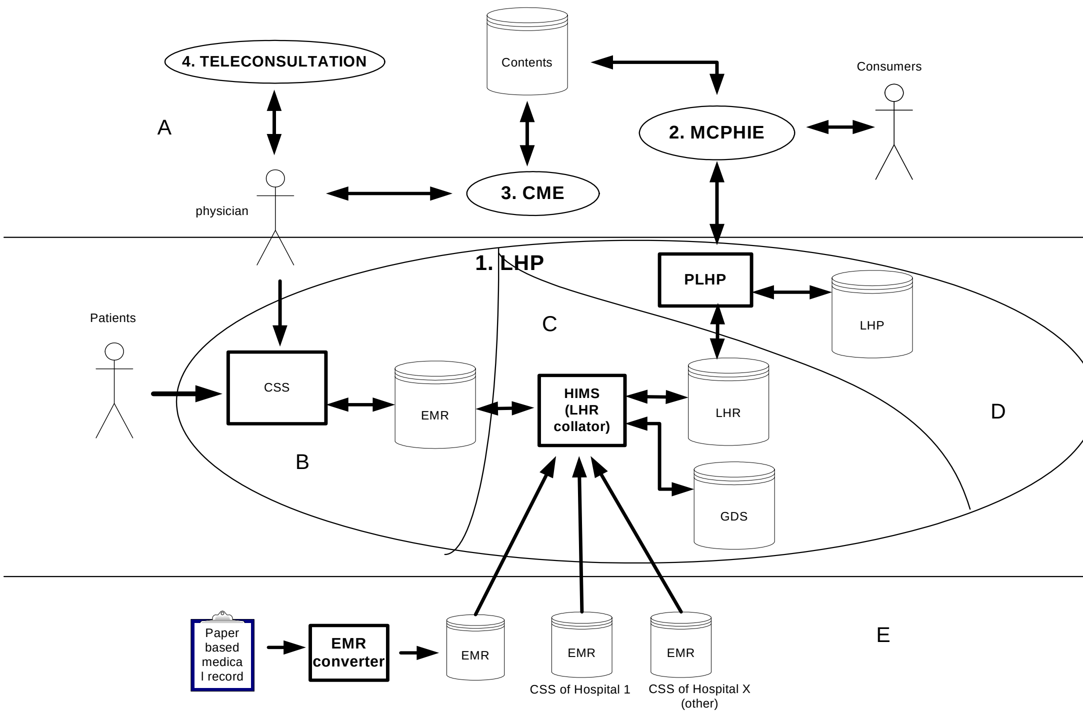

Figure 5.1: A Visualisation of the Entire Scope of the Telemedicine Pilot Project
Source: adapted from (Harun, 2007; Ministry of Health Malaysia, 1997e; Harun, 2002)

The top (A) of the diagram shows the three components of the Malaysian integrated telemedicine projects MCPHIE, CME and Teleconsultation. The bottom (E) part of the diagram shows the non-telemedicine projects or external systems including paper-based medical records and other clinical support systems (CSS) from various hospitals that link to LHP (LHR collator) for forming the LHR repository. The middle part of the diagram, LHP (B, C and D) has to interface with the A part for formulating, generating and providing a complete and integrated set of past medical records for the individual. Some of the very important points that can be derived from this overall diagram are as follows:

- CSS (B) component has to link/collect data from teleconsultation applications to form EMRs and this has to happen even if the CSS applications are not part of the telemedicine projects.

Examples are the legacy clinical information system (CIS), paper-based medical records and other types of CIS.

- HIMS-LHR Collator (C) has to collect all EMRs from a single healthcare centre from other healthcare centres using other CSS applications and from paper medical records converted to EMRs altogether to form LHRs in the LHR repository. The LHR repository then generates and delivers group data services for central agencies and various institutions for statistical analysis and health plans.
- PLHP (D) component may use the contents of the MCPHIE and CME project and LHR repository to formulate a generic plan called LHP.

Given these points, the LHR repository, which correlates each episode of care of an individual into a continuous health record, is the central key delivery of the Malaysian integrated telemedicine application. The CSS and HIMS are the core components of the Malaysian telemedicine project and they principally collect the EMRs for generating the LHRs of individuals. The question is, how is the current framework (the Malaysian pilot telemedicine project — for collecting EMRs and generating LHRs) able to provide the LHR of an individual continuously and seamlessly during possible disasters? In order to answer the above question, the functional requirements for modelling each component (CSS and HIMS) will be presented in the next section.

5.3.1.2 Concept solution requirements for maintaining LHRs

This section explores the activities involved from CSS (creates and collects EMRs) to HIMS (generates LHRs). First, the workflow involved in providing clinical services during a doctor–patient encounter (in healthcare facilities) and the collection and distribution of LHRs at the central system are analysed. The basic definitions of the application systems within the component (CSS and HIMS) are examined, at which point it should be possible to map the relevant parts of the workflow to the corresponding application systems. This will give an idea of what data objects or information are required and how the application systems will support the intended telemedicine framework. For this purpose, the analysis will continue to discuss the CSS and HIMS workflow in detail in the next section. In each component, the analysis process will focus on the workflow and map it to appropriate applications and discover the suitable data objects for developing the LHR components and structure.

5.3.1.2.1 Clinical support system (CSS)

Clinical services refers to the process of providing medical diagnosis and treatment for the patient who visits the healthcare centres for treatment. The clinical support system provides support for clinical and administrative services at healthcare centres and for creating electronic medical records (EMRs), which directly contributes towards the creation of lifetime health records (LHRs).

The clinical support system is crucial to providing decision support for the clinician during a consultation and diagnosis process (Hovenga et al., 1996). Support is required by the clinician in order to provide a high level of professional care and accurate diagnosis and treatment. Timely and seamless access to a patient's past medical record would ensure a continuum of care. Hence, the major requirement of the CSS is to be able to retrieve past medical records seamlessly from the same healthcare centres as well as from other healthcare providers. Before the researcher jumps for an alternative solution for a flexible framework to update the LHRs, it is perhaps best to have a look at the workflow involved in a consultation and diagnosis process using CSS.

5.3.1.2.1.1 Analysing the consultation and medical diagnosis workflow

Since the 1980s, continuous efforts have been made to exploit computers to enhance the collection, distribution and interpretation of patient data (Szirbika et al., 2006). These have involved a process of consultation and medical diagnosis during a doctor–patient encounter. The consultation and medical diagnosis process is a centre for building up and collecting the patient's medical record. It is important to explore this process and it provides important inputs for evaluating and identifying the alternative framework. For getting an idea of the consultation and diagnosis workflow in an outpatient clinic in the Malaysian public healthcare system, it is first best to look into a typical workflow for the process in Figure 5.2.

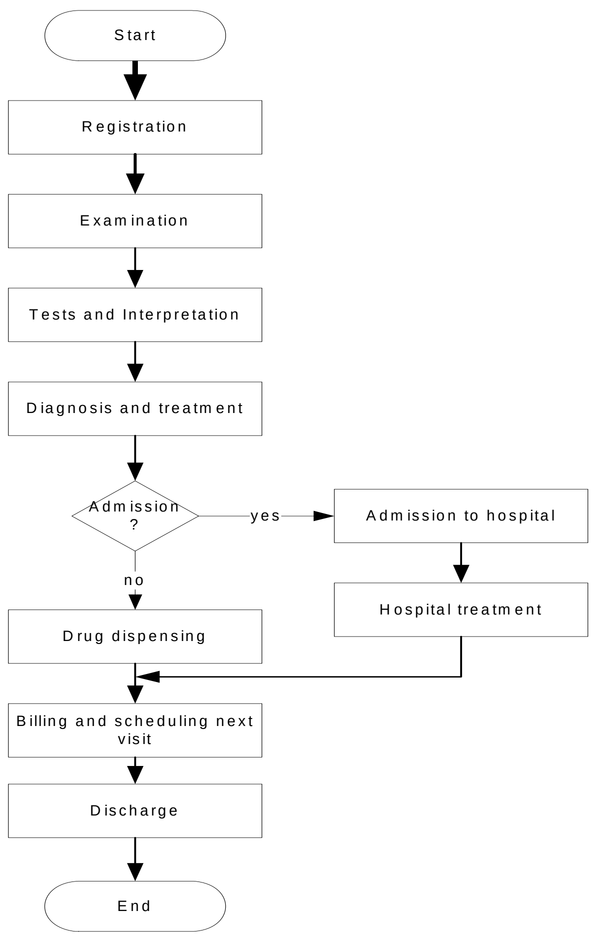

Figure 5.2: Typical Clinical Consultation and Diagnosis Workflow

The above workflow is based on a typical consultation process in outpatient clinics of MOHM. The workflow is a combination of processes from various levels of healthcare facilities that include primary care centres, health clinics and polyclinics, secondary or state hospitals and tertiary hospitals. Some healthcare facilities have fewer processes but the basic processes are covered for facilitating the consultation and medical diagnosis process.

In summary, the clinical consultation and diagnosis workflow starts when the patient comes for a clinical visit. The patient first has to register at the registration counter before he gets to see the doctor in the consultation room. The doctor performs an examination and if necessary orders for tests and an interpretation be made. These tests and investigations are normally carried out by clinical laboratories and a radiologist with the results and interpretation being returned to the doctor. The doctor makes a diagnosis and recommends the appropriate treatment based on the results and recommendations made by the pathologist and radiologist. Once the patient's diagnosis is decided on the treatment drugs may be prescribed if the patient is an outpatient, or else the patient will be admitted to the hospital for acute treatment. After receiving treatment, the patient may be billed or the treatment may be free of charge. The necessary appointment is scheduled before the patient is discharged.

The above explanation will continue with mapping to appropriate applications for supporting the workflow.

5.3.1.2.1.2 Analysing the workflow to application systems

There are two principal roles of the CSS applications. One is to assist in the workflow of practitioners at tertiary centres, polyclinics and primary care centres as well as to build up the

EMRs which will then contribute towards building the LHRs (Ministry of Health Malaysia, 1997e). These roles would be realised by replacing all paper-based medical records (MRs) with EMRs; these records must be made available at all times and anywhere. In this section we will continue to identify the candidate application systems by mapping the workflow to appropriate applications. The basic definitions of the various CSS components will be described according to the workflow depicted in Figure 5.3.

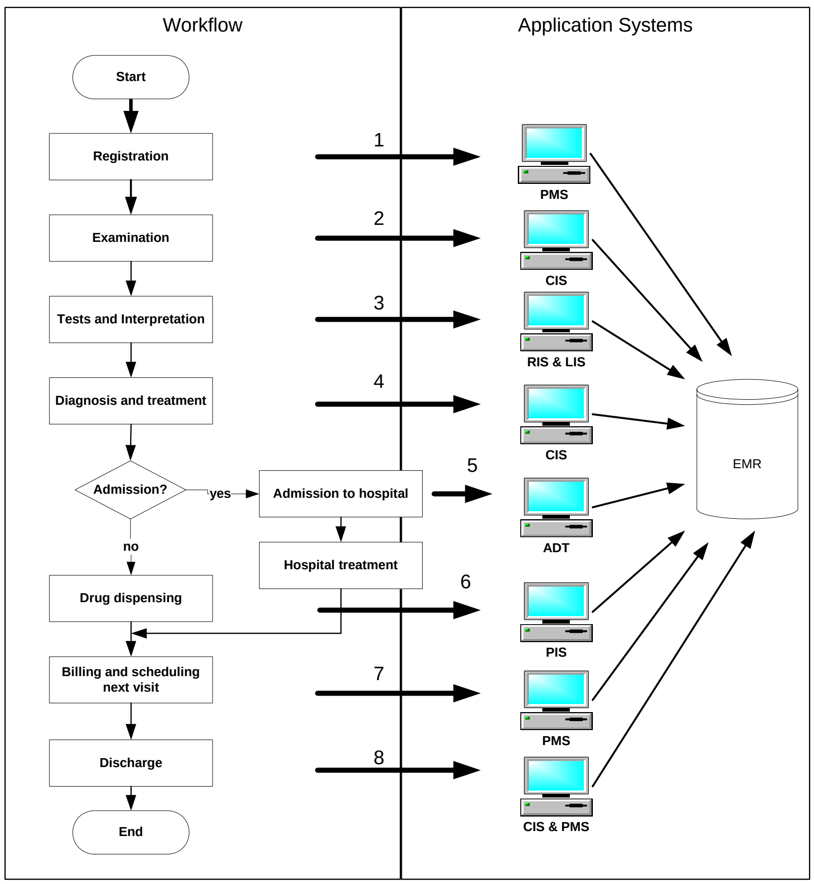

Figure 5.3: Consultation Workflow to Application Systems.

Patient management system

The first (1), seventh (7) and eighth (8) stages of the workflow, for the consultation can be mapped into the patient management system (PMS). This component takes care of all administrative functions at the registration centre, such as registering the patient's visit for the day, maintaining the patient's profile, scheduling of appointments and billing. A very important point is that this component takes care of the patient's entire demographic information; as such the component provides the patient's information necessary for clinical consultation and diagnosis.

Clinical information system

The next process, second (2) and fourth (4) stages of the workflow, can be mapped into the clinical information system (CIS). The CIS component mainly supports the administrative routines of the clinical processes in the workflow. This is where the data entry and retrieval of the patient's health record is done for viewing past visits, medical history, physical examinations, tests and interpretation and diagnosis and treatment. At the end of the consultation and diagnosis process the clinical findings and discharge summary will be stored in the EMR repository.

Laboratory information system and radiology information system

The third (3) process supports all the jobs at clinical laboratories and at the radiology department. The laboratory information system (LIS) and radiology information system (RIS) carry out tests on samples and examination orders delivered to them. The systems receive test orders via CIS and return the results of the requested analyses through the local area network (LAN) channel of the hospital.

Admit, discharge and transfer information system

In certain circumstances the patient suffers with a serious case of illness (critical diseases) and requires intensive treatment. The doctor recommends that the patient is admitted into the ward. This stage of the workflow (5) can be mapped to the admit, discharge and transfer information system (ADT). The component basically supports the administrative routines of the inpatient process in the workflow.

Pharmacy information system

Finally, the sixth (6) stage of the workflow could be mapped to the pharmacist information system (PIS). PIS supports pharmacists at the level of tertiary care and in hospitals, healthcare centres, polyclinics and primary care centres. The pharmacists receive prescriptions from healthcare professionals via CIS, prepare the drugs requested and check drug interactions and compatibilities.

At this stage, the basic processes of the consultation and medical diagnosis at hospitals and primary centres could be understood. It is also clear from the discussion above that the CIS is the main role within the group of CSS applications that houses the EMRs and then creates LHRs. The important point here is a suitable framework is required to ensure that the LHRs or EMRs can be accessed at appropriate times, and continually and seamlessly, during the consultation and diagnosis process anytime and anywhere. The functions and data objects of the CSS applications to be stored and manipulated for creating LHR datasets will be given in the next section.

5.3.1.2.1.3 Analysing functions and data objects

The previous section discussed the activities in the consultation workflow and showed how the workflow is mapped to the appropriate applications for supporting the consultation and diagnosis processes. In this section the suitable/critical datasets required during the consultation and diagnosis processes will be identified and defined. The identified datasets would be used to support the proposed framework and for forming the standard LHR structure. In the following table, the minimal functions and datasets for CSS are listed in a high-level format (by indicating the attribute's name).

Minimal functions and data objects for CSS		
Application	Possible functions	Data objects
PMS	• Patient registration • Appointment • Billing	The administrative component of EMRs, minimally the following: – Basic attributes of patient demographics include **(*name, identification certificate, date of birth, gender, race, religion, occupation, address, telephone number,* etc.)** – Next-of-kin information includes **(*emergency contact person, relationship, address, telephone number,* etc.)** – Appointment information includes **(*date and time of visit, doctor's name, type of case,* etc.)** – Billing information includes **(*government servant, insurance, self-paid*)**
CIS	• Do consultation • Order investigation/test • Order prescription	The clinical component of EMRs, minimally the following: – ***Diagnosis or problem*** – ***Signs and symptoms*** – ***Blood information*** – ***Allergy information*** – ***Onset date of problem*** – ***Lab test information*** – ***Radiology report*** – ***Medication information*** – ***Social history*** – ***Immunisation record*** – ***Family history*** – ***Disability information*** – ***Recent vital signs, etc.***
LIS	• Manage test orders • Manage data entry for laboratory test results and retrieval of EMRs	The laboratory components of EMRs, minimally the following: – ***Date and time of test*** – ***Test result*** – ***Test report*** – ***Type of test***

		– ***Number of test taken*** – ***Place and location of test done***
RIS	• Manage radiology order • Manage radiology data entry and retrieval of EMRs	The radiology component of EMRs, minimally the following: – ***Date and time of studies done*** – ***Study reports*** – ***Parts of body examined*** – ***Name of interpreter*** – ***Number of pictures taken*** – ***Place and location of studies done***
PIS	• Manage prescription order • Manage drug dispensing • Manage drug stock and retrieval of EMRs	The prescription component of EMRs, minimally the following: – ***Start date for taking the drug*** – ***Drug's name*** – ***Dosage*** – ***Frequency of taking the drug*** – ***Place and location the drug is taken***
ADT	• Manage ward • Manage patient discharge and retrieval of EMRs	The ADT component of EMRs, minimally the following: – ***Ward information*** – ***Date admitted*** – ***Date discharged*** – ***Etc.***

Table 5.1: Minimal Functions and Datasets for CSS

At this point the high-level functions and attributes that could be involved and required in the consultation and diagnosis workflow have been defined and presented. In order to enable the LHRs to be accessed anytime and anywhere, the LHR repository should be hosted and managed centrally by the application system, namely the health information management and support. The workflow of the system will be discussed in the next section.

5.3.1.2.2 Health information management and support (HIMS)

Like the CSS, the HIMS is also a set of applications and it has essentially two roles:

i) to create LHRs, which are critical for the basis of telemedicine services

ii) to create a health group data warehouse for policy makers and various healthcare institutions.

To achieve the goal of global information sharing, the health information systems must be able to integrate and communicate with one another (Roman et al., 2006). The medical record generated from different applications and locations should be hosted at a central location for accessibility anytime and anywhere. The creation of LHRs will be done by means of linking and integrating the summary of EMRs from various CSS applications as well as from paper medical records converted to EMRs.

The LHR repository requires an information system for ensuring the completeness of an individual's medical history in a health data warehouse. Hence, a principal target for the HIMS applications is to create as many LHRs as possible so that it is able to provide access to LHRs from CSS users thus giving the full set of integrated patient health records for a given patient regardless of time and location. This should help healthcare professionals to make better diagnoses and provide better treatment when compared to when they have to refer to episodic medical records that are essentially restricted to data available at the same healthcare centres only.

5.3.1.2.2.1 Analysing the HIMS workflow

As explained earlier, HIMS is responsible for managing the collection and the distribution of LHRs, and this summary of medical data is used by medical practitioners at healthcare centres, and the policy makers and health planners would prefer to see final reports such as health indicators and statistics. Hence, the workflow of HIMS would be referring more to the process of EMR collection for the generation of an LHR repository than to the workflow at healthcare centres. Within this context, below are the three activities involved in the HIMS workflow.

- LHR collection
- LHR management
- Health data mining

LHR collection

The workflow starts with the collection of LHRs from various healthcare facility centres such as hospitals and primary care centres. The LHR is the central key delivery point of the Malaysian integrated telemedicine application (Ministry of Health Malaysia, 1997d). The LHR consists of all episodes and encounters of an individual from all healthcare centres since birth. The LHR correlates each episode of care for an individual into a continuous health record. The LHR is the summarised health record of every individual compiled from their electronic medical records. The electronic medical records refer to a patient's medical records that are cumulatively derived from the clinical support system (such as the clinical information system, laboratory information system, pharmacy information system and patient management system) and they can be collected and gathered from the various spectra of health information systems and healthcare levels (EMRWorld, 2006; Coiera, 2003; Bates et al., 2001). The most important consideration, however, is that the LHR should not only contain longitudinal health summary information but also incorporate the on-line retrieval of a patient's health history whenever required. When the LHRs are generated and stored in a proper data store system, the LHR repository has to be managed and maintained.

LHR management

The LHR repository will have to be managed by HIMS in terms of security, data integrity and the retrieving and storing process. This is an important activity as the LHR repository is precisely the nerve centre of the Malaysian telemedicine project, and so such issues as data integrity and security are imperative.

Health data warehouse

The useful and effective delivery of healthcare services depends on the ability to deliver appropriate and proactive value-added services to different client segments on a timely basis. Irrespective of the access enablers, distribution channels and technology employed, the services need to be packaged according to usage patterns, demographics and behavioural psychographics (Ministry of Health Malaysia, 1997a). Such studies can be precisely part of the services offered by the health data warehouse. However, in this research the researcher is not going to discuss further details about the health data warehouse as it is out of the research focus.

At this point, it should be understood that the creation process of LHR depends mainly on the availability of EMRs from various healthcare centres. In fact, the LHR is not only a subset of the EMR but it also provides the possibility of online retrieval of all the details of the EMRs. As such, a suitable framework is required to ensure the continuous and seamless upkeep of patient health records (EMRs and LHRs).

The next section will map the HIMS workflow to appropriate applications that can be used as important inputs for identifying data objects and proposing the alternative framework for maintaining LHRs continuously.

5.3.1.2.2.2 Analysing the workflow to possible application systems

The HIMS workflow can be made up of the following set of applications. Firstly, the LHR collection can be mapped to the LHR collator application where it puts together an episode summary of EMR to form a single fully integrated LHR for each individual. The final LHR will contain all EMR summaries for that person in chronological order from birth to the current date as well as some form of summary (lifetime health summary) that is required for easy reference (Abd Ghani et al., 2007). Obviously, the HIMS needs to be active at all times because the LHR contents need to be updated with every new encounter at various healthcare centres.

Secondly, the LHR management should be mapped to the health record management application (HRM) where its major concern is managing the data retrieval and distribution from the LHR repository to CSS's users at healthcare facilities (healthcare professionals, nurses, etc.). In addition, the HRM is also responsible for managing the integration services, reference datasets, transactions and access.

Finally, data mining can also be mapped into a HRM module where it makes use of data in the LHR repository to produce value-added health group data services for researchers, policy makers and health planners. Figure 5.4 depicts the HIMS workflow mapped to the application systems.

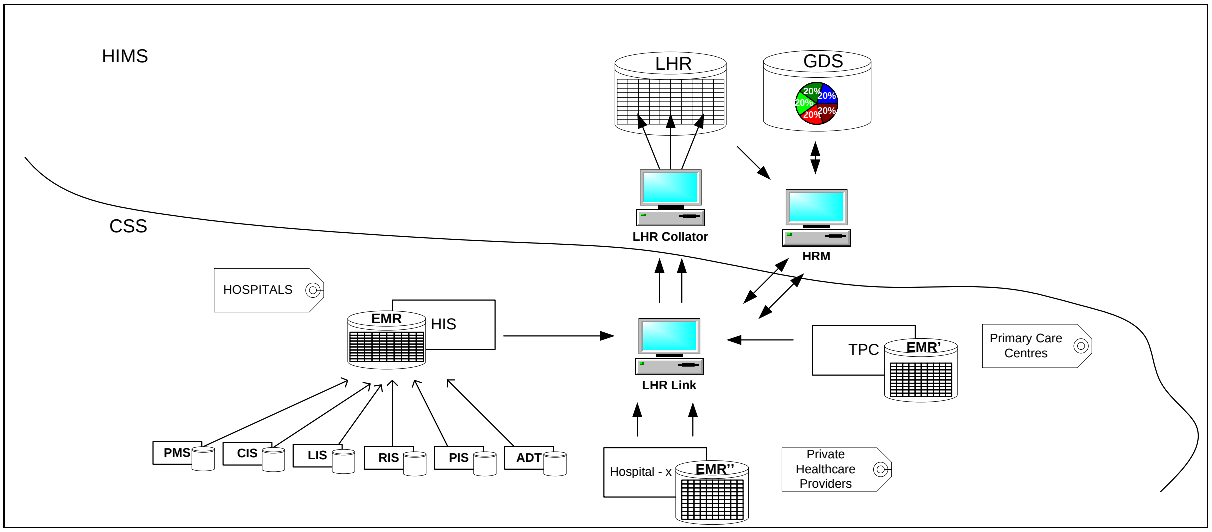

Figure 5.4: HIMS Workflow and the Applications

5.3.1.2.2.3 Analysing functions and data objects

This section presents and gives an indication of the functional requirements of the LHR collator and HRM, and defines the suitable datasets for forming the LHR components and structure. The format for this table is slightly different from that for the CSS applications mainly because this cluster of applications requires many other types of support to ensure success. The format of the table is explained as follows.

- Functions — the basic functions required of the said sets of applications
- Support needs — functions required from external sources
- Enablers — types of application and infrastructure technology required to support the main function
- Technical — some further details of the main function, and
- Data object — the data elements involved/required for performing the functions.

Functions	Support needs	Enablers	Technical	Data objects
LHR repository • LHR collection • Storage • Archiving	• Data centre organisation • Network communication infrastructure • Security, policy and enforcement group	• Enterprise management system • Network management system • Database management system • Performance management system	• Data entry at source • Dataset guidelines, protocols and format (e.g. DICOM, HL7, CTV3, etc.)	• ***Patient identification number*** • ***Patient demographics*** • ***Discharge summary/clinical notes***
HRM – access capabilities and data distribution • Who, how, what, when and where • Management of user groups	• 24 hours online • Network communication infrastructure	• Network management system	• Online 24 hours • Open system standards • Telecommunicat-ion network infrastructure • Dataset guidelines, protocols and format • Possible portable storage devices	• ***Patient demographics (name, identification number, DOB, allergy, blood type/rhesus)*** • ***Patient problem summary (disease e.g. hypertension, diabetes; chief complaint e.g. fever; condition e.g. pregnant; disability e.g. deaf, blind; social problem e.g. smoking, substance abuse; date of onset; date of resolution)*** • ***Patient episode summary (episode list, date of visit, healthcare facility name, test ordered, treatment ordered***
• LHR integration/ link	• Network communication infrastructure • Security, policy and enforcement group	• Network management system • Broadband • GSM	• Online 24 hours • Open system standards • Telecommunicatio n network infrastructure • Dataset guidelines, protocols and format • Possible portable storage devices	• ***Patient demographics (name, identification number, DOB, allergy, blood type/rhesus)*** • ***Patient problem summary (disease e.g. hypertension, diabetes; chief complaint e.g. fever; condition e.g. pregnant; disability e.g. deaf, blind; social problem e.g. smoking, substance abuse; date of onset;***

				date of resolution) • ***Patient episode summary (episode list, date of visit, healthcare facility name, test ordered, treatment ordered)***

Table 5.2: Minimal Functions and Data Objects for HIMS

5.3.1.2.3 Interface requirements

The interface requirements stipulated in this research are so that the LHR can be shared and maintained continuously across applications and healthcare centres. The application components described do not only have to interface between components but also with other applications within the health ICT initiatives in the MOHM's project such as THIS and TPC. Close integration and interfacing may be further required with other projects under the MSC flagship applications (Mohan and Raja Yaacob, 2004; MSC Malaysia, 2007).

In this research, the interface requirements had a single major role:

- to integrate all applications into a single gateway for managing order requests for a patient's LHR across applications and healthcare facilities.

An order is a request for materials or services, usually for a specific patient. These services include retrieving and maintaining a patient's master information and LHR, medication from the pharmacy, clinical observations from the consultation room or nursing service, tests in the laboratory, food from dietary room, films from radiology, and an order to give some medication (Coiera, 2003; Ministry of Health Malaysia, 2003a). The order request is part of the telemedicine services where it manages the orders across healthcare facilities, either within the healthcare facility (at the CSS level) or enterprise-wide (at the HIMS level). From the functionality perspective, the order request management provides transmission of orders or information about orders between applications that capture the order and other applications as needed (Katehakis et al., 2001; Liu et al., 2001). In order to explain how the interface requirements are derived, the analysis of the interface workflow will be discussed in the next section.

5.3.1.2.3.1 Analysing the interfaces workflow

As explained in the previous section, the interface component is responsible for managing the order request, especially for collecting and distributing the LHRs, and administration and clinical orders across healthcare facilities. The end-users of the interface components are essentially those using CSS applications within the facility and the HIMS application at the central system. Hence, the workflow of interfaces would be referring more to the process of managing the order request within CSS and between CSS and HIMS. This analysis was carried out during the case studies conducted at MOHM. Within this context, the workflow of the interfaces is described by the following four activities.

- Order within facility-based
- Order between facility-based
- Medical record storage management
- Communication management

The phenomenon of the interface workflow will be described in the following section.

How is an order managed within facility-based?

The interface workflow starts once the administration or clinical orders are requested from one department for another in the same or different healthcare facilities. Within a facility, there are two examples of order requests interfacing the administration department and clinical department.

1) When a patient comes for an appointment, the patient has to register with the healthcare centre before he/she gets to see the doctor in the consultation room. It can be realised from the workflow that there are order requests that have to be executed from the administration service to the clinical service, which include a) sending the patient to the consultation/clinical room and b) requesting patient information.

2) Once the patient gets to see the doctor, the doctor consults and examines the patient. The doctor then decides if further tests are necessary. In this process, the possibility of a clinical order request that needs to be executed includes a) viewing the patient's LHR, b) ordering a laboratory test, c) ordering the radiology service and d) ordering the prescription and other related orders.

The above examples of orders occur within the facility that normally provides internal services such as clinical lab tests, imaging examinations and dispensing medication by the pharmacy. From the above discussion, it can be learnt that the integration framework is needed for managing the order requests among departments within the healthcare centre.

How is an order managed between facilities?

Some healthcare facilities may not be provided with clinical support services (for example, lab tests, imaging examination and medication dispensing by the pharmacy). When these services are required they need to be referred to other facilities. Most healthcare facilities also tend to be located at sites quite remote from fully equipped tertiary centres. Such are the situations that give rise to order requests between facilities and applications.

Currently, the majority of orders requested by the various clinics for service providers are processed the conventional way — using a paper-based approach, telephone and fax (Ministry of Health Malaysia, 2003a). An integrated application system solution does not exist across healthcare facilities. Although various healthcare facilities have been installed with ICT applications such as THIS, the applications are only used for specific functions and for specific healthcare facility needs. With this kind of set-up, the requestor and provider cannot communicate and exchange the relevant order-processing information electronically. The requestor is a person or department that requests a service, and a provider is a person or department that provides the requested services (Health Level 7, 2007c).

Looking back at the two examples of managing order requests (register patient and do consultation) within a healthcare facility, the information for patient health records and the clinical support services tend to be located or provided at different healthcare facilities. This is where the orders for viewing patient health records and orders for conducting certain tests could be requested among healthcare facilities across MOHM's healthcare premises. Hence, there is a need to manage service orders among healthcare facilities to provide a timely service or information. Based on the above discussion, it becomes clearer that the integration gateway is needed for managing order request among healthcare facilities.

Medical record storage management

All clinical records created during consultation and medical examination will have to be managed by CSS or HIMS for later clinical references. This is an ideal health ICT infrastructure that needs to be provided. However, most of the healthcare centres in MOHM have dedicated record departments to manage the patient information and clinical records. Some of the doctors in certain healthcare centres provide small books for the patients to keep. The log book is used by the doctor to record consultation findings and the patient's problems. The log book could be used for later clinical references regardless of where the visit is made. Such storage can be precisely part of the portable storage to retrieve the patient's LHR for a continuum of care. From the above scenario, it becomes clearer that storage management could play an important role in ensuring a smooth integration process.

Communication management

To manage order requests amongst facilities across healthcare centres may require an effective communication medium. Communication technologies such as telephones, fax and e-mail are normal practices across healthcare centres in MOHM. E-mail could be used for those healthcare centres that are equipped with an Internet telecommunication network. Nevertheless, the use of Internet applications as a communication medium across healthcare facilities is very marginal (refer to Chapter 4 for survey results on the ICT infrastructure across healthcare facilities). It is my contention that a reliable communication technology should be introduced in healthcare services to ensure that patient LHRs can be maintained seamlessly. From the above discussion, it can be learnt that the appropriate communication technology is one of the important aspects for fulfilling the interface requirements.

5.3.1.2.3.2 Analysing the workflow to possible application systems

Interface requirements described in the previous section could be implemented through the development of an integration solution technology. Looking back at the CSS and HIMS applications described in the previous section, each system has dedicated roles and responsibilities. The CSS is a set of applications designed to support the clinical and administrative functions of healthcare facilities to generate the EMR. HIMS is a set of applications designed to collate, generate, manage and distribute the summary of the patient's health record, that is LHR. The existing architecture (refer to section 5.3.1.1) does not have a proper mechanism for integration. A clear separation in terms of data objects and standard document messaging for integration is not established. A proper integration framework needs to be established for standardising a gateway to send/receive order requests within/between healthcare facilities.

Having discussed the interface requirements, the integration component could be made up of the following set of applications. Firstly, managing orders within a facility could be mapped to the local order management service (LOMS). The major task of LOMS is managing the order request within a facility and acting as a common gateway to access patients' information and LHRs at the central system (HIMS). LOMS acts as a common framework for integration within a healthcare facility and its implementation would be supported using the proposed standard of the LHR dataset. This will be described in section 5.4.

Secondly, management of orders between facilities could be mapped to the remote order management service application (ROMS). Its major concern is managing the enterprise order requests from one healthcare centre to another across MOHM's healthcare facilities. ROMS acts as a common contact for other applications in the same or a different healthcare facility. By way of example, if the order services are located at a different healthcare facility, the orders will be routed first to the central system (ROMS-HIMS) before the ROMS-HIMS forwards the orders to the responsible service providers.

Thirdly, record and storage management could be mapped to a portable storage manager for maintaining patients' information and summaries of health records during the unavailability of the telecommunication network or downtime of the server system. The portable storage manager is software that dynamically controls the availability of the storage device medium. With this flexibility, the patients' health records could be accessed from the patient at his or her convenience or from the local hard disk of the physician.

Fourthly, communication management could be mapped to messaging services where they serve as the communication rescuer in case a breakdown happens to the landline telecommunication network. The messaging services send and retrieve order requests regarding the summary of patient health records and patient master information through a global system for mobile (GSM) communication and short message service (SMS) (Abd Ghani et al., 2007).

Figure 5.5 depicts the interface workflow mapped to the application system. The diagram shows the scenario where the Seremban Hospital has placed the LHR order for a particular patient to be produced at Hospital Kuala Lumpur (HKL). In order to describe the workflow, the following scenario is used as an illustration.

At Seremban hospital:

Patient A lives in Kuala Lumpur and he is on a holiday in a hotel somewhere in Seremban. Suddenly, he feels discomfort in his chest and decides to go to the nearest hospital, which is Seremban Hospital. On registering and seeing the doctor, the patient's background information and medical history are not found in Seremban Hospital. His past medical records have been kept in Hospital Kuala Lumpur (HKL). The doctor in Seremban Hospital uses the CIS system to request the patient's past medical records by placing a LHR order to HKL through ROMS at the remote system.

At HKL:

When LOMS at HKL connects to the remote system, it will receive Seremban Hospital's order message. The order message is viewed and the doctor at HKL authorises the doctor at Seremban Hospital to share and use LHR information. The response order message is built up and sent to Seremban Hospital through ROMS at the remote system.

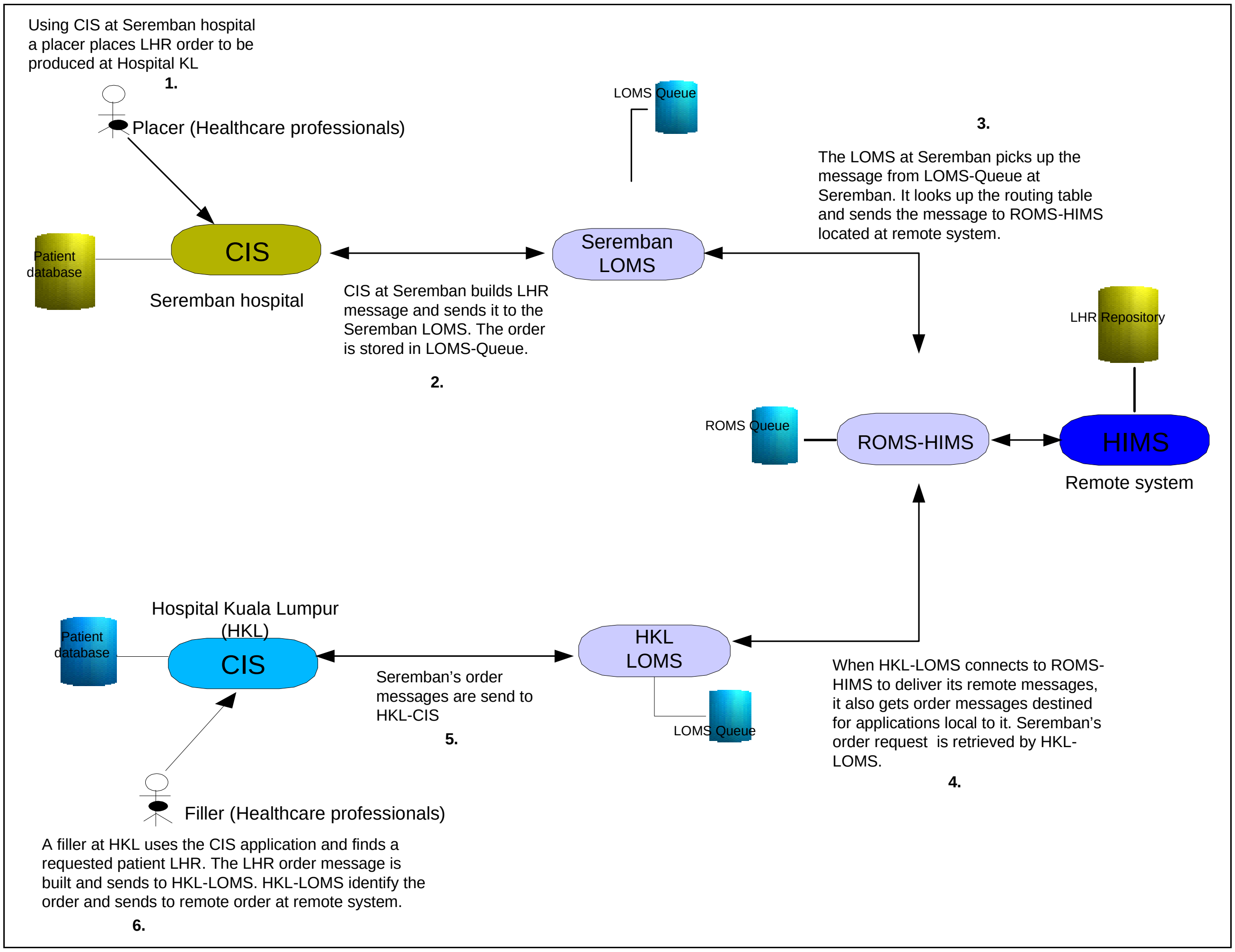

Figure 5.5: Interface Workflow Mapped to the Application System

5.3.1.2.3.3 Analysing functions and data objects

This section presents the functional requirements of LOMS and ROMS and defines the suitable datasets for forming the LHR components and structure. The format for this table is slightly different from that for CSS and HIMS applications mainly because the interface application requires the identification of other components to be integrated. The format of the table is explained as follows.

- Components — identified application components to be integrated

- Interface requirements — statements of requirements that it is essential to satisfy
- Data object — the data elements involved/required for performing the interface requirements and data sharing.

Components	Interface requirements	Data object
1. Across CSS applications	• There must be a seamless integration across CSS application systems • The collection/linkage of data to populate the EMR and LHR should be automatic and transparent to the user	• ***Patient identification number*** • ***Patient demographics*** • ***Discharge summary/clinical notes***
2. Between CSS and HIMS application systems	• There must be a seamless integration across CSS and HIMS • There must be tight data integration requirements for the formation of LHRs • CSS will be the main set of application systems that provide data to create LHRs • HIMS will need to have full access to all LHR data transmission paths in order to be able to fully manage and supply operational services for users	• ***Patient identification number*** • ***Patient demographics*** • ***Discharge summary/clinical notes***
3. Between the telemedicine project and other applications: a. THIS b. TPC	• Interfacing points to the LHR repository are mainly through HIMS components • If employed, it is expected that a standard LHR document messaging will be used	• ***Patient identification number*** • ***Patient demographics*** • ***Discharge summary/clinical notes***

Table 5.3: Minimal Functions and Data Objects for Interface

5.3.1.3 Summary of the system analysis

At this point the overall picture of the consultation and medical diagnosis workflow in outpatient clinics (CSS-EMRs) and LHR (HIMS-LHRs) collection processes have been described and presented. Evidently, it is critical to maintain the patient health records or EMRs because they are a source of information for other health record structures, especially for generating the LHR repository. Therefore, the continuity and the integrity of EMRs and linkages to the LHRs have to be established first. According to Coiera (2003), the more the doctor knows about his/her patient, the more knowledge he/she will gain to identify his/her patient's problems and the more accurate will be the treatment given. As a result of the system analysis, the applications system and data objects have been introduced and identified. This information would be used to design the LHR components and structure that could support the intended telemedicine framework.

With all the previous discussions in mind, the following section presents the discussion of the findings from the data collection of an analysis of a patient's demographic and clinical data obtained in an outpatient clinic.

5.3.2 Analysis of Patient Demographic and Clinical Data in Outpatient Clinics

To analyse further the appropriate and relevant patient health records to be retrieved, viewed and stored during doctor–patient consultations and medical diagnoses, structured interviews were carried out at outpatient clinics of MOHM for collecting accurate evidence for the case under study (analysis of patient demographics and clinical data). The analysis of patient demographic and clinical data was carried out using 30 doctors in various healthcare centres and polyclinics across the country. The respondents were interviewed by way of structured interviews and each of the interviews lasted 60 minutes. The interviews were carried out by the research assistants who had medical knowledge and experience.

5.3.2.1 Discussions of the findings from the primary data collection

When I first met the doctor in the outpatient clinic to conduct the interview, doctor ABC apologised for turning up ten minutes late as he had to consult the last patient before the clinic was closed for a one-hour break at 1.00pm. "*We have two hands to manage hundreds of patients daily*" said doctor ABC after the last notes were written on the prescription slip of her last patient. Although she was busy with her huge responsibility for managing patients daily in the outpatient clinic, she was very cooperative. This was one of the scenarios of the research process when conducting the interviews with the doctors in outpatient clinics. Time management, physiology and smart appearance were critical elements to be taken into consideration when handling uncertain situations (emergency cases). Finally, I managed to conduct the interview and collect the important data and evidence from 30 doctors in 30 different healthcare centres across states in Malaysia. The data were transformed, summarised and presented in a graphical format.

The first part of the questionnaire focused on the general knowledge of the doctors regarding health ICT and health informatics initiatives. Approximately 81% of the doctors had previously heard about health ICT and health informatics and 19% answered that they had never heard of them (refer to Figure 5.6). However, when the doctors were asked about the telemedicine, telehealth and e-health applications, the majority of them (94%) said that they had heard about the applications and only 6% answered they had never heard of them previously (refer to Figure 5.7). The statistics gave a good indication that the majority of doctors are aware of health informatics and its applications. It is important that this factor is known by the management in order to identify the level of informatics knowledge among the doctors. This factor is also important for implementing the health ICT initiatives in the healthcare system where the training and awareness programmes will be identified accordingly.

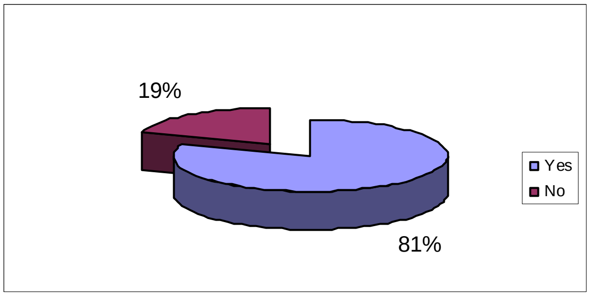

Figure 5.6: The Percentage of Doctors who Had Heard about Health ICT or Health Informatics

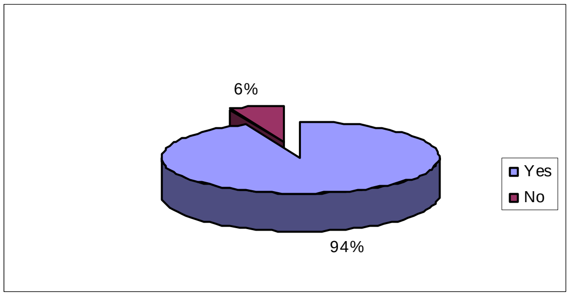

Figure 5.7: The Percentage of Doctors who Had Heard about Telemedicine, Telehealth and E-health

On the other hand, approximately 48% of the doctors answered that they had previously heard about EMRs and LHRs and 52% said that they had never heard about them (refer to Figure 5.8). The small percentage who answered "Yes" might be due to the fact that the term used in the questionnaire was unfamiliar to the doctors.

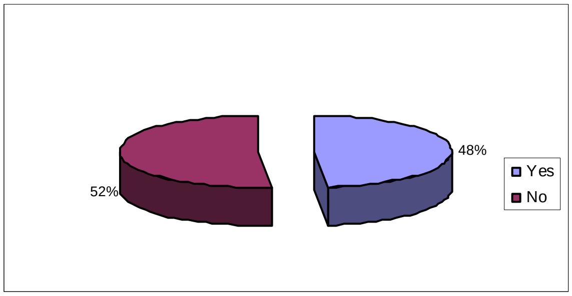

Figure 5.8: The Percentage of Doctors who Had Heard about EMRs and LHRs

Figure 5.9 shows the percentage of doctors who had heard about health ICT project initiatives in MOHM. Approximately 65% answered that they were aware of the project being implemented and developed at the time in certain healthcare facilities nationwide. However, 35% of the doctors did not know about the health ICT project being implemented and developed by the ministry at the time in various healthcare facilities. The doctors reported that most of them were not equipped in terms of ICT facilities (PCs and the Internet) and the nature of their work process meant that traditional methods (by way of a manual system such as pen and paper to record the clinical findings and thick medical reference books to make necessary references) were still ingrained in them when providing healthcare services for the patients. This finding is important for management to take action about in providing the ICT infrastructure and telemedicine application across healthcare centres and levels.

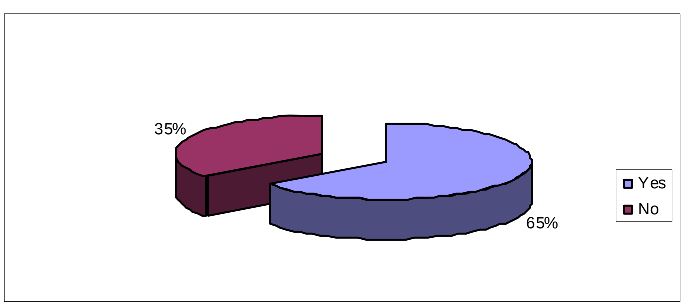

Figure 5.9: The Percentage of Doctors who Had Heard about the Health ICT Initiative in the Ministry of Health Malaysia

A proper way of handling and disseminating patient medical records is crucial for ensuring that the medical history can be accessed accordingly and promptly in future. Figure 5.10 shows that approximately 65% of the healthcare centres had a pre-defined way of creating, accessing and disseminating the patient medical records. However, the remaining 35% of the respondents said "No". This shows that the outpatient clinics still require improvement to enforce the case that all healthcare centres use a standardised process to update the patient health records continuously. These scenarios might have been due to time constraints and workloads faced by the doctors in the outpatient clinics. The main responsibility and priority of the doctors in outpatient clinics was to provide the best and a high quality of patient care.

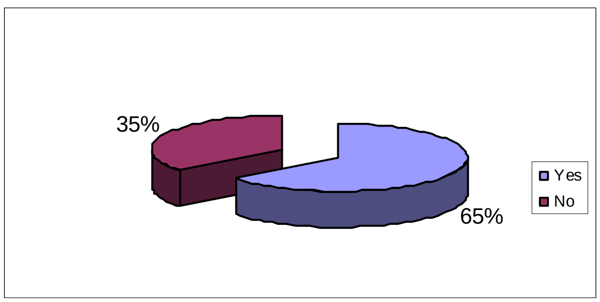

Figure 5.10: The Percentage of Outpatient Clinics that Had a Pre-defined way of Managing Patient Medical Records

The above scenarios were supported by the feedback presented in Figure 5.11, where 90% of the doctors agreed that most of the work was carried out in the outpatient clinics to aid in medical diagnosis and treatment. This indicated that the doctors in outpatient clinics should be provided with a flexible tool for helping them in providing healthcare services and managing the patient health records continuously and seamlessly.

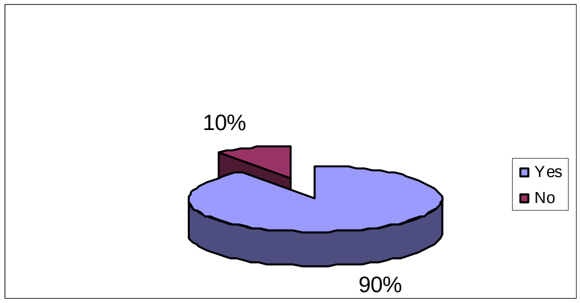

Figure 5.11: The Percentage of Doctors who Agreed that Most of the Work Was Carried out in Outpatient Clinics to Aid in Medical Diagnosis and Treatment

Figure 5.12 reflects the crucial questions asked by the doctors during consultations and medical diagnoses. The current problems (see column B) and past medical problems (see column F) are the most critical questions to be asked by doctors before further treatment is given to the patients (77% strongly agreed). The symptoms and the signs (see column C) when the problems occur (see column E) are also crucial information that the doctors need to know, as around 74% of the doctors said that they strongly agreed with them. This shows that the past health conditions of patients are very important and it is critical to know about them to help the doctors give accurate treatment and a high quality of healthcare services. The correct treatment requires an accurate past medical history and this is why the doctors also asked for the medication information (see column H) and family medical history (see column G) as they are ranked at 65% and 52% respectively. Such information should be available at all times and be accessible continuously and seamlessly. It is vital that integrated LHRs are provided through the telemedicine system for achieving accurate and continuous care.

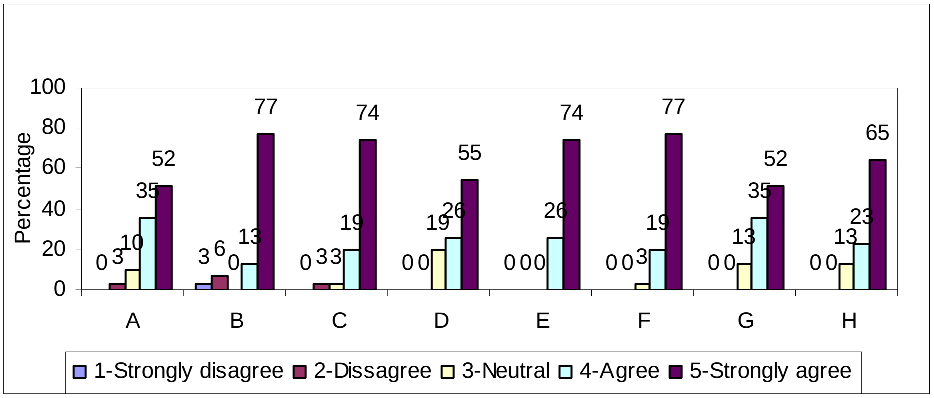

Figure legend:

A	Hello/How are you?
B	What is your problem?
C	Can you tell me your complaints/symptoms
D	How severe is your problem?
E	Since when were you aware of the problem?
F	Can you tell me your past medical problems?
G	Do your family have any chronic diseases?
H	Have you taken any medication before?

Figure 5.12: The Types of Questions Frequently Asked during a Doctor–patient Consultation

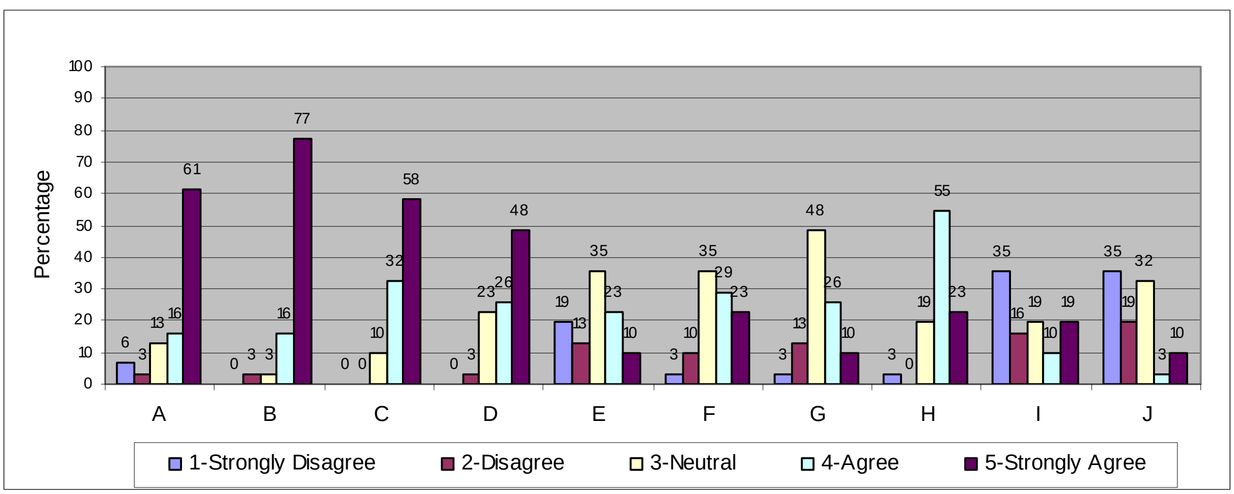

Figure legend:

A	Patient's name
B	Age/Date of birth
C	Sex

D	Race
E	Religion
F	Ethnicity
G	Nationality
H	Occupation
I	IC number
J	Passport number

Figure 5.13: Analysis of Patient Demographic Information to Be Viewed by Doctors during Consultations

Figure 5.13 shows the list of patient demographic information that needs to be known by the doctors during consultations and medical diagnoses. The use of demographic information is to get the biological (such as age and gender) and sociological (occupation, race, ethnicity and religion) background of the patient. According to the interviews with the doctors, they singled out five attributes (marked as A, B, C, D and H in Figure 5.13) that the doctors strongly agreed that they used during consultations and medical diagnoses. The doctors contended that three of the attributes of patient information — 1) name, 2) date of birth and 3) gender/sex — are more common. They elaborated that the patient's name is to ensure the patient's safety by treating the right patient and that date of birth and gender are the best practice guidelines to identify the biology aspects with regards to the medical problems. They also mentioned that the information to do with occupation is to extend the knowledge of the patient's work-related conditions that would contribute to the medical problems.

The majority of the doctors marked religion (35%), ethnicity (35%) and nationality (48%) as "neutral" in that they believe that the information is less important (nice to have) and does not have a major impact on providing treatment for the patients (see columns E, F and G in Figure 5.13). IC number (35%) and passport number (35%) are marked as "strongly disagreed", which means they are less important to the clinical aspect during the consultation process (see columns I and J in Figure 5.13).

The most important point to note from this finding is that not all demographic information is required by the doctors during the consultations and medical diagnoses. The minimum amount of information based on the crucial need could be summarised in simple text so that it could be stored in limited portable storage devices and transported via a limited sized bandwidth network (for example, the use of SMS via GSM digital network).

Figure 5.14 shows the list of patient contact information that could be applied to the LHR summary. The doctors felt that, although most of the communication methods presented were of importance, the hand phone, house phone and home address (see columns A, B and C) were marked as strongly agreed in terms of being known for contacting the patient. The telephone number is important so that the patient can be contacted in case of emergency and the home address is essential for reporting purposes such as epidemic cases.

The doctors elaborated that the e-mail address might also be useful once the LHR is generated and is accessible via the Internet. The patient could be contacted by way of sending and receiving an e-mail to/from healthcare providers/home.

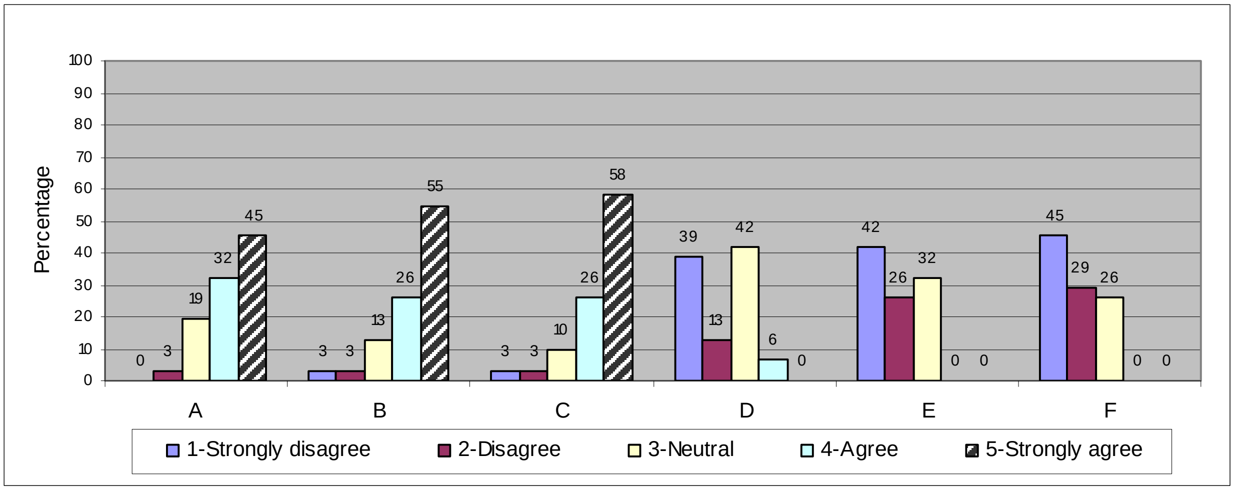

Figure legend:

A	Home address
B	Home phone number
C	Hand phone number
D	E-mail address
E	Fax
F	Pager

Figure 5.14: Analysis of the Patient's Contact Information that Needs to Be Known by the Doctors/Healthcare Providers

Figure 5.15 shows the ranking given by the doctors for the patient's next-of-kin information, which could be useful in the process of consultation and medical diagnosis in the outpatient clinics. The majority of doctors agreed (strongly agreed and agreed) that an emergency contact person, his or her relationship to the patient and the home address (see columns A, B, C and D) of the next-of-kin are required as an alternative way to contact a patient. The doctors contended that the e-mail address, fax number and pager number (see columns E, F and G) are not required and should not be involved in the consultation process. I would say that these attributes of information could be excluded from the proposed LHR.

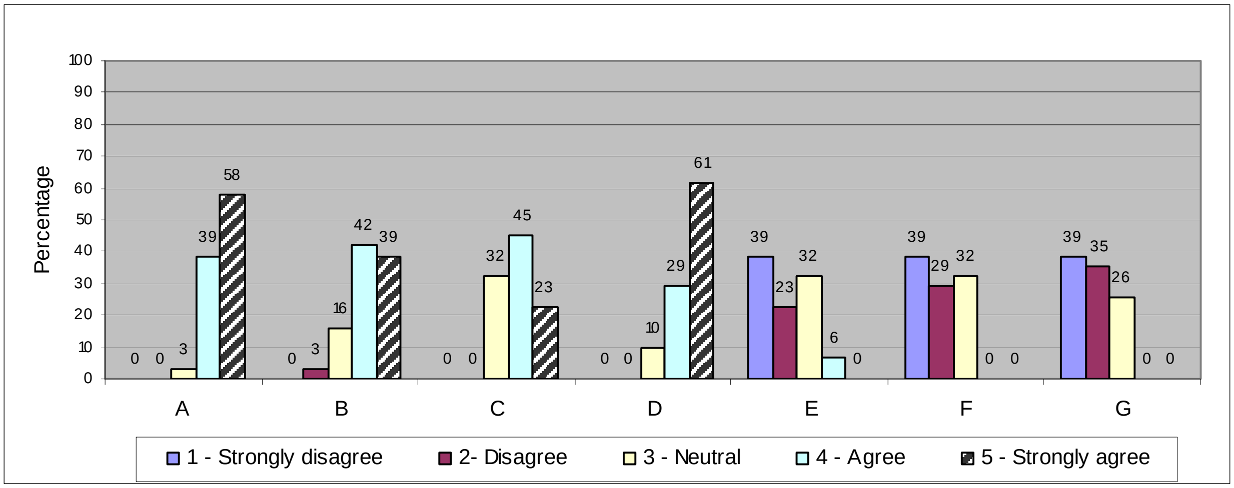

Figure legend:

A	Emergency contact person
B	Relationship to patient
C	Home address
D	Telephone number
E	E-mail address
F	Fax
G	Pager

Figure 5.15: Analysis of the Patient's Next-of-kin Information to Be Viewed by Doctors during Consultations

On the question regarding the importance of doctors viewing patients' medical histories during doctor—patient consultations, the doctors believe that all of the information is crucial for helping them to diagnose patients' problems and to provide the right treatments and accurate medication. Based on the findings given in Figure 5.16, the doctors agreed that blood information, immunisation, disability information, the name of the previous doctor attending to the problem and the previous healthcare facility attended (see columns B, K, M, N and O) are important but still could not be categorised as critical information. The doctors explained that the adoption of this information would only provide administrative advantages rather than clinical advantages.

The doctors ranked diagnosis/problems, allergy information, lab test result, radiology report, medication information, information about complaints, symptoms, vital signs, family history, social history, date of previous visit and onset date of diagnosis (see columns A, C, D, E, F, G, H, I, J, L, P and Q) as strongly agreed. They elaborated that this information provides critical evidence for and knowledge about a patient's health condition in the past. Such information could give the doctors the ability to carry out better clinical prognoses and provide accurate treatments for the patients.

Based on the above findings, evidently, the medical history is crucial in providing high-quality healthcare services for the patient. The doctors also mentioned that the availability of and accessibility to the information would improve patient safety and the efficacy of healthcare services.

Nevertheless, the challenge to be undertaken here is how to simplify the information, and maintain the critical attributes, so that it can be accessed and stored continuously and seamlessly when needed. The information listed in Figure 5.16 could be simplified and categorised into several levels based on the highest percentage of the survey results. Finally, the doctors further pointed out that if the listed medical history information could be provided continuously, the continuum of care could be achieved and the quality of healthcare services would improve continuously.

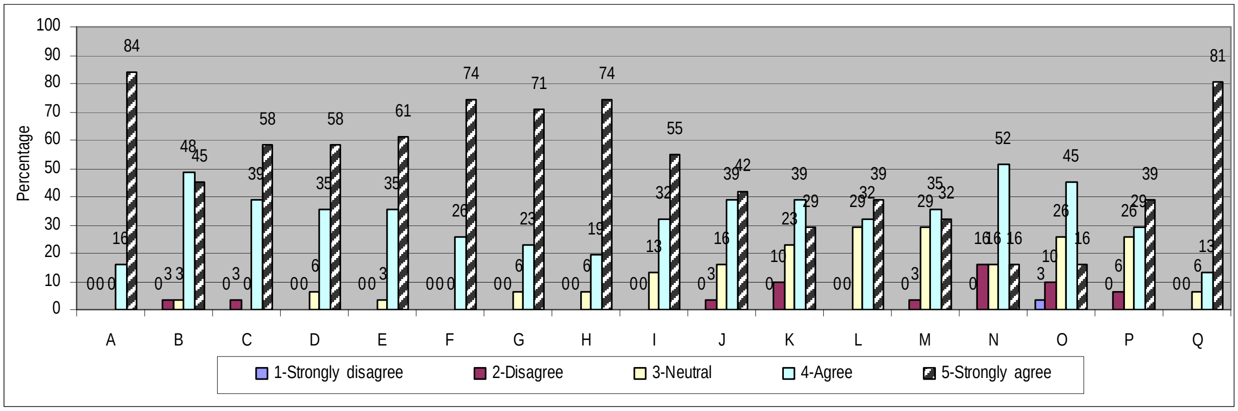

Figure legend:

A	Diagnosis/problems
B	Blood information
C	Allergy information
D	Lab test result
E	Radiology report
F	Medication information
G	Information about complaints
H	Symptoms
I	Vital signs
J	Family history
K	Immunisation
L	Social history
M	Disability information
N	Previous doctor attending to the problem
O	Previous healthcare facility
P	Date of the visit/episode
Q	Onset date of disease

Figure 5.16: List of Patient Medical History to Be Viewed by the Doctors during Consultations

Figure 5.17 shows the percentage of the patient medical notes (clinical findings) that it is critical for the doctors to record. It was strongly agreed that most of the listed clinical findings should be recorded during consultations, except the immunisation information (see column K). The findings show that more than 50% of the doctors strongly agreed that it is critical that the diagnosis/problems, blood information, allergy information, lab test result, radiology report, medication information, information about complaints, date of visit/episode and onset date of diseases (see column A, B, C, D, E, F, G, P and Q) are recorded in patient medical notes.

The doctors stated that although they have a limited amount of time to capture all the information or they are still using manual systems in their routine work processes, they still believe that it is critical that the clinical finding attributes listed in Figure 5.17 are recorded for continuous care. The doctors also said that they prefer a system that can provide a flexible and fast-track approach to viewing and capturing (by cloning the previous records) the patient health records. This would reduce the time and effort they spend on administrative work and would focus more time on providing care services for the patients.

The doctors pointed out that the existing clinical information application was not user friendly and the information required was not readily accessible. This was attributed to the lack of analysis of critical requirements for a patient's demographic and clinical data during the doctor–patient consultation.

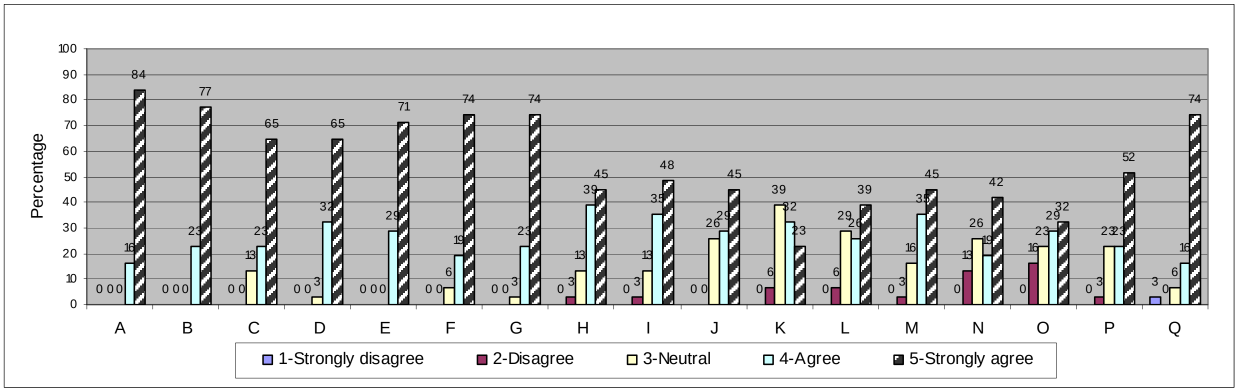

Figure legend

A	Diagnosis/problems
B	Blood information
C	Allergy information
D	Lab test result
E	Radiology report
F	Medication information
G	Information about complaints
H	Symptoms
I	Vital signs
J	Family history
K	Immunisation
L	Social history
M	Disability information
N	Previous doctor attending to the problem
O	Previous healthcare facility
P	Date of the visit/episode
Q	Onset date of diseases

Figure 5.17: List of Patient Medical Notes to Be Recorded by the Doctors during Consultations

Figure 5.18 shows the findings with regards to radiology information that would be useful in providing care during consultation processes. Most of the doctors strongly agreed and agreed that the date and time of studies carried out (52% and 45%), study reports (55% and 45%) and parts of the body examined (58% and 39%) are crucial pieces of information that need to be viewed to gives clues about the patient's condition. The doctors pointed out that the three attributes (see columns A, B and C) are being commonly accessed for medical diagnosis processes. The doctors explained that the date and time of studies carried out provide information about when the last investigation was performed, study reports state the most important findings and parts of the body examined provides information regarding the location of the body part being examined.

The doctors agreed that another three attributes including the name of the interpreter (39%), number of pictures taken (52%) and place or location of studies carried out (45%) are also useful and there was some interest in knowing them. The doctors pointed out, however, that they have observed that these attributes are not considered as being important information. The doctors further commented that these attributes of information would be more beneficial in administrative matters compared to in clinical functions.

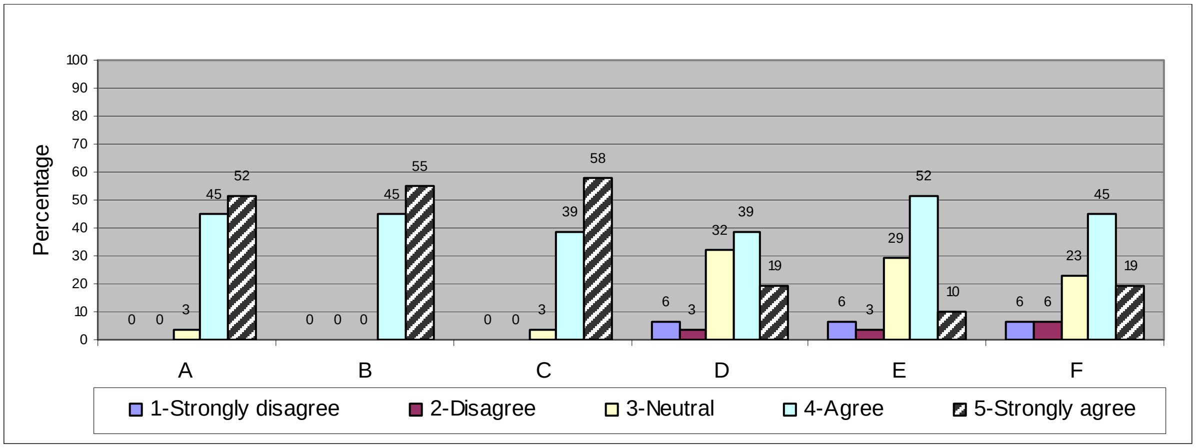

Figure legend

A	Date and time of studies done
B	Study reports
C	Parts of body examined
D	Name of interpreter
E	Number of pictures taken
F	Place and location of studies done

Figure 5.18: List of Radiology Information that Would Be Viewed by the Doctor during Consultations

On the question of which test information is important for assisting in consultations and medical diagnosis processes, the doctors strongly agreed that the date and time of the test (55%), test result (68%), test report (68%) and type of test (65%) (see columns A, B ,C and D in Figure 5.19) are being actively referred to by the doctors. The doctors pointed out that this is attributed to the fact that this information would be able to provide clinical evidence with regard to the problems suffered by the patients.

With regards to the information about the number of tests taken and the place and location of the test (see columns E and F in Figure 5.19), the doctors observed that the attributes are not considered to be important information. From the feedback given by the doctors approximately

26% strongly agreed and 48% agreed that the number of tests taken are important. With regards to the place and location of the test attribute, approximately 19% strongly agreed and 29% agreed that it is important to view the information. The doctors further pointed out that the information is not considered to be part of clinical concerns; it is merely for administrative purposes.

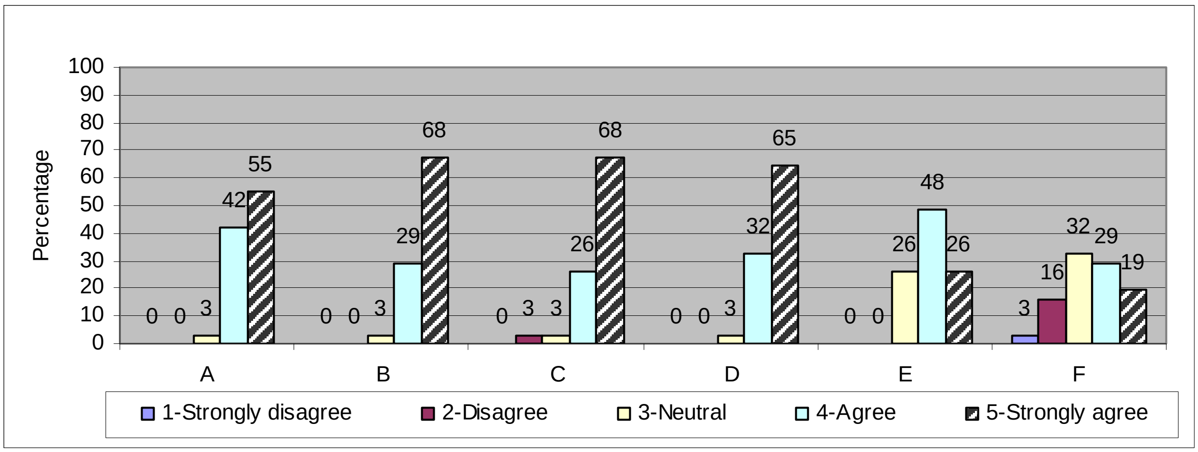

Figure legend

A	Date and time of test
B	Test result
C	Test report
D	Type of test
E	Number of tests taken
F	Place and location of test done

Figure 5.19: List of Test Information to Be Viewed by the Doctors during Consultations

Figure 5.20 shows the perception of doctors with regards to the medication information that influenced the decision outcome of the consultations and medical diagnoses. The doctors pointed out and strongly agreed that the date the drug was first taken (65%), drug name (61%), drug dosage (65%) and frequency of taking of the drug (64%) (see columns A, B, C and D in Figure 5.20) are being actively referred to by the doctors before prescribing the medication. The doctors pointed out that the best practice of preparing the medication is to continue prescribing the medication that has been taken by the patient before. The doctors also mentioned that the listed attributes of medication would avoid clinical mistakes in providing medication especially when dealing with the patients in outpatient clinics.

The findings also showed that the location of the drug taken (see column E in Figure 5.20) is considered less important in consultations and medical diagnosis processes. Approximately, only 19% strongly agreed and 35% agreed that the attribute should be known by the doctors. In fact, 26% were neutral, 13% disagreed and 6% strongly disagreed that it is very important to know about and view the attribute. This was attributed to the fact that each healthcare centre has an internal pharmacy service and normally the prescription would be dispensed in the same healthcare centre. As such, the location of the drug taken can be referred to at the healthcare facility that is visited by the patient.

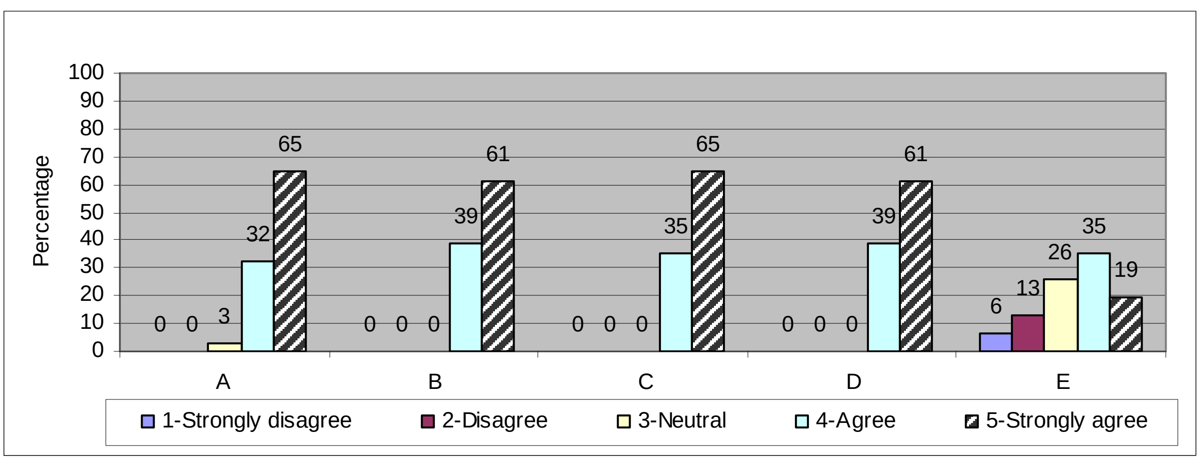

Figure legend

A	Date of starting the drug
B	Drug’s name
C	Dosage
D	Frequency of taking the drug
E	Place and location the drug was taken

Figure 5.20: List of Medication Information to Be Viewed by the Doctors during Consultations

Figure 5.21 shows the referral information that it would be important to note in the referral report and that was presented to the doctors to validate. The result of the survey showed that the doctors strongly agree that the patient’s demographic data (65%), purpose of referral (77%), diagnosis (84%), medical history (74%), symptoms (77%), allergies (55%), initial test result report (65%), radiology report (65%), medication information (65%), information about complaints(68%), vital signs (48%), name of the healthcare facility referred to (39%) and onset date of diseases (74%) are ranked as important information to report in the referral report (see columns A, C, D, E, F, G, H, I, J, K, M, P and Q in Figure 5.21). The doctors commented that this information should be digitised so that it could be transported across healthcare facilities electronically. The patient demographic and health record information described previously would give invaluable information about the patient to the referring doctor or healthcare provider.

The doctors further pointed out that the remaining attributes (see columns B, L, N, O and P in Figure 5.21) are observed as less important for providing the best referral report to the referring centre. The doctors explained that the name of the medical officer referred to and the name of the healthcare facility referred to are more beneficial for the administrative purposes. They pointed out further that the information about immunisation, social history and family history is not considered to be important for referral purposes and this could be acquired personally from the patient.

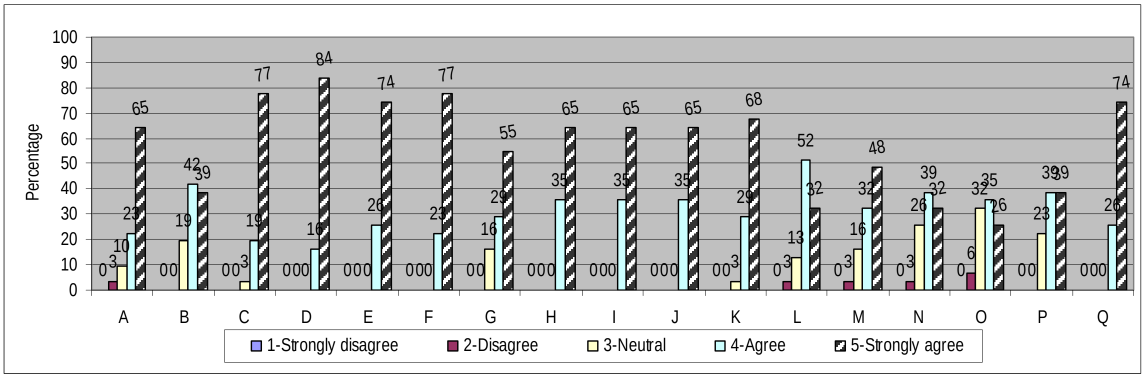

Figure legend

A	Patient's demographic data
B	Name of the medical officer referred to
C	Purpose of referral
D	Diagnosis
E	Medical history
F	Symptoms
G	Allergy information
H	Initial test result report
I	Radiology report
J	Medication information
K	Information about complaints
L	Family history
M	Vital signs
N	Social history
O	Immunisation
P	Name of the health facility referred to
Q	Onset date of diseases

Figure 5.21: Most Important Medical Information to Be Reported in the Referral Report for the Referral Case

With respect to the question regarding the referral method preferred by the doctors, approximately 65% of them strongly agreed and 35% agreed that the paper-based referral letter is still a preferred method for managing a referral process. The doctors pointed out that telephone is also a means of communication to manage the clinical referral as 42% agreed and 32% strongly agreed with this (see column A in Figure 5.22). This is attributed to the fact that the ICT infrastructure and applications have not been fully implemented across healthcare centres and levels. The doctors explained that this is why there is not much interest in using the e-mail application as a means of communication to manage the referrals. The e-mail application was ranked as strongly agreed and agreed, both 19% of the doctors in both cases (see column B in Figure 5.22).

The findings from the data collection also noted that there is a considerable interest in ensuring that the knowledge (health records) sharing through web-based application becomes an integral part for most healthcare providers and professionals. Approximately 29% of the doctors strongly agreed and 35% agreed with the web-based application method (see column C in Figure 5.22). However, this attitude differed from doctor to doctor, from healthcare institution to healthcare institution and the prevailing organisational culture.

With regards to the remaining attribute (see column E in Figure 5.22), facsimile was looked at as a low priority in terms of a method for managing the referral process across healthcare centres. The doctors commented that the privacy and confidentiality of patients' health records would not be protected when using facsimile machines. Only 16% of the doctors strongly agreed and 29% agreed that the facsimile is a means for referral processes, while 29% disagreed and 23% were neutral with regards to this method.

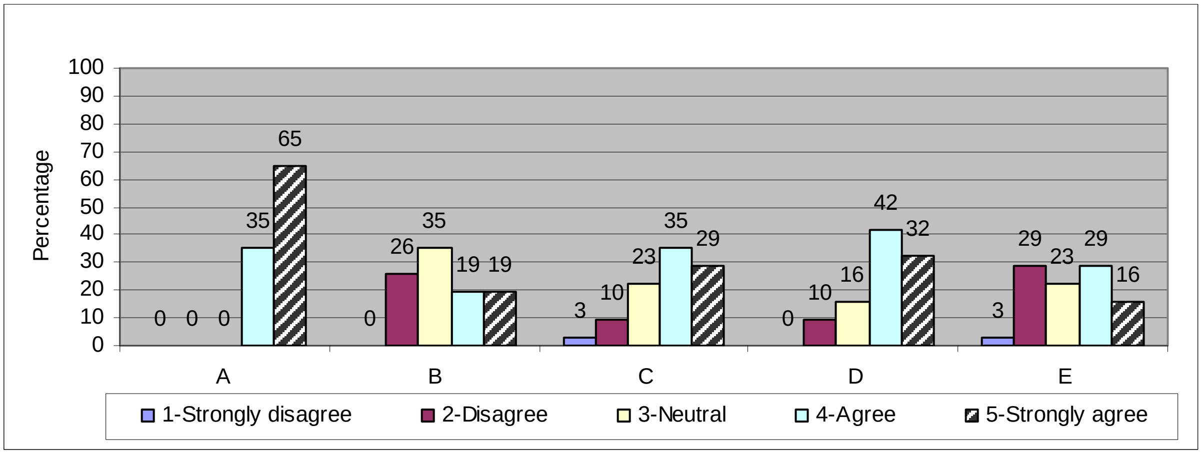

Figure legend

A	Paper-based referral letter
B	E-mail application
C	Web-based referral system with the ability to link to EMR
D	Telephone
E	Facsimile

Figure 5.22: Referral Method Preferred by the Doctors

Figure 5.23 shows the doctors' opinions about methods for accessing patients' medical records. The doctors pointed out that the manual system (see column A in Figure 5.23) is the most difficult method for accessing patients' medical records. The findings showed that 19% of the doctors strongly agreed and 39% agreed that the manual system is a difficult method compared to a computer system (see column B in Figure 5.23), and only 3% strongly agreed and 16% agreed that the computer system is a difficult method for accessing patients' medical records.

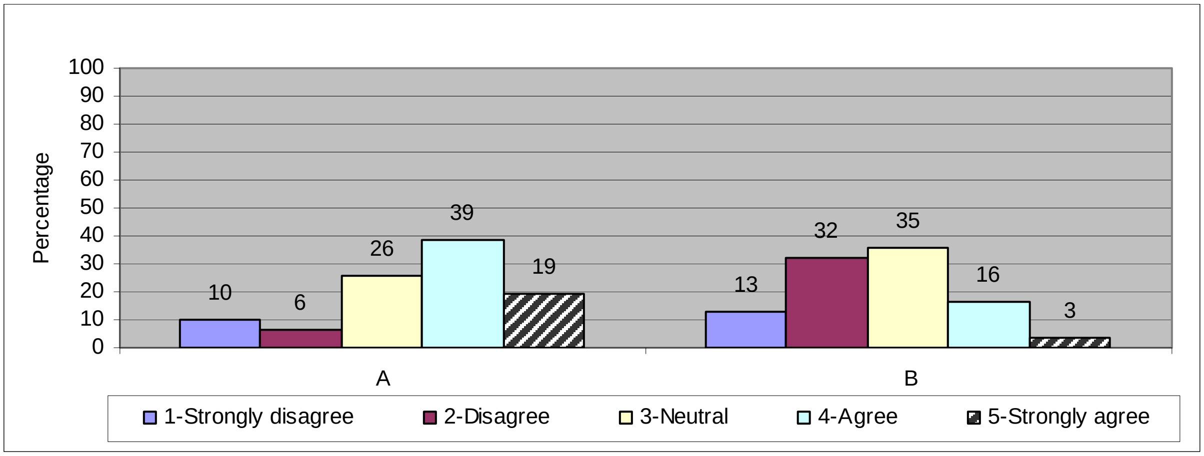

Figure legend

A	Manual system
B	Computer system

Figure 5.23: Most Difficult Method for Accessing Patients' Medical Records

On the next question (regarding doctors' opinions about the difficulties that they would face if they did not have adequate access to a patient's medical history), the survey found that 52% of the doctors strongly agreed, 35% agreed, 10% were neutral and 3% disagreed that they found it difficult when they did not have adequate medical records (see Figure 5.24). The doctors commented that they felt that it was difficult to provide the right treatment for the patient if the patient's medical record was inaccessible and recorded in an episodic manner. This finding from the data collection triggers the crucial need for integrated lifetime health records that could provide the continuous and seamless upkeep of health records.

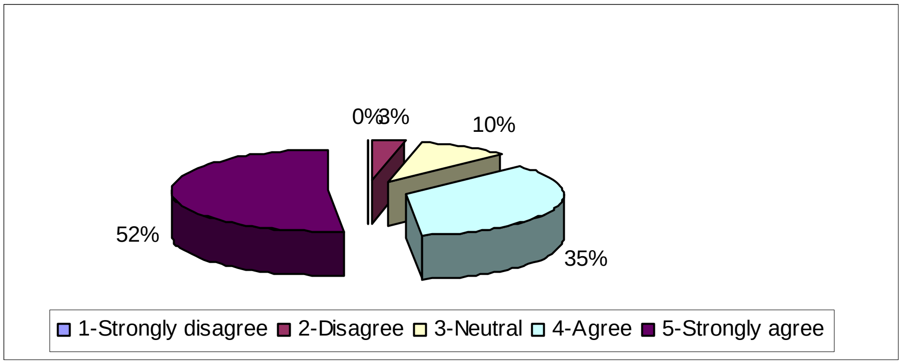

Figure 5.24: Percentage of Doctors Who Found It Difficult if They Did not Have Access to Patients' Medical Histories before Consulting the Patients

The doctors pointed out that in recent years (due to the workload and pressures in providing high-quality health services), the patient's health record is critically important in medical diagnosis processes for helping doctors in diagnosing and treating the patient's problems efficiently and accurately. This has been supported by the findings shown in Figure 5.25. Approximately 84% of the doctors in outpatient clinics strongly agreed and 16% agreed (see Figure 5.25) that the patient's health record is critically important for helping them in diagnosing and treating patients' problems.

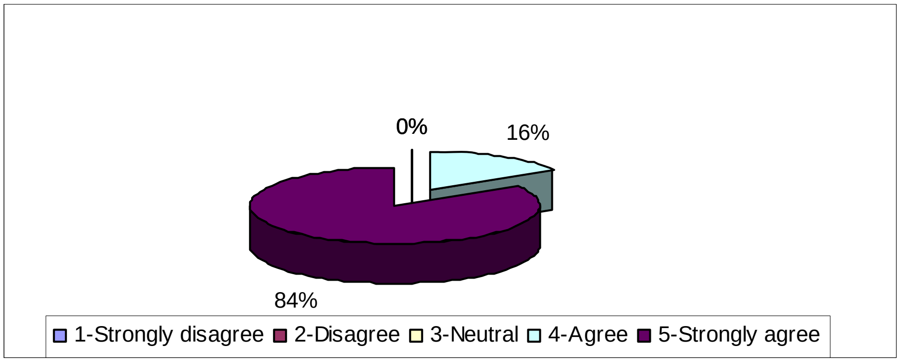

Figure 5.25: Percentage of Doctors who Agree that the Patient Medical Records Are Very Important for Helping Doctors to Diagnose and Treat Patients' Problems

They further pointed out that the quality of healthcare services would increase and the need for attending healthcare facilities to receive healthcare services would decrease if patients are empowered to maintain the condition of their health. Figure 5.26 shows the doctors' opinions with regards to empowering patients to be responsible for the condition of their health. Approximately 74% of the doctors said that they strongly agreed, 16% agreed and 10% were "neutral".

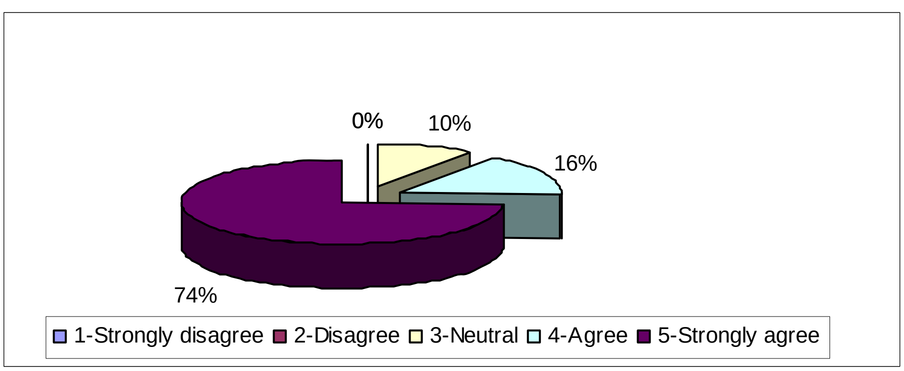

Figure 5.26: Do you Agree that Empowering Patients in Terms of Managing their Health Condition and Health Information Will Increase the Quality of Healthcare Services?

The doctors pointed out that for the past few years the patients have been very concerned about and up-to-date with their health status and health information. With this scenario it is highly possible that the patient should be given empowerment to maintain his/her health summary and this will make healthcare services more patient-centric. The doctors also pointed out that the quality of healthcare services would improve when patients are aware of the condition of their health.

Figure 5.27 shows the findings from the primary data collection regarding doctors' opinions about the improvement of healthcare services that have resulted from patients' awareness of the condition of their health. Approximately 74% of the doctors said that they strongly agreed and 26% said that they agreed with the question (do you agree that the quality of healthcare services will improve when the patients are aware about their health condition?).

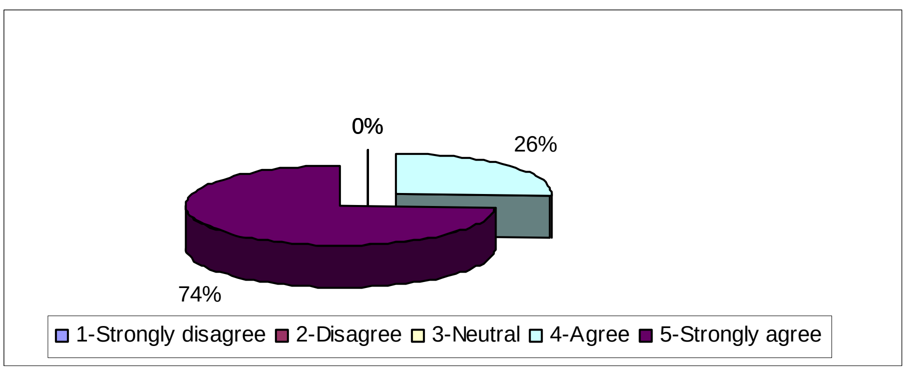

Figure 5.27: Do you Agree that the Quality of Healthcare Services Will Improve when the Patients Are Aware about the Condition of their Health?

With regards to the next question (what is the convenient mechanism that the doctors prefer to use to inform patients about their health condition), approximately 70% of the doctors said that they strongly agreed that they preferred to inform their patients about their health conditions verbally (see column A in Figure 5.28). The doctors pointed out that this is to ensure that the confidentiality and privacy of patients' health information are maintained. They further pointed out that the formal report (medical report) is another preferred mechanism for informing patients about their health conditions as 26% said they strongly agreed and 42% said they agreed with the mechanism (see column B in Figure 5.28).

The doctors commented that the use of electronic messages and web application technology in the healthcare services is still at the beginning stage and the doctors said that they are not yet ready to adopt the technology. The findings showed that only 10% of the doctors said they strongly agreed and the same percentage said they agreed with the use of periodic electronic messages. On the use of self-monitoring through the telehealth service for informing patients about their health conditions, approximately 10% said they strongly agreed and 23% said they agreed (see columns C and D in Figure 5.28). Nevertheless, the doctors pointed out that the electronic messages would have a potential in the near future since MOHM has been putting forward initiatives for developing and implementing the health ICT application throughout healthcare facilities nationwide.

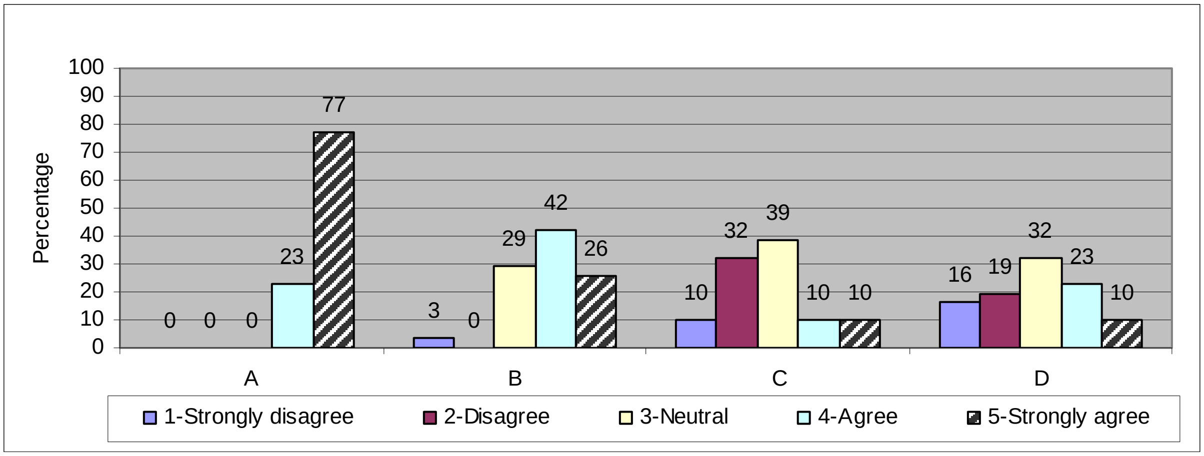

Figure legend

A	Verbally by the doctor
B	Formal reports e.g. medical reports
C	Periodical electronic messages e.g. alert, text, e-mail
D	Self-monitor through telehealth services e.g. personalised web

Figure 5.28: In your Opinion, which of the Following Mechanisms is Convenient for Informing Patients about their Health Conditions?

When the doctors were asked about convenient mechanisms for accessing, storing and displaying patients' health records anywhere at anytime, they pointed out that the centralised database system that is accessed via the Internet remains the top priority. Approximately 45% said they strongly agreed and 39% said they agreed on the mechanisms (see column A in Figure 5.29). The doctors felt that this system would involve proper system security and disaster planning for ensuring data reliability, confidentiality and availability. The doctors pointed out that the Malaysian's healthcare system allows the patients to freely visit any healthcare facility for the same medical problems and they can be referred to the appropriate hospitals anywhere in the country. As such, the convenient mechanism through Internet access should be the approach for accessing patients' health records continuously and seamlessly.

On the other hand, approximately 23% of the doctors said that they strongly agreed and 45% said they agreed that the paper-based medical records are another convenient way to access patients' medical records (see column C in Figure 5.29). However, they voiced concern that this method has not been suitable in recent years. This is due to the fact that the paper-based medical records are troublesome in managing patients' health records on a large scale and in a timely and seamless manner. In fact, they could not be shared across healthcare centres and accessed electronically anywhere at anytime.

Portable storage devices and decentralised databases residing on doctors' laptops are observed as less interesting to use. Only 19% said they strongly agreed and 16% said they agreed with the mechanisms (see column B and D in Figure 5.29). The doctors pointed out that they have no experience in using such technology (mobile phone, PDA and smart card) in delivering healthcare services, and this is why they could not make further comments on this technology.

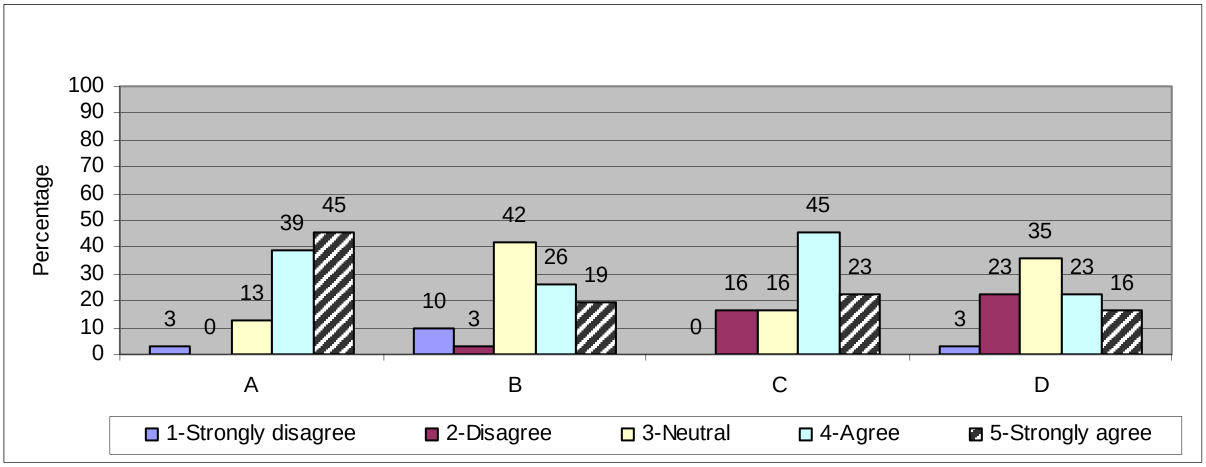

Figure legend

A	Centralised database system and access via the Internet
B	Portable storage devices (such as mobile phone, PDA & smart card) and wireless access
C	Paper-based medical record
D	Decentralised database residing in the doctor's laptop

Figure 5.29: Which of the Following Mechanisms do you Think Is Convenient for Storing, Accessing and Displaying a Patient's Medical Record Anytime and Anywhere?

With regards to the next question (which of the following telecommunication network types do you think is reliable for accessing patients' medical records anytime and anywhere?), approximately 39% of the doctors said that they strongly agreed and 26% said they agreed that the Internet/web is the most reliable mechanism for accessing patient medical records (see column A in Figure 5.30). The doctors commented that the network infrastructure might not be consistent across the country and among healthcare facilities. However, they pointed out that this constraint could be overcome by using dial-up connections via normal telephone lines for accessing the patients' health records.

With regards to the other types of telecommunication network (personal area network, wide area network and local area network), the doctors pointed out that they have no expertise with this technology and could not make further comments. Approximately 39% of the doctors were neutral with respect to a personal area network, 61% were neutral with respect to a wide area network and 42% were neutral with respect to a local area network (see columns B, C and D in Figure 5.30).

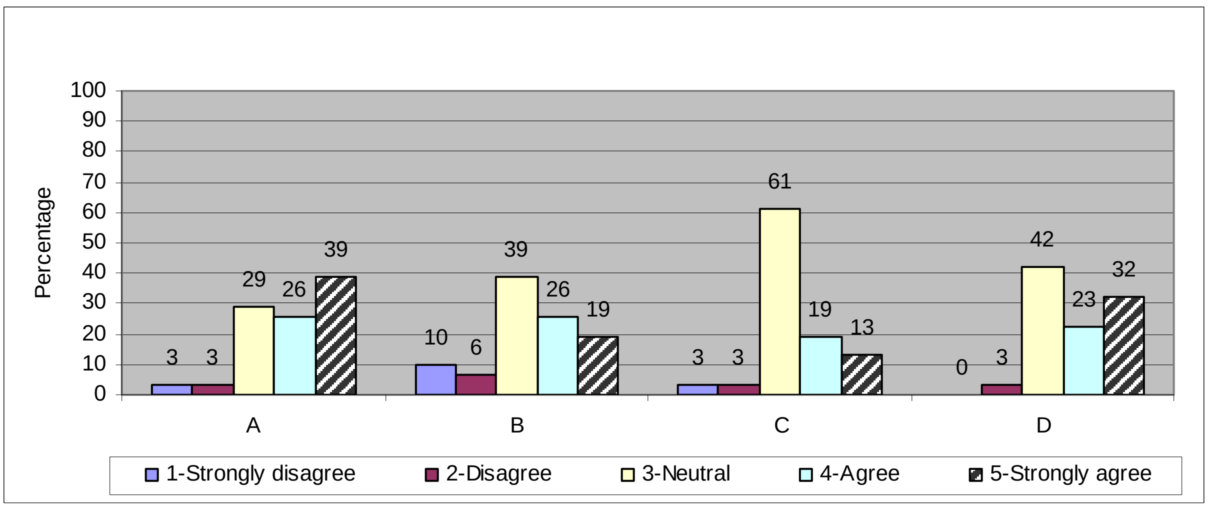

Figure legend

A	Internet/web e.g. dial-up, broadband
B	Personal area network (PAN) e.g. wireless – Bluetooth
C	Wide area network (WAN) e.g. dedicated leased line
D	Local area network (LAN) e.g. office network

Figure 5.30: Which of the Following Telecommunication Network Types Do you Think Is Reliable for Accessing Patients' Medical Records Anytime and Anywhere?

When the doctors were asked about reliable mechanisms for maintaining the confidentiality of patients' health records, approximately 39% of the doctors said they strongly agreed and 35%

said they agreed that the centralised database system hosted at a central system is the top priority (see column A in Figure 5.31).

On the other hand, 45% of the doctors said that they agreed and 19% said they strongly agreed that paper-based medical records kept in the record office are also one of the most reliable methods of keeping patients' medical records (see column C in Figure 5.31). However, they commented that this method would not be suitable in years to come. This is due to the fact that the paper-based medical records have many problems in managing patients' health records in a timely and seamless manner. Some of these problems are the sheer physical volume (over time), the difficulty in transferability and integration between providers and institutions and the necessity to record the same data many times (duplication) on different documents.

With regards to the other mechanisms such as portable storage devices (42% said neutral) and secured personal computers (35% said neutral), the doctors just said that they had no further comments on these mechanisms of technology (see columns B and E in Figure 5.31). Nevertheless, they pointed out that with the merging of ICT and healthcare practices, there is now a variety of items used on a daily basis on which medical records could be written and displayed. These included items such as PDAs, mobile phones, smart cards and laptops, which are in the possession of individuals and are, therefore, readily available at all times.

The doctors further pointed out that the accuracy, confidentiality and privacy of the patients' health records are considered to be a high priority in healthcare services. This is why 29% of them disagreed and 16% said they strongly disagreed that health records should be kept on personal computers and shared by all the doctors (see column D in Figure 5.31).

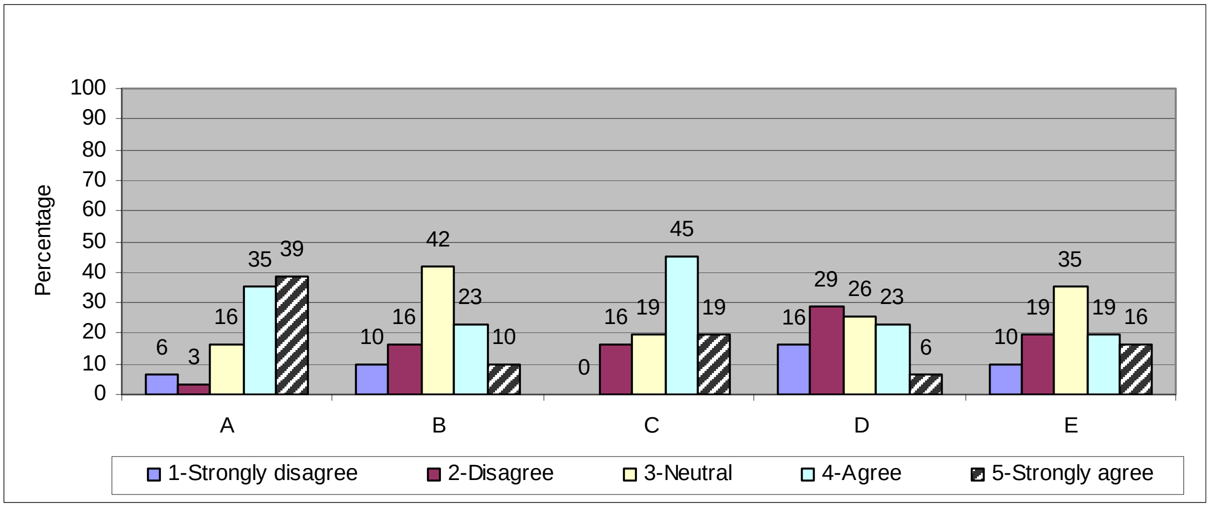

Figure legend

A	Centralised database system in the health facility data centre
B	Portable device storage in patients' possession
C	Paper-based medical records kept in the record office
D	Stored on personal computers used by all doctors
E	Stored securely on personal computers

Figure 5.31: Which of the Following Mechanisms do you Think Is Reliable for Maintaining the Confidentiality of Patients' Medical Records?

With regards to the next question (which of the following storage devices do you think is highly accessible to patients' medical records anytime and anywhere?), approximately 29% of the doctors said they strongly agreed and 39% said they agreed that the optical disks hosted in the healthcare facility data centres is the most preferred mechanism (see column A in Figure 5.32).

The findings from the primary data collection also showed that the paper-based medical records (see column C in Figure 5.32) are still the choice of doctors for maintaining the patients' health records. However, the doctors realised that the paper-based media have substantial limitations. Approximately 23% of them said they had no further comments (neutral), 23% said they disagreed and 10% said they strongly disagreed. The doctors commented that there is no enforcement to use ICT in delivering healthcare services and there are unclear procedures for maintaining patients' health records during system downtime.

On the other hand, approximately 55% of the doctors said they had no further comments on the use of portable storage devices in healthcare practices (see column B in Figure 5.32). They pointed out that the gadget is still new and they do not have experience in using the technology in the healthcare services.

The doctors pointed out that the internal optical disks of PCs (see column D in Figure 5.32) is considered to be insecure and inaccessible for doctors and healthcare centres. Only 6% said they strongly agreed and 55% said they had no further comments on the use of optical disks with PCs. However, the doctors felt that if the security mechanism is deployed in the workstation, confidence in using internal optical disks with PCs would increase.

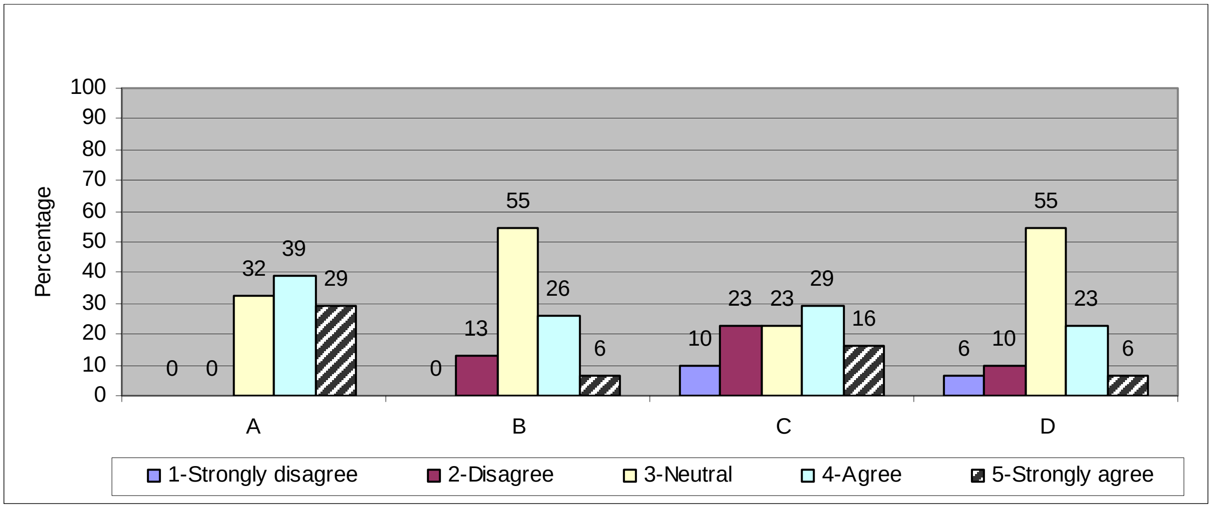

Figure legend

A	Optical disk hosted in the health facility data centre
B	Portable storage device in patients' possession
C	Paper-based medical records kept in the record office
D	Internal optical disk of a personal computer

Figure 5.32: Which of the Following Storage Devices Do you Think Is Highly Accessible to Patients' Medical Records Anytime and Anywhere?

With respect to the final question regarding the doctors' backgrounds, Figure 5.33, Figure 5.34 and Figure 5.35 depict the age group, work experience and gender classification of the doctors in the outpatient clinics. Figure 5.33 shows that approximately 61% of the doctors were between 26 and 30 years of age and the remaining 39% were between 31 and 35 years of age. Most of the doctors were junior and posted directly from medical universities. Figure 5.33 presents the age group of the doctors in outpatient clinics.

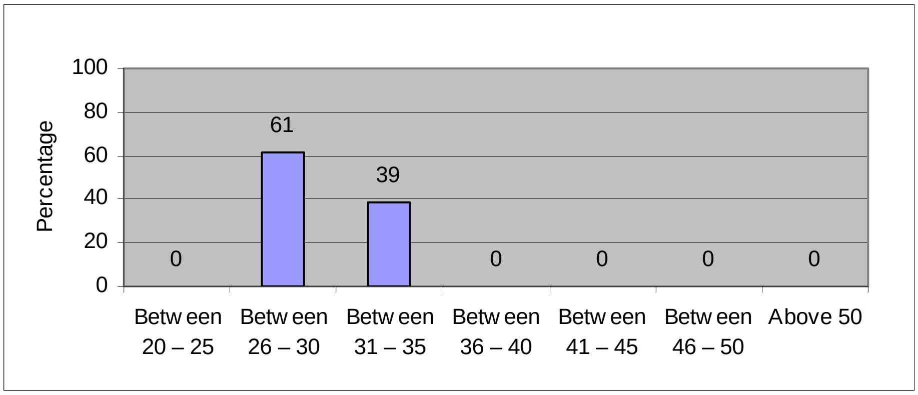

Figure 5.33: Average Age Group of the Doctors in Outpatient Clinics

In terms of work experience, approximately 77% of the doctors had worked in the clinics for one to five years, while the remaining 23% had work experience of more than five years (see Figure 5.34).

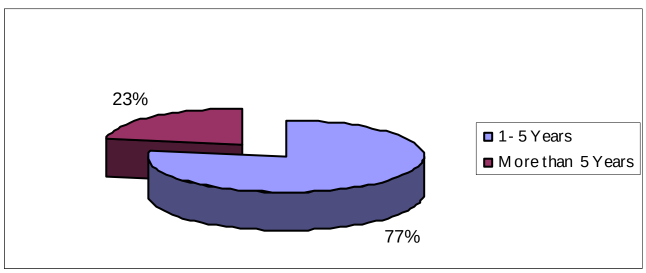

Figure 5.34: Number of Years' Work Experience of the Doctors in the Ministry of Health Malaysia

When compared in terms of gender, more than half (65%) of the doctors in the outpatient clinics were female and 35% were male.

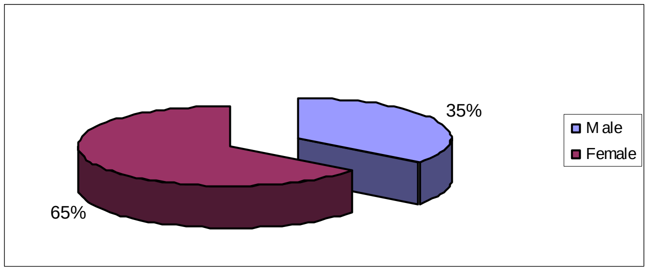

Figure 5.35: Percentage of Doctors in Outpatient Clinics in Terms of Gender

The doctors' backgrounds presented above show that most of the doctors were still young and very keen to use ICT in healthcare services. This might have given an indication to the management of MOHM that five years further on the health ICT would become prominent and essential for delivering healthcare services in the Malaysian healthcare system.

5.3.2.2 Summary of the analysis of patient demographic and clinical data

The findings and evidence obtained from the primary data collection show that seamless and continuous access to patient demographics and clinical data is critical and crucial. This fact is supported by the findings from the primary data collection in that approximately 52% of the doctors strongly agreed and 35% agreed that they face difficulties if they cannot access patients' medical histories (refer to Figure 5.24). Additional findings are that approximately 74% of the doctors strongly agreed that by sharing the health records with the patients, the quality of healthcare services would be improved (refer to Figure 5.26 and Figure 5.27).

The demographic data elements include the patient's name, date of birth, gender, race and occupation (refer to Figure 5.13). The clinical data elements include the patient's problem/diagnosis, allergies, chief complaint, symptoms, test conducted/result, medication ordered and onset date of disease (refer to Figure 5.17). These are the minimal clinical data elements required from which a prompt and accurate treatment could be provided.

Other data elements including home address and telephone number are the minimal data elements required for contact information purposes (refer to Figure 5.13 and Figure 5.14). In fact, the data elements for the test ordered also require minimal data, which include test date, type of test and test result/report (refer to Figure 5.17 and Figure 5.18), which are enough for the doctors to provide prompt treatment and accurate medication.

It was noted from the findings that the doctors in outpatient clinics have a limited amount of time to consult patients about their problems in that the average consultation duration is normally 20 minutes. This shows that the patient health records required by the doctors (for helping them to diagnose the patient problems) could be simplified (for example, the number of attributes and size in bytes) for facilitating the consultation process so that it is finished efficiently and effectively. It also facilitates the doctor in maintaining the LHR continuously within the limited time period allocated for each patient in the consultation room. Based upon evidence obtained from the primary data collection, the LHR could be simplified and it could be categorised into several components.

5.4 Design of the Proposed LHR Dataset

This section presents suitable LHR components, structures and finally the message format that could be used to support the intended telemedicine framework. The LHR components and structures were developed after a critical analysis of the consultation and medical diagnosis workflow and the LHR collection workflow (refer to section 5.3.1.2.1 and section 5.3.1.2.2) conducted at outpatient clinics of MOHM. The findings from the primary data collection (obtained from the outpatient clinics) also contributed to the development of the proposed LHR datasets.

The LHR is a lifetime summary of an individual's health record and basically it comprises data and information derived from the patient's episodes of care (Abd Ghani et al., 2008a). The LHR datasets provide a standard structure for retrieving and creating patient health records across healthcare levels and systems. The LHR performs the following tasks:

- supports the integration of all healthcare facilities to enable the delivery of seamless and continuous healthcare services
- enables the generation of an LHR repository and supports the delivery of the associated healthcare services (consultation and medical diagnosis during the telemedicine episode, medical tests, etc.)
- supports the generation and delivery of health group data services.

The above are the main requirements for defining the components and structures of the LHR. The suitable LHR message format is constructed so that it is capable of being useful in providing support for the intended telemedicine framework for maintaining patient health records continuously and seamlessly either using a central database or portable storage devices (Abd Ghani et al., 2008b).

5.4.1 LHR Components

The LHR components will be described through the decomposition view that serves to break a large component down into smaller, more manageable components within the context of the larger LHR components as a whole. The LHR components will be mapped into LHR messages from which it would be used and reused for a telemedicine episode at several different levels of healthcare services. Based on inputs and evidence obtained from the case study, the LHR was divided into three components.

1) Patient master information
2) Health condition summary
3) Episode summary.

Figure 5.36 depicts the proposed LHR components and their relationships within the components. A description of the components will be presented in the next section.

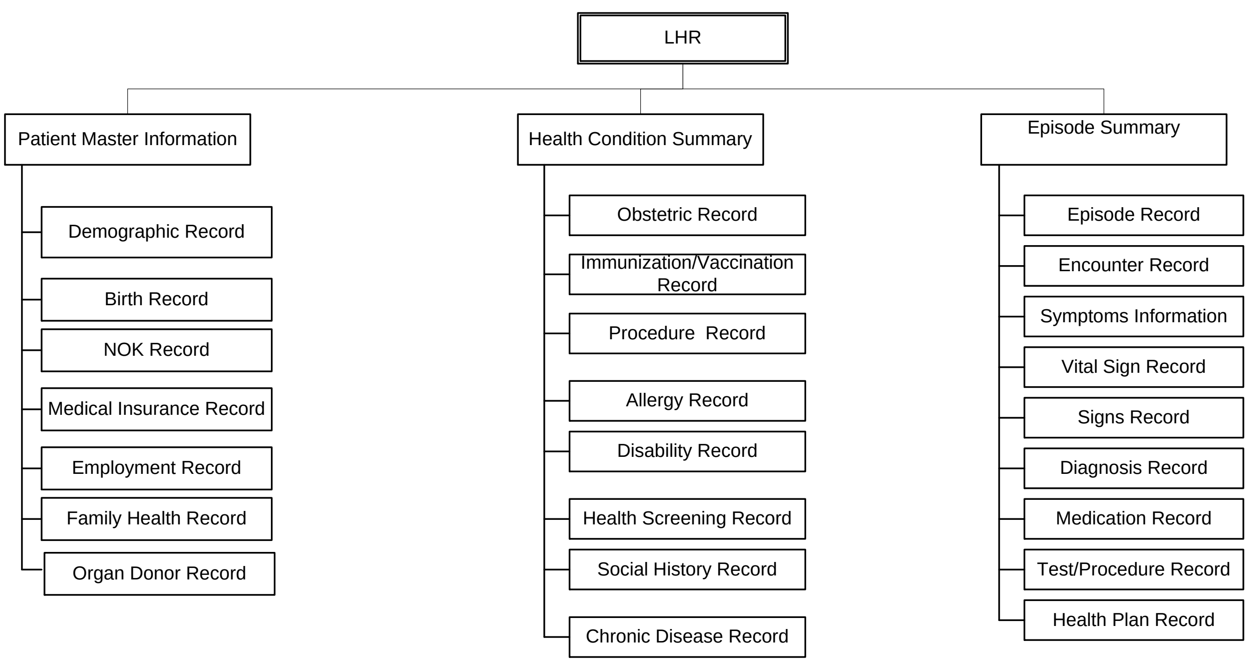

Figure 5.36: LHR Components

5.4.1.1 Patient master information (PMI)

Patient master information comprises administrative records and the required information to identify and distinguish the patient across healthcare facilities and levels (Health Level 7, 2008; Ministry of Health Malaysia, 2003b). It is often used to locate the patient identifier, including patient demographics and the related health administration information. The patient master information comprises the following set of information.

i) Demographic record – PDI
ii) Next of kin record – NOK
iii) Birth record – BIR
iv) Family health record – FMH
v) Medical insurance record – INS
vi) Employment record – EMP
vii) Organ donor record – OGN.

It was noted from the findings of the primary data collection (refer to Figure 5.13: Analysis of Patient Demographic Information to Be Viewed by Doctors during Consultations) that the patient demographic information is very important during the consultation and medical diagnosis workflow. The demographic information is indicated as compulsory due to the fact that it is a key identifier for the patient. The administrative records (examples are next-of-kin record, birth record, family health record, medical insurance record, employment record and organ donor record) could be included in the patient information as optional records.

5.4.1.2 Health condition summary

A summary of a health condition comprises records that summarise the illness and wellness condition of the patient. Each condition has a status indicator to indicate whether the condition is active or inactive. This summary of a patient's condition will enhance the continuity of care by providing a method for communicating the most relevant information about a patient and providing support for the generation of an LHR (Medical Record Institute, 2006; Ministry of Health Malaysia, 1997e). It was noted from the primary data collection (refer to figures 5.16, 5.17 and 5.20) that the first step to patient care or treatment was that the doctor would gather information about the patient's current health status. Here, many types of information were collected about the patient and placed in the patient's health record. By providing the summary of the most recent health condition of the patient at the beginning of a first doctor–patient encounter, the accuracy, quality, safety and continuity of care would be given.

The health condition summary component could be added and enhanced in future and the set of information given below is the initial information revealed from the primary data collection and system analysis. The health condition summary comprises the following information.

- i) Chronic or long-term disease record (high priority) – DGS
- ii) Allergy record (high priority) – ALG
- iii) Immunisation/vaccination record (high priority) – IMU
- iv) Social history record (high priority) – SOH
- v) Surgical medical procedure record (high priority) – SMP
- vi) Disability record (nice to have) – DAB
- vii) Obstetric record (optional) – OBS

5.4.1.3 Episode summary

The episode summary is comprised of data for a particular episode or visit. If required, it provides the necessary data for reference to the source of the information where details of the episodes are stored. It comprises the following information.

i) Episode record – EPI

ii) Encounter record – ECI

iii) Symptoms record – SMT

iv) Diagnosis record – DGS

v) Lab test record – LIR

vi) Radiology record – RRS

vii) Medication record – DDR

viii) Vital signs record – VTS

ix) Health plan record – HLP.

The LHR components defined above provide the conceptual structure of LHR information. The LHR components will be detailed in the LHR structure in the next section. The structure is developed after a critical analysis of the consultation workflow and findings from the primary data collection are obtained from MOHM.

5.4.2 LHR Structure

The LHR structure will be described in a tabular format. The table describes each of the LHR structures by listing the identified data elements and their descriptions and formats. Data elements are the basic attributes required of datasets, description is an explanation of the purpose of the data element or attribute, format and length are the format and size of the attribute and priority (0–3 = optional [O]; 4–5 = required [R]) indicates whether it is required or optional in terms of the minimal data elements being created for generating the LHR records.

5.4.2.1 Demographic record

A demographic record is not medical in nature and it contains information regarding the patient's identification (such as identifying number, name, address and contact number), bio data information (such as age, blood type, gender, race and religion) and other related health administration information (such as health insurance and employment record) (Medline Plus, 2008d; Medical Record Institute, 2006; Ministry of Health Malaysia, 2003a; Ministry of Health Malaysia, 2003b)(refer to Table H1 in Appendix H for the detailed structure of the demographic records obtained from the system analysis and primary data collection).

5.4.2.2 Next-of-kin record

The next-of-kin record contains information about the patient's immediate family members or other related parties (Health Level 7, 2007c; Ministry of Health Malaysia, 2003b). It includes the actual patient's personal relationship. By way of example, it might include information about the spouse, brothers, sisters, mother, father, friends, emergency contacts and employer of the patient. Every patient should have at least one next-of-kin record for immediate reference (refer to Table H2 of Appendix H for the detailed structure of the next-of-kin information).

5.4.2.3 Chronic, long-term and acute disease record

The chronic, long-term and acute disease record is an important piece of information that should be known by the doctor for predicting a patient's health status and providing further treatment (Halamka et al., 2008). The categorisation of a chronic or long-term and acute disease will be indicated automatically by the system. The system should be able to identify the diagnosis code entered by the doctor as a chronic disease by looking up the disease in the chronic diseases table provided by the MOHM (Ministry of Health Malaysia, 2003a; Ministry of Health Malaysia, 2003b) (refer to Table H3 of Appendix H for the structure of the chronic, long-term and acute disease information).

5.4.2.4 Allergy record

An allergy is a reaction of the immune system and people who have allergies are often sensitive to more than one thing (Medline Plus, 2008a). The allergy record is a semi-static clinical condition and it is important piece of information that should be known by the doctor as a precautionary measure in providing treatment and medication. Allergy information is provided by the patient and it is recorded on the patient health record by the doctor during the consultation (refer to Table H4 of Appendix H for the structure of the allergy information).

5.4.2.5 Immunisation/vaccination record

The immunisation/vaccination record contains information about immunisations/vaccinations the patient has had since birth until the present day. Immunisation is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine (WHO, 2008a; Ministry of Health Malaysia, 2003a). The chronology history of immunisation/vaccination records could provide clues to underlying illnesses and it gives the doctor a feel for what has happened to the patient (refer to Table H5 of Appendix H for the structure of the immunisation/vaccination record).

5.4.2.6 Social history record

The social history record is a chronicle of human infections and various habits that impact health. Examples are occupational types that could be exposed to health impacts; tobacco use, alcohol and recreational drug use are often regarded as part of the social history. This information helps the doctor know what sorts of community support the patient might expect during a major illness; and it also explains the behaviour of the patient in relation to illness or loss (WHO, 2004; Wikipedia, 2007; Ministry of Health Malaysia, 2003a) (refer to Table H6 in Appendix H for the dataset structure of the social history).

5.4.2.7 Procedures record

The procedures record includes descriptions of surgical procedures and the procedure code, date and time. The procedures record provides a surgical history performed on the patient in order to support the safety, quality and continuity of care (refer to Table H7 in Appendix H for the dataset structure of the procedures record).

5.4.2.8 Disability record

The disability record may contain a summary of the patient's disability profile, which includes the disability type, date of the disability occurrence and disability status. A disability includes hearing loss, mental disability, physical limitation or vision loss (Centers for Disease Control and Prevention, 2007; Ministry of Health Malaysia, 2003a). This information helps the doctor to know the behaviour of the patient in relation to his/her illness (refer to Table H8 in Appendix H for the dataset structure of the disability).

5.4.2.9 Obstetric record

The obstetric record lists prior pregnancies and their outcomes and includes any complications with the pregnancies (refer to Table H9 in Appendix H for the detailed structure of the obstetric record).

5.4.2.10 Episode record

The episode record lists chronicled visits of the patient across healthcare levels that include hospitals, health centres, polyclinics and primary care centres. It records the date and time of the visit, the name of the healthcare providers, the type of visit and the name of the doctor attending to the patient. The episode of care is an interval of care by a healthcare facility or healthcare provider for a specific medical problem or condition. It may be continuous or it may consist of a series of intervals marked by one or more brief separations from care and it can also identify the sequence of care (for example, emergency, inpatient, outpatient), thus serving as one measure of healthcare provided. An episode of care comprises a clinical encounter with a healthcare professional plus any other related clinical and administrative services. An individual must be a registered patient to receive service under an episode of care. The detailed structure of the episode record is listed in Table H10 of Appendix H.

5.4.2.11 Encounter record

An encounter is a face-to-face meeting, recorded chronologically in an episode of patient care. It records the date of the visit or an episode of care and the date and time of the encounter session. The encounter session could happen either for clinical or administrative purposes. The clinical encounter is a session between patient and healthcare professional in the process of delivering the clinical health service in an episode of care. An administrative encounter is a session between patient and healthcare officer in the process of a delivering administrative health-related service in an episode of care. The dataset structure of the encounter record is listed in Table H11 of Appendix H.

5.4.2.12 Chief complaint/symptoms information

During a doctor–patient encounter, the patient tells the doctor about his/her chief complaints or symptoms of the problem (Ministry of Health Malaysia, 2003b). Along with the consultation, the information on the nature and duration of the complaint and symptoms will be explored and predicted. Symptoms are the subjective evidence of a disease or physical disturbance observed by the patient, which indicates the presence of a physical disorder (Medline Plus, 2008c). Examples of these symptoms are headache, cough and fever. The symptom information documents the date of the clinical visit and encounter, and the symptom code and description. In addition, the information also records free text remarks written by the healthcare professionals who ascertained the patient's problem. The dataset structure of the symptoms is listed in Table H12 of Appendix H.

5.4.2.13 Diagnosis information

The diagnosis information is the critical patient's medical condition diagnosed by the healthcare professional after a series of clinical tests and an examination performed for a particular problem (Ministry of Health Malaysia, 2003a; Medline Plus, 2008c). The diagnosis information contains episode and encounter dates (the onset date of the problem), diagnosis code and a description. The datasets structure of the diagnosis information is listed in Table H13 of Appendix H.

5.4.2.14 Test result information

The test result information includes laboratory test results and radiology examination reports. A laboratory test is a medical procedure that involves testing a sample of blood, urine or other substances taken from the body (National Cancer Institute, 2003). The radiology examination refers to technologies that doctors use to look inside a patient's body for clues about a medical condition (Medline Plus, 2008b). These tests can help determine a diagnosis, plan the treatment, check to see if the treatment is working or monitor the disease over time. The test result information contains the date of the test or examination performed, the test or examination code and description and the test or examination result's code and description. The dataset structure of the test result information is listed in Table H14 of Appendix H.

5.4.2.15 Medication record

The medication record contains a summary of the patient's current and previous medications. The medication history should have a great impact on the quality of care where the next healthcare provider will not have to search or guess about a patient's medication. By knowing exactly which medications and regimens patients use can help doctors to avoid drug interactions, manage side effects and more effectively direct patients' treatment (Staroselsky et al., 2008). In addition, a complete history of medication records could facilitate safe drug treatment and potentially avoid prescribing errors (Kawasumia et al., 2008). The medication record contains the drug code and name, the dosage or quantity of each drug taken, the start date of taking the medication and the end date when the medication was discontinued. The dataset structure of the medication records is listed in Table H15 of Appendix H.

5.4.2.16 Vital signs record

The vital signs record contains previous and recent information about the patient's physical organ systems that might directly be responsible for the symptoms the patient is experiencing (Wikipedia, 2008). The vital signs information includes a vital sign code (such as body temperature, blood pressure, weight and height), a vital sign value and the unit of measurement used to measure the value. The dataset structure for vital signs is listed in Table H16 of Appendix H.

5.4.2.17 Health plan record

The health plan record is a collection of health plans generated by the healthcare professional. The health plan record contains the follow-up or appointment date and health advice given by the healthcare professional. The dataset structure for the health plan record is listed in Table H17 of Appendix H.

5.4.3 LHR Messages

This section defines the LHR messages that would be used by the intended telemedicine framework for disseminating and receiving the LHR data across healthcare facilities, levels and healthcare professionals. A message is the atomic unit of data transferred among systems. It is comprised of a group of segments in a defined sequence (Health Level 7, 2007c).

The collection and dissemination of LHRs would be transferred through standard LHR documents, namely LHR messages. The LHR message would be triggered either through a telemedicine event at the point of a doctor–patient encounter and/or at several different levels of healthcare services. As an example, the trigger event "*do consultation*" use case may cause the need for lifetime health summary data about the patient to be sent to the healthcare professionals. The trigger event "*register patient*" use case may cause the need for patient demographic data to be retrieved during the registration encounter. All of these events require a standard format of messages for enabling the patient's LHR to be transferred among healthcare facilities and applications. The LHR message format will be presented in the next section.

5.4.3.1 LHR message format

The proposed LHR message set provides for the transmission of new or updated lifetime health records about the patient. The proposed LHR message format is a conception of what and how the LHR information is transferred and retrieved across healthcare facilities through the proposed framework (*My*Tel). The defined LHR message set (see Figure 5.37) is one of the most commonly used during a doctor–patient encounter. The receiving and transferring of the message would most likely utilise the HL7 messaging protocol. Nevertheless, this thesis will not discuss the detailed implementation of the messages; it will focus on the definition of the generic LHR message format. The LHR message format is intended to be technology-neutral and vendor-neutral in order to maximise its applicability. It is up to MOHM to choose the standard protocols to be used for the actual implementation.

In general, each LHR message consists of message segments and special notation. The special notation is used to indicate that the segment would appear in the message. A brace {…} indicates one or more repetitions of the enclosed group of segments. Brackets […] indicate that the enclosed group of segments is optional. If a group of segments is optional and may be repeated, it should be enclosed in brackets and braces — { […] } — (Health Level 7, 2007c). If a segment is required or compulsory, it should not be enclosed with any of the notation.

In the actual implementation, the LHR is defined as one of the order entry transactions from which it would be maintained and retrieved from various healthcare facilities and levels. As such, it is mandatory that each LHR message is enclosed with an LHR header (MSH) and LHR common order request control (ORC). The LHR's MSH segment defines the purpose, source, destination and some specifics of the syntax of a message. LHR's ORC segment defines the requestor and the receiver/filler information, the destination and some specifics profiles of the order. Other segments include a group of patient master information segments, health condition summary segments and episode summary segments defined as optional, and which may appear more than once. This is due to the fact that some of the patients may never receive healthcare services in their lives while some may receive healthcare services regularly. The generic format of the LHR message enables the user (MOHM) to include additional segments for incorporating business requirements and expansion in future. Figure 5.37 depicts the proposed generic format of the LHR message.

Segment Name/ID	Description	Source/Standard
MSH	LHR header provides LHR document profile	HL7/locally defined
ORC	Common order request control	HL7/locally defined
*Patient master information		
PDI	Patient demographic information	Locally defined
[NOK	Next of kin information	Locally defined
INS	Medical insurance record	Locally defined
EMP	Employment record	Locally defined
BIR	Birth record	Locally defined
OGN	Organ donor record	Locally defined
FMH	Family health record	Locally defined
]		
**Health condition summary		
{ [DGS	Chronic diseases	Locally defined
ALG	Allergy	Locally defined
IMU	Immunisation	Locally defined
SOH	Social history	Locally defined
SMP	Surgical medical procedure	Locally defined
DAB	Disability	Locally defined
OBS	Obstetrics information	Locally defined
]		
}		
***Episode Summary		
{ [EPI	Episode information	Locally defined
ECI	Encounter information	Locally defined

```
    SMT                         Symptoms                          Locally defined
    DGS                         Diagnosis                         Locally defined
    LIO                         Laboratory order                  Locally defined
    ROS                         Radiology order                   Locally defined
    DDR                         Medication                        Locally defined
    VTS                         Vital signs                       Locally defined
    HLP                         Health plan                       Locally defined
   ]
}
```

Figure 5.37: Generic LHR Message Format

5.4.3.2 LHR events and message definitions

This section defines the LHR events and message based on the critical use cases defined for the proposed framework (see section 6.2.2.3 in Chapter 6). The basic LHR trigger events for supporting the implementation of the proposed framework include the following.

1. Maintain patient master information (MPI)
2. View patient master information (VPI)
3. Maintain health records (MHR)
4. Retrieve health records (RHR).

In order to elaborate on how the above events could be initiated, "a register patient" and "do consultation" scenario will be presented. Firstly, when the patient walks in to the healthcare provider, the patient has to present his/her identification to the registration counter. The receptionist collects the patient identity and the triggering event ***register patient*** is required. The register patient process might be served by the view patient master information (VPI) and maintain patient master information (MPI) messages.

Secondly, when the patient sees the doctor for a clinical consultation, the triggering event for ***requesting patient lifetime health records*** will be initiated. These might be served by the retrieve health records (RHR) and maintain health records (MHR) messages.

Each LHR event might consist of several segments for fulfilling the patient registration process and consultation process. The schematic form for these two scenarios of exchange of messages is shown in the next section.

5.4.3.2.1 View patient master information (VPI)

This triggering event is served by the VPI request and VPI response messages. Before the patient information can be viewed, the patient is searched for by transmitting a VPI request message to the central system. The message consists of MSH, ORC and PDI segments. The ORC segment defines the order profile. The PDI segment contains minimum search criteria information (including the patient master index number, national identification number and name) for searching the patient's records at the central system (see Figure 5.38 for the VPI request message format).

Segment ID	Segment Description
MSH	Message header
ORC	Order request control
PDI	Patient demographic information

Figure 5.38: Message Format for the VPI Request

Let us assume that the patient has made some visits before and the order request has been successful. The intended patient master information will be responded to using the VPI response message. The message consists of MSH and patient master information segments. The patient master information is an optional item due to the fact that this might be his/her first visit or the detailed information is incomplete. Figure 5.39 shows the message format for the VPI response.

```
Segment ID          Segment Description
MSH                 Message header
[  PDI              Patient demographic information
   NOK              Next of kin information
   MDI              Medical insurance information
   INS              Medical insurance info
   EMP              Employment info
   OGN              Organ donor info
]
```

Figure 5.39: Message Format for the VPI Response

5.4.3.2.2 Maintain patient master information (MPI)

At the end of the registration process some of the patient's information might be changed or updated. Examples are the patient's request to update the address, next of kin information, etc. The updated information would be maintained by sending a MPI message as depicted in Figure 5.40.

```
Segment ID          Segment Description
MSH                 Message header
ORC                 Common order request
PDI                 Patient demographic information
 [{
   NOK              Next of kin
   INS              Medical insurance info
   EMP              Employment info
   OGN              Organ Donor info
   }
 ]
```

Figure 5.40: Message Format for MPI

5.4.3.2.3 Retrieve health records (RHR)

When a patient is called for clinical a consultation, the doctor initiates a request to retieve his/her health records for getting clues about his/her problem. The ORC segment defines the order profile and the PDI segment provides the patient's identifier for exracting his/her relevant medical history. The request is defined in the RHR request message as depicted in Figure 5.41.

Segment ID	Segment Description
MSH	Message header
ORC	Order request control
PDI	Patient information

Figure 5.41: Message Format for the RHR Request

The receiving system (HIMS) authenticates the request and formats the patient's health record using the RHR message format as depicted in Figure 5.42. The RHR responses consist of MSH and PDI as compulsory segments. The health records include the patient's health condition and episode summary. The health record segments are optional and might have more than one occurrence due to the fact that the patient might not have visited any healthcare provider before, or he/she might have a history of several visits in the past.

```
Segment ID            Segment Description
MSH                   Message header
PDI                   Patient demographic information

{  [ DGS              Chronic diseases
     ALG              Allergy
     IMU              Immunisation
     SOH              Social history
     SMP              Surgical medical procedure
     DAB              Disability
     OBS              Obstetrics information
     ]
}

{  [ EPI              Episode information
     ECI              Encounter information
     SMT              Symptoms
     DGS              Diagnosis
     LIO              Laboratory order
     ROS              Radiology order
```

```
     DDR            Medication
     VTS            Vital signs
     HLP            Health plan
    ]
}
```

Figure 5.42: Message Format for the RHR Response

5.4.3.2.4 Maintain health records (MHR)

Once the consultation process is done, the patient will be discharged and the doctor initiates a request to update the patient's lifetime health record. The patient's clinical summary data for the episode will be formatted using the MHR message format as depicted in Figure 5.43. The MHR message will be submitted to the central system for maintaining the patient's lifetime health record.

```
Segment ID          Segment Description
MSH                 Message header
ORC                 Common order request
PDI                 Patient demographic information

{  [ DGS            Chronic diseases
     ALG            Allergy
     IMU            Immunisation
     SOH            Social history
     SMP            Surgical medical procedure
     DAB            Disability
     OBS            Obstetrics information
     ]
}

{  [ EPI            Episode information
     ECI            Encounter information
     SMT            Symptoms
     DGS            Diagnosis
     LIO            Laboratory order
     ROS            Radiology order
     DDR            Medication
     VTS            Vital signs
     HLP            Health plan
    ]
}
```

Figure 5.43: Message Format for MHR

5.5 Summary

This chapter began by describing the underlying research process followed for the case study. Thereafter, a critical analysis of patient demographic and clinical records was examined. The process flow of the existing IS and interface requirements was also analysed. The aim of these analyses was to corroborate evidence and to examine a suitable conceptual framework for this research (a framework for a Malaysian telemedicine system). An analysis of suitable LHR datasets that could be used for supporting the implementation of the proposed framework was also carried out.

The data determined and collated from the analyses were qualitative in its nature. The case assisted in determining the suitable components for conceptual framework. Based on the data collected from workflow analysis and primary data collection (by way of structured interviews from thirty doctors), the candidate components for conceptual framework and the suitable LHR dataset were discussed and proposed in this chapter. The following chapter will draw and describe the proposed conceptual framework for this research.

Chapter 6 Framework for the Continuous Upkeep of Patient Lifetime Health Records (*My*Tel)

6.1 Introduction

*My*Tel framework is a technology framework that makes possible the continuous and seamless upkeep of patients' lifetime health summaries across healthcare centres as well as healthcare facilities and disciplines in Malaysia. The framework provides a vision and direction for how information technology will be employed to allow the patients' health records to be accessed, created and stored during the unavailability of the telecommunication network, the downtime of the back-end system and the setting up of the many different information systems used in healthcare facilities .

The proposed framework was developed after a critical appraisal of the existing findings of telemedicine in the Malaysian context and telemedicine approaches in other countries described in Chapter 2. The exploration of the workflow of the outpatient clinics and the data collected from the case study interviews contribute to the proposed framework (*My*Tel). As mentioned earlier, this framework is supposed to enhance the flexibility of the telemedicine system for creating, displaying and storing LHRs seamlessly and continuously during the downtime of computer systems and the unavailability of telecommunication networks. *My*Tel is constructed so that it is capable of being useful for providing patient health records continuously and seamlessly using portable storage devices such as PDA, mobile phones and smart cards (Lu et al., 2005). The framework enables the system to be operated in a stand-alone manner (off-line) and allows LHRs to be easily available and accessible during disaster scenarios. The framework will be described using a unified modelling language (UML) such as the use case model and process model to represent the behavioural logic of the framework (Fowler, 2004).

6.1.1 Scope

This chapter details the proposed framework (*My*Tel) for maintaining the patient's LHR continuously and seamlessly during the unavailability of the landline network and the downtime of the back-end system. The objective of the framework is to ensure that the patient lifetime health summary can be accessed, viewed and stored continuously during the doctor–patient encounter. This thesis does not go into the specific requirements in any more detail than the use cases elicit. It will focus on the conceptual framework design and how *My*Tel will be implemented with a logical presentation and elaboration.

It has to be noted that the healthcare services are complex and involve multiple-disciplines. For this reason, the proposed framework as outlined will focus on the outpatient clinic services of health clinic premises and the framework has the ability to develop incrementally/iteratively in future.

The proposed framework chapter is divided into three main sections. Section 6.1 elaborates the introduction and the objective of the chapter. Section 6.2 presents the proposed framework starting with a high-level overview of the framework in section 6.2.1 and continuing to section 6.2.2 to present the detailed description of the *My*Tel architectural framework layer. The description of the framework is covered in sections 6.2.2.1 to 6.2.2.5. Section 6.2.2.1 describes the design approach used in developing the *My*Tel architectural framework and section 6.2.2.2 continues by elaborating on the *My*Tel components and their role the using the decomposition view model. The framework description continues in section 6.2.2.3, which further elaborates on the *My*Tel functionalities using the use case model. Section 6.2.2.4 presents and elaborates on the *My*Tel solution framework for certain critical scenarios in accessing, viewing and storing LHRs continuously. The physical implementation of the framework system is presented in section 6.2.2.5 through the deployment view model. Finally, the conclusion to the proposed framework is summarised in section 6.3.

6.2 Proposed Framework

This section proposes a framework (*My*Tel) for mitigating the problems associated with accessing patients' health records during the unavailability of telecommunication networks and the downtime of computer systems. This section starts with the framework overview and workflow and continues with the description of the components of the architectural framework. Figure 6.1 depicts the proposed framework and the relationship between the components within the framework.

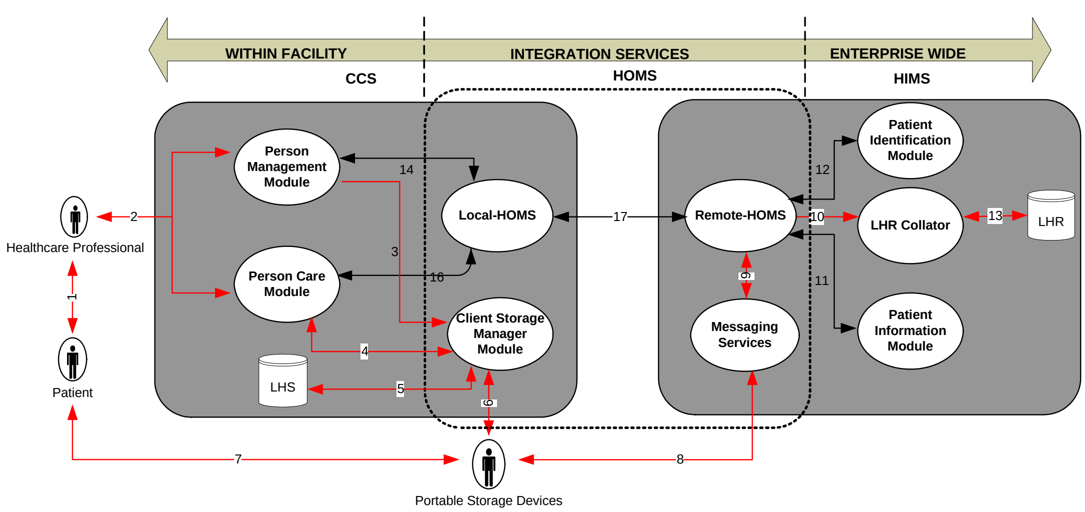

Figure 6.1: Proposed Framework (MyTel)

6.2.1 Framework Overview

The framework is divided into three components, namely clinical care support (CCS), the health order management service (HOMS) and health information management service (HIMS). It should be stressed that the three components provide a set of services needed to attain particular visions and goals of the research project. As such, the *My*Tel framework provides a common solution to cover the whole range of needs for accessing, creating and storing patient LHRs continuously and seamlessly.

Clinical Care Support

The left part of the diagram shows the position of the clinical care support (CCS) component, which focuses on providing support for clinical and administrative services at healthcare facility centres. The essential goals of the CCS are:

1) to provide support for clinical and administrative functions at healthcare centres
2) to create health records that directly contribute towards the creation of LHRs
3) to make sure the lifetime health summaries can be accessed, created and stored continuously and seamlessly.

The principal target for the CCS is to provide support for the clinician during a consultation and diagnostic process at the point of system disaster (the unavailability of the telecommunication network and downtime of the computer system). Support is required by the clinician in order to provide a high level of care, and more accurate diagnosis and treatment (Coiera, 2003). To ensure seamless and continuous care, the clinician would require the past health records of his patient, such as past treatments, drug prescriptions and past chronic problems provided earlier by himself or by other clinicians (Reichertz, 2006). Thus, the major requirement of the CCS is the ability to retrieve past health records seamlessly from the same healthcare centre as well as from other providers.

As described in a previous chapter (see section 5.3.1.2.1 in Chapter 5), CCS is crucial because it is a source for generating EMRs and forming the LHR repository and group data services (Haux, 2006). A meaningful LHR repository cannot be expected before sufficient LHRs are collected and the collection of LHRs will also depend on the usage of the CCS applications (Reichertz, 2006). As such, a flexible system should be provided for doctors to retrieve, capture and store the health records of patients continuously. This will ensure that sufficient EMRs are collected to form the LHR repository. Based on the critical evaluation of the consultation and medical diagnosis workflow in the outpatient clinics (see Chapter 5), the CCS component should have minimal functions that are needed for the application system to be delivered. As such, among the basic applications involved in the CCS are the following:

- person management module
- person care module
- lifetime health summary storage.

Health Order Management Service

The central part of the diagram is the health order management service (HOMS) components that act as integration services between the CCS component in healthcare centres and the HIMS component at the enterprise level. HOMS provides a common contact link in managing the health order request (to retrieve and maintain health records and retrieve and maintain patient master index information) flow within the healthcare facility base, and between the healthcare facility base and the enterprise level. The essential goals of HOMS are as follows:

1) to make all systems within and between the healthcare facility work together to share relevant information (patient health records and demographics) electronically
2) to establish a common framework for integration between systems (in particular, between CCS and HIMS) that enables the participating healthcare facility to send and receive orderable requests electronically.

HOMS provides a common "gateway" for the CCS application and other application systems to retrieve/send the patient's LHR from/to HIMS. The HOMS architecture will be a common framework for integrating all EMRs from other participating sources that may come from other types of CCS applications (such as teleprimary care and other HIS). HOMS acts as a central agent to delegate and acknowledge an order for an LHR from the requestor to the service provider regardless of the application or location of a healthcare facility.

HOMS's features enable all participating healthcare centres to send and receive LHR requests electronically, where the contents of the data should be standardised. When a system disaster occurs (for example, the unavailability of a telecommunication network), and to achieve fault tolerance without affecting the scalability of integrating applications, the solution is to communicate asynchronously through a portable storage device interface. That is where HOMS plays its "rescuer" role.

The HOMS will grow in term of services to be provided and its architecture should be flexible to incorporate enhancements of future functionalities as well as non-functionalities (such as load balance, for getting a reasonable performance). For this proposed framework, only three order services are offered: maintaining and retrieving patient lifetime health records (LHRs), maintaining and retrieving patient master indexes and maintaining patient identification numbers. In order to achieve the objectives, the HOMS's architecture consists of four modules as follows:

- local-HOMS module
- remote-HOMS module
- client storage manager
- messaging service

Health Information Management Service

The right-hand side of the diagram is the HIMS component hosted centrally (enterprise-wide) for accessing its services anywhere and anytime nationwide. The HIMS component is responsible for managing the request services for LHRs and patient information continuously and seamlessly (such as collecting and distributing a patient's master information and LHR) (Ministry of Health Malaysia, 1997e). The essential roles of HIMS are as follows:

1) to manage the collection, creation, retrieval and distribution of LHRs
2) to collate and manage the patient master index information
3) to manage the generation of patients' unique identification numbers.

The LHR repository and patient information database require an information system for ensuring the completeness of an individual's demographics and medical history from birth to death. The HIMS puts together all EMRs to form a single integrated LHR for each individual, where the integration transgresses time as well as location (as the person may have visited the same healthcare centre at different times or may have visited different health centres). However, what if the system is down or the participating healthcare centres do not have the capability to provide a landline network connection to HIMS for accessing the LHR? If this is the case, the "client storage manager module" is invaluable. The LHRs located in HIMS will be accessible from CCS using portable storage devices through the global system mobile (GSM) digital network and short messaging service (SMS).

The final LHR will contain all EMR summaries for that person in chronological order from birth to the current date and some form of summary (lifetime health summary) is also required for easy reference. Obviously, HOMS and HIMS need to be active at all times because the LHR contents need to be updated with every new encounter at various healthcare centres. For this proposed framework, four basic applications are involved in achieving HIMS objectives:

- patient identification module
- LHR collator module
- patient information module
- lifetime health record (LHR) repository.

6.2.2 *My*Tel Architectural Framework Layer

This section starts with the description of the design approach and continues with the description of the components of the architectural framework.

6.2.2.1 Design approach

The architectural approach for *My*Tel is based on the unified modeling language (UML) (Conallen, 2000; Fowler, 2004). The *My*Tel architectural solution uses the system layer to organise the view of the framework structure (Ahmed and Umrysh, 2001; Sharma et al., 2001). This layered architecture is a mental model that enables the business user to understand the practice of engineering application systems from component systems (Jacobson et al., 1998). Jacobson et al. (1998) pointed out that by having distinct layers and clear interfaces between components, this architecture would provide platform-independent interfaces (such as a HOMS common contact link) to distribution and interoperability mechanisms. Hence, the framework provides openness and flexibility for allowing the systems to evolve independently, as new technologies and healthcare system functionalities arise (Wang et al., 2004; Vargas and Pradeep, 2003). For this proposed framework, the selected views are described as follows.

- *Use case view* describes the functional requirements of a system and interactions between users and the system itself.
- *Decomposition view* serves to break a large system down into smaller, more manageable systems within the context of the larger system as a whole.
- *Logical view* represents the processes involved in each of the tiers for the *My*Tel application.
- *Deployment view* exposes the *My*Tel deployment diagram functionality in the extensibility interface.

6.2.2.2 *My*Tel decomposition view

The *My*Tel framework will be described in terms of its component roles. The decomposition view decomposes the framework into individual components in a way that eases the understanding of the roles and responsibilities of the components that make up the whole *My*Tel system.

Person Management Module

The person management module (PMM) is an administrative function for patient registration, which starts off the whole process of consultation and diagnosis at a healthcare facility (Health Level 7, 2007a). The PMM takes care of the data entry and retrieval of the patient's registration, maintains the patient master index (demographics) and establishes the patient's episode record for general outpatient clinics. The use cases involved in this module are:

- register patient
- maintain patient's demographics
- search for and verify patient's identification.

Person Care Module (PCM)

The person care module (PCM) supports the administrative routines of the clinical processes of the consultation and diagnosis workflow. It is from this PCM that the data entry, retrieval and maintenance of health records are done for examination, diagnosis and treatment. The use cases involved in this module are Do Consultation, Review Health summary and Discharge Patient.

Client Storage Manager

Based on Lu's (2005) findings, the portable devices and mobile computing allowed by PDAs and smart phones are becoming important tools in healthcare and have grown in popularity among healthcare professionals during the past five years. The *My*Tel framework utilises portable storage devices to mitigate disasters. The client storage manager module manages and determines the available portable storage devices medium dynamically. If more than one medium is available it will alert the user as to whether to write to all media or write to only one medium. Only one storage medium can be used to retrieve patient health data even though multiple storage media are available to write to. The user should give an option to retrieve the patient health data from the preferred medium. An example is to retrieve data from local hard disks or portable devices such as mobile phones or smart cards (in this research, the data will only be retrieved from mobile phones or PC/laptop hard disks).

Local HOMS

Local HOMS manages the order service requests within healthcare facility centres (for example, the CCS component) and acts as a common contact for other application in the same or different healthcare facility or to HIMS at the enterprise level. The Local HOMS identifies the order's destination from the order message header file to ensure that the order will be submitted to the right location or recipient. By way of example, if the message is for a remote recipient the message is flagged for latter delivery to Remote-HOMS. When Local-HOMS is triggered for remote delivery it grabs a chunk of messages that were earlier marked for remote delivery and connects to HIMS before the Remote-HOMS at the enterprise level forwards the order message to the remote recipient (another healthcare facility). In the same call, Local-HOMS also accepts a chunk of new messages meant for the local (home) healthcare centre.

Remote HOMS

Remote HOMS manages the order request services located centrally at the enterprise level (HIMS). Remote-HOMS has similar functions to Local-HOMS. However, it only acts as a common contact for other applications among various healthcare facilities.

Messaging Services

Messaging services is a middleware application and this module manages the incoming and outgoing messages from/to CCS and other participating healthcare centres for retrieving patients' health records and demographic information. The messaging services located at the HIMS system is a gateway to send (and receive) SMS messages from a doctor's computer to the health record management system. The messaging service located at the MOH office is linked to the mobile network operator using either the wireless or Internet protocol (IP) connection.

LHR Collator

LHR collator collates the summary of the patients's health records submitted by participating healthcare centres. The LHR collator puts together summary of all EMRs to form a single fully integrated LHR for each individual. The Collate LHR service receives the summary of an episodic health record from all participating healthcare centres (CCS, TPC and THIS) using a standard format of LHR document messages. The service will create the LHR records received from all participating healthcare centres by mapping the data with the LHR data structure. Every health record will be identified whether the health record is for a new episode or for an old episode and will add a new health record or update an existing health record accordingly.

Patient Identification Module

The patient identification module manages the generation of a unique identification number for a patient, which is common across healthcare facility centres. The patient identification number is generated using a specified algorithm and assigned to a new patient during the initial registration (for example, during the registration of the patient use case).

Patient Information Module

The patient information module (PIM) manages and maintains the patient's master index centrally at the enterprise level. PIM receives requests from participating healthcare centres to create or update the patient's master index information. The module also distributes the patient's information to either the same or different healthcare centres visited by the patient. The patient information is requested from the PIM repository by using the patient's unique identification number or national identification certification number. With a system disaster, only the crucial patient demographic attribute information examined in the research survey (see Figure 5.13: Analysis of Patient Demographic Information to Be Viewed by Doctors during Consultations) is used to minimise the size of the data to be stored into portable storage devices and transport them through the global system for mobile (GSM) digital cellular network and short message service (SMS).

LHR Repository

The LHR repository stores the summary data of EMRs and the links to all EMRs wherever they may be in such a way that all details may be retrieved on-line whenever they are required. LHRs are generated based on EMRs by the LHR collator, which is located centrally in the HIMS component. The LHR repository contains a patient's dynamic and static health records of her/his clinical episodes from birth (depending on when (s)/he participates in the system) to the current date. The CCS component and other HIS retrieve and maintain patient health records from/to the LHR repository by using Retrieve Health Records and Maintain Health Records use cases through HOMS contact links, where the contents of data are standardised.

LHS File

The LHS file stores the crucial summary of LHRs decentralised at every healthcare facility centre and even within doctors' PCs and patients' portable storage devices. The LHS' data contain patients' critical health conditions that the doctors must be aware of for diagnosing problems and providing accurate treatment for the patients. Based on the critical study carried out in the outpatient clinic, the LHS should have at least seven visits in terms of outpatient episodes and three admission visits in terms of inpatient episodes. During a system disaster, the LHSs can be retrieved and stored from/to the local hard drive of a doctor's PC or portable storage devices in the patient's possession. This can be done by using Retrieve Health Records" and Maintain Health Record use cases through the client storage manager module.

6.2.2.3 *My*Tel use case view

The use cases are identified to support the system implementation and to mitigate those issues described in the literature chapter. The crucial use cases are identified to support the critical process of the consultation workflow during a system disaster. In the use case approach, functional requirements are defined in terms of actors, who are users of the system, and use cases (Gomaa, 2005). A UML use case model (Figure 6.2) describes the functional requirements of the *My*Tel system in terms of the actors and use cases and the interaction between the actors/users and the system in a sequential manner (Conallen, 2000). The healthcare professional, registrar, portable storage devices, requestor and provider are the actors of the use cases. The healthcare professional and registrar are the main users interacting with the system.

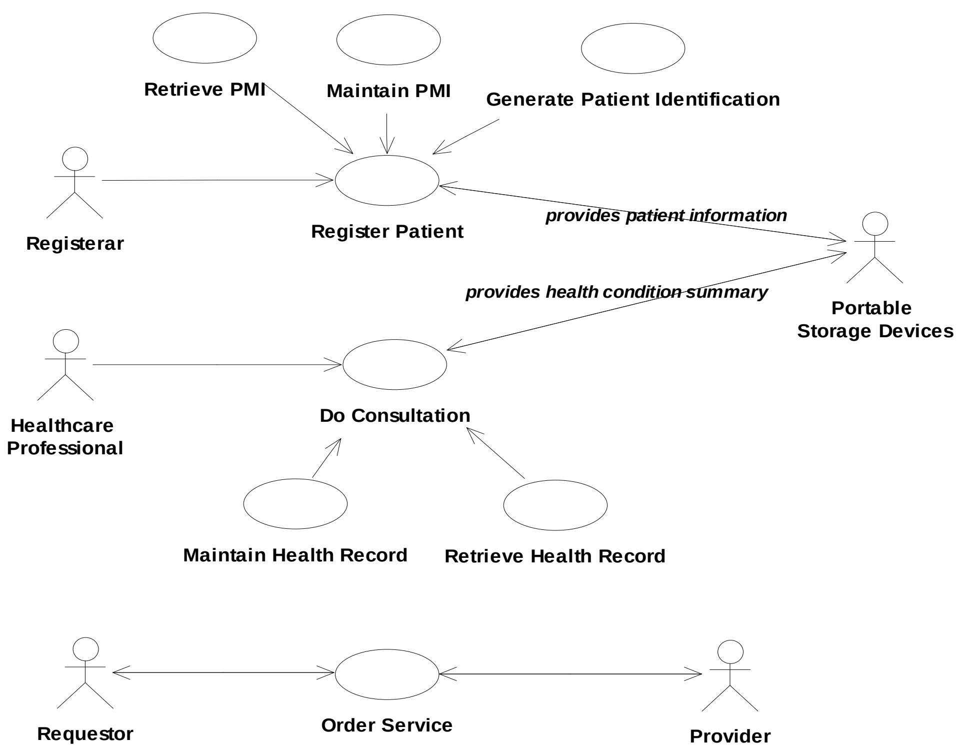

Figure 6.2: MyTel Use Case View

### *i)	Register Patient*

This use case is meant to register outpatient patients. Outpatient registration covers new, follow-up and referred cases. All patients who come to a healthcare facility are registered into the system before they can receive a healthcare service in an episode of care. The registration process includes the process of searching for the patient (Verify Patient Identification use case) for verifying the patient's identification. In addition, the registration process provides an option to maintain the patient's demographic information (Maintain Patient Demographics use case). A very important point is that this system can capture the minimum information about the patient during a system disaster. It is not appropriate to implement the formal process of patient registration during a system disaster. The tasks for processing patient arrival and registration are relatively complex and time-sensitive involving the capturing of administrative data (Health Level 7, 2007a). Critical to this workflow is the ability to manage the patient. Quick registration is the process that allows healthcare professionals to enter a sufficient amount of data to generate a new episode or patient identification number. This permits healthcare professionals to capture or maintain health records on the patient although formal registration and verification of administrative data have not yet occurred. The Register Patient use case addresses the following issues.

a) <u>Generation of the Patient Identification Number</u>

The Register Patient use case initiates the generation of the patient identification number (PIN). The PIN is a unique patient health record identifier. A patient identification number is generated once; and it will be used by the patient for his/her lifetime. The aim of the module is to formulate a PIN that will be the standard for the nation. The workflow and rule of generating the PIN will be discussed in the PIN use case.

b) Common Framework for Integration with Portable Storage Devices

The Register Patient use case involves retrieving patient data (PIN, name, citizen ID, date of birth, gender and address) from the patient's portable storage devices. This will be the common framework used for integration with portable storage devices.

c) Common Framework for Integration with HIMS

The registration process involves verifying the patient's identification, generating the PIN and maintaining patient demographic information. These data are retrieved from the patient information module and patient identification module in the HIMS. The HOMS will be a common framework for integration with HIMS.

ii) Maintain PMI

The purpose of the use case is to maintain the patient's demographics during the registration of the visit. All patients who come to a healthcare facility are able to update their most recent information during the registration of the visit. This can be done by requesting the registration clerk to update the changes. If the patient's record does not exist within the healthcare facility, the PMI information should be made available from the health information management and support component (HIMS). In the event of a system disaster, the system will be operating offline and the patient demographics should be retrievable from the available portable storage devices. The basic datasets for patient demographics include the patient's identification number

(PIN), name, date of birth, gender, race, religion, address and telephone number (Health Level 7, 2007b; Roman et al., 2006).

iii) Do Consultation

The purpose of the use case is to enable doctors to continue capturing the consultation findings into the system during a system disaster. The consultation process can be continued for gathering the medical history of the patients, recording the examination details of the patients, providing one or more diagnoses if required, prescribing treatment if required, entering clinical examination reports and informing of subsequent appointment dates (EMRWorld, 2006; Medline Plus, 2008d).

The consultation process begins once the person gets to see the doctor. In the event of a system disaster (the unavailability of a network connection), the *My*Tel framework should be able to provide a tool for the doctor to create, display and store the patient's health records seamlessly and continuously. The *My*Tel should provide the ability to record a minimum amount of consultation notes such as the chief complaint, history of the present illness, past medical history, social history, drug history, family history and diagnoses and treatment.

The consultation process involves viewing the patient's LHS for a better picture of the patient. The patient's health records are captured and kept for future care. During a system disaster, these data can be retrieved and saved from/to portable storage devices. This will be the common framework used for integration with portable storage devices.

iv) Retrieve Health Record

This use case is meant to view the lifetime health summary (LHS) of the patient during the doctor-patient encounter. The record of previous visits (including diagnoses and treatment) are consulted to give the doctor a better understanding of the patient's case. During a system disaster, this LHS is retrieved from portable storage devices or from HIMS. The HOMS architecture will be a common framework for integration with portable storage devices and HIMS.

v) Order Service

This use case is meant to place the order relating to the health transaction (access, browse and store LHR). The order transaction can be new, cancel or response and all of them will be transacted into HOMS's order queue list. During a system disaster, doctors can retrieve the patient's demographics and LHS using the short messaging system (SMS) from HIMS through HOMS integration services.

All orders which are already placed either by the placer or filler will be distributed/routed to the destination by the HOMS Manager and the destination address is looked up in the service directory address index. HOMS Manager is a software program that is also responsible for validating the order information in order to ensure that the order information meets the standard order specifications.

Upon completion of the placing or distributing of the order processes for a particular order's transaction, the acknowledgement message is prepared and then placed in the order queue. An acknowledgement is then sent to the placer or filler to acknowledge the status (success, failure, received or rejected) of the order. The order transaction can be tracked and monitored by identifying the status of the order. The order status could be success, failure, just received, in progress or rejected.

vi) Maintain Health Record

This use case is meant to maintain a patient's lifetime health record (LHR). The LHRs are maintained centrally in HIMS and are accessible anywhere via an Internet connection or global system mobile (GSM) network through portable storage devices. The Maintain Health Record use case receives episodic personal health records (EMRs) from the healthcare facility system (CCS) and adds them into the LHR repository. The LHR Collator will translate and format the health data into a standard dataset before inserting the health data into the LHR repository. During a system disaster (by way of example, the unavailability of a telecommunication network), the HOMS integration service and portable storage devices will be a common framework of integration for submitting/retrieving the LHRs to/from HIMS.

vii) Generate Patient Identification Number

This use case is to generate a unique patient identification number at the national level. This is to ensure that each and every person carries a single PMI number only. The system should be able to generate the PMI number, which is used as a unique identifier. PMI is a standard structure of a person's demographic data indexed by a unique identifier. Every patient who visits the healthcare facility will be given a unique identifier, the PMI number, which can be used to retrieve his/her registration details and health records. The system should be able to generate the

PMI number centrally at HIMS to ensure the uniqueness of the PMI number at the nationwide level and to assure that each and every person carries a single PMI number only. The PMI number will serve as a medical ID for the patient and the patient may present his/her PMI number for his/her subsequent visit to the healthcare facility, replacing other documents such as the national identity card number (IC) to retrieve his/her records.

The generation of the PMI number should cover two events.

a) Online mode: at the respective healthcare facility, when there is a request to assign a PMI number to a person at the point of registration, the system should be able to search for the PMI number at the specific hub (health facility data centre) through the new or old IC number. This is to ensure that the person has not been assigned a PMI number previously. If the PMI number does not exist at the specific hub, the system should be able to send the request to HIMS to search for it at the central location. If the PMI number exists at HIMS, the system would be able to send the respective PMI number along with the person's PMI details. If it does not exist it should notify the specific hub that the person's PMI number does not exist at HIMS; thus, the system at the specific hub will auto assign a PMI number to the person.

b) Offline mode: the system is in the offline mode when the network connection is unavailable or the computer system is down. During this time the system should be able to generate the PMI number offline and it would be decentralised at the respective healthcare facility. This PMI number is assigned to the person who has not been assigned any PMI number previously. For those who already have a PMI number, the same number will be maintained for the upkeep of the LHR. By using the PMI number within or beyond a healthcare facility, the medical records from different healthcare facilities could be consolidated into a single ID domain. The goals to have seamless and continuous healthcare services among all healthcare providers would be achieved.

6.2.2.4 *My*Tel process view

The process view represents the logical processes and interaction flow involved in each component within the framework (Conallen, 2000). The scenarios for accessing, creating and storing LHRs during normal system operations and system disasters will be used to present the solution framework for *My*Tel. In order to give a clear understanding of how the framework mitigates the above scenarios, the crucial solution framework for *My*Tel will be presented. This includes 1) the solution framework for generating the patient's master index number (PMI), 2) the solution framework for retrieving the PMI and LHR, 3) the solution framework for maintaining the PMI and LHR and 4) the solution framework for the ordering service.

6.2.2.4.1 Solution framework to retrieve the PMI number during normal system operation

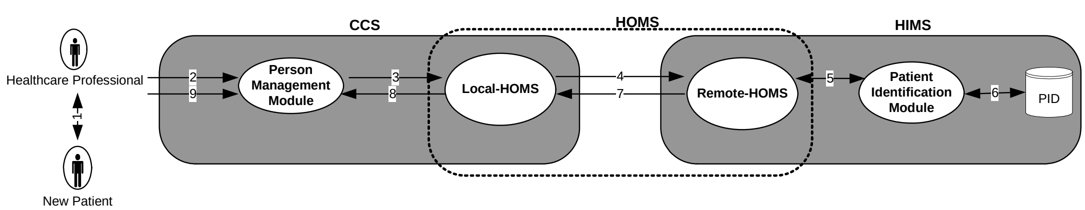

Figure 6.3: Logical View to Retrieve the PMI Number during Normal System Operation

1. The new patient visits the healthcare centre and sees the doctor.
2. The healthcare professional invokes the PMM module and enters the patient's national identification number (NIC) to request the PMI number from HIMS.
3. The PMM module invokes Local-HOMS to send the order request.
4. Local-HOMS sends the order request to Remote-HOMS through the Internet connection.

5. Remote-HOMS identifies the order message and invokes the Patient Identification (PID) module.
6. The PID module searches for the patient using the NIC from the PID database to ensure that each patient is assigned with one PMI number across all participating healthcare facilities. The PID module then generates a unique PMI number using a specific algorithm, assigns it to the patient and adds/saves it into the PID database.
7. Remote-HOMS returns the order request to Local-HOMS.
8. The PMM module receives the PMI number for the new patient.
9. The healthcare professional enters the patient's information.

6.2.2.4.2 Solution framework to retrieve the PMI number during the unavailability of the landline telecommunication network

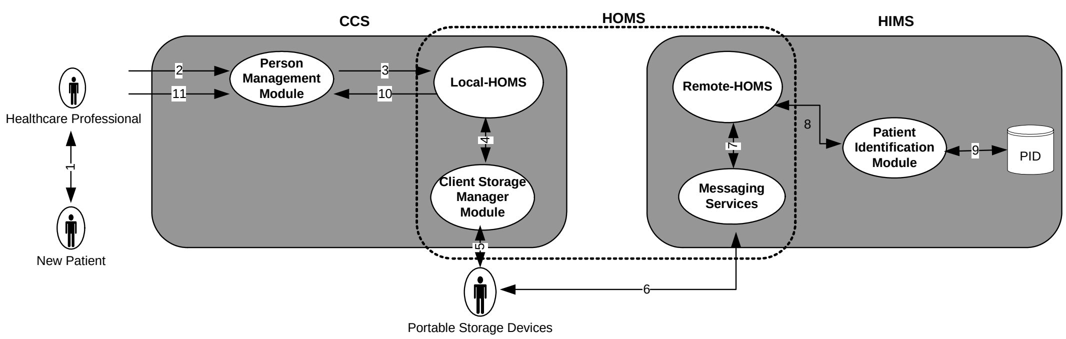

Figure 6.4: Logical View to Retrieve the PMI Number during the Unavailability of the Landline Network

1. The new patient visits the healthcare centre and sees the doctor.
2. The healthcare professional invokes the PMM module to request the PMI number from HIMS by providing the patient's national identification number. (NIC)
3. The PMM module invokes Local-HOMS to send the order request.
4. Local-HOMS invokes the ClientStorageManager module to identify the communication network status.
5. ClientStorageManager informs Local-HOMS of the network status, identifies the available devices and performs data formatting to send the order request to/through portable storage devices.
6. Portable storage devices send the order request to Remote-HOMS through the Messaging Service module located at HIMS.
7. Remote-HOMS receives the order request from the Messaging Service module.
8. Remote-HOMS identifies the order message and invokes the Patient Identification (PID) module.
9. The PID module searches for the patient NIC in the PID database to ensure that each patient is assigned with one PMI number across all participating healthcare facilities.

The PID module then generates a unique PMI number using a specific algorithm, assigns it to the patient and adds/saves it into the PID database.

10. The PMM module receives the PMI number for the new patient.
11. The healthcare professional enters the patient’s information.

6.2.2.4.3 Solution framework to retrieve the PMI number during downtime of the back-end system

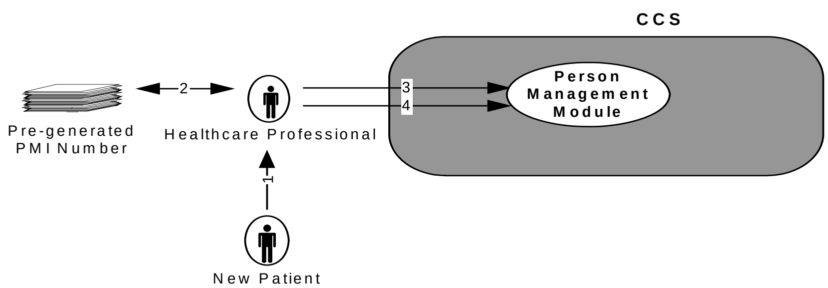

Figure 6.5: Logical View to Retrieve the PMI Number during Downtime of the Back-end System

1. The new patient visits the healthcare centre and sees the doctor.
2. The healthcare professional takes the PMI number from the pre-generated list of PMI numbers.
3. The healthcare professional assigns the PMI number to the patient and enters it into PMM.
4. The healthcare professional starts recording the patient’s information.

6.2.2.4.4 Solution framework to retrieve and maintain the PMI and LHR during normal system operation

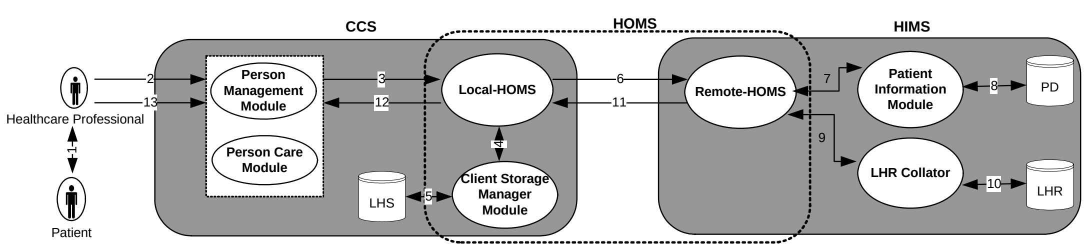

Figure 6.6: Logical View to Retrieve and Maintain the PMI and LHR during Normal System Operation

Retrieve PMI and LHR

1. A clinical visit episode begins when the patient visits the healthcare centre and sees the doctor. The patient presents his/her identity card.
2. The doctor/nurse invokes the PMM module to retrieve the patient's demographic information by entering the patient's unique identification number or national identification number.
3. The PMM module invokes Local-HOMS to send the order request.
4. Local-HOMS invokes the ClientStorageManager module to identify available devices.
5. The ClientStorageManager module retrieves the patient's information and health record summary from the local LHS database. If the patient health summary exists in the LHS database, go to step 12; or else go to step 6.
6. Local-HOMS identifies the order destination and contacts Remote-HOMS to forward the order request.
7. Remote-HOMS identifies the order message and invokes the patient information module.
8. The PIM module retrieves the patient information from the PD database.
9. Remote-HOMS precedes the request by invoking the LHR Collator module to retrieve the patient's health records.
10. The LHR Collator module retrieves the patient's health summary from the LHR database using the patient identification number and returns the request to Remote-HOMS.
11. Remote-HOMS returns the request (patient information and health record summary) to Local-HOMS.
12. PMM and PCM retrieve the patient's information and populates it onto the PMM and PCM screens.
13. The healthcare professional views the patient information.

Maintain the PMI and LHR

1. The patient informs the healthcare professional of his/her problem.
2. The healthcare professional investigates the patient's problems and records the clinical findings and clinical notes into CCS component (PMM and PCM module).
3. The CCS component invokes Local-HOMS to send the updated LHR and PMI.
4. Local-HOMS invokes the ClientStorageManager module to identify available devices.
5. The ClientStorageManager module adds LHRs and the PMI into the local LHS file.
6. Local-HOMS contacts Remote-HOMS to update the latest LHR and PMI in HIMS centrally.
7. Remote-HOMS invokes the PIM module.
8. PIM module updates the patient's information onto the patient information database (PD).
9. Remote-HOMS processes the update by invoking the LHR Collator module.
10. LHR Collator adds the patient health record onto the LHR repository.
11. Remote-HOMS returns the order request to Local-HOMS.
12. CCS component receives the order status message acknowledging the order request to update LHR and PMI has been completed.

6.2.2.4.5 Solution framework to retrieve and maintain the PMI and LHR during the unavailability of the landline telecommunication network

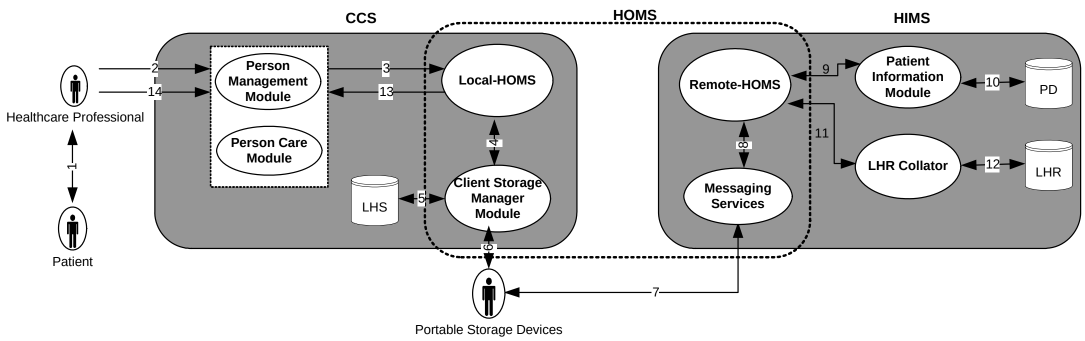

Figure 6.7: Logical View to Retrieve and Maintain the PMI and LHR during System Unavailability of the Landline Network

Retrieve the PMI and LHR

1. The patient sees the doctor and presents his/her national identity card.
2. The healthcare professional invokes the CCS component (the PMM and PCM module) to retrieve the patient's demographics and health records by entering the patient's unique identification number or national identification number.
3. The CCS component invokes Local-HOMS to send the order request.
4. Local-HOMS invokes the ClientStorageManager module to identify the available devices for accessing the patient's information and health record summary.
5. The ClientStorageManager module retrieves the patient's information and health record summary from local storage — LHS. If the patient exists in Local LHS go to step 13 or else go to step 6.
6. The ClientStorageManager module performs data formatting and invokes the portable storage device.
7. The portable storage device sends the order request to Remote-HOMS through Messaging Service located at HIMS.
8. Remote-HOMS receives the order from the Messaging Service.
9. Remote-HOMS reads the order message and invokes the PIM module.
10. The PIM module verifies the PMI number and retrieves the patient's information from PD.
11. Remote-HOMS continues with the request by invoking the LHR Collator module.
12. LHR Collator retrieves the patient's health record summary from the LHR repository.
13. The CCS component receives the patient's information and health record summary and populates onto CCS screen.
14. The healthcare professional views the patient's information and lifetime health summary.

Maintain the PMI and LHR

1. The patient informs the healthcare professional of his/her problem.
2. The healthcare professional investigates the patient's problems and enters the clinical findings and clinical notes into the CCS component.
3. The CCS component invokes Local-HOMS to send the new episode of LHR and the updated PMI.
4. Local-HOMS invokes the ClientStorageManager module to identify available devices.
5. The ClientStorageManager module performs data formatting and updates the LHR summary and PMI into the local LHS.
6. The ClientStorageManager module then invokes the portable storage device to submit the formatted data.
7. The portable storage device sends the order request to Remote-HOMS through the Messaging Service located at HIMS.
8. Remote-HOMS receives the order from the Messaging Service.
9. Remote-HOMS reads the order message and invokes the PIM module.
10. The PIM module verifies the PMI number and updates the patient's information into PD.
11. Remote-HOMS continues with the request by invoking the LHR Collator module.
12. LHR Collator adds new episodes of the patient's health records into LHR repository.
13. The CCS component receives the order status message acknowledging that the order request to update the LHR and PMI has been completed.

6.2.2.4.6 Solution framework to retrieve and maintain the PMI and LHR during downtime of the back-end system

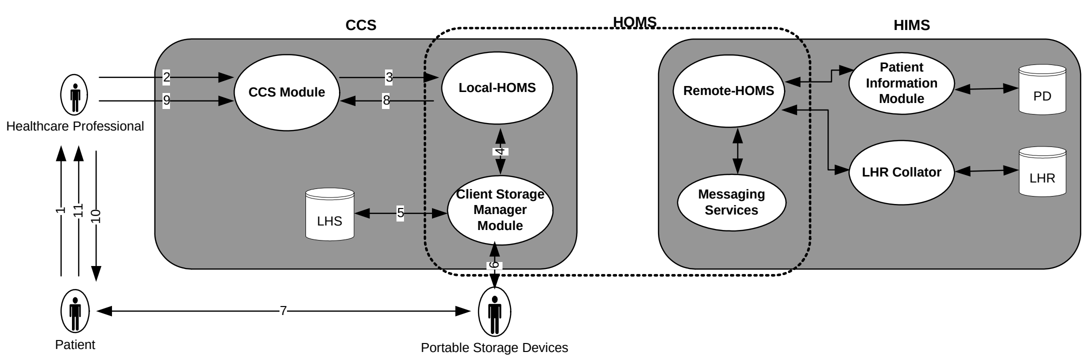

Figure 6.8: Logical View to Retrieve and Maintain the PMI and LHR during Downtime of the Back-end System

Retrieve the PMI and LHR

1. The patient visits healthcare centres and sees the doctor during system downtime.
2. The healthcare professional invokes the CCS module and enters the patient's PMI number or NIC number.
3. The CCS module invokes Local-HOMS to send the order request to retrieve the patient's health records and PMI.
4. Local-HOMS invokes the ClientStorageManager module to identify available devices.
5. The ClientStorageManager module retrieves the patient's health records and PMI from the local LHS. If the patient exists in the local LHS go to step 8 or else go to step 6.
6. The ClientStorageManager module invokes the portable storage device to retrieve the patient's health record summary and PMI.
7. The patient authorises the use of his/her portable storage devices and the health record summary is sent to the ClientStorageManager module.
8. The CCS module receives the patient's health record summary and the patient's information, and the data is populated into the CCS screen.
9. The healthcare professional views the patient's information and patient's health record summary.

Maintain PMI and LHR

1. The patient informs the healthcare professional of his/her problem during downtime of the back-end system.
2. The healthcare professional investigates the patient's problems, enters the clinical findings and updates the necessary patient demographics into the CCS module.
3. The CCS module invokes Local-HOMS to send the new episode of LHR and the updated PMI.
4. Local-HOMS invokes the ClientStorageManager module to identify available devices
5. The ClientStorageManager module performs data formatting and updates the LHR summary and PMI with the "off-line" indicator into the local LHS.
6. The ClientStorageManager module then invokes the portable storage device to pass on the formatted data.
7. The patient authorises the use of his/her portable storage devices and the health record summary is written into the portable storage device.
8. The CSS module receives the message that the order request to update the LHR and PMI has been completed.

6.2.2.5 *My*Tel deployment view

The deployment view exposes the *My*Tel deployment diagram's functionality in the extensibility interface (Fowler, 2004). Figure 6.9 show a system's physical layout, revealing which pieces of *My*Tel's components (CCS, HOMS and HIMS) run on which pieces of hardware. The deployment view describes and exposes the unit of software, firmware, hardware and telecommunication network to be installed and executed in the user's actual environment. The *My*Tel framework component is installed in all doctors' PCs at health centres. GSM mobile phones (Lua et al., 2005) are attached to all PCs to enable the sending and receiving of data (lifetime health summary) between doctors at health centres and HIMS — located centrally at the Ministry of Health office (MOHM) (for example, the telehealth data centre of MOHM). The retrieving and storing of the patients' health records would use the SMS applications as transport for data transmission. In order to protect the captured clinical findings from being lost during system downtime, the local data storage (LHS) is also provided by *My*Tel.

*My*Tel can also be used by the mobile paramedic for retrieving the patient's health history in providing treatment to an emergency patient. The SMS server located at HIMS is a gateway to send (and receive) SMS messages from a doctor's computer to the health information management system.

For the hospital environment set-up, a GSM modem is deployed remotely as a gateway for all users in the hospital's local area network to send (and receive) message to HIMS. During normal circumstances, a request for a lifetime health summary can be made through an Internet connection via the hospital's web server. The existing application systems (TPC, THIS and other HIS) could also request the LHR from HIMS through Local-HOMS or switch to the *My*Tel application for accessing and storing patients' health records. Finally, HIMS located at the MOHM office is linked to the mobile network operator either using the wireless or Internet protocol (IP) connection (Geier, 2001).

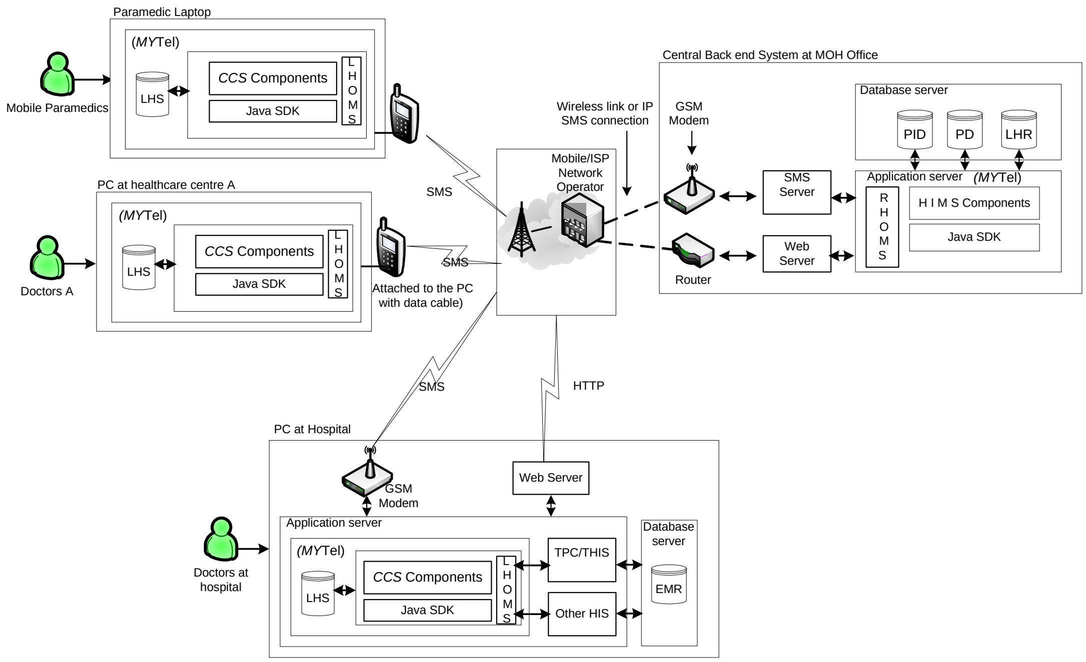

Figure 6.9: MyTel Deployment View

6.3 Summary

This chapter proposes a new flexible framework for the telemedicine system derived from the literature, case study and close collaboration with MOHM. The lessons learned from the previous health ICT projects implemented in the public healthcare facilities of MOHM such as telehealth, TPC and THIS contributed important elements into the proposed framework.

The framework has proposed portable storage devices and an interoperable order management system for increasing the flexibility in accessing the LHR seamlessly and continuously during system disasters. Seamless and continuous access to LHR mitigates the episodic health records stored fragmentally in individual HISs of healthcare facilities. In addition, the framework would help to resolve the inconsistency of telecommunication networks across healthcare centres and would be cost effective if implemented at health clinics in rural areas.

The minimum functionalities (*My*Tel use cases) are proposed for the framework after taking into consideration the existing investment in the HIS system such as TPC and THIS. The proposed HOMS component would also have the important responsibility of providing the standard architecture for integration across applications (such as TPC, THIS and other HISs). The ability to work off-line and the use of global system mobile (GSM) communication for retrieving and sending the LHS increase the flexibility of the telemedicine system.

The following chapter will describe the validation process to be conducted at MOHM in validating the proposed conceptual framework of this research. This should allow the proposed framework to be reviewed and improved on in the revised framework.

Chapter 7 Validating the Framework (*My*Tel)

7.1 Introduction

This chapter presents the details obtained from three case studies (existing case study plus two additional ones), which will be used to validate the proposed framework. In order to ensure it can be used for the Malaysian telemedicine system for the continuous and seamless upkeep of LHRs, the framework was shown to three divisions/projects in the Ministry of Health that were involved directly in the development of the national health ICT project across healthcare facilities and levels. The divisions are the Telehealth Division, the Family Health Development Division and Health Planning and Development Division. The three divisions are directly involved in managing and developing the telehealth application, teleprimary care application and total hospital information application respectively. The three major health ICT projects provide a crucial contribution to the success of the Malaysian integrated telehealth system (Ministry of Health Malaysia, 2007).

7.2 Undertaking the Validation

This process was carried out in order to generate evidence for the following three issues:

i) to validate the need for the flexible framework for the continuous and seamless upkeep of LHRs

ii) to validate the need for integrated LHRs for accessing patients' health records continuously and seamlessly

iii) to validate the proposed framework.

The first and second issues were discussed in chapters two and four. The questionnaire for validating the proposed flexible framework are enclosed in Appendix F. The third issue had the following possible outcomes:

i) the *My*Tel framework is acceptable as it is;

ii) the *My*Tel framework is acceptable, but requires certain modifications;

iii) the *My*Tel framework is not suitable.

According to Yin (2003), the use of multiple case studies would generate complimentary evidence and it was widely acceptable for the *My*Tel framework. The questions with regards to the validation of the *My*Tel framework were organised into the following sections: 1) the *My*Tel solution framework model; 2) the viability of the framework; and 3) the implementation process. The framework was validated by analysing the feedback and responses from the following questions:

1. *My*Tel architectural framework

*My*Tel components

a) Is the explanation for *My*Tel components concise and clear?
b) Are the roles of *My*Tel components described adequately?
c) Do you have any suggestions that you would like to make to revise the *My*Tel components (please provide particulars)?

*My*Tel functionalities

d) Are the *My*Tel functionalities (use cases) concise and easy to understand and implement?
e) Do you agree with the processes described in the *My*Tel use cases?
f) Based upon your experience, are there any critical use cases that you would like to incorporate in the *My*Tel functionality (please provide particulars)?

*My*Tel solution framework process

g) Is the *My*Tel solution framework process easy to understand and implement?
h) Do you agree with the solution framework flow described in each of the scenarios?

i) Do you have other important scenarios that should be described in the *My*Tel solution framework process (please provide particulars)?

*My*Tel framework design

j) Do you think that the design of the *My*Tel framework is concise and clear?
k) Is the *My*Tel framework design scalable, flexible and easy to integrate with the existing system?
l) Are there any suggestions that you would like to make to revise the *My*Tel framework design (please provide particulars)?

2. Viability of the framework

a) Do you think there are any specific benefits that may not have been stated that might arise from the implementation of the *My*Tel framework?
b) What are probably the main problems that can impede the implementation of the *My*Tel framework?
c) If accompanied by a detailed supporting documentation, would you be willing to implement the *My*Tel framework (system)?
d) Do you think you will use the *My*Tel framework in future?

3. Implementation process

a) Was the introduction to the *My*Tel framework adequate?
b) Do you have any suggestions for how the *My*Tel framework might be introduced in a more coherent and simple manner (please provide particulars)?
c) Given the *My*Tel user guide, would you be willing to implement the *My*Tel framework (system)?
d) Was there any dispute by your users with regards to the possible implementation/acceptance of the *My*Tel framework?
e) If so, how could the barriers to the possible implementation/acceptance of the *My*Tel framework be overcome (please provide particulars)?
f) Are any cultural changes required before the implementation of the *My*Tel framework (system) (please provide particulars)?
g) Are any standards required before the implementation of the *My*Tel framework (system) (please provide particulars)?

7.3 Selection Criteria of the Case Study Organisation

There are three major health ICT's projects embarked on across healthcare facilities and levels in the Ministry of Health Malaysia (MOHM). The three health ICT projects (namely Total Hospital Information System (THIS), Teleprimary Care (TPC) and Telehealth (TH)), which were involved in computerising the administration for and clinical information about patients in various levels of healthcare services, were selected to validate the proposed framework. These projects are owned by the three different divisions within the MOHM: the Health Planning and Development Division owns the THIS project; the Family Health Development Division owns the TPC project and the Telehealth Division owns the telehealth project. In other words, the three divisions are responsible for providing the business directions, requirements and implementation of the system to be developed and deployed in their healthcare facility premises. However, the technology direction and management are still reporting to and managed by the ICT Division of MOHM. The ICT Division provides technical advice, technical planning, system development, maintenance and support and ICT infrastructure and data centre for the project.

Yin (2003) stressed that it is important that the case study nominations are screened and it is important to ensure that the selected nominations must have contextual similarities with the main case study. If not, it could not be claimed that the theory and model created have been validated. The rationales for selecting the three projects to validate the *My*Tel framework are as follows.

1. The organisation has to be a Malaysia healthcare information technology solution provider or operate in the healthcare sector offering ICT consultancy services.
2. The project has mainly been developed for use by the Malaysia healthcare system under the Ministry of Health Malaysia.
3. The project has to be directly or indirectly contributing to the development of telehealth/telemedicine system in the Malaysia context

4. The organisation should be one of the divisions under the Ministry of Health Malaysia that provide services for the health and medical sector in public healthcare facilities.
5. The project should be willing to consider implementing the new framework in the Malaysia telemedicine system.
6. The organisation is willing to answer the research questions and, whenever required, be willing to provide data for detailed discussions.
7. The organisation has to allow their responses to be documented separately and allow the findings to be made available to the academic community. Respondent confidentiality is offered to all the three cases.
8. The organisation has to allow their responses to be compared with the responses of other cases and authorise the dissemination of the findings to the academic community. Respondent confidentiality is offered to all the three cases.

Selection criteria for the case study nominations	THIS	TPC	TH
Be a Malaysia healthcare information technology solution provider	***	***	***
Has been developed for the Malaysia healthcare system under the Ministry of Health Malaysia	***	***	***
Has to be directly or indirectly contributing to the development of the telehealth/telemedicine system in the Malaysia context	**	**	***
Should be one of the divisions under the Ministry of Health Malaysia that provide services for the health and medical sector in public healthcare facilities	***	***	***
Be willing to consider implementing the new framework in the Malaysian telemedicine system	**	**	***
Be willing to answer the research questions and, whenever required, be willing to provide data for detailed discussions	***	***	***
Allow their responses to be documented separately and allow the findings to be made available to the academic community	***	***	***
Allow their responses to be compared with the responses of other cases and authorise the dissemination of the findings to the academic community.	***	***	***

Figure 7.1: Selection Criteria for the Case Study Nominations

Note:
* - The case did not meet the minimum requirements.
** - The case met the minimum requirements.
*** - The case met all the requirements.

7.4 Generalisation Strategy

Generalisation is defined as the degree to which the findings or results can be generalised from the study sample to the entire population (Yin, 2003b; Patton, 2002; Miles and Huberman, 1994). The key to generalisation is to understand how much the results can be applied backwards to represent the group or population as a whole (Patton, 2002).

In conducting qualitative research, Patton (2002) warned that there are some disadvantages associated with this type of research and listed one of them as "fewer people are studied and as a result it is less easily generalised". Another criticism of qualitative research is regarding the value of its dependence on small samples, which is believed to render it incapable of generalising conclusions (Yin, 2003b; Yin, 2003a).

The issue regarding fewer respondents was overcome in this research by utilising a population rather than a sample. In this research, the population consisted of the users or owners of the three different divisions within MOHM including the Planning and Development Division, Public Health and Family Division and Telehealth Division. The issues of generalisation were overcome by demonstrating that the study was conducted according to a structured methodology and guided by theoretical concepts and models and a number of data gathering methods and processes were used (Cohen and Manion, 1986). This addressed the issue of generalisation.

The small sample size used in testing led to the issue of external validity where the results could not be transferable to other populations or contexts (Creswell, 1994). In this research, the issue of external validity was addressed by using the proximal similarity (William, 2006). As an example, if the sample was obtained from one healthcare facility, it was dangerous to assume that it represented all healthcare facilities. It was also inappropriate to assume that if the sample was obtained from one clinical discipline or one clinical specialty, its workflow represented all disciplines. It was, however, reasonable to assume that the results should apply to a similar sized or similar clinical discipline of the healthcare facility with similar workflow processes. To illustrate another example, this research chose outpatient clinics and clinical diagnosis processes for generalising the doctor–patient consultation workflow. The processes or phenomena in providing consultation and diagnoses is typically similar around the globe and the results could be replicated to other researches in Southeast Asian countries that have similar a set-up for healthcare services (Nguyen et al., 2008). It could very well be replicated in other developed countries as well. If the phenomena in providing healthcare services in certain countries are slightly different due to different socio-economic backgrounds and cultures, the domain workflow is still the same and it should produce the same results. Although not perfect, it certainly contains more external validity and would be an acceptable generalisation.

The selection of a significance sampling was one of the case study's challenges in collecting and gathering evidence (Eisenhardt, 1989; Irani et al., 1999). The selected sample group should be as truly representative of the whole context as possible. The issue regarding "truly representative" was addressed by using multiple case studies. MOHM's actual health ICT projects, including THIS, TPC and Telehealth, were proposed. The aim was that these multiple cases should validate the phenomenon and the proposition of the framework through different entities (Rowley, 2002). This in turn overcame the issue of behavioural changes with respect to the generalisation.

To recapitulate, the use of proximal similarity, significance sampling and multiple case studies for generalisation were the verification and validation processes pursued in this research. All these were not only used to increase the "sophisticated rigour" of the analysis, but also to help disclose the "richness" of social settings for a qualitative inquiry (Neuman, 1991). The next section will provide a description regarding validation results from the three cases in MOHM.

7.5 Discussion of the Case Study Investigations

The responses from the three case study investigations are discussed and presented in a textual structure. The case starts with a brief elaboration of the project background and continues to the discussion of the case study investigations.

7.5.1 Case A – Total Hospital Information System Project

7.5.1.1 Project background

The Total Hospital Information System (THIS) project is one of the national health ICT projects embarked on by the government since 1996 in Selayang Hospital. The role of the project is to computerise new individual healthcare facilities or hospitals. THIS was designed to provide in-depth information on services in an individual hospital by automating the total running and managing of the processes in the hospital including the clinical, financial and administrative systems. Documenting the care provided in hospitals accurately will be provided through this THIS project. As a result, data from different parts of the hospital are made available in a seamless fashion within the hospitals. Then, the individual THIS application system will be integrating with the Telehealth application for generating the lifelong health record services.

The THIS project is headed by the Health Planning and Development Division of MOHM and technically advised by the ITCD. As of now, five new hospitals (Selayang Hospital in Selangor state, Putra Jaya Hospital in Putra Jaya Territory, Pandan Hospital in Johor state, Lahad Datu Hospitals in Sabah state, Hospital Kepala Batas in Penang state and Serdang Hospital in Selangor state) have been installed with this THIS application and another 13 new hospitals will be developed and installed with THIS by the year 2010. The developmental approach of the THIS application is through outsourcing and software package integration. Although the applications in each hospital use different software technologies and platforms, a minimum critical requirement for all these facility-based systems is that they must contribute to generating the EMRs and building the LHRs of patients.

The crucial role of the THIS project in establishing EMRs for building the LHR services in telehealth applications provided significant justification for adopting the THIS project as an additional case study for collecting evidence and validating the proposed framework. The questionnaire was centred on (1) the need for a flexible framework for the continuous and seamless upkeep of LHRs, (2) the need for an integrated LHR system for seamless and continuous care and (3) the need to validate the applicability of the proposed framework. Questions 1 and 2 were obtained through the structured and open-ended interviews conducted with various levels of the THIS project's team members. The answers to question 3 (accepted, modified and rejected) were obtained through the assessment and reviewed process carried out by THIS's key project personnel. The comments and suggestions would be analysed in order to present the applicability of the proposed framework.

7.5.1.2 Feedback on the conciseness of the *My*Tel architectural framework

***My*Tel components**

On the question of the conciseness of the explanation for the *My*Tel components, the organisation felt that the explanation was very clear and effective in assisting them to get an overall overview of the *My*Tel framework. They further pointed out (response to the question of whether the roles of the components were described adequately) that the description of the role of every *My*Tel component was adequate and clear. These made it easy for them to understand and incorporate the existing application system (THIS) flow with the *My*Tel framework. The organisation avoided making suggestions to revise the *My*Tel components at this stage.

***My*Tel functionalities**

On the question of the *My*Tel functionalities' conciseness and clarity, they pointed out that the use cases described in the framework were easy to understand and implement in the actual setting of healthcare services. They also agreed with the use cases' description and highlighted the fact that the proposed use cases were parts of the existing healthcare service process during doctor–patient encounters in hospitals. They had no further suggestions to incorporate additional use cases into the *My*Tel framework at this stage.

***My*Tel solution framework process**

On the question of whether the *My*Tel solution framework process was easy to understand and implement, they were of the opinion that the explanation was very clear and concise. They also agreed with the solution framework process described in each of the scenarios that gave a clear view of how the framework provides alternative solutions for escalating the problem of unavailable landline telecommunication networks and the downtime of computer systems. The organisation suggested that the *My*Tel solution framework should include a scenario for identifying the PMI number during the downtime of a back-end system. They further pointed out that this scenario is important for ensuring that the patient will carry a unique identifier across healthcare facilities and levels.

***My*Tel framework design:**

When their opinions were gauged on whether the design of the *My*Tel framework was concise, the organisation replied that it was clear but too brief. They pointed out that the design of the framework needed further elaboration and should preferably be presented in detail (in a technical specification perspective), including the architectural implementation design and application deployment specification.

Regarding the interoperability of the *My*Tel framework (scalability, flexibility and integratability), the organisation agreed that the framework had interoperability characteristics where the three components were designed in a modular manner with less coupling to each other.

With regards to the possibility of revising the *My*Tel framework design, the organisation felt that the *My*Tel architecture framework was quite robust in its current form for incorporating such an innovative system.

7.5.1.3 Discussion on the feedback of the viability of the *My*Tel framework

The organisation was asked if there were specific benefits to be derived from the implementation of the *My*Tel framework. They were of the opinion that the *My*Tel system was flexible and enabled the patient's health record to be accessed anytime and anywhere through the portable storage devices. They further pointed out that the implementation of the framework required some policies to be established before its implementation. They cited an example that the patient had to acknowledge and give consent to allow his or her health records to be stored in the portable storage devices.

To the question of the possibility of problems that can impede the implementation of the *My*Tel framework, the organisation pointed out that the health order management services component needed further elaboration.

When asked whether they were willing to implement the *My*Tel framework if accompanied by detailed supporting documents, the organisation answered in the affirmative that they were very keen to collaborate in incorporating the *My*Tel solution in the THIS project for maintaining the health records of the patient continuously across healthcare facilities and levels.

They also said that the *My*Tel framework had a future in providing a flexible and cost-effective solution for maintaining patients' health records continuously and seamlessly during unavailable landline telecommunication networks and the downtime of computer systems. They further commented that the use of portable devices and mobile telecommunication are critical features of the future health information system.

7.5.1.4 Discussion on the feedback from the implementation process

When asked whether the introduction to the *My*Tel framework was adequate, the organisation said that it was presented concisely and clearly. They were interested to know about further details on the implementation of the framework by providing a detailed technical specification report.

With regards to the question of how the framework could be introduced in a coherent and simple manner, the organisation requested a detailed technical specification and verbal presentation so that issues about which they were unsure could be highlighted and discussed in detail.

When asked about their willingness to implement the *My*Tel framework if the necessary documentations were provided, they responded in the affirmative that they were willing to implement the *My*Tel system through the proof-of-concept approach in certain health clinics.

With regards to the probability of disputes by the users with the implementation of the *My*Tel framework, the organisation highlighted the fact that the disputes from the users for implementing the *My*Tel framework would be marginal. They pointed out that the users were welcome to share any innovative ICT solution especially for improving the continuum of care through uninterrupted and seamless access to patients' health records.

To provide the essential infrastructure for all physicians was probably a major barrier in implementing the *My*Tel framework, according to the organisation. To cite an example, the portable storage devices (mobile phones, PDAs and laptops) should be provided for all physicians and related health workers. They further pointed out that this would eliminate a critical barrier to the implementation of the system.

When asked about the culture changes required before the implementation of the *My*Tel framework, the organisation said that there would be a minimum amount of culture change if the *My*Tel system was deployed incrementally through the proof-of-concept approach in the existing health clinics. They further pointed out that the obvious culture change needed before the implementation of the *My*Tel framework was a change in the work process of a physician during clinical consultation episodes.

With regards to the question of whether the necessary standards needed to be provided before implementing the framework, the organisation replied that the necessary standard should be established such as the administrative code set and clinical code set standards.

7.5.2 Case B — Teleprimary Care Project

7.5.2.1 Project background

The Teleprimary Care (TPC) project is one of the telemedicine initiatives that focus on the computerisation of the primary healthcare system in Malaysia. The project started in February 2003 and has been piloted from 2004 until now in the three states of Johor, Sarawak and Perlis. The total healthcare facilities (sites) involved in the pilot project include two reference hospitals, 46 health clinics, two state health offices, four district health offices and five divisions in the Public Health Department.

The TPC project is intended to overcome the existing inefficient methods of consultation and the workflow process between primary care centres and secondary care centres. Examples of limitations include episodic care, physical distances that incur patients' travel costs and insufficient specialist care as well as the sheer volume of paper-based medical records that need to be digitised and shared across healthcare facilities. The TPC project was designed to computerise all the functions (clinical and administrative) in the health clinic with the exception of the dental health service. Documenting care provided in health clinics accurately will be provided through the TPC project and, as a result, data from different parts of the health clinic are made available in a seamless fashion across health clinics.

The TPC project is headed by the Family Health (Primary Care) Department under the Public Health Division of MOHM. The development of the TPC application system is through smart collaboration between MOHM and the awarded ICT company. The genuine experience and knowledge of project team members in developing and implementing the TPC project for the country undoubtedly make the TPC project highly suitable for selection in my additional case study.

7.5.2.2 Feedback on the conciseness of the *My*Tel architectural framework

***MyTel* components**

The organisation felt that the overall explanation for the *My*Tel components was fairly clear and simple enough to be used in its form by the project wishing to use it to initiate the *My*Tel system. To the question of whether the roles of the *My*Tel components were described adequately, they said that the elucidation of each component was fairly adequate and the separation of responsibility for each component was clearly defined in a modular manner. The organisation had no further suggestions for any revision to the *My*Tel components.

***MyTel* functionalities**

With regard to the question of whether the *My*Tel functionalities were concise and easy to implement, the organisation said that there were no problems with understanding and implementing them. The organisation agreed with the process described in the *My*Tel use cases, and further pointed out that the *My*Tel use cases were enough to facilitate the collection of patients' health records in the outpatient clinics.

When asked about whether other important scenarios should be included in the framework, Case B said that they had no suggestions for adding another use case in the framework. They added that the proposed *My*Tel use cases had enough features to capture, view and store patients' health records during the consultation events in outpatient clinics.

***My*Tel solution framework process**

The organisation felt that the *My*Tel solution process was fairly clear and easy to understand. They also agreed with the solution framework described in each of the given scenarios. However, they suggested a field study to validate the actual workflow processes. When asked to suggest any other important scenarios that should be included in the *My*Tel solution framework process, the organisation had no suggestions at that time.

***My*Tel framework design**

Case B agreed that the design of the *My*Tel framework was fairly clear and provided clear roles for the components.

When asked whether the *My*Tel framework design was scalable, flexible and easy to integrate with the existing system (TPC), they could not give any suggestions and comments. They were interested to know the detailed system design (discussed in terms of the technical perspective) for helping them to measure the framework interoperability accurately.

When asked to comment and suggest how to revise the model, Case B suggested that the framework (shown in the high level proposed diagram) should present the integration flow between *My*Tel and other existing systems (for example, TPC and THIS) for showing how they link to each other.

7.5.2.3 Discussion on the feedback with regards to the viability of the *My*Tel framework

When asked about specific benefits that may not have been stated that might arise from the implementation of the *My*Tel framework, the organisation pointed out that the *My*Tel framework can provide a low-cost telecommunication network solution by using the global system for mobile (GSM) communication and short message services (SMS) for transporting the health records of patients to the central system. They further highlighted the fact that the *My*Tel solution could overcome the issue of inconsistency of the telecommunication network infrastructure across the healthcare facilities nationwide.

They suggested that the framework should consider the physical infrastructure requirements and the integration strategy to be deployed for making the existing information system (TPC) into an integrated one. They pointed out that the presentation of a high-level model could not predict exactly the problems that would be encountered before implementing the *My*Tel framework. They added that the problems that could most probably impede the implementation of the *My*Tel system were patient consent and application integration (TPC system).

The organisation could not provide any answers as to whether they were willing to implement the *My*Tel framework. However, they were looking forward to the technical specification of the framework that could give them a better picture of the system implementation. They appreciated the existing form of the framework presentation and requested further discussion on the technical perspective.

With regards to the final question about the framework viability (do you see any future for the *My*Tel framework?), the organisation was satisfied with the high-level conception of the *My*Tel framework. They were looking forward to the detailed technical implementation to continue research on the possible implementation of TPC in the next pilot sites of implementation.

7.5.2.4 Discussion on the feedback with regards to the implementation process

In response to the question of whether the introduction to the *My*Tel framework was adequate, the organisation felt it was fairly adequate. When asked about how the framework could be introduced in a more coherent manner, they suggested that the framework features should be highlighted using a special font for making recognition of its key features and benefits easier.

They pointed out that the existing form of explanation was likely to be quite academic and it required time to read every paragraph.

When asked about whether they were willing to implement the *My*Tel framework if the user guide was provided, the organisation replied that they looked forward to discussing the technical perspective and the detailed specification of the *My*Tel system. With regards to possible disputes with the users for implementing the *My*Tel framework, they said that it was too early to gauge. They pointed out that the cost, business process reengineering and people could be impending challenges in implementing the *My*Tel system.

When asked about the culture changes required before the implementation of the *My*Tel framework (system), at that time, the organisation had not seen any need for cultural changes for implementing the *My*Tel framework. They pointed out that the pilot implementation experiences of the TPC project in the three states provided an invaluable test bed and awareness of the ICT used in the healthcare sector. They added that the use of ICT in the health clinics had become the norm and provided advantages for implementing the *My*Tel system in future.

The organisation felt that it was crucial to establish the communication protocol (HL7), administration code set (national data dictionary) and clinical code set standard (such as clinical terminology) for integrating the *My*Tel system and TPC system.

7.5.3 Case C – Telehealth Project

7.5.3.1 Project background

The telehealth project is another main case study for my research project. The Telehealth Division is responsible for planning, conceptualising, managing, developing and implementing the Multimedia Super Corridor (MSC) Telehealth Project of Malaysia. The name has been changed from Integrated Telemedicine to Integrated Telehealth due to the change in its concept and scope as described in Chapter 2.

The Telehealth Division had extensive sources of information regarding the telemedicine/telehealth project and had given me a great opportunity to explore, access and acquire the sources of evidence and validate the applicability of the proposed framework. The vast experience of the team members and the availability of sources of evidence were the main reasons to adopt the Telehealth Division as a main case study. At the initial stage of the case study, this division was contacted, and communication was established informally using e-mails, the phone and letters. A good relationship was established especially with the deputy director of Telehealth Application, the deputy director of Contents Manager and the key project team members. The documentation and archival records were obtained with a straightforward confidentiality arrangement. They were analysed to advance knowledge about Malaysia's telehealth concept and approach and to validate the evidence obtained from the initial case study. Detailed questionnaires for collecting primary data were prepared. The questionnaires were developed based on the responses given from the initial case study and evidence obtained from the documentation and archival records. The interview questions were centred on the research questions that were prepared for designing a suitable framework for the continuous and seamless upkeep of patients' LHRs and the appropriate LHR structure to support the framework.

The case study conducted at the Telehealth Division significantly enhanced the researcher's knowledge and understanding of (1) the objectives, concept and approach of the Malaysian Integrated Telemedicine/Telehealth System, (2) the crucial components of the telehealth system that needed to be developed and (3) the crucial challenges for implementing the telehealth system in the Malaysian health system.

7.5.3.2 Feedback with regards to the conciseness of the *My*Tel architectural framework

***MyTel* components**

Responding to the questionnaire, Case C affirmed that the explanation for the *My*Tel components was concise and easy to understand. With regards to the question of whether the roles of each component were adequately described, they replied in the affirmative that almost all the components' roles and responsibilities were described clearly and it was easy to relate them to the telehealth functional requirements.

With regards to the question of whether it was necessary for any revision of the *My*Tel components, Case C had asked for a few clarifications as follows: 1) they would like to know the results of the study done in the outpatient clinic that was mentioned in one of the paragraphs regarding the source of information for developing the proposed framework; 2) they asked for clarification on how the system checks if one has been assigned a patient master index (PMI) previously during the system offline mode; and 3) they further pointed out that during the downtime of the back-end system, it could not be assured that a new patient had no previous PMI and that a new PMI had been assigned from a pre-generated list. Case C suggested that the system should be able to assign a temporary PMI.

***My*Tel functionalities**

On the question of whether the *My*Tel functionalities were concise and easy to understand and implement, Case C said they were clear and concise. Case C pointed out that the proposed use cases could be of use to any outpatient clinics that had yet to implement the electronic medical record system.

When Case C was asked about its viewpoint regarding the *My*Tel use cases processes, they observed that most of the processes outlined were appropriate and logical at an abstract level of functionality with little change.

With regards to the question about any critical use cases that could be incorporated into the *My*Tel functionality, Case C requested that reference be made to the previous answers for *My*Tel components (refer to paragraph 2 of *My*Tel components).

***My*Tel solution framework process**

The respondent for Case C was of the opinion that it required little effort to understand and implement the *My*Tel solution framework process. The respondent for Case C also agreed with the solution framework flow described in each of the scenarios. The respondent for Case C observed that the proposed solution framework could benefit those healthcare centres that still have an inadequate telecommunication network infrastructure and could provide continuous access to and upkeep of patients' health records.

When asked to add any other important scenarios that should be described in the *My*Tel solution framework process, the respondent for Case C said to refer to the previous answers and suggestions in the *My*Tel components (refer to paragraph 2 of *My*Tel components).

***My*Tel framework design**

In the first question of the questionnaire regarding the conciseness and clearness of the design of the *My*Tel framework, the respondent of case C said that it was concise and the design was clear and straightforward.

When asked the second question (Is the *My*Tel framework design scalable, flexible and easy to integrate with the existing system?), the respondent for Case C noted that the design of *My*Tel framework was scalable. The respondent for Case C further added that although the proposed components provided basic functionalities in its current form, the framework could easily and readily accommodate future requirements. The respondent for Case C pointed out that further information on data standards (code sets and the communication protocol) were required in order to comply with the standard and integration requirements of the telehealth system.

When asked whether the respondent for Case C had any suggestions to revise the *My*Tel framework design, the respondent said that there were some changes required to cater for the events raised in question three of section A's answers (refer to paragraph 2 of *My*Tel components).

7.5.3.3 Discussion on the feedback with regards to the viability of the *My*Tel framework

When asked to comment on the viability of the *My*Tel framework, the respondent for Case C said that *My*Tel was designed in a modular manner; this provided advantages for maintaining the system for accommodating new and future requirements

With regards to the question about the probability the main problems could impede the implementation of the *My*Tel framework, the respondent for Case C mentioned that there were two possible challenges:

i. to get the patient's consent for keeping the health record data in portable devices
ii. to get the patient to carry the portable devices.

For Case C, the respondent was willing to implement the *My*Tel framework if it was accompanied by detailed supporting documentation, particularly from a technical perspective. In addition, the respondent for Case C believed that the framework was able to provide the back-up when the telecommunication network collapsed, and the framework could expand the telemedicine system into an integrated and distributed one.

When asked about the future of *My*Tel, the respondent for Case C noted that the *My*Tel system would result in an enhanced level of continuous and seamless access to patients' health records and continuity of care. The respondent suggested that it was possible to test the *My*Tel system in the public support unit for its pilot implementation, especially for patients who suffered chronic illnesses to ensure continuity of care.

7.5.3.4 Discussion on the feedback with regards to the implementation process

In section C of the questionnaire regarding the implementation process of the *My*Tel framework (system), the respondent for Case C indicated that greater emphasis would have to be placed on effective change management at the operational level and acceptance by the physicians to use the system. The respondent for Case C stressed that without effective change management and the acceptance of physicians, the *My*Tel system was not likely to succeed. With regards to the question of the adequacy of the introduction to the *My*Tel framework, the respondent for Case C agreed that it was presented adequately.

The respondent for Case C replied that she had no suggestions on how the *My*Tel framework could to be introduced in a more coherent and simple manner. When asked if Case C was willing to implement the *My*Tel framework (system), she replied in the affirmative that Case C had no objection to implementing the system if it could benefit the project and particularly MOHM and Malaysia.

The respondent for Case C said there were possible obstacles to implementing the *My*Tel framework but she did not mention the barriers specifically. The respondent for Case C continued to answer the fifth question of section C by highlighting that patients' confidentiality and data security should be given attention before implementing the *My*Tel system. She pointed out that this was crucial for influencing physicians and patients to ensure that the health records were protected from security vulnerability and privacy infringement.

When asked about the culture changes required, the respondent for Case C pointed out that the care providers had to change their current processes of capturing the clinical records during consultation. The records should be captured continuously in a structured manner.

With regards to the final question of section C, the respondent highlighted the fact that the technical standards should be established. The data definition standard, document standard and communication protocols should be standardised and ready before the implementation of the system.

7.5 ***My*Tel Discussions and Amendments**

The responses and feedback from the validation process conducted at three divisions/projects of the Ministry of Health Malaysia were both beneficial and practical. The objective of doing the three case studies was to provide evidence for whether it was suitable to incorporate the *My*Tel framework/system in the Malaysian telemedicine system, particularly for the continuous and seamless upkeep of patients' LHRs during the unavailability of landline telecommunication network and downtime of computer system. The observations made and experiences gained advocated that some modifications were essential for making the *My*Tel framework more functional.

It was hoped that by carrying out these desired amendments the framework would become more flexible and acceptable in all the three projects, particularly the telehealth project. From the research methodological perspective, the empirical evidence gathered during the validation process could assist in convincing the top management and other organisations to adopt the validated *My*Tel framework.

For this purpose, the following amendments were made in the *My*Tel framework.

1. To give greater clarity with respect to the link/integration between the *My*Tel framework and existing systems, the integration flow was introduced. The integration flow was shown through HOMS, which acts as a gateway to integrate *My*Tel and other applications.
2. All aspects of the data standards including the communication protocol, administration code sets and clinical code sets were included in order to standardise the integration requirements between various applications.

3. The solution framework to retrieve the PMI number during the downtime (offline mode) of back-end system was given greater explanation in terms of how the system checks whether the patient had been assigned a PMI previously.

4. The functionality (use cases) of the *My*Tel was added for mitigating the duplication case of the patient identifier. The additional use cases included are as follows:
   i) Assign a Temporary PMI: to provide functionalities for assigning a temporary patient identifier number (PMI)
   ii) Merge Health Records: to provide functionality to merge health records between temporary and existing PMI.

5. The scenario in terms of how the HOMS manages the order was presented for giving greater clarity to the HOMS architecture in terms of its functionalities and responsibilities.

Based on the above modification requirements and invaluable suggestions for improving the first draft of the *My*Tel framework, the validated or final *My*Tel framework is presented in Figure 7.2.

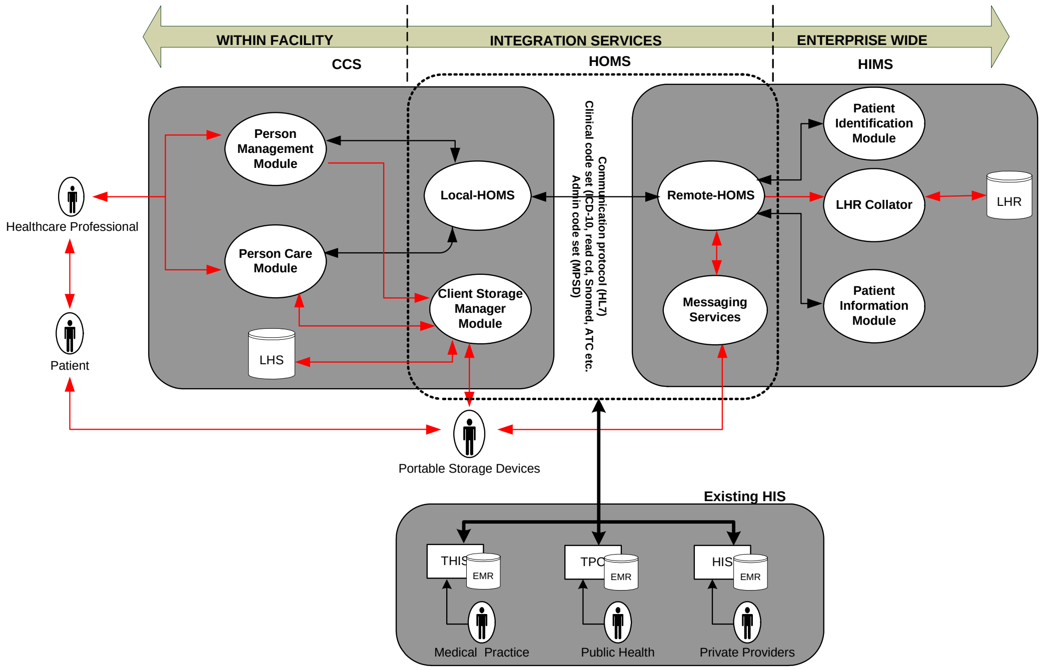

Figure 7.2: Final Version of the MyTel Framework

7.7 Summary

This chapter began by describing the research process followed in undertaking the validation process. The chapter started with the discussion about the generalisation concepts and strategies. From the aforementioned discussion, it can be learnt that population respondents, proximal similarity and multiple-case studies assist in mitigating the issues related to fewer respondents, the small sample number and the genuineness of the representatives.

Thereafter, the chapter presented the findings that were obtained from the three health ICT projects under MOHM that were requested to validate the *My*Tel framework. Based on the discussion, it was learnt that the elements of conciseness, viability and implement ability help in designing a flexible architectural framework. The flexible framework, in turn, assists in building a scalable and maintainable application system that can mitigate such integration issues as the disparate and heterogeneous set-up of the HIS application. With these characteristics, LHRs could be maintained continuously and seamlessly.

The responses and feedback obtained from the three case studies validate the fact that this conceptual framework has been captured from practical situations. A screening process was used in this research in selecting significant representatives for validating the proposed framework. By way of example, the three cases confirmed that the *My*Tel framework is concise and viable and can be incorporated with the existing HIS (TPC, THIS and telehealth) application flows. This was achieved through the HOMS component of *My*Tel, which provided a common gateway for integration. Finally, the comments and feedback were analysed and incorporated into the revised framework.

Having validated the framework in the real-life setting, the next chapter will conclude the research project and a reflection on the overall process will be presented.

Chapter 8 Conclusions

8.1 Introduction

This chapter concludes the research undertaken in this dissertation and recommends directions for further research. It begins with the summary of the works completed, which were based on both the literature and empirical studies carried out during the case study work and literature review, followed by the research contribution to the body of knowledge, the healthcare industry or our nation, Malaysia. The chapter also presents the constraints and limitations that we experienced from the beginning until to the end of the research. Recommendations for further research are offered in the next section. The final section shares the personal experiences and reflections on this PhD journey.

8.2 Summary of the Completed Work

This research has contributed to the body of existing knowledge in the domain of health informatics, in particular the telemedicine system and electronic lifetime health record from a Malaysian perspective.

The introduction of the problems described in Chapter 1 highlighted the fact that patient health records are generally inaccessible and incomplete. This is due to the fact that the existing health information systems (in particular, telemedicine system) were implemented in a fragmented manner and the electronic medical records were kept in silos. There were many reasons that contributed to these issues such as inadequate telecommunication networks and a rigid system framework for maintaining the health records continuously and seamlessly. The issues provided the impetus to focus on the cases to be explored for revealing the research questions. In line with the process of finding the research questions and to fulfil the answer to the questions, the research objectives were identified and prioritised. Five research objectives were identified: a critical review of the telemedicine and electronic health record initiatives in ten countries; an extensive review of the health ICT initiatives in Malaysia; an analysis of patient demographics and clinical data in various outpatient clinics in Malaysia; the development of and proposition for a flexible framework for a Malaysian telemedicine system; and validation of the proposed framework in collaboration with the Ministry of Health Malaysia. Based on the identified objectives, the main accomplishments of this research are as follows.

1. The research identified the best practices and lessons learned about the telemedicine and electronic health record approaches and challenges in the ten countries via an extensive literature review. Lessons can be learned from these initiatives by reviewing, comparing and contrasting the telemedicine approaches and concepts between the ten countries and Malaysia. The findings from the review/comparison revealed the best practices and approaches that might be suitable for developing the telemedicine framework from a Malaysian perspective.

2. An extensive analysis (for the comparing and contrasting) of electronic health record approaches and challenges between four East Asian countries and Malaysia was presented for identifying the common issues, gaps, lessons learned and best practices for implementing the EHR system nationwide.

3. The research also identified the current state of the health of ICT initiatives in the Malaysia health system through a collaborated effort with the Ministry of Health Malaysia. The collaboration arrangement was engaged for accessing and providing empirical information especially on health informatics development initiatives. As a result, the healthcare system and health ICT initiatives, especially the integrated telehealth flagship system/project, was explored and described extensively.

4. The research methodology suitable for this research was identified including the verification and validation strategies. A case study approach was selected for facilitating the processes and development of this research.

5. First-hand information (the primary data collection) was obtained at the Ministry of Health Malaysia for validating the information gathering from the initial case study. The data were collected by way of structured interviews and were used for validating and exploring evidence for the case under study. The data were obtained from the four divisions that were involved in the development of health ICT initiatives in MOHM.

6. Based on inputs obtained both from the literature review and case study, a framework for maintaining patient health records continuously and seamlessly for the Malaysia telemedicine system was developed and proposed.

7. The proposed framework was evaluated for testing its validity; it was used by the three divisions/projects that were involved in the development of the health information system in

MOHM. The proposed framework report was provided to ease understanding of the framework model. The respondents were also provided with validation response forms for filling in comments and suggestions.

8. A high-level development of novel lifetime health record components and structure for Malaysia telemedicine system perspectives was proposed. The LHR component was developed after a critical analysis of patient demographic and clinical data were used during consultations and medical diagnosis encounters. An analysis of patient demographic and clinical data usage was conducted using thirty doctors in outpatient clinics across health centres of MOHM. The analysis for studying the validity of the LHR components across outpatient clinics of MOHM was carried out by structured interviews.

9. Based on input from the framework validation, the proposed framework was modified and refined, and the revised version was presented to MOHM for them to consider whether they should adopt the framework.

8.3 Contributions

In general, this research has contributed to the body of knowledge in the field of health informatics through the dissemination of journals and conference papers. The publications below are some of the contributions produced from the main research work. The journal articles and conference papers published include the following.

1. Electronic health records approaches and challenges: a comparison between Malaysia and four East Asian-countries, published in *International Journal of Electronic Healthcare (IJEH)*.
2. An analysis of healthcare informatics and systems in Southeast Asia: a current perspective from seven countries, published in *International Journal of Electronic Healthcare (IJEH)*.
3. An integrated and distributed framework for a Malaysian telemedicine system (*My*TEL), to be submitted in *International Journal of Biomedical Engineering and Technology (IJBET)*.
4. The Design of Flexible Front End Framework for Accessing Patient Health Records through Short Message Service, presented in *IEEE Asia-Pacific Conference on Applied Electromagnetics 2007, Malaysia*.
5. Issues and Challenges in the Development of Electronic Health Records in Malaysia and Vietnam, presented in *Conference on Applications of Medical Informatics in Hospital Management - VN-HISMANAG'08, Vietnam*.
6. A Flexible Telemedicine Framework for the Continuous Upkeep of Patient Lifetime Health Records (F2U-LHR), to be presented at *Proceedings of the Fourteenth Americas Conference on Information Systems, Toronto, ON, Canada August 14th–17th 2008*.
7. Healthcare Knowledge Management Primer, Case Exercise: KM and Personal Health Records – A Malaysian Perspective, p.p.45–49, Routledge, ISBN: 978-0-415-99443-9.

Let us return to the aim of the research. The main intention of this research was to try to find a suitable framework for the continuous and seamless upkeep of patient health records for Malaysia's telemedicine system. This means that the primary objective of this research was to contribute to the development of the telemedicine system and lifetime health records in the healthcare system of Malaysia. A comprehensive research study was carried out to provide evidence that the suitable framework needs to be implemented in Malaysia's telemedicine system, in particular to maintain the patient health records continuously and seamlessly. This research has made contributions to the Malaysian healthcare system perspectives in the following ways

1. A critical analysis of telemedicine and electronic health records initiatives in other countries (see Chapter 2) would provide best practices and approaches that would be learned and used for the development of health ICT initiatives in Malaysia. The findings demonstrated that a) the continuation and seamless upkeep of patients' health records is essential for continuity of care, b) the fragmented implementation of the health information system would lead to integration issues and would not sustain the health information system (telemedicine or telehealth services) in the long term, c) the telecommunication network infrastructure is vital for implementing telemedicine services across healthcare facilities and d) finally, it was critically important to establish management changes and business process reengineering before implementing the telemedicine system. The research concluded that the above factors should be taken into consideration in the development of the framework for a Malaysian telemedicine system.

2. The analysis of the data collected from the case study (refer to Chapter 4) emphasised the need for a flexible framework for Malaysia's telemedicine system for maintaining patient lifetime health records continuously and seamlessly during possible disasters (inadequate landline telecommunication networks and the downtime of the back-end system). The

analysis also highlighted the fact that the lifetime health record is critically important for integrating and sharing the health information across application systems and healthcare levels. Less focus on collecting and generating LHRs was also noted as one of the critical drawbacks that halted the nationwide rollout of the pilot telemedicine/telehealth system.

3. The analysis of patient demographics and clinical data usage in public outpatient clinics (refer to Chapter 5) across the country reinforced the evidence that the summary of the patient's health condition is the most invaluable piece of information required by the physician during a consultation and medical diagnosis encounter. The analysis concluded that the simplified version of patient health records should be developed. This was to be done by developing and proposing the lifetime health record components and structure that were tailored to the Malaysian telemedicine perspectives and needs.

4. The proposed flexible framework (provides flexibility in mitigating the current limitation and constraints of healthcare facilities in Malaysia) provides the foundation for implementing the telemedicine system and approach to maintain patients' health records continuously (see Chapter 6). The feedback from the framework validation in several divisions and projects in the Ministry of Health Malaysia enhanced the credibility and validity of the proposed framework — *My*Tel.

5. The development of *My*Tel has introduced the usage of portable storage device technology for maintaining the patient's health records in the patient's possession. This idea would empower the patient with his/her health records and introduce the patient-centred paradigm

of healthcare service. With this, the summary of the patient's health records would be carried anywhere and be accessible anytime regardless of where his/her visit was made.

6. The development of *My*Tel has also introduced the usage of short messages services (SMS) via global system for mobile (GSM) technology in transporting the health records of patients across healthcare facilities. The SMS and GSM were introduced to provide an alternative resolution for mitigating the inadequacy and inconsistency of landline telecommunication networks across healthcare facilities nationwide.

7. The research has made an additional contribution in the area of research methodology (see Chapter 3) for health informatics research, particularly in terms of Malaysian perspectives and, if relevant, to other countries around the globe.

8.4 Constraints and Limitations

The research was focused around the two key research questions: (1) "*What are the most critical aspects for a framework to implement a Malaysian integrated telemedicine system that ensures that patient LHRs can be maintained continuously and seamlessly?*" and (2) "*What is the crucial LHR dataset to be used for supporting the framework?*". These questions have been answered through a step-by-step approach described in the research design and methodology sections. Nevertheless, it was noted that every journey has challenges and barriers that need to be managed to ensure the mission will be achieved. I would like to translate the challenges and barriers of the PhD journey into research constraints and limitations that could be used as lessons for others. The research constraints and limitations are listed as follows.

1. *Inadequate access to other countries' information regarding telemedicine initiatives*

A comprehensive literature review needs to be researched for acquiring best practices and approaches that have been experienced by others. There were ten countries involved in the review. However, the availability of the information required was different from one country to another. This was because the information regarding government projects in certain countries was considered confidential. Hence, some of the telemedicine initiatives of the ten countries had not been described extensively.

2. *Inadequate model of success in implementing the telemedicine, telehealth and electronic medical records at the national level.*

The success story in implementing the telemedicine system and electronic health records at the national level has not been reported in any of the countries in the world (ATA, 2006; Coiera, 2003). All countries around the globe are struggling with the efforts of implementing and integrating the telemedicine system and electronic health record (EHR) system for achieving an integrated EHR system and continuity of care. Hence, there were no right and wrong approaches practiced by each country in implementing the telemedicine and EHR system. ,The challenges for selecting the best practices and the right approaches were definitely complex and uncertain.

3. *Dealing with private and confidential information*

The information contained in the medical records is treated as confidential and considered to be dealing with the patient's privacy. In addition, high protocol requirements were encountered in acquiring sample medical records and information. In fact, some of the divisions/departments in the Ministry required me to sign a non-disclosure agreement for accessing certain information related to the government documents and information. This entire journey was an invaluable experience and a meaningful learning process for me to become a good researcher in future.

4. *Dealing with the complexity of the healthcare system*

The healthcare system or sector is complex and involves multi-level clinical disciplines and organisation structures (Bali and Wickramasinghe, 2008). The analysis of the consultation and medical diagnosis workflow in outpatient clinics through case study research conducted at the Ministry of Health Malaysia only focuses on one of the many disciplines in healthcare services. Specialist care was not covered in the research, and health record requirements for treating specialists' patients were not included in the development of the LHR components and structure. However, a modular and scalable design of LHR components makes it possible to add the specialist care information in future research.

8.5 Further Research

The research aimed to produce a validated integrated and distributed framework for a Malaysian telemedicine system (*My*Tel). This has been done through the framework validation conducted by the three divisions in MOHM. The feedback and input from the validation have been incorporated into the revised version of the *My*Tel framework. The next step of the research would be finalising the LHR structure in detail and realising the *My*Tel framework into a working prototype system and piloting the system in certain healthcare centres.

The findings from the research are based on the healthcare system in terms of the Malaysia perspective. The *My*Tel framework would be designed so that it is dedicated to the requirements of the Malaysian healthcare system. Future directions could include generalisation of the findings and framework by studying additional healthcare systems in other Southeast Asian countries including Brunei, Indonesia, Vietnam, Myanmar and the Philippines. The scattered set-up of health clinics across the Southeast Asian countries were relevant to the *My*Tel framework and could be relevant for mitigating the inadequacy and inconsistency of the telecommunication infrastructure faced by the five countries.

8.6 Reflections

The *My*Tel framework was developed based on comprehensive case studies and analysis conducted at MOHM. Literature reviews on telemedicine and health informatics initiatives in ten countries provided the initial understanding of the case study and helped to inform my development of theories associated with the research domain. The telemedicine framework evaluation, best practices, lessons learned and implementation experiences of health informatics in other countries helped to shape the initial design of theory building and the conceptual framework. The *My*Tel framework should be developed according to the Malaysian telemedicine perspective. This was carried out through a collaborative arrangement with MOHM, which provided insights and understanding of the Malaysian telemedicine context.

The case study conducted at MOHM provided evidence for theory building and an appropriate platform for verifying and validating the *My*Tel framework. The validity and reliability issues with regards to the results from the case study research have been highlighted in previous research (Ammenwerth et al., 2003; Miles and Huberman, 1994); the *My*Tel research is no exception. In order to overcome such issues, I used methodological and data triangulation strategies by obtaining and collecting evidence from multiple sources. By way of an example, the data collected through open-ended interviews, structured interviews, archival records, documents and observation provided strong evidence and greater validity. In addition, the selection of the three cases (TPC, THIS and telehealth) for validating the *My*Tel framework added credence and allowed the overall study to be more robust. Hence, I strongly believe that the case study research method designed for the *My*Tel framework was suitable and could be replicated for other similar studies. My viewpoint is supported by Myers and Haase (1999) who hold the opinion that since the research environment (healthcare research) is holistic and interactive, it (research environment and background) should be observed in its entirety as this will allow the identification of patterns of information exchange between system components, all of which, when seen as a whole, bring together the vision of an integrated system.

It was noted from the research experiences that healthcare workflow is a complex system that involves various specialties and deals with substantial issues regarding information privacy and confidentiality (Wickramasinghe and Schaffer, 2006; Wickramasinghe et al., 2005). The telemedicine and telehealth services involved a multidisciplinary paradigm. As the research objective involved building and extending theory by creating the *My*Tel framework, it became evident that the empirical data were qualitative in nature. The adoption of qualitative research approaches provided this research with the following advantages: 1) it provided an understanding of the health informatics (telemedicine/telehealth) implementation approach, challenges and barriers, technological necessities and best practices; 2) it gave an insight into EHR implementation approaches and challenges and their impetus for developing a LHR dataset; 3) it provided an understanding of health ICT initiatives in the Malaysian context where the pilot implementation of telehealth was revealed, the three major health ICT projects were identified and the technological level was measured; 4) it provided an insight into organisational culture and processes where the minimum impact on the existing workflow should be designed for implementing the proposed framework; 5) it provided an insight into outpatient (clinical consultation and diagnosis) workflow processes. The analysis of these empirical data and inputs from the literature review formed the first draft of the *My*Tel framework. The framework was validated by the three cases in order to test its applicability and suitability.

The data regarding feedback on the applicability of the *My*Tel framework was used to carry out a cross-case analysis. This resulted in a revised *My*Tel framework that incorporated comments and suggestions from three cases. In summary, all cases were positive, confirming that they required the framework for maintaining patient LHRs continuously and seamlessly across applications and healthcare centres (refer to section 7.5).

The three main components of *My*Tel (CCS, HOMS and HIMS — refer to section 6.2) provided modular and scalable designs for facilitating the interoperable requirements and flexibility. To facilitate this, HOMS became an integration framework or gateway to communicate between applications within MOHM's health information systems. Nevertheless, the results and data collected from the validation feedback were to suffer from some inherent limitations. For example, the empirical data obtained from structured interviews and open-ended interviews can be difficult to generalise and may result in inherent inconsistencies. Of course, phenomenon analysis cannot be generalised due to the variation in the phenomenon being studied and this was frequently used as a template with which to compare the empirical results of the case study (Amaratunga and Baldry, 2001).

With regards to the *My*Tel framework (which aimed to be flexible), it essentially required confirmation and validation from the collaborator, especially regarding system requirements and implementation applicability. The *My*Tel framework was also derived based on consultations and the medical diagnosis workflow being studied in outpatient clinics. The phenomenon and results obtained from the *My*Tel framework research could be compared with other case studies. The same approach and preparation for conducting data collection could be generalised and replicated for other case studies in other developing countries having similar healthcare systems and similar social and economic backgrounds.

Based on framework feedback (and validation), the *My*Tel framework is relevant and is essential for MOHM to maintain patients' health records in a continuous and seamless manner.

8.7 Concluding Observations

An integrated telemedicine or telehealth system is looked on as a feature of a future healthcare system. A combination of ICT and health knowledge enables the generation of LHRs that contain a large amount of data and information, which can then be transformed into usable knowledge and hence need to be managed appropriately. Thus, *My*Tel served this need by providing a flexible solution for the continuous and seamless upkeep of LHRs.

Based on the survey conducted by the Malaysian Communication and Multimedia Commission (2007) on cellular phones used in Malaysia in 2007, approximately 85% of Malaysian owned cellular phones. The cellular phones and global system mobile (GSM) telecommunication could be utilised in the healthcare services of Malaysia. It appears that these technology enablers (mobile phones and the GSM network) have paved the way for the emergence of a variety of daily used items by which health records can be written and displayed. A combination of the Internet and mobile technology including portable storage devices used in the *My*Tel framework would realise the above features.

Constructive feedback from MOHM on the *My*Tel framework evidently showed that *My*Tel is truly a relevant and critical necessity for realising the telemedicine system across public healthcare facilities of Malaysia.

Finally, it is mentioned again here that the dissertation has made five unique, original and significant contributions to knowledge as follows.

- *Critical review of Telemedicine and EHR approach in other countries.* The approaches, concepts, barriers and lessons of different countries provide a better understanding and invaluable reference for implementing an effective and successful health information system in the healthcare facilities at the national level. The information can be used to guide researchers in conducting a literature review relevant to telemedicine or electronic health records.
- *Critical analysis of the Malaysian health ICT initiative and approach.* The appraisals of the strengths and limitations of a number of existing health ICT infrastructures and health information systems from the analysis can be used to improve the current system framework and implementation strategy by identifying their complimentary features, as demonstrated in the research findings (primary data collection). The findings can also be used to inform

researchers and practitioners about the important aspects of a particular framework that may be relevant to telemedicine system and LHRs.

- *Critical analysis of the usage of patient demographic and clinical records during doctor–patient consultations.* The analysis of the usage of patient demographics and clinical records provides a better understanding of the crucial data that need to be captured for creating and generating centralised lifetime health records of patients. The findings (essential data attributes) can be used to support decision-making in relation to system design (integration and interoperability requirement) and development and the data entry procedure.
- *Proposed MyTel framework.* The three major components of the MyTel framework — CCS, HOMS and HIMS — provide flexibility and enable the process of viewing and storing of patient health records to be maintained continuously and seamlessly. It was found that the use of the *MyTel* framework can unfold the information fragmentation and can greatly increase the continuity in accessing patient health records seamlessly. The new framework is also beneficial in facilitating the integration process in collecting the LHRs from various types of HISs at different health facilities.
- *Proposed LHR dataset.* The proposed LHR components (structure and message) provide a framework for developing and managing the lifetime health knowledge of a person incrementally. The proposed LHR dataset and structure can be used to support decision-making in relation to the development of health ICT initiatives. In addition, the findings (data attributes and structures) can be used by the administrator, researchers and practitioners for their clinical research and statistical purposes.

With these contributions, the originality of the research has been presented and it is believed that the research output can benefit MOHM in particular and also the body of knowledge in general.

List of References

Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Shibghatullah, A. S. (2007) "The design of flexible front end framework for accessing patient health records through short message service", *IEEE Asia-Pacific Conference on Applied Electromagnetics*, Melaka, Malaysia, 4-6 December 2007, pp.1-5.

Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Wickramasinghe, N. S. (2008a) "Electronic health records approaches and challenges: a comparison between Malaysia and four East Asian countries", *International Journal of Electronic Healthcare,* Vol.4, Iss.1, pp.78-104.

Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. M., Baskaran, V., Wickramasinghe, N. & Puentes, J. (2008b) "A flexible telemedicine framework for the continuous upkeep of patient health record", *Proceedings of the Fourteenth Americas Conference on Information Systems*, Toronto, Canada, August 14th-17th 2008.

Abu Bakar, M. A. (2007) "Malaysia healthcare delivery system", *Personal Interview*

Ahmed, K. Z. & Umrysh, C. E. (2001) *Developing enterprise Java applications with J2EE and UML*, Addison-Wesley.

Al-Qirim, N. (2003) "Teledermatology: the case of adoption and diffusion of telemedicine health Waikato in New Zealand", *Telemedicine and e-Health,* Vol.9, Iss.2, pp.167-177.

Al-Qirim, N. (2004) "The strategic planning of health information systems in New Zealand: a telemedicine perspective", *International Journal of Healthcare Technology and Management* Vol.6, Iss.2, pp.189-209.

Al-Qirim, N. (2005) "Critical success factors for strategic telemedicine planning in New Zealand", *Telemedicine Journal and e-Health,* Vol.11, Iss.5, pp.600-607.

Al-Qirim, N. (2006) "The case of telepsychiatry adoption and diffusion in a healthcare organization in New Zealand", *Journal of Cases on Information Technology,* Vol.8, Iss.1, pp.31-48.

Al-Qirim, N. (2007) "Championing telemedicine adoption and utilization in healthcare organizations in New Zealand", *International Journal of Medical Informatics,* Vol.76, Iss.1, pp.42-54.

Altrichter, H., Posch, P. & Somekh, B. (1996) *Teachers investigate their work: an introduction to the methods of action research*, London: Routledge.

Amaratunga, D. & Baldry, D. (2001) "Case study methodology as a means of theory building: performance measurement in facilities management organisations", *Work Study*, Vol.50, Iss.3, pp.95-104.

Ammenwerth, E. & de Keizer, N. (2005) "An inventory of evaluation studies of information technology in health care: trends in evaluation research 1982-2002", *Methods of Information in Medicine,* Vol.44, pp.44-56.

Ammenwerth, E., Iller, C. & Mansmann, U. (2003) "Can evaluation studies benefit from triangulation? A case study", *International Journal of Health Informatics,* Vol.70, Iss.2-3, pp.237-248.

Anantharaman, V. & Han, L. S. (2001) "Hospital and emergency ambulance link: using IT to enhance emergency pre-hospital care", *International Journal of Medical Informatics,* Vol.61**,** pp.147 - 161.

Ariff, Kamil, M. & Teng, C. L. (2002) "Rural health care in Malaysia", *Australian Journal of Rural Health,* Vol.10**,** Iss.2**,** pp.99-103.

Arnold, S., Wagner, J., Susan, J. H. & Gary, M. K. (2007) "Electronic health records: a global perspective - overview", Available at http://www.himss.org/content/files/ DrArnold20011207EISPresentationWhitePaper.pdf**,** (accessed January 23, 2008).

ATA (2006) "Telemedicine, telehealth and health information technology: an ATA issue paper", Available at http://www.americantelemed.org/news/policy_issues/HIT_Paper.pdf**,** (accessed January 15, 2007).

Australian Bureau of Statistics (2008) "Australian demographic statistics, Sep 2007", Available at http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3101.0Main+Features1Sep %202007?OpenDocument**,** (accessed 5 May 2008).

Australian Department of Health and Ageing (2001) "National telehealth plan for Australian and New Zealand", Available at http://www.health.gov.au/internet/hconnect/publishing.nsf/content/7746B10691FA666CCA257128007B7EAF/$File/teleplan.pdf**,** (accessed 15 September 2006).

Australian Department of Health and Ageing (2003) "HealthConnect business architecture version 1.0", Available at http://www.health.gov.au/internet/hconnect/publishing.nsf/Content/2FD500E405B5576DCA257128007B7EAC/$File/bav1.pdf**,** (accessed 15 May 2008).

Australian Department of Health and Ageing (2005) "Overview of the Australian health care system: " Available at http://www.health.gov.au/internet/wcms/publishing.nsf/Content/ healthsystem-overview-1-Introduction.html**,** (accessed April 24, 2006).

Australian Department of Health and Ageing (2007) "Broadband for health ", Available at http://www.health.gov.au/internet/wcms/publishing.nsf/Content/health-ehealth-broadband-index.htm**,** (accessed 5 May 2008).

Avison, D. & Myers, M. (2002) *Qualitative research in information systems: a reader***,** Sage Publications, London.

Bali, R. K. & Wickramasinghe, N. (2008) "Achieving successful EPR implementation with the penta-stage model", *International Journal of Healthcare Technology and Management* Vol.9**,** Iss.1**,** pp.97-105.

Barnett, G. O. (1984) "The application of computer-base medical record systems in ambulatory practice", *New England Journal of Medicine,* Vol.310**,** pp.1643-50. .

Bashshur, R. L. & Lovett, J. (1997) "Assesment of telemedicine: results of the initial experience", *Aviation space and environmental medicine,* Vol.48**,** pp.65 - 70.

Bates, D., Cohen, M. & Leape, L. (2001) "Reducing the frequency of errors in medicine using information technology", *Journal of the American Medical Informatics Association,* Vol.8**,** pp.301-308.

Benbasat, G., Goldstein, D. & Mead, M. (1987) "The case research strategy in studies of information systems", *MIS Quarterly,* Vol.111**,** Iss.3**,** pp.369-386.

Bergmo, T. (1996) "An economic analysis of teleradiology versus a visiting radiologist service", *Journal of Telemedicine and Telecare,* Vol.2, Iss.3**,** pp.136-142.

Berler, A., Pavlopoulos, S. & Koutsouris, D. (2004) "Design of an interoperability framework in a regional healthcare system"**,** *Proceedings of the 26th Annual IEEE International Conference on Engineering in Medicine and Biology Society (EMBS)***,** 1-5 September 2004**,** Vol.2**,** pp.3093-3096.

Billie, W. (2003) "Telehealth and electronic medical records", *Nursing Economic,* Vol.21**,** pp.245-246.

Blossfeld, H. P. & Rohwer, G. (1995) *Techniques of event history modeling: new approaches to causal analysis***,** Hillsdale, Lawrence Erlbaum Associates, New Jersey.

Bonnardot, L. & Rainis, R. (2009) "Store-and-forward telemedicine for doctors working in remote areas", *Journal of Telemedicine and Telecare,* Vol.15**,** pp.1-6.

Brender, J. (1997) *Methodology for assessment of medical IT-based systems***,** IOS Press, Amsterdam.

Brennan, S. (2007) "The NHS IT project: the biggest computer programme in the world ever! How's it going", *Journal of Information Technology,* Vol.22**,** pp.202-211.

Business Wire (2001) "Singapore and Eclipsys partner in major information initiative; SingHealth's HCOs to be interconnected using Eclipsys solutions." Available at http://www.allbusiness.com/health-care/health-care-overview/6062095-1.html**,** (accessed January 15, 2008).

Canada Health Infoway (2006a) "E-Health KnowledgeWay: EHRS blueprint", Available at http://knowledge.infoway-inforoute.ca/CHIPortal/EHRSearch/EHRS+Blueprint/**,** (accessed May 5, 2006).

Canada Health Infoway (2006b) "EHRS blueprint – an interoperable EHR framework : executive overview", Available at http://knowledge.infoway-inforoute.ca/en/**,** (accessed March 19, 2007).

Canada Health Infoway (2006c) "What we do: overview", Available at http://www.infoway-inforoute.ca/en/WhatWeDo/Overview.aspx**,** (accessed October 15, 2006).

Canadian Medical Association (2005) "IT in general practice: a 10-country comparison", Available at http://www.cma.ca/index.cfm/ci_id/49047/la_id/1.htm**,** (accessed August 21, 2007).

Centers for Disease Control and Prevention (2007) "Disability and health: disability and health state chartbook - profiles of health for adults with disabilities", Available at http://www.cdc.gov/ncbddd/dh/chartbook/**,** (accessed 4 April 2008).

Chaudhry, B., Wang, J., Wu, S., Maglione, M., Mojica, W., Roth, E., Morton, S. C. & Shekelle, P. G. (2006) "Systematic review: impact of health information technology on quality, efficiency, and costs of medical care", *Annals of Internal Medicine,* Vol.144**,** pp.742-752.

Chen, H. S., Guo, F. R., Chen, C. Y., Chen, J. H. & Kuo, T. S. (2001) "Review of telemedicine projects in Taiwan", *International Journal of Medical Informatics,* Vol.61 pp.117-129.

Cheung, N. T., Fung, K. W., Wong, K. C., Cheung, A., Ho, W., Cheung, C., Shung, E., Fung, V. & Fung, H. (2001) "Medical informatics – the state of the art in the hospital Authority", *International Journal of Medical Informatics,* Vol.62**,** pp.113 - 119.

Chew, S. J., Cheng, H. M., Lam, D. S. C., Cheng, A. C. K., Leung, A. T. S., Chua, J. K. H., Yu, C. P., Balakrishnan, V. & Chan, W. K. (1998) "OphthWeb-cost-effective telemedicine for Ophthalmology", *Hong Kong Medical Journal,* Vol.4.

Chronaki, C. E., Lelis, P., Demou, C., Tsiknakis, M. & Orphanoudakis, S. C. (2001) "An HL7/CDA framework for the design and deployment of telemedicine services", *Proceedings of the 23rd Annual IEEE International Conference of the Engineering in Medicine and Biology Society*, 25-28 October 2001, Vol.4, pp.3504-3507.

Cohen, L. & Manion, L. (1986) *Research Methods in Education*, London: Croom Helm.

Coiera, E. (2003) *Guide to Health Informatics (second edition)*, Hodder Arnold.

Coleman, J. S. (1981) *Longitudinal data analysis*, Basic Books, New York.

Collis, J. & Hussey, R. (2003) *Business research: a practical guide for undergraduate and postgraduate students*, Palgrave Macmillan, Houndmills, New York.

Conallen, J. (2000) *Building web applications with UML*, Addison-Wesley.

Cooper, D. R. & Schindler, P. S. (2003) *Business Research Methods*, Irwin/McGraw-Hill, New York.

Creswell, J. W. (1994) *Research Design: Qualitative & Quantitative Approaches*, Sage, London.

Dahle, J. & Callahan, D. W. (2002) "Methodology for the development of an electronic medical record", *Proceedings of the Thirty-Fourth IEEE Southeastern Symposium on System Theory*, 18-19 March 2002, pp.406-411.

David , M. (1993) *Longitudinal research on individual development: present status and future perspectives (European network on longitudinal studies on individual development)*, Cambridge University Press.

Denzin, N. (1978) *Sociological Methods: A Sourcebook*, NY: McGraw Hill, 2nd ed.

Denzin, N. K. (1970) *The Research Act in Sociology*, Chicago: Aldine.

Department of Health Taiwan (2008) "General health statistics, 2006", Available at http://www.doh.gov.tw/statistic/english/1-3/2006.rar, (accessed January 25, 2008).

Department of Statistics Malaysia (2006) "Key statistics", Available at http://www.statistics.gov.my, (accessed May 3, 2006).

Dillon, E., Loermans, J., Davis, D. & Xu, C. (2005) "Evaluation of the Western Australian Department of Health telehealth project", *Journal of Telemedicine and Telecare,* Vol.11, Iss.Supplement 2, pp.19-21.

Doolittle, G. C. & Spaulding, R. J. (2006) "Defining the needs of a telemedicine service", *Journal of Telemedicine and Telecare* Vol.12, Iss.6, pp.276–284.

Dwivedi, A. N., Bali, R. K. & Naguib, R. N. G. (2007) "Telemedicine: the next healthcare delivery medium: fad or future?" *International Journal Healthcare Technology and Management,* Vol.8, pp.226-249.

Edward, I. H. (2005) *Innovation Management in the ICT Sector: How Frontrunners Stay Ahead* Edward Elgar Publishing Ltd.

Eisenhardt, K. M. (1989) "Building theories from case study research", *Academy of Management Review* Vol.14, Iss.4, pp.532-550.

Elford, D. R. (1997) "Telemedicine in Northern Norway", *Journal of Telemedicine and Telecare,* Vol.3, Iss.1, pp.1-22.

Ellram, L. M. (1996) "The use of the case study method in logistics research", *Journal of Business Logistics,* Vol.17, Iss.2, pp.93-138.

EMRWorld (2006) "Electronic medical records - EMR vs EHR", Available at http://www.emrworld.net/emr-research/emr.php, (accessed 23 February, 2008).

Esser, P. E. & Goossens, R. H. (2009) "A framework for the design of user-centred teleconsulting systems." *Journal of Telemedicine and Telecare,* Vol.15**,** Iss.1**,** pp.32-39.

Falas, T., Papadopoulos, G. & Stafylopatis, A. (2003) "A review of decision support systems in telecare", *Journal of Medical System,* Vol.27**,** Iss.4**,** pp.347-356.

Ferguson, E. W., Doarn, C. R. & Scott, J. R. (1995) "Survey of global telemedicine", *Journal of medical system,* Vol.19**,** pp.35 - 46.

Ferrer-Roca, O. & Sosa-Iudicissa, M. (2002) *Technology and Informatics: Handbook of Telemedicine***,** IOS Press.

Fetterman & David, M. (1998) *Ethnography step-by-step, second edition***,** Thousand Oaks, CA: Sage Publications.

Fowler, M. (2004) *UML Distilled Third Edition: A Brief Guide to The Standard Object Modeling Language***,** Addison-Wesley.

Frances, M., Tracy, F., Carl, M., Julia, H., Susan, B., Pauline, G. & Siobhann, M. Q. (2007) "Perceptions of risk as a barrier to the use of telemedicine", *Journal of Telemedicine and Telecare,* Vol.13**,** pp.38-39.

Friedman, C. P. & Wyatt, J. C. (2006) *Evaluation Methods in Biomedical Informatics Second Edition***,** New York: Springer-Verlag.

Garshnek, V. (1991) "Application of space communications technology to critical human needs: Rescue, disaster relief and medical assistant", *Space communications,* Vol.8**,** pp.311-317.

Garshnek, V. & Burkle, F. (1999a) "Application of telemedicine and telecommunications to disaster medicine: Historical & future perspectives", *Journal of the American Medical Informatics Association,* Vol.6**,** Iss.1**,** pp.26-37.

Garshnek, V. & Burkle, F. (1999b) "Telecommunications systems in support of disaster medicine: Applications of basic information pathways", *Anal of emergency medicine,* Vol.34**,** pp.213-218.

Gbrich, C. (1999) *Qualitative Research in Health: An Introduction***,** Sage.

Geier, J. (2001) "Saving lives with roving LANs", Available at http://wireless.itworld.com/4246/NWW0205bgside/pfindex.html**,** (accessed March 30, 2007).

Giuse, D. A. & Kuhn, K. A. (2003) "Health information systems challenges: the Heidelberg conference and the future", *International Journal of Medical Informatics,* Vol.69**,** Iss.2-3**,** pp.105-114.

Glaser, B. G. & Strauss, A. L. (1967) *The Discovery of Grounded Theory: Strategies for Qualitative Research***,** Aldine De Gruyter.

Gomaa, H. (2005) *Designing Software Product Lines with UML: From use cases to pattern-based software architectures***,** Addison-Wesley.

Gomez, E. J., Francisco, d. P., Emilio, J. O., Norberto, M. & Hellmer, R. (1998) "A broadband multimedia collaborative system for advanced teleradiology and medical imaging diagnosis", *IEEE Transaction on Information Technology in Biomedicine,* Vol.2**,** Iss.3**,** pp.146-155.

Government of Malaysia (2007) "The Malaysia Government's Official Portal", Available at http://www.gov.my**,** (accessed February 12, 2007).

Gubrium, J. F. & Holstein, J. A. (2002) *Handbook of interview research***,** Sage, Thousand Oaks, CA.

Hailey, D. (2001) "Some successes and limitations with telehealth in Canada", *Journal of Telemedicine and Telecare,* Vol.7**,** Iss.2**,** pp.73-75.

Hair, J. F., Barbin, B., Money, A. H. & Samouel, P. (2003) *Essentials of business research methods***,** London.

Halamka, J. D., Mandl, K. D. & Tang, P. C. (2008) "Early experiences with personal health records", *Journal of American Medical Informatics Association,* Vol.15**,** Iss.1**,** pp.1-7.

Hall, E. S., Vawdrey, D. K., Knutson, C. D. & Archibald, J. K. (2003) "Enabling remote access to personal electronic medical records", *IEEE Engineering in Medicine and Biology Magazine,* Vol.22**,** Iss.3**,** pp.133-139.

Harun, M. H. (2001) *Integrated Telehealth: The Malaysian Experience***,** DTP Enterprise Sdn Bhd.

Harun, M. H. (2002) *Integrated Telehealth: What Does It All Mean?***,** DTP Enterprise Sdn Bhd.

Harun, M. H. (2007) "Early Experience of Integrated Telehealth - Lessons learned", *Personal Interview*

Hashim, A. (2000) "Epidemiology of cervical cancer in Malaysia women", Faculty of Medicine**,** Kuala Lumpur, Malaysia**,** National University of Malaysia**,** PhD dissertation.

Haux, R. (2006) "Health information systems - past, present, future", *International Journal of Medical Informatics,* Vol.75**,** Iss.3-4**,** pp.268-281.

Health-4-U (2007) "The patient education of the Singapore general hospital", Available at http://www.sghhealth4u.com.sg./health4u/Main/SGH_Patient_Education2.htm**,** (accessed February 10, 2007).

Health Canada (2006) "Health Care System: eHealth", Available at http://www.hc-sc.gc.ca/hcs-sss/ehealth-esante/index_e.html**,** (accessed October 15, 2006).

Health Level 7 (2007a) "EHR-S Functional Model - Emergency Department Information Systems (EDIS) Functional Profile", Available at http://www.hl7.org/documentcenter/public/standards/EHR_Functional_Model/R1/EHR_Functional_Model_R1_final.zip**,** (accessed July 2, 2007).

Health Level 7 (2007b) "Electronic Health Record – System Functional Model Release 1 (Chapter Three : Direct Care Functions)", Available at http://www.hl7.org/documentcenter/public/standards/EHR_Functional_Model/R1/EHR_Functional_Model_R1_final.zip**,** (accessed July 3, 2007).

Health Level 7 (2007c) "HL7 Reference Information Model", Available at http://www.hl7.org/Library/data-model/RIM/C30213/rim0213c.zip**,** (accessed July 3, 2007).

Health Level 7 (2008) "HL7 Electronic Health Record", Available at http://www.hl7.org/ehr/**,** (accessed 27 March 2008).

HealthConnect (2004) "The HealthConnect Implementation Approach", Available at http://www.health.gov.au/internet/hconnect/publishing.nsf/content/43598FE37A3E7270CA257128007B7EB7/$File/ia_jan2005.pdf**,** (accessed 5 May 2008).

Heinzelmann, P. J., Lugn, N. E. & Kvedar, J. C. (2005) "Telemedicine in the future", *Journal of Telemedicine and Telecare* Vol.11**,** Iss.7**,** pp.384-390.

Hisan, A. (2006) "Malaysia's health: Transforming healthcare services through ICT", Available at http://www.un-gaid.org/kl06/docs/ (accessed January 15, 2007).

Hjelm, N. M., Hazlett, C., Hsieh, R. K. C. & Lee, J. C. K. (2001) "Moving with the sun", *International Journal of Medical Informatics,* Vol.61**,** pp.97-101.

Holliday, I. & Tam, W. K. (2004) "E-health in the East Asian tigers", *International Journal of Medical Informatics,* Vol.73**,** pp.759-769.

Hong Kong's Domestic Health Accounts (HKDHA) (2005) "Total Health Expenditure", Available at http://www.fhb.gov.hk/statistics/download/dha/en/tf1.pdf**,** (accessed January 30, 2008).

Horsch, A. & Balbach, T. (1999) "Telemedical information systems ", *IEEE Transactions on Information Technology in Biomedicine,* Vol.3**,** Iss.3**,** pp.166-175.

Hovenga, E., Kidd, M. & Cesnik, B. (1996) *Medical Informatics: An Overview***,** Churchill Livingstone.

HPBonline (2007) "Singapore Health Promotion Board Online: Vision, Mission & Values", Available at http://www.hpb.gov.sg/hpb/default.asp?pg_id=948**,** (accessed January 5, 2007).

Hsia, D. C., Krushat, W. M. & Fagan, A. B. (1988) "Accuracy of diagnostic coding for medicare patients under the prospective-payment system", *New England Journal of Medicine,* Vol.318**,** pp.352-355.

Hsieh, R. K. C., Hjelm, N. M., Lee, J. C. K. & Aldis, J. W. (2001) "Telemedicine in China", *International Journal of Medical Informatics,* Vol.61 pp.139-146.

Hsieh, S. L., Lai, F., Cheng, P. H., Chen, J. L., Lee, H. H., Tsai, W. N., Weng, Y. C., Hsieh, S. H., Hsu, K. P., Ko, L. F., Yang, T. H., Chen, C. H. & Chen, C. H. (2006) "An integrated healthcare enterprise information portal and healthcare information system framework"**,** *Engineering in Medicine and Biology Society, 2006. EMBS '06. 28th Annual International Conference of the IEEE***,** New York City, USA, Aug 30-Sept 3, 2006**,** pp.4731-4734.

Hu, P. J. H., Wei, C. P. & Cheng, T. H. (2002) "Investigating telemedicine developments in Taiwan: implications for telemedicine program management"**,** *Proceedings of the 35th Hawaii IEEE International Conference on System Sciences***,** 7-10 January 2002**,** pp.8.

Hussey, J. & Hussey, R. (1997) *Business research: a practical guide for undergraduate and postgraduate students***,** Macmillan Business.

IAB (2006) "Health IT in Government - Transforming Health Care and Empowering Citizens'", Available at http://www.himss.org/Content/files/healthit_govt.pdf**,** (accessed February 25, 2008).

Inamura, K. & Lemke, H. (2007) "Technology and its clinical application in the field of computer-assisted radiology and surgery", *Biomedical Imaging and Intervention Journal,* Vol.3**,** Iss.3**,** pp.e41.

Industry Canada (2006) "Information & Communication Technologies: Report on the 5th International Conference on the Medical Aspects of Telemedicine", Available at http://strategis.ic.gc.ca/epic/internet/inict-tic.nsf/en/it07656e.html**,** (accessed May 8, 2006).

Ingeborg, S. & Volker, W. (2001) "Incremental EHR introduction considering the situation in health care and the current standards under development", *International Congress Series,* Vol.1230**,** pp.889-894.

Irani, Z., Ezingeard, J. N., Grieve, R. J. & Race, P. (1999) "A case study strategy as part of an information systems research methodology: A critique", *International Journal of Computer in Technology,* Vol.12**,** pp.190-198.

Jacobson, I., Griss, M. & Jonsson, P. (1998) *Software Reuse: Architecture, Process and Organization for Business Success***,** Addison-Wesley.

Jankharia, B. (2001) "Current status and history of teleradiology in India", *nternational Journal of Medical Informatics,* Vol.161**,** Iss.2-3**,** pp.163-166.

Kaplan, B. & Shaw, N. T. (2004) "Future directions in evaluation research: people, organisational, and social issues", *Methods of Information in Medicine,* Vol.43**,** Iss.3**,** pp.215-231.

Karhu, K. (2002) "Expertise cycle - an advanced method for sharing expertise", *Journal of Intellectual Capital,* Vol.3**,** Iss.4**,** pp.430-446.

Katehakis, D. G., Sfakianakis, S., Tsiknakis, M. & Orphanoudakis, S. C. (2001) "An infrastructure for integrated electronic health record services: the role of XML (extensible markup language)", *Journal of Medical Internet Research* Vol.3**,** Iss.1**,** pp.e7.

Kawasumia, Y., Tamblyna, R., Platt, R., Ernstc, P., Abrahamowicza, M. & Taylor, L. (2008) "Evaluation of the use of an integrated drug information system by primary care physicians for vulnerable population", *International Journal of Medical Informatics,* Vol.77**,** pp.98-106.

Koch, S. (2006) "Home telehealth - current state and future trends", *International Journal of Health Informatics,* Vol.75**,** pp.565-576.

Kyriacou, E., Pavlopoulos, S., Koutsouris, D., Andreou, A. S., Pattichis, C. & Schizas, C. (2001) "Multipurpose health care telemedicine system"**,** *Proceedings of the 23rd Annual IEEE International Conference on Engineering in Medicine and Biology Society***,** 25-28 October 2001**,** Vol.4**,** pp.3544-3547.

Larsen, F., E., G., Obstfelder, A. & Lundvoll, L. (2003) "Implementing telemedicine services in northern Norway: barriers and facilitators", *Journal of Telemedicine and Telecare,* Vol.9**,** Iss.1**,** pp.17-18.

Lessing K. & Blignault I. (2001) " Mental health telemedicine programmes in Australia", *Journal of Telemedicine and Telecare,* Vol.7**,** Iss.6**,** pp.317-323.

Leung, G. M., YU, P. L. H., WONG, I. O. L., JOHNSTON, J. M. & TIN, K. Y. K. (2003) "Incentives and barriers that influence clinical computerization in Hong Kong: a population-based physician survey", *Journal of the American Medical Informatics Association* Vol.10**,** Iss.2**,** pp.201-202.

Liaw, S. T. (1993) "The Computer-Based Patient Record - An Historical Perspective", Available at http://www.project.net.au/hisavic/hisa/mag/nov93/the.htm**,** (accessed August 29, 2006).

Lin, C. C., Lee, R. G. & Hsiao, C. C. (2008) "A pervasive health monitoring service system based on ubiquitous network technology", *International Journal of Medical Informatics,* Vol.77**,** Iss.7**,** pp.461-469.

Linhoff, M. (2002) "Mobile computing in medical and healthcare industry", Available at http://www.mocomed.com/workshop2002/beitraege/Linhoff.pdf**,** (accessed August 24, 2007).

Liu, C. T., Long, A. G., Li, Y. C., Tsai, K. C. & Kuo, H. S. (2001) "Sharing patient care records over the World Wide Web", *International Journal of Health Informatics,* Vol.61**,** pp.189-205.

Liu, C. T., Yang, P. T., Yeh, Y. T. & Wang, B. L. (2006) "The impacts of smart cards on hospital information system - an investigation of the first phase of the national health insurance smart card project in Taiwan", *International Journal of Medical Informatics,* Vol.75**,** pp.173-181.

Lovell, N. H. & Celler, B. G. (1999) "Information technology in primary health care", *International Journal of Medical Informatics* Vol.55**,** pp.9-22.

Lu, Y. C., Xiao, Y., Sears, A. & Jacko, J. A. (2005) "A review and a framework of handheld computer adoption in healthcare", *International Journal of Medical Informatics,* Vol.74**,** pp.409-422.

Lua, Y. C., Xiaoa, Y., Sears, A. & Jacko, J. A. (2005) "A review and a framework of handheld computer adoption in healthcare", *International Journal of Medical Informatics,* Vol.74**,** pp.409-422.

Luh, J. J., Cheng, P. H., Chen, S. J., Lai, J. S., Chen, H. S. & Chung, H. C. (2005) "Evaluation of the low cost telemedicine system in Taiwan"**,** *Proceedings of 7th International Workshop on Enterprise Networking and Computing in Healthcare Industry (HEALTHCOM 2005)***,** 23-25 June 2005**,** pp.316-319.

Lun, K. C. (1999) "Health informatics in the Asia Pacific region", *International Journal of Medical Informatics,* Vol.55**,** pp.3-7.

Maheu, M. M., Whitten, P. & Allen, A. (2001) *E-Health, Telehealth and Telemedicine: A Guide to Start-up and Success***,** Jossey-Bass, A Wiley Company San Francisco.

Mahncke, R. J. & Williams, P. A. H. (2006) "Secure transmission of shared electronic health records: A review", Available at http://scissec.scis.ecu.edu.au/conference_proceedings/2006/aism/Mahncke%20Williams%20-%20Secure%20transmission%20of%20shared%20electronic%20health%20records%20-%20A%20review.pdf**,** (accessed January 19, 2008).

Malaysian Communication and Multimedia Commission (2006) "Malaysian Communication and Multimedia Commission: Roles and Responsibilities", Available at http://www.mcmc.gov.my/about_us/roles.asp,**,** (accessed May 31, 2006).

Malaysian Communication and Multimedia Commission (2007) "Communications and Multimedia: Selected facts and figures Q4 2007", Available at http://www.skmm.gov.my/facts_figures/stats/pdf/Quarter4.pdf**,** (accessed 15 April 2008).

Malaysian Communications and Multimedia Commission (2005) "Household use internet survey", Available at http://www.mcmc.gov.my/facts_figures/stats/pdf/Household_use_internet_survey2005.pdf**,** (accessed March 11, 2006).

Martin, P. Y. & Turner, B. A. (1986) "Grounded theory and organizational research", *The Journal of Applied Behavioral Science* Vol.22**,** Iss.2**,** pp.141-157.

Martinez, A., Villarroel, V., Seone, J. & Pozo, F. D. (2004) "Rural telemedicine for primary healthcare in developing countries", *IEEE Technology And Society Magazine,* Vol.23**,** Iss.2**,** pp.13-22.

Masuda, Y., Sekimoto, M., Nambu, M., Higashi, Y., Fujimoto, T., Chihara, K. & Tamura, Y. (2005) "An unconstrained monitoring system for home rehabilitation", *Engineering in Medicine and Biology Magazine, IEEE,* Vol.24**,** Iss.4**,** pp.43-47.

Mathews, J. & Cho, D. (2000) *Tiger Technology: The Creation of a Semiconductor Industry in East Asia***,** Cambridge University Press.

Medical Record Institute (2006) "Continuity of Care Record (CCR) - The Concept Paper of the CCR - Version 3", Available at http://medrecinst.com/pages/about.asp?id=54**,** (accessed 2 April 2008).

Medline Plus (2008a) "Allergy", Available at http://www.nlm.nih.gov/medlineplus/allergy.html**,** (accessed 4 April 2008).

Medline Plus (2008b) "Health topic: Diagnostic Imaging", Available at http://www.nlm.nih.gov/medlineplus/diagnosticimaging.html**,** (accessed 6 April 2008).

Medline Plus (2008c) "Medical Dictionary Website ", Available at http://www.nlm.nih.gov/medlineplus/mplusdictionary.html**,** (accessed 6 April 2008).
Medline Plus (2008d) "Personal Medical Records", Available at http://www.nlm.nih.gov/medlineplus/personalmedicalrecords.html**,** (accessed 2 April 2008).
Menard, S. W. (1991) *Longitudinal Research***,** Sage, Newbury Park.
Miles, M. B. & Huberman, A. M. (1994) *Qualitative Data Analysis: An Expanded Sourcebook (Second Edition)***,** Sage Publication, Thousand Oaks, California.
Miller, E. A. (2002) "Telemedicine and doctor-patient communication: a theoritical framework for evaluation", *Journal of Telemedicine and Telecare,* Vol.8**,** Iss.6**,** pp.311-318.
Ministry of Energy Water and Communications Malaysia (2008a) "Bridging the Digital Divide", Available at http://www.ktak.gov.my/template01.asp?contentid=54**,** (accessed 13 May 2008).
Ministry of Energy Water and Communications Malaysia (2008b) "Organisation, vision and mission", Available at http://www.ktak.gov.my/images/Organisation.pdf**,** (accessed 14 May 2008).
Ministry of Health Malaysia (1995) "Health Facts 1995", Available at http://pnd.moh.gov.my/uploads/health_facts_1995.htm**,** (accessed 3 May 2006).
Ministry of Health Malaysia (1997a) "Concept Request for Proposal for Lifetime Health Plan - Schedule 3: Network Infrastructure", Copyright 1997 Government of Malaysia.
Ministry of Health Malaysia (1997b) "Concept Request for Proposal for Lifetime Health Plan - Schedule 5: Operation Data Centre", Copyright 1997Government of Malaysia.
Ministry of Health Malaysia (1997c) "Concept Request for Proposal for Lifetime Health Plan - Schedule 8: Application Software", Copyright 1997 Government of Malaysia.
Ministry of Health Malaysia (1997d) "Concept Request for Proposal for Lifetime Health Plan: Telemedicine Flagship Application", Copyright 1997 Government of Malaysia.
Ministry of Health Malaysia (1997e) "Telemedicine Blueprint : Telemedicine Flagship Application", Copyright 1997 Government of Malaysia.
Ministry of Health Malaysia (2000) "National Telehealth Policies: Telemedicine Flagship Application", Unpublished document Government of Malaysia.
Ministry of Health Malaysia (2002) "Health Facts 2002", Available at http://pnd.moh.gov.my/uploads/health_facts_2002.htm**,** (accessed May 3, 2006).
Ministry of Health Malaysia (2003a) "Business Process Reengineering Workshop Report: National Consensus Meeting for Standard Operating Procedure of Outpatient and Inpatient." Copyright 2003 Government of Malaysia.
Ministry of Health Malaysia (2003b) "Business Process Reengineering Workshop Report: National Consensus Meeting for Standard Operating Procedure of Patient Management", Copyright 2003 Government of Malaysia.
Ministry of Health Malaysia (2003c) "Health Facts 2003", Available at http://pnd.moh.gov.my/uploads/health_facts_2003.pdf**,** (accessed 3 May 2006).
Ministry of Health Malaysia (2003d) "What is TPC", Available at http://www.tpc.gov.my/groupy/tiki-index.php?page_ref_id=4**,** (accessed February 15, 2006).
Ministry of Health Malaysia (2004) "Health Facts 2004", Available at http://pnd.moh.gov.my/uploads/health_facts_2004.htm**,** (accessed May 13, 2006).

Ministry of Health Malaysia (2005) "Health Facts 2005", Available at http://pnd.moh.gov.my/uploads/health_facts_2005.htm, (accessed May 3, 2006).
Ministry of Health Malaysia (2006a) "Health ICT Initiative: Project Progress Report", *Personal Interview*
Ministry of Health Malaysia (2006b) "Vision and Mission", Available at http://www.moh.gov.my/opencms/opencms/moh/MOH_Eng/misi_kkm.html, (accessed November 10, 2006).
Ministry of Health Malaysia (2007) "ICT Strategic Plan (ISP): 2006 - 2010", Government of Malaysia.
Ministry of Health Malaysia (2008a) "Bahagian Teknologi Maklumat dan Komunikasi - Carta Organisasi", Available at http://btmk.moh.gov.my/uploads/CARTA_060208.pdf, (accessed 29 April 2008).
Ministry of Health Malaysia (2008b) "Ministry of Health Malaysia - Organisation Structure", Available at http://www.moh.gov.my/opencms/opencms/moh/carta.html, (accessed 29 April 2008).
Ministry of Health New Zealand (2003) "Child Health Information Strategy", Available at http://www.moh.govt.nz/moh.nsf/f872666357c511eb4c25666d000c8888/70f4c5544b6fbdb0cc256d86007fa2a2/$FILE/ChildHealthInfoStrategy.pdf, (accessed 6 May 2008).
Ministry of Health New Zealand (2005) "Health Information Strategy for New Zealand", Available at http://www.moh.govt.nz/moh.nsf/0/1912064EEFEC8EBCCC2570430003DAD1/$File/health-information-strategy.pdf, (accessed 6 May 2008).
Ministry of Health New Zealand (2008) "The New Zealand Health and Disability System", Available at www.moh.govt.nz/healthsystem, (accessed 5 May 2008).
Ministry of Health Singapore (2007a) "Health Facts Singapore", Available at http://www.moh.gov.sg/mohcorp/statistics.aspx?id=5524, (accessed 7 May 2008).
Ministry of Health Singapore (2007b) "Singapore Healthcare System", Available at http://www.moh.gov.sg/mohcorp/hcsystem.aspx?id=102, (accessed 7 May 2008).
Ministry of Science Technology and Innovation of Malaysia (2008) "ICT Policy Division", Available at http://www.mosti.gov.my/ mosti/index.php?option=com_content&task=view&id=39&Itemid=28, (accessed 13 May 2008).
Moehr, J. R., Schaafsma, J., Anglin, C., Pantazi, S. V., Grimm, N. A. & Anglin, S. (2006) "Success factors for telehealth - a case study", *International Journal of Medical Informatics,* Vol.75, pp.755-763.
Mohamad, M. (1996) "The Way Forward: Malaysia Vision 2020", Available at http://www.wawasan2020.com/vision/, (accessed May 3, 2006).
Mohan, A. V., Omar, A. A. & Ab. Aziz, K. (2002) "Malaysia's Multimedia Super Corridor Cluster: Communication Linkages Among Stakeholders in a National System of Innovation", *IEEE Transactions on Professional Communication,* Vol.45, Iss.4, pp.265-275.
Mohan, J. & Raja Yaacob, R. R. (2004) "The Malaysian telehealth flagship application: a national approach to health data protection and utilisation and consumer rights", *International Journal of Medical Informatics,* Vol.73, Iss.3, pp.217-227.
Mohd Yusof, M., Kuljis, J., Papazafeiropoulou, A. & Stergioulas, L. K. (2007) "Investigating evaluation framework for health information systems", *International Journal of Medical Informatics,* Vol.77, Iss.6, pp.377-385.

MSC Malaysia (2007) "MSC Malaysia Flagship Applications", Available at http://www.mscmalaysia.my/topic/12071142100873**,** (accessed March 6, 2007).
Myers, S. M. & Haase, J. E. (1999) "Guidelines for integration of quantitative and qualitative approaches", in: F.S. Downs, ed. *'Reading in research methodology'*, Philadelphia, Pa.: Lippincott,**,** pp.58-60.
Mykkanen, J., Porrasmaaa, J., Rannanheimob, J. & Korpela, M. (2003) "A process for specifying integration for multi-tier applications in healthcare", *International Journal of Health Informatics,* Vol.70**,** pp.173-182.
Naiburg, E. J. & Maksimchuk, R. A. (2001) *UML for Database Design***,** Addison-Wesley.
National Cancer Institute (2003) "Interpreting Laboratory Test Results", Available at http://www.cancer.gov/cancertopics/factsheet/Detection/laboratory-tests**,** (accessed 6 April 2008).
National Health Services (2006a) "Connecting for Health - Fact sheets: N3." Available at http://www.connectingforhealth.nhs.uk/publications/toolkitaugust05/factsheet_n3.doc**,** (accessed 17 May 2006).
National Health Services (2006b) "How the NHS works", Available at http://www.nhs.uk/England/AboutTheNhs/Default.cmsx**,** (accessed 10 May 2006).
National Health Services (2006c) "The National Programme for IT Implementation Guide", Available at http://www.connectingforhealth.nhs.uk/all_images_and_docs/implementationdocs/national_programme_implementation_guide_v4.pdf. **,** (accessed 15 May 2006).
National Health Services (2007) "The NHS Care Records Service Better information for better, safer care", Available at http://www.nhscarerecords.nhs.uk/patients/what-do-i-need-to-do-now/how-can-i-find-out-more/nhs-crs-summary-leaflets/summary_leaflet_online.pdf**,** (accessed July 19, 2007).
Nelson, D. A. (1997) "Why does medicine need standards?" Available at http://www.medicalcomputing.org/archives/0astandwhy.php**,** (accessed November 20, 2006).
Neuman, W. L. (1991) *Social Research Methods: Qualitative and Quantitative Approaches***,** Allyn and Bacon, Boston.
Nguyen, Q. T., Naguib, R. N. G., Abd Ghani, M. K., Bali, R. K., Marshall, I. M., Phuong, N. H., Culaba, A. B., Wickramasinghe, N. S., Shaker, M. H. & Lee, R. V. (2008) "An analysis of healthcare informatics and systems in South East Asia: a current perspective from seven countries", *international Journal of Electronic Healthcare,* Vol.4**,** Iss.2**,** pp.184-207.
Nonaka, I. & Takeuchi, H. (1995) *The knowledge creating company***,** Oxford University Press, New York.
Norris, A. C. (2002) *Essentials of Telemedicine and Telecare***,** John Wiley & Sons, Ltd.
Norum, J., Bergmo, T., Holdø, B., Johansen, M., Vold, I., Sjaaeng, E. & Jacobsen, H. (2007a) "A teleobstetric broadband service including ultrasound, videoconferencing and cardiotoccogram. A high cost and a lower volume of patients." *Journal of Telemedicine and Telecare,* Vol.13**,** Iss.4**,** pp.180-184.
Norum, J., Pedersen, S., Størmer, J., Rumpsfeld, M., Stormo, A., Jamissen, N., Sunde, H., Ingebrigtsen, T. & Larsen, M.-L. (2007b) "Prioritisation of telemedicine services for large scale implementation in Norway", *Journal of Telemedicine and Telecare,* Vol.13**,** Iss.4**,** pp.185-192.

Norwegian Centre for Telemedicine (2004) "Te@mwork 2007 - Electronic Cooperation in the Health and Social Sector", Available at http://www.telemed.no/getfile.php/119375.357/te@mwork_2007.pdf**,** (accessed 10 May 2008).

Norwegian Centre for Telemedicine (2006) "Excellent Health Services Available to All", Available at http://www2.telemed.no/publikasjoner/nedlastbare/a4enbrosjyre_24_07_02.pdf.**,** (accessed 18 May 2006).

Norwegian Centre for Telemedicine (2007) "20 years of telemedicine in Tromsø – a historical retrospective." Available at http://www.telemed.no/history.4457212-43160.html**,** (accessed 15 November 2007).

Norwegian Ministry of Health and Care Services (2007) "The Ministry of Health and Care Services: Organisations and Services", Available at http://www.regjeringen.no/upload/HOD/Vedlegg/HOD-brosjyre_engelsk.pdf**,** (accessed 12 May 2008).

Noseworthy, T. (2004) "Advancing electronic health records in Canada: why, how and key learnings of potential value to China"**,** *Proceedings of IDEAS Workshop of The Digital Hospital on Medical Information Systems (IDEAS '04-DH)***,** 1-3 September 2004**,** pp.129 -132.

NSWHEALTH (2003) "New South Wales Telehealth Initiative: Statewide Update", Available at http://www.health.nsw.gov.au/pubs/t/pdf/tele_newsletter9.pdf**,** (accessed 20 April 2007).

NSWHEALTH (2004) "Minister Announces $87,000 Telehealth Boost For Ambulance Service", Available at http://www.health.nsw.gov.au/news/2004/20040318_02.html**,** (accessed 15 Aug 2006).

O'Reilly, K. (2005) *Ethnographic Methods***,** Routledge.

Oakley, A. M., Kerr, P., Duffill, M., Rademaker, M., Fleischl, P. & Bradford, N. (2000) "Patient cost-benefits of realtime teledermatology-a comparison of data from Northern Ireland and New Zealand", *Journal of Telemedicine and Telecare,* Vol.6**,** Iss.2**,** pp.97-101.

Oakley, A. M. & Rennie, M. H. (2004) "Retrospective review of teledermatology in the Waikato, 1997-2002", *Australasian Journal of Dermatology,* Vol.45**,** Iss.1**,** pp.23-28.

Patton, M. Q. (1987) *How to Use Qualitative Methods in Evaluation***,** Newbury Park, CA:Sage.

Patton, M. Q. (2002) *Qualitative Research & Evaluation Methods***,** Thousand Oaks: Sage Publication.

Police, G., Augustine, L. & Madhur, J. (2004) *Software Development for Small Teams: A RUP-Centric Approach***,** Addison-Wesley.

Puentes, J., Bali, R. K., Wickramasinghe, N. & Naguib, R. N. G. (2007) "Telemedicine trends and challenges: a technology management perspective", *International Journal of Biomedical Engineering and Technology,* Vol.1**,** Iss.1**,** pp.59-72.

Rasid, M. F. A. & Woodward, B. (2005) "Bluetooth telemedicine processor for multichannel biomedical signal transmission via mobile cellular networks"**,** *IEEE Transactions on Information Technology in Biomedicine***,** Vol.9**,** Iss.1**,** pp.35-43.

Reason & Bradbury (2001.) *Handbook of Action Research***,** London: Sage.

Reichertz, P. L. (2006) "Hospital information systems - past, present, future", *International Journal of Medical Informatics,* Vol.75**,** Iss.3-4**,** pp.282-299.

Rice, P. L. & Ezzy, D. (1999) *Qualitative Research Methods: A Health Focus***,** Oxford University Press.

Richard, W., John, C. & Patterson, V. (2006) *Introduction to Telemedicine Second Edition***,** Royal Society of Medicine Press Ltd.

Roman, I., Roa, L. M., Reina-Tosina, J. & Madinabeita, G. (2006) "Demographic management in a federated healthcare environment", *International Journal of Medical Informatics,* Vol.75**,** Iss.9**,** pp.671-682.

Rowley, J. (2002) "Using case studies in research", *Management Research News,* Vol.25**,** Iss.1**,** pp.16-27.

Saunders, M., Lewis, P. & Thornhill, A. (2003) *Research methods for business students***,** Pearson Education: Harlow, UK.

Schutz, H., Wiedemann, P. M., Hennings, W., Mertens, J. & Clauberg, M. (2006) *Comparative Risk Assessment: Concepts, Problems & Applications***,** WILEY-VCH.

Scott, R. E. (2006) "e-Records in health - preserving our future", *International Journal of Health Informatics,* Vol.75**,** Iss.5-6**,** pp.427-431.

Selayang Hospital (2002) "Total Hospital Information System (THIS)", Available at http://www.selayanghospital.gov.my/HTML/THIS.html (accessed January 27, 2007).

Seung Jae Huh, Hiroki Shirato, Seiko Hashimoto, Shinichi Shimizu, Dae Yong Kim, Yong Chan Ahn, Dong-Rak Choi, and, K. M. & Mizuno, J. (2000) "An integrated service digital network (ISDN)-based international telecommunication between Samsung Medical Center and Hokkaido University using telecommunication helped radiotherapy planning and information system (THERAPIS)", *Radiotherapy and Oncology,* Vol.56**,** Iss.1**,** pp.121-123.

Sharma, R., Stearns, B. & Ng, T. (2001) *J2EE Connector Architecture and Enterprise Application Integration,***,** Addison-Wesley.

Singapore Department of Statistics (2008) "Demography Statistics", Available at http://www.singstat.gov.sg/stats/themes/people/demo.html**,** (accessed 7 May 2008).

SingHealth (2007) "Continue Medical Education", Available at http://www.sgh.com.sg/ForDoctorsnHealthcareProfessionals/EducationandTraining/PostgraduateMedicalInstitute/CME/**,** (accessed February 10, 2007).

Stake, R. (1995) *The Art of Case Research***,** Thousand Oaks, CA: Sage Publications.

Staroselsky, M., Volk, L. A., Tsurikova, R., Newmark, L. P., Lippincott, M., Litvak, I., Kittler, A., Wang, T., Wald, J. & Bates, D. W. (2008) "An effort to improve electronic health record medication list accuracy between visits: Patients' and physicians' response", *international Journal of Medical Informatics,* Vol.77**,** pp.153-160.

Statistics Bureau of Japan (2008) "Population Estimates", Available at http://www.stat.go.jp/english/data/jinsui/2.htm**,** (accessed 7 May 2008).

Statistics Canada (2005) "Population Projections for Canada, Provinces and Territories 2005-2031", Available at http://www.statcan.ca/english/freepub/91-520-XIE/00105/t431_en.htm?**,** (accessed 9 May 2008).

Stoop, A. P. & Berg, M. (2004) "Integrating quantitative and qualitative methods in patient care information systems evaluation: guidance for the organisational decision maker." *Methods of Information in Medicine,* Vol.42**,** pp.458-462.

Sucurovic, S. (2007) "Implementing security in a distributed web-based EHCR", *International Journal of Medical Informatics* Vol.7 Iss.6 pp.491-496.

Suleiman, A. B. (2001) "The untapped potential of telehealth", *International Journal of Medical Informatics,* Vol.61**,** Iss.2-3**,** pp.103-112.

Sullivan, P. & Lugg, D. J. (1995) "Telemedicine between Australia and Antarctica, 1911 - 1995. Warrendale", Telemedicine between Australia and Antarctica, 1911 - 1995. Warrendale.

Szirbika, N. B., Pelletier, C. & Chaussalet, T. (2006) "Six methodological steps to build medical data warehouses for research", *International Journal of Medical Informatics* Vol.75**,** pp.683-691.

Taiwan Directorate General of Budget Accounting and Statistics (2007) "National Statistics", Available at http://eng.stat.gov.tw/mp.asp?mp=5**,** (accessed 7 May 2008).

Takahashi, T. (2001) "The present and future of telemedicine in Japan", *International Journal of Medical Informatics,* Vol.61**,** pp.131-137.

Tay-Yap, J. & Al-Hawamdeh, S. (2001) "The impact of the Internet on healthcare in Singapore", *Journal of Computer-Mediated Communication*, Vol.6 Iss.4.

TEIS (2006) "UK Telemedicine and E-health Information Services: National Programme for Information Technology - makingIThappen", Available at http://www.teis.nhs.uk/chapters/npfit/npfit_brochure_v14.pdf**,** (accessed May 15, 2006).

Toyoda, K. (1998) "Standardization and security for the EMR", *International Journal of Medical Informatics,* Vol.48**,** Iss.1-3**,** pp.57-60.

Tsai, W.-H. & Kuo, H.-C. (2007) "The internet and healthcare in Taiwan: value-added applications on the medical network in the National Health Insurance smart card system", *International Journal of Electronic Healthcare,* Vol.3**,** Iss.4**,** pp.417-432.

Tsiknakis, M., Katehakis, D. G. & Orphanoudakis, S. C. (2002) "An open, component-based information infrastructure for integrated health information networks", *International Journal of Health Informatics,* Vol.68**,** pp.3-26.

Tsuji, M., Suzuki, W. & Taoka, F. (2003) "An economic evaluation of the Japanese telehealth system by CVM: comparison of four regions"**,** *Proceedings of 5th IEEE International Workshop on Enterprise Networking and Computing in Healthcare Industry (Healthcom 2003)***,** 6-7 June 2003**,** pp.24-28.

Uldal, S. B. (1999) "A survey of Norwegian telemedicine", *Journal of Telemedicine and Telecare,* Vol.5**,** Iss.1**,** pp.32-37.

Van Bemmel, J. H. & Musen, M. A. (1997) *Handbook of Medical Informatics***,** Springer-Verlag, Heidelberg.

Vargas, B. & Pradeep, R. (2003) "Interoperability of hospital information systems: a case study"**,** *Proceedings of 5th IEEE International Workshop on Enterprise Networking and Computing in Healthcare Industry (Healthcom 2003)***,** 6-7 June 2003**,** pp.79-85.

Varghese, S. & Scott, R. E. (2004) "Categorizing the telehealth policy response of countries and their implications for complementarity of telehealth policy", *Telemedicine Journal and e-Health,* Vol.10**,** Iss.1**,** pp.61-69.

Wang, H., Wang, H. & Shen, J. (2004) "Architectural design and implementation of highly available and scalable medical system with IBM Websphere middleware"**,** *Proceedings of 17th IEEE Symposium on Computer-Based Medical Systems (CBMS 2004)***,** 24-25 June 2004**,** pp.174-179.

Warren, S., Craft, R. L., Parks, R. C., Gallagher, L. K., Garcia, R. J. & Funkhouser, D. R. (1999) "A proposed information architecture for telehealth system interoperability"**,** *Proceeding of 21st Annual IEEE Conference and the 1999 Annual Fall Meeting on the Biomedical Engineering Society in Medicine and Biology***,** October 1999**,** Vol.2**,** pp.702.

Webb, E. J., Campbell, D. T., Schwartz, R. D. & Sechrest, L. (1966) *Unobtrusive Measures: Nonreactive Measures in the Social Sciences***,** Chicago:Rand McNally.

Whiddett, R., Hunter, I., Engelbrecht, J. & Handy, J. (2006) "Patients' attitudes towards sharing their health information", *International Journal of Medical Informatics,* Vol.75**,** Iss.7**,** pp.530-541.
Whitten, P. & Sypher, B. D. (2006) "Evolution of telemedicine from an applied communication perspective in the United States", *Telemedicine and E-Health,* Vol.12**,** Iss.5**,** pp.590-600.
WHO (2004) "Religious faith can certainly help to stop tobacco habits: An experience from a pilot study", Available at http://www.who.int/bulletin/bulletin_board/82/ jabbour12041/en/**,** (accessed 4 April 2008).
WHO (2007) "International Classification Diseases (ICD)", Available at http://www.who.int/classifications/icd/en/**,** (accessed September 30, 2007).
WHO (2008a) "Immunization", Available at http://www.who.int/topics/immunization/en/**,** (accessed 4 April 2008).
WHO (2008b) "World Health Organisation - National Health Accounts", Available at http://www.who.int/nha/country/en/**,** (accessed 15 May 2008).
WHOSIS (2006) "WHO Statistical Information System : Core Health Indicators", Available at http://www.who.int/whosis/database/core/core_select.cfm**,** (accessed May 25, 2006).
Wickramasinghe, N., Fadlalla, A., Geisler, E. & Schaffer, J. (2005) "A framework for assessing e-health preparedness", *International Journal of Electronic Healthcare,* Vol.1**,** Iss.3**,** pp.316-334.
Wickramasinghe, N., Geisler, E. & Schaffer, J. (2006) "Realizing the value proposition for healthcare by incorporating KM strategies and data mining techniques with the use of information communication technologies", *International Journal of Healthcare Technology and Management,* Vol.7**,** Iss.3/4**,** pp.303-318.
Wickramasinghe, N. & Schaffer, J. (2006) "Creating knowledge driven healthcare processes with the intelligence continuum", *International Journal of Electronic Healthcare,* Vol.2**,** Iss.2**,** pp.164-174.
Wikipedia (2007) "Medical Records", Available at http://en.wikipedia.org/wiki/Medical_record#Demographics**,** (accessed 3 April 2008).
Wikipedia (2008) "Vital signs", Available at http://en.wikipedia.org/wiki/Vital_signs_%28medicine%29**,** (accessed 7 April 2008).
William, M. K. T. (2006) "Research Methods Knowledge Base", Available at http://www.socialresearchmethods.net/kb/external.php**,** (accessed 15 June 2009).
Williams, F. & Moore, M. (1995) "Telemedicine: Its place on the information highway", Available at http://www.csua.berkeley.edu/~utsai/Telemed.html**,** (accessed April 20, 2005).
Williams, M. & Smith, A. (2004) "Paediatric outreach services", *Journal of Paediatrics and Child Health,* Vol.40**,** Iss.9-10**,** pp.501-503.
Wootton, R. & Craig, J. (1999) *Introduction to Telemedicine***,** The Royal Society of Medicine Press Limited.
Wua, J. H., Wanga, S. C. & Lind, L. M. (2007) "Mobile computing acceptance factors in the healthcare industry: A structural equation model," *International Journal of Health Informatics,* Vol.76**,** pp.66-77.
Wyatt, J. C. & Wyatt, S. M. (2003) "When and how to evaluate health information systems?" *International Journal of Medical Informatics,,* Vol.69**,** Iss.2-3**,** pp.251-259.

Yahoo Education (2005a) "World Factbook - Canada People", Available at http://education.yahoo.com/reference/factbook/ca/popula.html;_ylt=AgnqCfbhUejB930PMB.E3824ecYF**,** (accessed 9 May 2008).
Yahoo Education (2005b) "World Factbook: Australia", Available at http://education.yahoo.com/reference/factbook/as/;_ylt=AgDPjH_pW.n3iFQOyCQh6py4ecYF**,** (accessed 15 May 2008).
Yahoo Education (2005c) "World Factbook: China", Available at http://education.yahoo.com/reference/factbook/ch/;_ylt=AgDPjH_pW.n3iFQOyCQh6py4ecYF**,** (accessed 9 May 2008).
Yahoo Education (2005d) "World Factbook: Hong Kong People", Available at http://education.yahoo.com/reference/factbook/hk/popula.html;_ylt=AgnqCfbhUejB930PMB.E3824ecYF**,** (accessed 7 May 2008).
Yahoo Education (2005e) "World Factbook: Japan", Available at http://education.yahoo.com/reference/factbook/ja/;_ylt=AgDPjH_pW.n3iFQOyCQh6py4ecYF**,** (accessed 7 May 2008).
Yahoo Education (2005f) "World Factbook: New Zealand", Available at http://education.yahoo.com/reference/factbook/nz/;_ylt=Asg7VLisom5VYGHUV_H9G5G3ecYF**,** (accessed 5 May 2008).
Yahoo Education (2005g) "World Factbook: Norway", Available at http://education.yahoo.com/reference/factbook/no/geogra.html;_ylt=Ahfp5dc8kwMPMbcXKIaOiKG4ecYF**,** (accessed 12 May 2008).
Yang, K. H., Lee, S. M. & Lee, S.-G. (2007) "Adoption of information and communication technology: Impact of technology types, organization resources and management style Journal: Industrial Management & Data Systems ", *Industrial Management & Data Systems,* Vol.107 Iss.9 pp.1257-1275.
Yellowlees, P. (2001) "An analysis of why telehealth systems in Australia have not always succeeded", *Journal of Telemedicine and Telecare,* Vol.7**,** Iss.2**,** pp.29-31.
Yin, R. (2003a) *Applications of Case Study Research (Second Edition)***,** Sage Publications.
Yin, R. (2003b) *Case Study Research: Design and Methods (Third Edition)* Sage Publications.

Appendices

APPENDICES

Appendix A **:** Research papers published

Appendix B **:** Questionnaire used to investigate the ICT infrastructure in public healthcare facilities

Appendix C **:** Questionnaire used to analyse patient demographic and clinical data usage in outpatient clinics

Appendix D **:** Questionnaire used to evaluate the need of flexible framework

Appendix E **:** Questionnaire used to evaluate the need of flexible framework

Appendix F **:** Feedback from framework validation exercised

Appendix G **:** Telemedicine initiatives and approaches in ten countries

Appendix H **:** LHR data structure

Appendix I **:** Pictures of healthcare centres in Malaysia

Appendix J **:** Validation of the *My*Tel framework: a cross-case analysis

APPENDIX A

Research papers published

1. Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Shibghatullah, A. S. (2007) "The Design of Flexible Front End Framework for Accessing Patient Health Records Through Short Message Service"**,** *IEEE Asia-Pacific Conference on Applied Electromagnetics***,** Melaka, Malaysia**,** 4-6 December 2007**,** pp.1-5

2. Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Wickramasinghe, N. S. (2008) "Electronic Health Records Approaches and Challenges: A Comparison between Malaysia and 4-East-Asian-Country", *International Journal of Electronic Healthcare*, Vol.4, No.1, pp.78-104.

3. Nguyen, Q. T., Naguib, R. N. G., Abd Ghani, M. K., Bali, R. K., Marshall, I. M., Phuong, N. H., Culaba, A. B., Wickramasinghe, N. S., Shaker, M. H. & Lee, R. V. (2008) "An Analysis of Healthcare Informatics and Systems In South East Asia: A Current Perspective from Seven Countries", *International Journal of Electronic Healthcare*, Vol.4, No.2, pp.184-207.

4. Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. M., Baskaran, V., Wickramasinghe, N. & Puentes, J. (2008) "A Flexible Telemedicine Framework for the Continuous Upkeep of Patient Health Record", *Proceedings of the Fourteenth Americas Conference on Information Systems,* Toronto, Canada, August 14th-17th 2008.

5. Nguyen, Q. T., Abd Ghani, M. K., Naguib, R. N. G., Bali, R. K., Marshall, I. M. & Phuong, N. H. (2008) "Issues and Challenges in the Development of Electronic Health Records in Malaysia and Vietnam", *Conference on Applications of Medical Informatics in Hospital Management (VN-HISMANAG'08)*, Hanoi, Vietnam, 9th January 2008.

6. Wickramasinghe, N., Bali, R.K., Lehaney, B., Jonathan S., M. Chris G. (2009) "Healthcare Knowledge Management Primer", In Abd Ghani M.K, ed. (2009) Case Exercise: KM and Personal Health Records – A Malaysian Perspective, Routledge, ISBN: 978-0-415-99443-9.

7. Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Wickramasinghe, N. S. (xxxx) "An Integrated and Distributed Framework for Malaysia Telemedicine Framework - *My*Tel", *International Journal of Healthcare Technology and Management,* to be submitted.

8. Abd Ghani, M. K., Bali, R. K., Naguib, R. N. G., Marshall, I. & Wickramasinghe, N. S. (xxxx) "Critical Analysis on the Usage of Patient Demographic and Clinical Record during Doctor-Patient Consultation – A Malaysian Perspective", *International Journal of Healthcare Technology and Management,* to be submitted.

APPENDIX B

Questionnaire used to investigate the ICT infrastructure in public healthcare facilities

Current state of ICT infrastructure and general use of ICT in Public Health Care Facility (hospitals/clinics)

Questionnaire Contents:

1. Introductory Notes
2. Abbreviation
3. Glossary
4. Questionnaire

Introductory Notes

1. This is an academic study on PhD research project titled: ***A Flexible Framework for Malaysian Integrated and Distributed Telemedicine System***

2. This questionnaire will take about 120 minutes to complete. I would be grateful if you could allocate some time out from your schedule to answer this questionnaire.

3. Your answers will be treated with the strictest confidence and are to be exclusively used for my PhD research project. No information will be forwarded to any individual and/or external organisation.

4. The main respondents for the questionnaire are ICT Infrastructure officers who involved in health ICT projects of Ministry of Health Malaysia.

5. This questionnaire is in Malay/English

6. If there are any further questions, I can be contacted at

Mohd Khanapi Abd Ghani
PhD Candidate, Biomedical Computing and Engineering Technologies
Applied Research Group (BIOCORE),
Faculty of Engineering and Computing,
Coventry University, CV1 5FB,
United Kingdom.

Tel: +44 2476688444
E-mail: abdghanm@coventry.ac.uk

THANK YOU FOR YOUR COOPERATION

Abbreviation

ICT	Information and communication technology
MOH	Ministry of Health
PC	Personal computer
ISDN	Integrated services digital network
PSTN	Public switched telephone network

Glossary

Intranet	A private computer network that uses Internet protocols, network connectivity, and possibly the public telecommunication system to securely share part of an organization's information or operations with its employees.
Extranet	A private network that use internet protocols, network connectivity, and possibly the public telecommunication system to securely share part of an organization's information or operations with suppliers, vendors, partners, customers or other businesses.
Broadband	Broadband or broadband internet is a high data-transmission rate internet connection. Normally broadband used cable modem or digital subscriber line (DSL) that capable of transmitting faster than dial-up modem.

1. Have you heard about health ICT or health informatics before?

   ❑ YES ❑ NO

2. Have you heard about Telemedicine or Telehealth or E-health before?

   ❑ YES ❑ NO

3. Do you agree with the statement that the ICT info structure and infrastructure are crucial for implementing the health ICT project?

   ❑ YES ❑ NO

4. Can you estimate the percentage of health care facilities having any kind of ICT infrastructure in place to assist health workers in the delivery of healthcare services? (*Please specify in percentage*)

   A. Hospitals ______%
   B. Community polyclinics ______%
   C. Rural clinics ______%
   D. Maternal and child health clinics ______%

5. What level of ICT infrastructure in place at MOH health care facilities (*Please circle ICT infrastructure level below at each type of health facilities*)?

   I Internet
   II Intranet
   III Extranet
   IV Local area network
   V Stand alone PCs
   VI Telephone/Facsimile

a. Hospitals	I	II	III	IV	V	VI
b. Community polyclinics	I	II	III	IV	V	VI
c. Rural clinics	I	II	III	IV	V	VI
d. Maternal and child health clinics	I	II	III	IV	V	VI

6. Does all health care facility have its own workgroup server?

   ❑ YES ❑ NO

7. Does a health care facility provide a proper/dedicated room to allocate computer's equipments (*i.e. servers, routers, hubs, printers etc.*)?

   ❑ YES ❑ NO

8. Does MOH provide internet access to all health care facilities?

   ❑ YES ❑ NO

9. Do all staff/healthcare professionals have access to internet?

   ❑ YES ❑ NO

10. What type of telecommunication network is used/installed at a normal health care facility? (*Tick the relevant box and circle the bandwidth size*)

    ❑ Wired broadband (256KB, 512KB, 1MB, 2MB, 4MB, 8MB)
    ❑ Wireless broadband (256KB, 512KB, 1MB, 2MB, 4MB, 8MB)
    ❑ ISDN leased-lined (32KB, 64KB, 128KB, 256KB, 512KB, 1MB)
    ❑ PSTN leased-lined (32KB, 64KB, 128KB, 256KB, 512KB, 1MB)
    ❑ Dial-up (32KB, 56KB)
    ❑ None of the above (*Please specify*) ____________________________

11. What mechanisms are used to distribute healthcare information around the organisation and across health care facility levels

    ❑ Staff meeting
    ❑ Memorandum
    ❑ Bullet boards e.g. bulletin
    ❑ E-mail/ICT e.g. intranets
    ❑ Facsimile

12. Does MOH provide e-mail/web mail application to assist in communicating around the health care facility?

    ❑ YES ❑ NO

13. Does MOH provide e-mail accounts to all staff/healthcare professionals

    ❑ YES ❑ NO

14. Does MOH provide mobile computing facilities to the Doctors in delivering healthcare services? (*Please specify the relevant ones*)

- ❑ Smart Mobile phone
- ❑ PDA
- ❑ Laptop
- ❑ Pager

(*Circle the number under the initials that applies 1=Strongly Disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=Strongly Agree*)

15. Which of the following category of health workers had been provided with computer facility?

a. Healthcare professionals (i.e. Doctors, pharmacist, radiologist, pathologist)	1	2	3	4	5
b. Medical assistants	1	2	3	4	5
c. Nurses	1	2	3	4	5
d. Registration clerks	1	2	3	4	5
e. Medical attendances	1	2	3	4	5
f. Administrators	1	2	3	4	5

16. Which of the following departments/services do you think used computer in delivering healthcare services?

e. Registration counter	1	2	3	4	5
f. Consultation room	1	2	3	4	5
g. Laboratory services	1	2	3	4	5
h. Radiology services	1	2	3	4	5
i. Pharmacy services	1	2	3	4	5
j. Operation theatres	1	2	3	4	5
k. Ward services	1	2	3	4	5
l. Admin office e.g. finance and human resource	1	2	3	4	5

17. Which of the following application software do you think almost exists in department/service to assist health workers in delivering the healthcare services?

a. Clinical information system (CIS)	1	2	3	4	5
b. Patient management system	1	2	3	4	5
c. Radiology information system	1	2	3	4	5
d. Pharmacy information system	1	2	3	4	5

e. Laboratory information system	1	2	3	4	5
f. Administration system i.e. Billing, Human resources etc	1	2	3	4	5
g. Others (Please specify) ______________________________	1	2	3	4	5

18. Do you agree with the statement that the health workers need continuous ICT training for encouraging them to use ICT in delivering healthcare services?

❑ YES ❑ NO

19. Which of the following ICT skills level do you think the current health workers are having?

❑ Most of them dislike computer
❑ Most of them are entry level users
❑ Most of them are intermediate users
❑ Most of them are advanced users

20. Has MOH provide continuous ICT training to health workers?

❑ YES ❑ NO

- END OF QUESTIONNAIRE -

APPENDIX C

Questionnaire used to analyse patient demographic and clinical data usage in outpatient clinics

Analysis of Patients' Demographic and Clinical Information in Outpatient Clinics

Questionnaire Contents:

Introductory Notes

7. This is an academic study on PhD research project titled: ***A Flexible Framework for Malaysian Integrated and Distributed Telemedicine System***

8. This questionnaire will take about 120 minutes to complete. I would be grateful if you could allocate some time out from your schedule to answer this questionnaire.

9. Your answers will be treated with the strictest confidence and are to be exclusively used for my PhD research project. No information will be forwarded to any individual and/or external organisation.

10. The main respondents for the questionnaire are Medical officers and Specialists who involved in providing healthcare services in general outpatient clinics (such as Polyclinics and Health Centres).

11. This questionnaire is in English

12. If there are any further questions, I can be contacted at

Mohd Khanapi Abd Ghani
PhD Candidate, Biomedical Computing and Engineering Technologies
Applied Research Group (BIOCORE),
Faculty of Engineering and Computing,
Coventry University, CV1 5FB,
United Kingdom.

Tel: +44 2476688444
E-mail: abdghanm@coventry.ac.uk

THANK YOU FOR YOUR COOPERATION

Abbreviations

EMR	Electronic Medical Records
LHR	Lifetime Health Records
PDA	Personal Digital Assistant
ICT	Information and Communication Technology
MOH	Ministry of Health
TPC	Tele-Primary Care
THIS	Total Hospital Information System

Glossary

Personal area network (PAN)	A computer network used for communication among computer devices (including telephones and personal digital assistants) close to one person. PANs can be used for communication among the personal devices themselves (intrapersonal communication), or for connecting to a higher level network and the Internet
Bluetooth	Bluetooth provides a way to connect and exchange information wirelessly between devices such as mobile phones, laptops, PCs, printers, digital cameras and video game consoles via a secure short-range radio frequency
Electronic medical record	The structuring and storing of a patient's record (clinical and non-clinical) electronically according to a complete listing of his medical problems accompanied by progress notes for each problem.
Lifetime health record	The summarised health records of every individual from womb to tomb compiled from their EMR.

1. Have you heard about health ICT or health informatics before?

   ❑ YES ❑ NO

2. Have you heard about Telemedicine, Telehealth and E-health before?

   ❑ YES ❑ NO

3. Have you heard about EMR and LHR before?

   ❑ YES ❑ NO

4. Have you heard about health ICT project initiative in MOH such as Telehealth, TPC and THIS before?

   ❑ YES ❑ NO

5. Do you have a pre-defined way of creating, storing, accessing and disseminating patients' medical record in outpatient clinic workflow?

   ❑ YES ❑ NO

6. Do you have a pre-defined question or standard template for capturing clinical finding during a patient-doctor encounter?

   ❑ YES ❑ NO

7. Do you agree with the statement that most of the works are carried out in outpatient clinics to aid in medical diagnosis and treatment?

   ❑ YES ❑ NO

8. How much time is normally required by a Doctor for completing a consultation session for each patient? (*Please tick one*)

Within 10 minutes	
Between 11 – 20 minutes	
Between 21 – 30 minutes	
Between 31 – 40 minutes	
Between 41 – 50 minutes	
Between 51 – 60 minutes	
More than 60 minutes	

(*Circle the number under the initials that applies 1=Strongly Disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=Strongly Agree*)

9. Which of the following questions are frequently asked during a patient-doctor consultation?

a. Hello/How are you?	1	2	3	4	5
b. What is your problem?	1	2	3	4	5
c. Can you tell me your Complaints/Symptoms	1	2	3	4	5
d. How severe is your problem?	1	2	3	4	5
e. Since when you realize of the problem?	1	2	3	4	5
f. Can you tell me your past medical problem?	1	2	3	4	5
g. Do your family have any chronic diseases?	1	2	3	4	5
h. Do you have taken any medication before?	1	2	3	4	5

10. Which of the following patient's demographic information are important to be viewed during consultation?

a. Patient's name	1	2	3	4	5
b. Age/Date of birth	1	2	3	4	5
c. Sex	1	2	3	4	5
d. Race	1	2	3	4	5
e. Religion	1	2	3	4	5
f. Ethnicity	1	2	3	4	5
g. Nationality	1	2	3	4	5
h. Occupation	1	2	3	4	5
i. IC number	1	2	3	4	5
j. Passport number	1	2	3	4	5

11. Which of the following patient's contact information are important to be known by the doctor/healthcare providers?

a. Home Address	1	2	3	4	5
b. Home phone number	1	2	3	4	5
c. Hand phone number	1	2	3	4	5
d. E-mail address	1	2	3	4	5
e. Fax	1	2	3	4	5
f. Pager	1	2	3	4	5

12. Which of the following patient's next-of-kin information is important to be known by the doctor/healthcare providers?

a. Emergency contact person	1	2	3	4	5
b. Relationship to patient	1	2	3	4	5
c. Home address	1	2	3	4	5
d. Telephone number	1	2	3	4	5
e. E-mail address	1	2	3	4	5
f. Fax	1	2	3	4	5
g. Pager	1	2	3	4	5

13. Which of the following patient's medical history information is important to be viewed during consultation?

a. Diagnosis/problems	1	2	3	4	5
b. Blood information	1	2	3	4	5
c. Allergies information	1	2	3	4	5
d. Lab test result	1	2	3	4	5
e. Radiology report	1	2	3	4	5
f. Medication information	1	2	3	4	5
g. Complains information	1	2	3	4	5
h. Symptoms	1	2	3	4	5
i. Vital signs	1	2	3	4	5
j. Family history	1	2	3	4	5
k. Immunisation	1	2	3	4	5
l. Social history	1	2	3	4	5
m. Disability information	1	2	3	4	5
n. Previous doctor attending to the problem	1	2	3	4	5
o. Previous health care facility	1	2	3	4	5
p. Date of the visit/episode	1	2	3	4	5
q. Onset date of diseases	1	2	3	4	5

14. Which of the following patient's medical findings/notes is important to be recorded during/after consultation?

a. Diagnosis information	1	2	3	4	5
b. Provisional diagnosis	1	2	3	4	5
c. Allergies information	1	2	3	4	5
d. Test result report	1	2	3	4	5
e. Radiology report	1	2	3	4	5
f. Medication information	1	2	3	4	5
g. Complains information	1	2	3	4	5

h. Family history	1	2	3	4	5
i. Vital signs	1	2	3	4	5
j. Social history	1	2	3	4	5
k. Immunisation	1	2	3	4	5
l. Health plan	1	2	3	4	5
m. Next appointment	1	2	3	4	5
n. Name of doctor attending to the problem	1	2	3	4	5
o. Health facility name	1	2	3	4	5
p. Date of the visit/episode	1	2	3	4	5
q. Onset date of diseases	1	2	3	4	5

15. Which of the following radiology information are important during consultation and medical diagnosis?

a. Date and time of studies done	1	2	3	4	5
b. Study reports	1	2	3	4	5
c. Parts of body examined	1	2	3	4	5
d. Name of interpreter	1	2	3	4	5
e. Number of pictures taken	1	2	3	4	5
f. Place and location of studies done	1	2	3	4	5

16. Which of the following test (laboratory) information are important during consultation and medical diagnosis?

a. Date and time of test	1	2	3	4	5
b. Test result	1	2	3	4	5
c. Test report	1	2	3	4	5
d. Type of test	1	2	3	4	5
e. Number of test taken	1	2	3	4	5
f. Place and location of test done	1	2	3	4	5

17. Which of the following medication information are important during consultation and medical diagnosis?

a. Date the drug start taken	1	2	3	4	5
b. Drug’s name	1	2	3	4	5
c. Dosage	1	2	3	4	5
d. Frequency of taking of the drug	1	2	3	4	5
e. Place and location the drug taken	1	2	3	4	5

18. Which of the following medical information are important to be reported in referral report for referral case?

a. Patient’s demographic data	1	2	3	4	5
b. Name of referred medical officer	1	2	3	4	5
c. Purpose of referral	1	2	3	4	5
d. Diagnosis	1	2	3	4	5
e. Medical history	1	2	3	4	5
f. Symptoms	1	2	3	4	5
g. Allergies information	1	2	3	4	5
h. Initial test result report	1	2	3	4	5
i. Radiology report	1	2	3	4	5
j. Medication information	1	2	3	4	5
k. Complains information	1	2	3	4	5
l. Family history	1	2	3	4	5
m. Vital signs	1	2	3	4	5
n. Social history	1	2	3	4	5
o. Immunisation	1	2	3	4	5
p. Name of referred Health facility	1	2	3	4	5
q. Onset date of diseases	1	2	3	4	5

19. Which of the following system is convenience for informing/reporting a patient’s conditions to referring doctor/healthcare provider?

a. Paper-based referral letter	1	2	3	4	5
b. E-mail application	1	2	3	4	5
c. Web-based referral system with the ability to link to EMR	1	2	3	4	5
d. Telephone	1	2	3	4	5
e. Facsimile	1	2	3	4	5

20. Which of the following methods do you think is difficult for accessing patients’ medical records?

a. Manual system	1	2	3	4	5
b. Computer system	1	2	3	4	5

21. Do you have any difficulty if you don’t have access to a patient’s medical history before consulting the patient?

1 2 3 4 5

22. Do you agree that the patients' medical records are highly important for helping doctors in diagnosing and treating patients' problem?

1 2 3 4 5

23. Do you agree that empowering patients for managing their health condition and health information will increase the quality of healthcare services?

1 2 3 4 5

24. Do you agree that the quality of healthcare services will be improved when the patients are aware about their health condition

1 2 3 4 5

25. In your opinion, which of the following mechanisms provides convenience to inform patients regarding their health condition?

a. Verbally by the doctor	1	2	3	4	5
b. Formal reports e.g. medical reports	1	2	3	4	5
c. Periodically electronic messages e.g. alert, text, e-mail	1	2	3	4	5
d. Self monitor through Telehealth services e.g. personalised web	1	2	3	4	5

26. Which of the following mechanisms do you think is convenient to store, access and display a patient's medical record anytime and anywhere?

a. Centralised database system and access via internet	1	2	3	4	5
b. Portable storage devices (such as mobile phone, PDA & smart card) and access wirelessly	1	2	3	4	5
c. Paper-based medical record	1	2	3	4	5
d. Decentralised database residing in Doctor's laptop	1	2	3	4	5

27. Which of the following telecommunication network type do you think is reliable for accessing patients' medical record anytime and anywhere?

a. Internet/web e.g. dial-up, broadband	1	2	3	4	5
b. Personal area network (PAN) e.g. wireless - Bluetooth	1	2	3	4	5
c. Wide area network (WAN) e.g. dedicated leased line	1	2	3	4	5
d. Local area network (LAN) e.g. office network	1	2	3	4	5

28. Which of the following mechanisms do you think is reliable to upkeep confidentiality of patients' medical record?

a. Centralised database system in Health Facility Data Centre	1	2	3	4	5
b. Portable device storage at patients' possession	1	2	3	4	5
c. Paper-based medical record kept in the record office	1	2	3	4	5
d. Stored in personal computer used by all doctors	1	2	3	4	5
e. Stored securely in personal computer	1	2	3	4	5

29. Which of the following devices do you think is highly accessible to patients' medical record anytime and anywhere?

a. Optical disk hosted in Health Facility Data Centre	1	2	3	4	5
b. Portable storage device located at patients' possession	1	2	3	4	5
c. Paper-based medical records kept in the record office	1	2	3	4	5
d. Internal optical disk of personal computer	1	2	3	4	5

30. Finally could you give us a few bits of information about yourself?

a. Age group

	Between 20 – 25	
	Between 26 – 30	
	Between 31 – 35	
	Between 36 – 40	
	Between 41 – 45	
	Between 46 – 50	
	Above 50	

b. Sex

Male	
Female	

c. Year of join MOHM

d. District/State (*hospitals/clinics location*) ____________

- END OF QUESTIONNAIRE -

APPENDIX D

Questionnaire used to evaluate the need of flexible framework

Flexible Framework Needs Analysis

Questionnaire Contents:

Introductory Notes

13. This is an academic study on PhD research project titled: ***A Flexible Framework for Malaysian Integrated and Distributed Telemedicine System***

14. This questionnaire will take about 120 minutes to complete. I would be grateful if you could allocate some time out from your schedule to response to this questionnaire.

15. Your answers will be treated with the strictest confidence and are to be exclusively used for my PhD research project. No information will be forwarded to any individual and/or external organisation.

16. The main respondents for the questionnaire are :
    - ❑ Project leader of Telehealth System
    - ❑ Project leader of Teleprimary Care System
    - ❑ Project leader of Hospital Information System

17. This questionnaire is in Malay/English

18. If there are any further questions, I can be contacted at

Mohd Khanapi Abd Ghani
PhD Candidate, Biomedical Computing and Engineering Technologies
Applied Research Group (BIOCORE),
Faculty of Engineering and Computing,
Coventry University, CV1 5FB,
United Kingdom.

Tel: +44 2476688444
E-mail: abdghanm@coventry.ac.uk

THANK YOU VERY MUCH FOR YOUR COOPERATION

Abbreviation

EMR	Electronic Medical Record
LHR	Lifetime Health Record
TPC	Teleprimary Care
ICT	Information and Communication Technology
THIS	Total Hospital Information System
HL7	Health Level Seven
ICD-10	International Statistical Classification of Diseases and Related Health Problem 10^{th} Revision
PDA	Personal Digital Assistant
MP3	Moving Picture Expert Group or MPEG Audio Layer 3

Glossary

Framework	Considered as systematic processes and technologies used to solve a complex issue. It is the skeleton upon which various objects are integrated for a given solution.
Software framework	A reusable design for a software system and contains pieces of software components.

1. Can you explain in brief the background of the project?

2. Which one of the following development approaches is used in your projects?

   - ❑ Custom development (in-house)
   - ❑ Custom development (out-source)
   - ❑ Buy on-the-shelf product
   - ❑ Package integration and customisation
   - ❑ Others, *(Please specify)*______________________________

3. Can you explain in brief the technology used in the projects? For instance, software, hardware, telecommunication network, firmware and database system.

4. Does your project implement health informatics standard? For instance, standard clinical codes, messages standard and National code standard.

   ❑ YES ❑ NO

5. Have you heard about framework before? For instance, solution framework, application framework, software/system framework and architectural framework.

   ❑ YES ❑ NO

6. Do you agree that healthcare information system, telehealth system, telemedicine system and e-health system are complex systems?

   ❑ YES ❑ NO

7. Does your organisation have a proper system development process for developing and implementing the health ICT projects?

   ❑ YES ❑ NO

8. If yes, what type of methodology?

   - ❑ SSADM
   - ❑ OOAD/OOSE
   - ❑ CBSE
   - ❑ XP
   - ❑ ISO

9. Does your organisation have a standard architecture framework for developing and implementing health ICT projects?

   ❑ YES ❑ NO

10. Do all projects use a same standard architecture framework?

    ❑ YES ❑ NO

11. Do you agree with the statement that a standard architecture framework is crucial for system integration and information exchange?

    ❑ YES ❑ NO

12. Which one of the following application approaches is used in your project?

    - ❑ Web-based application
    - ❑ Workgroup client-server application
    - ❑ Mainframe dumb-terminal application
    - ❑ Stand-alone application

13. What type of application deployment is applied by your project?

    - ❑ Within facility (local area network)
    - ❑ Enterprise wide (wide area network/virtual private network)
    - ❑ Internet

14. If the deployment type is enterprise-wide or internet, what is the size of the network bandwidth?

❑ 32 Kbps	❑ 64 Kbps	❑ 128 Kbps	❑ 384 Kbps
❑ 512 Kbps	❑ 1 Mbps	❑ 2 Mbps	❑ > 2 Mbps

15. How do you rate the response time of the applications?

- ❑ Bad
- ❑ Moderate
- ❑ Good
- ❑ Excellent

16. Have you experienced system downtime? If yes, please indicate how often.

- ❑ Less than 3 times per month
- ❑ More than 3 times per month
- ❑ Never
- ❑ Other, *(Please specify)* ________________________

17. Which one of the following causes the system to be down?

a. Telecommunication network fails or operates intermittently	1	2	3	4	5
b. Operating system server crashes or hangs	1	2	3	4	5
c. Database server crashes or hangs	1	2	3	4	5
d. Power failure	1	2	3	4	5
e. Application bugs	1	2	3	4	5

18. What was the turnaround time for recovering the problems?

- ❑ Within an hour
- ❑ Within 12 hours
- ❑ Within 24 hours
- ❑ More than 24 hours

19. Do you have any disaster recovery plan for maintaining the services during the downtime of the computer system?

❑ YES ❑ NO

20. If yes, list the main type of recovery technology used in your project.

21. Taking into account the criticality of patient's medical records that need to be seen continuously by the doctor during patient-doctor encounter, do you foresee that the mobile technology (such as mobile phone, PDA, smart card and MP3) can provide high flexibility to access and store patient's LHR during any possible system's downtime?

   ❑ YES ❑ NO

22. Do you consider mobile technology to have economic benefits for the healthcare system of the country?

   ❑ YES ❑ NO

23. Do you consider the mobile technology to have educational value?

   ❑ YES ❑ NO

(*Circle the number under the initials that applies 1=Strongly Disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=Strongly Agree*)

24. What, in your opinion, may be the possible hindrances to the use of a mobile technology in healthcare system?

f. Integration into existing healthcare information system	1	2	3	4	5
g. Convincing the patients that the confidentiality and privacy of their LHR will be assured	1	2	3	4	5
h. Training issues for users	1	2	3	4	5
i. Change of work process issues	1	2	3	4	5
j. People such as attitudes, knowledge, role and habits	1	2	3	4	5
k. Reliability of the technology	1	2	3	4	5

25. Which of the following do you think are essential for the information system interoperability, if it has to integrate and share patient's medical record across systems/health care levels?

k. Standardisation of technology used	1	2	3	4	5
l. Standardisation of code set (e.g. clinical term, ICD-10 etc.)	1	2	3	4	5
m. Standardisation of communication protocol (e.g. HL7)	1	2	3	4	5
n. Establishing telecommunication infrastructure availability	1	2	3	4	5
o. Design an open system standard	1	2	3	4	5
p. Standardisation of business functional solution	1	2	3	4	5
q. Establishing and standardising a best practice change management	1	2	3	4	5
r. Establishing a collaborative project management	1	2	3	4	5

26. Finally, please describe key lessons to be highlighted and used for moving forward in your project

- END OF QUESTIONNAIRE -

APPENDIX E

Questionnaire used to evaluate the need of integrated lifetime health record

Integrated Lifetime Health Record Needs Analysis

Contents:

Introductory Notes

1. This is an academic study on PhD research project titled: ***A Flexible Framework for Malaysian Integrated and Distributed Telemedicine System***

2. This interview will take about 90 minutes to complete. I would be grateful if you could allocate some time out from your schedule to participate in this interview.

3. Your answers will be treated with the strictest confidence and are to be exclusively used for my PhD research project. No information will be forwarded to any individual and/or external organisation.

4. The main respondents for the questionnaire are :

   - ❑ Deputy Director of Telehealth project, Telehealth Division, Ministry of Health Malaysia
   - ❑ Project Manager of Teleprimary Care project, Public Health Department, Ministry of Health Malaysia
   - ❑ Project Manager of Hospital Information System project, Ministry of Health Malaysia
   - ❑ Director of Information Technology and Communication Division, Ministry of Health Malaysia

5. This interview is in Malay/English

6. If there are any further questions, I can be contacted at

Mohd Khanapi Abd Ghani
PhD Candidate, Biomedical Computing and Engineering Technologies
Applied Research Group (BIOCORE),
Faculty of Engineering and Computing,
Coventry University, CV1 5FB,
United Kingdom.

Tel: +44 2476688444
E-mail: abdghanm@coventry.ac.uk

THANK YOU VERY MUCH FOR YOUR COOPERATION

Organisation/project background

1. Can you explain briefly the background of the project?
   (If the correspondent is not ITCD, please continue to question 3)
2. Can you explain briefly about ITCD's roles and responsibilities with regard to the development and implementation of ICT project in healthcare facilities of MOH?
   (If the correspondent is ITCD, please continue to question 8)

Project objectives and planning

3. Can you explain in brief the objective of the project?
4. Can you describe the status and the progress of the project? Is the project implementation according to the planned schedule?
5. Can you brief the phases and the milestones of the project? What will happen from now and the next two years?

Project scope

6. What are the components of the system involved in the project?
7. Which one of the system components is integral to the project and to National healthcare services?

System integrations

8. MOH has a variety of information systems in the various healthcare facilities; some have been implemented and some are still under development. How do you see this situation (varieties of systems and vendors) in terms of the capability of the systems to be integrated to each other?
9. What are most probably the obstacles and challenges to integrate those disparate systems?

Electronic medical records/Lifetime health records

10. At present, is there any effort to integrate all the clinical systems for collecting and generating the electronic medical records and lifetime health records?
11. Which of the system components do you think are crucial to be integrated?
12. What type of healthcare level do you think is crucial to be focused and prioritised for implementing the IS and generating the EMRs/LHRs?

Technology

13. What are the crucial infrastructures to be deployed at each healthcare facility for the purpose of integrating the systems, collecting the EMRs and, generating and sharing the LHRs?

14. Looking at telecommunication infrastructure scenario (inconsistent) across healthcare facilities and the country in general, we should have flexible system framework for capturing, displaying and storing the EMR/LHR continuously. Do you agree on this idea?
15. Taking into account the criticality of patient's medical records that need to be seen continuously by the doctor during patient-doctor encounter, do you foresee that the mobile technology (such as mobile phone, PDA, smart card and MP3) can provide high flexibility to access and store patient's LHR during any possible system's downtime?
16. Do you consider mobile technology to have economic benefits for the health system of the country?
17. Do you consider the mobile technology to have educational value?

Lessons learned

18. Finally, could you please describe key lessons to be highlighted and used for moving forward

- END OF INTERVIEW -

APPENDIX F

Feedback from framework validation exercised

FRAMEWORK VALIDATION RESPONSE FORM

Respondent name :

Date :

Division/Project name :

Organisation :

Address :

Main areas of business :

INTRODUCTORY NOTES

19. The objective of these questions is to validate the *My*Tel framework for its suitability to be implemented in outpatient clinics of the Ministry of Health Malaysia.

20. This is an academic study on PhD research project entitled: **An Integrated and Distributed Telemedicine System for Malaysia *(My*Tel*)*.** The research focuses in formulating a suitable framework for Malaysia to upkeep patient lifetime health record continuously and seamlessly during disaster scenarios (inadequacy of telecommunication network and downtime of back-end system).

21. This validation will take about 90 minutes to complete. I would be grateful if you could allocate some time out from your schedule to response to this questionnaire.

22. If there are any further questions, I can be contacted at

Mohd Khanapi Abd Ghani
PhD Candidate,
Biomedical Computing and Engineering Technologies (BIOCORE)
Applied Research Group,
Faculty of Engineering and Computing,
Armstrong Siddeley Building
Coventry University
Priory Street, Coventry
CV1 5FB,
United Kingdom.

Tel: +44 2476688444
E-mail: abdghanm@coventry.ac.uk; mkhanapi@yahoo.com

THANK YOU VERY MUCH FOR YOUR COOPERATION

Section A: *My*Tel Architectural Framework

*My*Tel components (refers to section 5.2.2.2):

1. Is the explanation of *My*Tel components concise and clear?

___

2. Are the roles of *My*Tel components described adequately?

___

3. Do you have any suggestions that you would like to revise for the *My*Tel components? (please provide particulars)

___

___

*My*Tel functionalities (refers to section 5.2.2.3):

4. Are the *My*Tel functionalities (use cases) concise and effortless to understand and implement?

___

5. Do you agree with the processes described in the *My*Tel use cases?

___

6. Based upon your experience, are there any critical use cases that you would like to incorporate to the *My*Tel functionality? (please provide particulars)

___

___

*My*Tel solution framework process (refers to section 5.2.2.4)

7. Is *MY*Tel solution framework process effortless to understand and implement?

---

8. Do you agree with the solution framework flow described in each of the scenarios?

---

9. Do you have other important scenarios that should be described in the *My*Tel solution framework process? (please provide particulars)

---

*My*Tel framework design:

10. Do you think that the design of *My*Tel framework is concise and clear?

---

11. Is the *MY*Tel framework design scalable, flexible and easy to integrate with the existing system?

---

12. Are there any suggestions that you would like to revise for the *My*Tel framework design? (please provide particulars)

Section B: Discussion on the viability of the *My*Tel framework

1. Do you think there are any specific benefits that may not have been stated that might arise from the implementation of the *My*Tel framework?

____

____

2. What are probably the main problems that can impede the implementation of the *My*Tel framework?

____

____

3. If accompanied by detailed supporting documentation, would you be willing to implement the *My*Tel framework (system)?

____

____

4. Have you any future for the *My*Tel framework?

____

Section C: The implementation process

1. Was the introduction to the *My*Tel framework adequate?

2. Do you have any suggestions on how the *My*Tel framework is introduced in a more coherent and simple manner? (please provide particulars)

3. Given the *My*Tel user guide, would you be willing to implement the *My*Tel framework (system)?

4. Was there any dispute from your users to the possible implementation/acceptance of the *My*Tel framework?

5. If so, how the barriers to the possible implementation/acceptance of the *My*Tel framework overcome? (please provide particulars)

6. Are any culture changes required before the implementation of the *My*Tel framework (system)? (please provide particulars)

---

7. Are any standards required before the implementation of the *My*Tel framework (system)? (please provide particulars)

*** End of question ***

APPENDIX G

Telemedicine initiatives and approaches: findings from the literature review

Table G1: Telemedicine experience

Years of experience in Telemedicine initiatives	Asia Pacific								Europe			
	Singapore	Japan	Korea	Hong Kong	Taiwan	China	New Zealand	Australia	U.K.	Norway	Canada	Malaysia
< 5 years												
Between 5 & 10 years	9											9
Between 10 & 15 years			12			11	13	13				
Between 15 & 20 years				15	16				14		15	
Above 20 years		29								26		

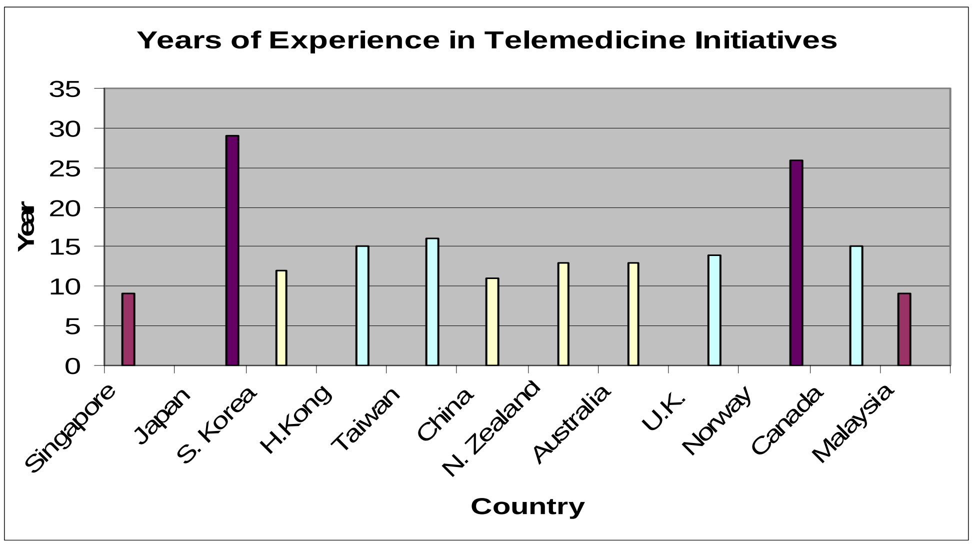

Table G2: Telemedicine components

Telemedicine/Telehealth Component/Specialty	Asia Pacific								Europe			
	Singapore	Japan	Korea	Hong Kong	Taiwan	China	New Zealand	Australia	U.K.	Norway	Canada	Malaysia
<u>Clinical Applications:</u>												
Teleconsultation - medical consultation/clinical practice in any disciplines/specialty e.g. pediatrics, phychiatry, cardiolog, primarycare and etc.	x	x	x	x	x	x	x	x	x	x	x	x
Telemonitoring	x	x					x	x	x	x	x	
TeleSurgery												
Non-Clinical Application:												
TeleEducation	x				x		x	x	x	x	x	x
Administration	x							x	x	x	x	x
Application Features:												
Wellness paradigm	x								x			x
Illness paradigm		x	x	x	x	x	x	x		x	x	
Personalised Lifetime Health Record												x
Links with patients EMR	x							x	x	x	x	x
Integrate with Clinical Support System/existing HIS												x
Integrated system - links between components									x		x	x
National Health Group Data Services								x	x	x	x	x

Table G3: Telemedicine challenges

Telehealth/Telemedicine Challenges	Asia Pacific								Europe			
	Singapore	Japan	Korea	Hong Kong	Taiwan	China	New Zealand	Australia	U.K.	Norway	Canada	Malaysia
Integration into existing healthcare delivery system	Low	High	High	Medium	High	High	High	High	High	High	High	Low
Laws & Regulations - Policy issues such as confidentiality, privacy, security and safety	High	High	High	High	High	Medium	High	High	High	High	High	Medium
Funding of Telemedicine Program	Medium	High	High	Medium	Medium	High	Low	Low	Low	Medium	Low	Low
Process reengineering	Low	High	High	Low	High	High	Low	High	High	High	High	High
People Issues - Change Management, Communication, Training & Development	Low	High	High	Low	High	High	Low	High	High	High	High	High
Healthcare organisation - reorganising the delivery of health services.	Low	High	High	Low	High	High	Low	High	High	Medium	High	Low
Telecommunication Infrastructure	Low	Low	Low	Low	Low	High	Medium	Low	Low	Low	Medium	High

Table G4: Various telecommunication types used in telemedicine initiatives

Transmission Channel	Bandwidth	Asia Pacific								Europe			
		Singapore	Japan	Korea	Hong Kong	Taiwan	China	New Zealand	Australia	Norway	U.K.	Canada	Malaysia
POTS	64 Kbps	x	x					x	x				
Switched 56	56 or 64 Kbps												x
ISDN	Two 64 Kbps - 2 Mbps			x	x	x	x	x	x	x	x	x	x
T-1	1.544 Mbps												
Cable	10 to 30 Mbps downstream & 128 Kbps to 10 Mbps upstream												
DSL	1.5 to 8 Mbps downstream & 1.544 Mbps upstream			x							x		
ATM	155 to 622 Mbps	x			x	x	x	x	x	x			
Satellite	16 Kbps to 92 Mbps downlink		x				x	x	x			x	

Table G5: Telemedicine development approach

Development Approach	Asia Pacific								Europe		Canada	Malaysia
	Singapore	Japan	Korea	Hong Kong	Taiwan	China	New Zealand	Australia	U.K.	Norway		
National agenda and initiated by the Government	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Support & drive by National Telemedicine policy and strategy	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Starts and initiates from research & development project by research organisations/institutions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Implementation approach through pilot run and transformed into production	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
The programs/services are develop by specialties independently	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Consolidate and integrate from fragmented services/programs into integrated one	No	No	No	Yes	No	No	No	No	Yes	No	Yes	Yes
Integrate with Electronic Health Record Infostructure for sharing the health information	Yes	No	No	Yes	No	No	No	Yes	Yes	No	Yes	Yes
Provide dedicated telecommunication insfrastructure for health network services/programs	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No
Wellness paradigm (WP) or illness paradigm (IP)	IP & WP	IP	IP	IP	IP	IP	IP	IP	WP & IP	IP	IP	WP & IP
Funded by the Government	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	*30%
System development approach - Custom Development (CD) or Package Integration (PI)	CD	CD	CD	CD	CD	PI	PI	CD	PI	CD	CD	CD
Telemedicine/Telehealth Technology - Realtime (RT) or store and forward (SF) or both (BT)	SF	RT	RT	BT	BT	RT	BT	BT	SF	BT	BT	SF

Table G6: Telemedicine integration characteristics

Integration Characteristics	Asia Pacific								Europe		American	Malaysia
	Singapore	Japan	Korea	Hong Kong	Taiwan	China	New Zealand	Australia	U.K.	Norway	Canada	
Use of central EMR as a based for integrating/sharing the patient health information in delivering telemedicine services?	Yes	No	No	No	No	No	No	Plan	Plan	No	Plan	Plan
Integrate telemedicine delivery services into existing healthcare delivery services? E.g. expand telemedicine services in existing healthcare facility instead of creating a new telemedicine centres separately.	No	No	No	No	No	No	No	No	Plan	No	Plan	Plan
Services Integration? E.g. TelePrimaryCare integrate with Teleradiology or other telemedicine specialties and components.	No	No	No	No	No	No	No	Plan	Plan	No	Plan	Plan
System/Application Integration? Applications can be integrated with existing application system such as healthcare information system and etc.	No	No	No	No	No	No	No	No	Yes	No	No	Plan
Network integration? Use one network platform.	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No
Integrate with legacy system?	No	No	No	No	No	No	No	No	No	No	No	Plan
Use of portable devices as a meant for integrating patient health records across healthcare levels . E.g. Smart Cards	No	No	No	Yes	No	No	No	No	No	No	No	Plan

Table G7: Current status of the availability of online health information

Current status of the availability of online health information	Asia Pacific								Europe		American	
	Singapore	Japan	Korea	Hong Kong	Taiwan	China	New Zealand	Australia	Norway	U.K.	Canada	Malaysia
Provision of online health care advice to patients?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Patients can retrieve their health records online?	Yes	No	No	No	No	No	No	No	No	No	No	No
Patients able to make appointment online?	Yes	No	No	No	Plan	No	No	No	No	Yes	No	No
Use smart card to keep patients health records?	No	No	No	Yes	No	No	No	No	No	No	No	Pilot
Online information sharing among healthcare professional?	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	No	No	Plan
Medical web sites	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table G8: Health ICT and EHR initiatives in ten countries

Country	Ministry of Health Website	National ICT project for Health	Electronic Health Record initiatives
Malaysia	moh.gov.my and dph.gov.my	MSC Telehealth, Teleprimary Care, Total Hospital Information System	Lifetime Health Record (LHR)
Singapore	moh.gov.sg	Health ONE	EMR Exchange (EMRX)
Taiwan	doh.gov.tw	Telemedicine, e-health	NHI-IC cards
Hong Kong	hwfb.gov.hk	Telemedicine, e-health	Patient Card
China	Moh.gov.cn	Telemedicine, e-health	
Japan	mhlw.gov.jp	e-Japan	Computerised patient medical records (CPRM)
Australia	health.gov.au	HealthConnect	National EHR
N.Zealand	moh.govt.nz	NTPANZ, HIS-NZ	Distributed EHR
U.K	dh.gov.uk	NPfIT	NHS CRS
Norway	odin.dep.no/hod/english/bn.html	Te@mwork 2007, Telemedicine	Longitudinal patient's EHR
Canada	hc-sc.gc.ca	Health InfoWay – i-EHR, Telehealth & e-health	myEHR

APPENDIX H

LHR Data Structure

Table H1: Demographic record

NO	DATA ELEMENT	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	PMI Number	A unique person identification number used throughout life for healthcare purpose.	Alphanumeric	9	R
2.	Name	Name of the patient	Alphanumeric	80	R
3.	Alias Name	Other name of the patient	Alphanumeric	80	O
4.	IC No	National registration identification number	Alphanumeric	12	O
5.	Old IC No	Old personal identification that is used before 1990	Alphanumeric	80	O
6.	ID Type	Type of the other ID number such as Military Number	Alphanumeric	10	O
7.	ID Number	Identification number other than New and Old IC No	Alphanumeric	12	O
8.	Birth Date	Date of birth	Date (ddmmyyyy)	8	R
9.	Sex	Sex of patient	Alphanumeric	1	R
10.	Race Code	Individual race code	Alphanumeric	4	R
11.	Blood Type	Blood Group [A/B/AB/O]	Alphanumeric	2	O
12.	Blood Rhesus	Positive or Negative	Alphanumeric	1	O
13.	Marital Status Code	Individual marital status code	Alphanumeric	1	O
14.	Religion Code	Individual religion code	Alphanumeric	2	O
15.	Nationality Code	Nationality code	Alphanumeric	3	O
16.	Home Address 1	Address line 1	Alphanumeric	30	R
17.	Home Address 2	Address line 2	Alphanumeric	30	O
18.	Home Address 3	Address line 3	Alphanumeric	30	O
19.	Home Town Code	Town code	Alphanumeric	4	O
20.	Home State Code	State code	Alphanumeric	2	O
21.	Home Country Code	Country code	Alphanumeric	3	O
22.	Home Postcode	Postcode number	Alphanumeric	5	O
23.	Home Phone	Home phone number	Alphanumeric	15	R
24.	Postal Address 1	Address line 1	Alphanumeric	30	O
25.	Postal Address 2	Address line 2	Alphanumeric	30	O
26.	Postal Address 3	Address line 3	Alphanumeric	30	O
27.	Postal Town Code	Town code	Alphanumeric	4	O
28.	Postal State Code	State code	Alphanumeric	2	O
29.	Postal Country Code	Country code	Alphanumeric	3	O
30.	Postal Postcode	Postcode number	Numeric	5	O
31.	Office Phone	Office phone number for working patient	Alphanumeric	15	O
32.	Mobile Phone	Personal phone number	Alphanumeric	15	R
33.	E-mail	Electronic mail address	Alphanumeric	50	O
34.	Organ Donor Indicator	This denotes that the patient is an organ donor	Alphanumeric	1	O
35.	Chronic Disease Indicator	This denotes that the patient is having a chronic disease	Alphanumeric	1	O
36.	Allergy Indicator	This denotes that the patient is allergy to any medication	Alphanumeric	1	O
37.	Death Certified Indicator	Death medical certified	Alphanumeric	1	O

Total size of demographic record : 612 bytes
Total size of required data elements : 162 bytes

Table H2: Next of Kin

NO	DATA ELEMENT	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	New IC No	New personal identification	Alphanumeric	12	R
2.	Old IC No	Old personal identification that was used before 1990	Alphanumeric	8	O
3.	ID Type	Type of the other ID number such as Military Number	Alphanumeric	10	O
4.	ID Number	Identification number other than New and Old IC No	Alphanumeric	12	O
5.	Next of Kin Name	Name of the next of kin	Alphanumeric	80	R
6.	Next of Kin Relationship Code	Relationship to the patient	Alphanumeric	2	O
7.	Birth Date	Date of birth	Date	8	O
8.	Occupation code	Occupation code	Alphanumeric	5	O
9.	Address 1	Address line 1	Alphanumeric	30	R
10.	Address 2	Address line 2	Alphanumeric	30	O
11.	Address 3	Address line 3	Alphanumeric	30	O
12.	Town Code	Town code	Alphanumeric	4	O
13.	State Code	State code	Alphanumeric	2	R
14.	Country Code	Country code	Alphanumeric	3	R
15.	Postcode	Postcode number	Numeric	5	R
16.	Home Phone	Home phone number	Alphanumeric	15	R
17.	Office Phone	Office phone number	Alphanumeric	15	O
18.	Mobile Phone	Personal phone number	Alphanumeric	15	R
19.	E-mail	Electronic mail address	Alphanumeric	50	O

Total size of next of kin : 336 bytes
Total size for required data elements : 152 bytes

Table H3: Chronic, long-term and acute disease record

NO	DATA ELEMENT	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Date of diagnosis (onset)	Date (ddmmyyyy)	8	R
2.	Diagnosis Code	Diagnosis code	Alphanumeric	5	R
3.	Status	Active status	Alphanumeric	1	O

Total size of disease record : 14 bytes
Total size for required data elements : 13 bytes

Table H4: Allergy record

NO	DATA ELEMENT	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Registration date and allergy date (onset)	Date (ddmmyyyy)	8	R
2.	Allergy Code	Allergy code	Alphanumeric	5	R
3.	Status	Active status	Alphanumeric	1	O

Total size of allergy record : 14 bytes
Total size for required data elements : 13 bytes

Table H5: Immunization/vaccination record

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Registration date of immunization	Date (ddmmyyyy)	8	H
2.	Immunization Code	Immunization code	Alphanumeric	7	H
3.	Immunization Date	Date of immunization taken	Date (ddmmyyyy)	8	H
4.	Status	Active status	Alphanumeric	1	O

Total size of immunization record : 24 bytes
Total size for required data elements : 23 bytes

Table H6: Social history record

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Registration date	Date	8	R
2.	Social History Code	Social history code such as smoking, alcoholic or drug addict	Alphanumeric	5	R
3.	Start Date	Start date of history	Date	8	R
4.	End Date	End date of history	Date	8	R
5.	Status	Active status: 1- Active; 0 – Inactive	Alphanumeric	1	O

Total size of social history record : 30 bytes
Total size for required data elements : 29 bytes

Table H7: Procedures record

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Registration date and surgery date	Date	8	R
2.	Procedure Type Code	Procedure type code	Alphanumeric	7	R
3.	Diagnosis Code	Diagnosis code	Alphanumeric	5	R
4.	Procedure Date	Date of procedure	Date	8	R
5.	Status	Active status: 1 – Active; 0 - Inactive	Alphanumeric	1	O

Total size of procedures record : 29 bytes
Total size for required data elements : 28 bytes

Table H8: Disability record

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Registration date or disability date	Date	8	R
2.	Disability Code	Physical or mental disability code	Alphanumeric	5	R
3.	Disability Status	Status of disability (Rectified or Not Rectified)	Alphanumeric	1	R
4.	Disability Date	Detection date of disability	Date	8	R
5.	Status	Active status: 1 – Active; 0 – Inactive	Alphanumeric	1	O

Total size of disability record : 23 bytes
Total size for required data elements : 22 bytes

Table H9: Obstetric record

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Date of onset	Date	8	R
2.	Expected Delivery Date	Expected delivery date	Date	8	R
3.	Delivery Date	Delivery date of child	Date	8	O
4.	Procedure Classification	Birth procedure code such as forceps or vacuum for assisted delivery	Alphanumeric	7	O
5.	Pregnancy Outcome	Pregnancy outcome such as live birth, still birth or abortion	Alphanumeric	7	O
6.	Pregnancy Type	Type of pregnancy for live birth such as Full term, Premature term or Post term	Alphanumeric	10	O
7.	Delivery Health Facility Code	Health facility code for delivery	Alphanumeric	10	O
8.	Sex Code	Sex of the child	Alphanumeric	1	O
9.	Weight	Child’s weight (KG)	Decimal	5,2	O
10.	Length	Child’s length (CM)	Decimal	5,2	O

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
11.	Child's Congenital Abnormality	This denotes the child's congenital abnormality indicator - Y = Yes; N = No	Alphanumeric	1	O
12.	Status	Status of pregnancy: 1 = Active; 0 = Inactive	Alphanumeric	1	O

Total size of obstetric record : 39 bytes
Total size for required data elements : 16 bytes

Table H10: Episode record

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	PMI Number	A unique patient master index identification	Alphanumeric	9	R
2.	Health Facility Code	Healthcare providers code or places of care received	Alphanumeric	10	R
3.	Episode Date	Registration/clinical visit date	Date	8	R
4.	Patient Category	Patient category such as Outpatient or Inpatient	Alphanumeric	2	R
5.	Discharge Date	Discharge date (for Inpatient)	Date	8	O
6.	Discharge Time	Discharge time (for Inpatient)	Date	8	O
7.	Case Summary	Any comments for each episode	Alphanumeric	200	O
8.	Doctor 's Name	Name of the doctor	Alphanumeric	80	O

Total size of episode record : 325 bytes
Total size for required data elements : 29 bytes

Table H11: Encounter record

NO	NAME	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Health Facility Code	Health facility code for each episode	Alphanumeric	10	R
2.	Episode Date	Registration date	Date	8	R
3.	Patient Category	Patient category such as Outpatient or Inpatient	Alphanumeric	2	O

Total size of encounter record : 20 bytes
Total size for required data elements : 18 bytes

Table H12: Chief complaint/Symptoms information

NO	NAME	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Registration or visit date	Date	8	H
2.	Encounter Date	Meeting date	Date	8	H
3.	Symptoms Code	Symptom code	Alphanumeric	5	H
4.	Symptoms name	Name of the symptoms	Alphanumeric	30	O
5.	Remarks	The free text explanation of the symptoms	Alphanumeric	50	O

Total size of symptoms record : 101 bytes
Total size for required data elements : 21 bytes

Table H13: Diagnosis information

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Registration or visit date	Date	8	H
2.	Encounter Date	Meeting date	Date	8	H
3.	Diagnosis code	Coded ICD10 diagnosis code	Alphanumeric	10	H
4.	Diagnosis	Coded CTV3 diagnosis code	Alphanumeric	10	O
5.	Diagnosis Description	Description of diagnosis using CTV3	Alphanumeric	30	O

Total size of diagnosis record : 66 bytes
Total size for required data elements : 26 bytes

Table H14: Test results information

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Registration or visit date	Date	10	H
2.	Encounter Date	Meeting date	Date	10	H
3.	Test Date	Date performing the test	Date	8	H
4.	Test Code	Test code	Alphanumeric	7	H
5.	Test description		Alphanumeric	30	O
6.	Test result code	Test result code	Alphanumeric	5	H
7.	Test result description	The description of the result	Alphanumeric	30	O

Total size of test results record : 105 bytes
Total size for required data elements : 45 bytes

Table H15: Medications record

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode Date	Registration or visit date	Date	8	R
2.	Encounter Date	Meeting date	Date	8	R
3.	Drug Code	Medication code	Alphanumeric	7	R
4.	Drug name	Name of medications	Alphanumeric	30	R
5.	Dosage	Dosage Code	Alphanumeric	9	R
6.	Start Date	Start date of taking medication	Date	8	R
7.	End Date	End date of taking medication	Date	8	R

Total size of medication record : 78 bytes
Total size for required data elements : 78 bytes

Table H16: Vital sign record

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode date	Registration or visit date	Date	8	R
2.	Encounter date	Meeting date	Date	8	R
3.	Vital Sign Code	Vital Sign Code	Alphanumeric	5	R
4.	Unit of measure	Unit of measurement	Alphanumeric	10	R
5.	Value	Value of vital sign	Decimal	9	R

Total size of vital sign record : 40 bytes
Total size for required data elements : 40 bytes

Table H17: Health plan record

NO	DATA ELEMENTS	DESCRIPTION	FORMAT	LENGTH	PRIORITY (R/O)
1.	Episode date	Registration or visit date	Date	8	O
2.	Encounter date	Meeting date	Date	8	O
3.	Follow-Up Date /Appointment date	Date of follow-up or next appointment of care	Date	8	O
4.	Advice	Advice given by healthcare professional or provider	Alphanumeric	500	O

Total size of health plan record : 524 bytes
Total size for required data elements : 0 bytes

APPENDIX I

Pictures of healthcare centres in Malaysia

Polyclinic Community Ayer Keroh Melaka

Registration counter

Pharmacy counter

APPENDIX J

Validation of the MyTel framework: a cross-case analysis

The analysis of the qualitative feedbacks (responses given by the respondents for the three organisations/projects under the Ministry of Health Malaysia) that was obtained from the interviews and from the debriefing questionnaire revealed a commonality of interests and experiences in a number of different areas, the most important of which are listed below.

Case	**Is the explanation of *My*Tel components concise and clear?**
A - THIS	Yes - clear and concise
B - TPC	Fairly clear enough to initiate the telemedicine system.
C - Telehealth	Yes, it was clear and easy to understand.

Case	**Are the roles of *My*Tel components described adequately?**
A - THIS	Yes - easy to understand & incorporate with the existing system
B - TPC	Fair, the roles of each component was described adequately. Looking forward for technical specification.
C - Telehealth	Almost all components' roles and responsibilities were described and effortless to relate with telehealth functional requirements

Case	Do you have any suggestions that you would like to revise for the *My*Tel components?
A - THIS	No - we don't have any suggestion at the moment
B - TPC	No suggestion
C - Telehealth	1. The respondent request further elaboration on study done in outpatient clinics 2. The respondent had asked, "During offline mode how does the system check if one has been assigned a PMI previously?" 3. The respondent further commented during downtime of backend system, it cannot be assured that a new patient has no previous PMI, and that it cannot be assured that the new PMI is assigned from a pre-gen list. The system should be able to assign a temporary PMI number.

Case	Are the *My*Tel functionalities (use cases) concise and effortless to understand and implement?
A - THIS	Yes - easy to understand and implement
B - TPC	Yes - painless to understand and implement.
C - Telehealth	Yes - concise and clear. Could be implemented in outpatient clinics that still have no EMR system.

Case	Do you agree with the processes described in the *My*Tel use cases
A - THIS	Yes - agreed with the use cases' flow described
B - TPC	Yes - agreed with the use cases' flow described and enough to facilitate the collection of patients' health records in the outpatient clinics.
C - Telehealth	Yes. It was observed that most of the processes outlined were appropriate and logical at an abstract level of functionality with little changes.

Case	Based on your experience, are there any critical use cases that you would like to incorporate to the *My*Tel functionality?
A - THIS	No - No further suggestion to incorporate additional use cases
B - TPC	Not at the moment. The proposed use cases were enough to capture, view and store patients' health record during consultation events in outpatient clinics
C - Telehealth	Refer to A3 answers

Case	Is *My*Tel solution framework process effortless to understand and implement?
A - THIS	Yes - the solution framework process was clear and concise
B - TPC	Fair
C - Telehealth	Yes, it was concise and the design is clear and straight forward.

Case	Do you agree with the solution framework flow described in each of the scenarios?
A - THIS	Yes - provides clear process how to escalate the problems during unavailable landline telecommunication network and downtime of computer system.
B - TPC	The respondent agreed with the solution framework described in each of the scenarios. However, she suggested performing field study to validate the actual workflow processes.
C - Telehealth	Yes, agreed with the solution framework flow described in each of the scenarios. The proposed solution framework could bring benefit to those healthcare centres that still have inadequate telecommunication network infrastructure, and the framework could provide continuous access and upkeep to patients' health records.

Case	**Do you have other important scenarios that should be described in the *My*Tel solution framework process?**
A - THIS	The respondent asked to add a scenario for identifying PMI number during downtime of back-end system. Unique PMI number is important to ensure patients carry a unique identifier across healthcare facilities and levels.
B - TPC	The respondent has no suggestion at the moment.
C - Telehealth	Refer to A3 answers

Case	**Do you think that the design of *My*Tel framework is concise and clear?**
A - THIS	Very clear, but possibly too brief. Suggested to provide detailed design including architectural implementation design and deployment structure.
B - TPC	The respondent said that the description of the *My*Tel framework is fairly clear and concise.
C - Telehealth	Yes

Case	**Is the *My*Tel framework design scalable, flexible and easy to integrate with the existing system?**
A - THIS	Yes - the design of three modular components have interoperability characteristics.
B - TPC	At the moment, the respondent could not give any suggestion and comment. She intented to know a detailed system design for helping her to measure the framework interoperability accurately (show in high level diagram of the proposed framework)
C - Telehealth	Yes, if the data comply to the standard. the design of *My*Tel framework is scalable. I observed that although the proposed components provide basic functionalities in the current form, with scalable design, the framework could easily accommodate the future requirements.

Case	Are there other suggestions that you would like to revise for the *My*Tel framework design?
A - THIS	No suggestion but interested to know further details of the framework. The design is quite robust in its form and an excellent starting point for Malaysian integrated telemedicine system to incorporate with such an innovative system.
B - TPC	The respondent suggested that the framework should present the link between *My*Tel and other existing systems (e.g. TPC)
C - Telehealth	Some changes are required to cater the events raised in A3's answers

Case	Do you think that there are specific benefits that may not have been stated that might arise from the implementation of the *My*Tel framework?
A - THIS	The respondent pointed out that the *My*Tel is flexible and accessible anytime. However, some policies have to be established and incorporated before its implementation. E.g. consent from patient to store health record into portable storage devices.
B - TPC	The respondent pointed out that the *My*Tel framework can provide low cost telecommunication network solution by using global system mobile f(GSM) and short messaging system (SMS) for transporting the health record of patients to the central system. She further highlighted that *My*Tel solution could arrest the issue of inconsistent telecommunication network infrastructure across the healthcare facilities nationwide.
C - Telehealth	The respondent highlighted that the *My*Tel was designed in modular manner and provides advantages in maintaining the system for accommodating new and future requirements

Case	What are probably the main problems that can impede the implementation of the *My*Tel framework?
A - THIS	The respondent pointed out that the HOMS architecture needs further elaboration.
B - TPC	The respondent suggested that the framework should consider physical infrastructure and integration strategy for integrating the existing information system into an integrated one.
C - Telehealth	1. To get patient's consent to keep the data into portable devices 2. To get patient to carry the portable devices

Case	If accompanied by detailed supporting documentation, would you be willing to implement the *My*Tel framework (system)?
A - THIS	Yes
B - TPC	The respondent required further detailed specification on the framework implementation. Hence, the accurate and invaluable ideas could be suggested and proposed. She appreciated the existing form of the framework presentation and asked for further discussion on the technical perspective.
C - Telehealth	Yes

Case	Have you any future for the *My*Tel framework?
A - THIS	The respondent agreed that the *My*Tel framework has future.
B - TPC	The respondent was satisfied with the high-level conceptual of the *My*Tel framework. However, she was looking forward on the detailed technical implementation for continuing research on the possible implementation.
C - Telehealth	The respondent proposed that the system shall be tested in the Public Support Unit. This unit provides services to patients with chronic illnesses. By using the *My*Tel system, care episodes could be maintained continuously and it could ensure the continuity of care.

Case	Was the introduction to the *My*Tel framework adequate?
A - THIS	The introduction to *My*Tel framework was elaborated adequately and clearly. The respondent was very interested to know the detailed implementation of the framework.
B - TPC	The introduction to *My*Tel framework was fairly adequate.
C - Telehealth	Yes, it was presented adequately.

Case	Do you have any suggestions on how to introduce the *My*Tel framework in a more coherent and simple manner?
A - THIS	She requested for a detailed technical specification and verbal presentation - questions and answers could be discussed further.
B - TPC	The respondent suggested that the framework features should be highlighted using special font for ease of recognising the key benefits.
C - Telehealth	No suggestion.

Case	Given the *My*Tel user guide, would you be willing to implement the *My*Tel framework (system)?
A - THIS	It should be accompanied with a proto-type system. The project was willing to implement the *My*Tel system through proof-of-concept approach in certain clinics.
B - TPC	The respondent looked forward to discuss technical perspective and the detailed specification of the framework.
C - Telehealth	Yes, we have no objection if the solution could bring benefit to the project and particularly MOHM and Malaysia

Case	Was there any dispute from your users to the possible implementation/acceptance of the *My*Tel framework?
A - THIS	The respondent highlighted that the dispute from the users for implementing the *My*Tel framework was marginal. They are welcome at any health ICT project.
B - TPC	At the moment, the respondent has not seen any dispute from the users for implementing the *My*Tel framework. It was too early to decide on implementing the system in the organisation.
C - Telehealth	The respondent said that there was possible disputes from the users for implementing the *My*Tel framework

Case	How would the barriers to the possible implementation/acceptance of the *My*Tel framework be overcome?
A - THIS	The respondent explained that the users/physicians shall be provided with PDA or mobile phones for eliminating the barriers to the implementation of *My*Tel system.
B - TPC	The respondent pointed out that the cost, business process reengineering and people could pose challenges for implementing the *My*Tel system.
C - Telehealth	The respondent highlighted that patient's confidentiality and data security should be given attention in implementing the system.

Case	Are any culture changes required before the implementation of the *My*Tel framework (system)?
A - THIS	The respondent said that there will be minimum culture changes if the *My*Tel system was deployed incrementally through proof-of-concept approach in existing hospitals. The obvious changes needed in implementing the framework are changes in physician work processes.
B - TPC	At the moment, the respondent has not seen any need of culture changes for implementing the *My*Tel framework. She pointed out that the pilot implementation experienced of the TPC project in three states provide invaluable test bed and awareness of ICT used in healthcare sector.
C - Telehealth	The respondent pointed out that the care provider has to change its current processes of capturing the clinical record during consultation. The records should be captured continuously in a structured manner.

Case	Are any standards required before the implementation of the *My*Tel framework (system)?
A - THIS	The respondent agreed that the necessary standards should be established. Examples are the administrative code set standard and clinical code set standard.
B - TPC	The respondent suggested to put focus on the development of code set standard (National Data Dictionary) and the use of communication protocol standard (HL7) for integrating all health information systems into an integrated one.
C - Telehealth	The respondent highlighted that the technical standards should be established. Examples are data definition standard, document standard and communication protocols.