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Research paper

Investigating Telemedicine Approaches: a 10-Country Comparison

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Abstract

This paper investigates and appraises the current state of knowledge and practice and the existing telemedicine approaches in ten countries, namely China, Taiwan, Hong Kong, Singapore, Japan, South Korea, Canada, the U.K, Australia and New Zealand. The literature dealing with telemedicine development approaches was reviewed, compared and contrasted between Malaysia and the 10-country. Based on our analysis results, the suitable approaches and technologies were discussed. 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.

Keywords: Telemedicine system, framework, Patient health records, continuous and seamless

1. Introduction

The availability, accuracy and completeness of health records will be of great help to clinicians in treating patients [1]. The completeness of a patient's lifetime health records (LHR) should not only be present chronologically in a single applications 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 form the basis for formulating proper and accurate advice, diagnosis and treatment wherever a patient seek such care or services. Such a longitudinal (and hence seamless) view of a patient's health records 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. However, the above characteristics would not be achieved if health ICT applications (e.g. telehealth, telemedicine and e-health 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 setup of hospital information system (HIS)). Evidently, the healthcare system is complex and the telemedicine/telehealth system under development should be able to mitigate the complexity by giving more attention on its flexibility for accessing, creating and storing patient lifetime health records continuously and seamlessly.

This paper starts with the general review on telemedicine and the evolution of medical services globally. Subsequently, the paper discusses the three generations of telemedicine approaches and continues to review telemedicine approaches in five other countries. The Malaysian telemedicine context will be discussed and examined and the summary of all countries' approaches will be elaborated. The lessons learned and critical aspects from the approaches of other countries suitable for Malaysia will be highlighted and presented.

2. Methodology

This research was conducted in two approaches. The first commenced with the literature review of the state of the current telemedicine approaches in five other countries including Singapore, Taiwan, Hong Kong, Canada and the UK. 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 to 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 Integrated Telehealth. The relevant approach is used as input for developing the basic proposed framework.

The research proceeds with the field (case study) visit at Ministry of Health Malaysia (MOHM) 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 [2,3]. For this research, the key respondents were asked to comment and inquire about certain events.

3. Telemedicine and The Evolution Of Medical Services

There are great differences between developing and developed worlds on issues of health and healthcare services. The emphasis of the developing world is on basic survival (such as to provide better access to healthcare and to increase the quality of health); whilst in the developed world, the emphasis is to reduce 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 [4]. Table 1 shows an increasing total cost (% GDP) of health expenditure among the G-7 countries from 1999 to 2002.

Table 1: Total Health Expenditure of the G-7 Countries [5]

Year	USA	Canada	France	Germany	Italy	Japan	UK
1999	13	9	9.3	10.6	7.8	7.4	7.2
2000	13.1	8.9	9.3	10.6	8.1	7.6	7.3
2001	13.9	9.4	9.4	10.8	8.3	7.8	7.5
2002	14.6	9.6	9.7	10.9	8.5	-	7.7

Asian countries also experienced an increase in healthcare expenditures; most of them saw a gradual annual increase in their expenditures on health. Table 2 shows the total health expenditure between 1999 and 2002.

Table 2: Total Health Expenditure of the Asian Countries [5]

Year	Singapore	Thailand	Malaysia	Brunei	Philippines	Indonesia	Myanmar
1999	4.1	3.7	3.1	3.5	3.5	2.6	1.8
2000	3.6	3.6	3.3	3.6	3.4	2.8	2.2
2001	3.9	3.5	3.7	3.5	3.2	3.0	2.1
2002	4.3	4.4	3.8	3.5	2.9	3.2	2.2

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. These scenarios were happening in developing countries such as Singapore, Malaysia and Thailand where the percentage of population aged over 60 years had increased [5]. Chronic and lifestyle diseases are expensive to be treated because they often require lifelong management. A study shows that, over a 30-year period, the disease burden had shifted from communicable diseases to mainly lifestyle related diseases where, ischemic heart problems have become the highest disease burden suffered globally as depicted in Table 3.

Table 3: Change in Global Disease Burden [6]

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

Due to the new trend of diseases that would be suffered globally, governments, payers 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 broaden the reach of healthcare systems [4,7,8].

4. Telemedicine, Telehealth and Internet

Telemedicine literally means "medicine at a distance" that can be used to deliver a range of services; information, education, consultation, diagnosis, treatment, supports and governance [9]. According to [10] 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. Evidently, telemedicine and telehealth initiatives were essentially about providing communication links between medical experts and remote locations. They also act as an electronic vehicle to transport patient health records across healthcare levels and services by way of 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 [11]. The internet is used as a low cost vehicle for telemedicine services, best suited to services which are transactional in nature, and which do not have a strong synchronous requirement [12]. However, the internet remains a poor vehicle for large images and files to be viewed in real time [13]. 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 (e.g. inconsistency and unavailability of telecommunication network).

5. Telemedicine Technologies and Approach

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 patient health records continuously and seamlessly.

5.1 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 [14]. In the late 1950s, interactive video communication technology was introduced for transmitting radiological images and providing tele psychiatry consultation via coaxial cable in the Nebraska Psychiatric Institute [15,16]. 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 [17,18,19].

In 1985, NASA changed its interest from disaster assistance to telehealth service provision internationally. Among the projects developed included the Space Bridge project for providing medical consultation to earthquake victims in Armenia and the SatelLife/Health Net to provide health communication information and services in developing countries [20,21]. These various approaches of telemedicine demonstrated many benefits to mankind. However, the technology used at that time was not cost-effective and failed to sustain itself financially [22]. The most important remark from the previous literature is that the early telemedicine framework was not given due attention on the efficacy of integrated health records in delivering healthcare services.

5.2 Recent Telemedicine Systems

The most common types of telemedicine technologies used recently are interactive tele videoconferencing and store-and-forward technology [23]. Interactive tele videoconferencing used synchronous connections while store-and-forward technology utilised asynchronous connections [12]. The field of internet-mediated EMRs is in a stage of rapid development. The problem with the two approaches of telemedicine technology - interactive tele videoconferencing (ITV) and tele radiology - is that they were too dependent on the availability of healthcare professionals, computer systems and telecommunication networks. To cite an 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 [24,25]. Without proper setup and adequate bandwidth telecommunication, the consultation service cannot proceed. The approaches have not provided alternatives for continuing the consultation session during inadequacy of telecommunication network and system downtime, and this leads to discontinuity of care due to inability to create, display and store seamlessly the medical records.

Generally, the recent telemedicine's system framework does not pay attention on the integration and sharing of patient medical records across telemedicine services, healthcare levels and healthcare facilities [26]. By way of example, in New Zealand, the research on telemedicine system diffusion showed that majority of medical records are fragmentally stored in individual hospital information systems within healthcare facility centres [27]. This scenario resulted in a lack of continuity and seamless integration of patient LHRs. In 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 info structure [28]. This demonstrates that telemedicine programmes in Canada, which have received investment since 1991, still require improvement in terms of integration and continuation of patient LHRs.

The same scenario occurred with the Malaysian Integrated Telehealth project. Due to a lack of focus in collecting and integrating EMRs for generating centralised patient LHRs, the project suffered from significant drawbacks leading to suspension of the full nationwide implementation [29]. The Malaysian telehealth framework leverages the internet as its main transport for a communication network [30]. Unfortunately, the telehealth framework gives less consideration to the issues of inconsistency and inadequacy of telecommunication infrastructure across healthcare facility centres. The system strictly depends on network availability and only works well in big cities such as Kuala Lumpur, Johore Bahru and Penang [31]. The framework should take into consideration the situation associated with inconsistency and inadequacy of the telecommunication infrastructure during unpredictable system disasters.

5.3 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 its main communication transport to carry medical information across healthcare providers and healthcare professionals [32]. The internet has two basic and essential features for telemedicine and telehealth: firstly, its ability to disseminate knowledge rapidly and without boundaries. Secondly, the ability of the internet to bring down interaction costs [33]. 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 [34]. Mobile applications being used in telemedicine or telehealth environment include: tele-homecare, disease management, emergency ambulance patient service [35], clinical triage systems, remote vital sign readings [36]. Mobile access to patient health summaries were also made available in wards and at emergency outpatient locations.

Those applications are, however, often 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 [37,38]. To discuss further the ideas of current healthcare delivery systems and telemedicine/telehealth systems (and hospital information system), the founder of *Malaysian Integrated Telehealth* was interviewed [38]; 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 be 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 judgement, 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 were operating in a fragmented manner. If current telemedicine systems were 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 telemedicine system should be flexible for the seamless and continuous upkeep of patient health records.

6. The Need for Integrated Lifetime Health Records for Continuing Care

In a 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 organized manner before a diagnosis can be made or before an appropriate treatment can be prescribed and administered. Furthermore, if the patient is required to 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 gathering of pathological (and perhaps radiological) data is a laborious task, one which cannot be delegated to another professional [22]. 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 [39]. According to a study conducted by the Institute of Medicine, the situation is quite worrying as 30% of physicians find great difficulty in accessing patient records at the right time and that 70% of hospital records are found to be incomplete. An iintegrated LHR is crucial for continuing care and these efforts are currently progressing in many countries such as Canada, the UK and in mainland Europe.

The government of Canada has 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 [40]. Similar efforts are also being undertaken in the UK's NHS through its extensive health ICT project, Connecting for Health [41,42]. EHR services are the most integral components among the applications and a crucial backbone of NHS health info structure. Both Canada and the UK have acknowledged that disparate health information systems and independent telemedicine systems will not be sustained in the long term. The healthcare services will not be improved if the services are still episodic and accessing to health records are always restricted within healthcare facility and application system. Good care is dependent on access to the previous medical records which should be a feature of healthcare systems in the future.

7. The need for flexible frameworks for continuous upkeep of LHRs

As healthcare organizations grew and obtained new HIS, the need arose to integrate these systems with older (legacy) systems which continued to function in parts of the organization [26,43]. The integration of existing and forthcoming information systems represents one of the crucial challenges both technically challenging as well as expensive [44]. It is clear that new ICTs have integration problems in healthcare because of the way this sector is organized for meeting the increasing clinical, organizational and managerial needs. A survey conducted by the Ministry of Health Malaysia on the category of information system implemented in the organization (refer Figure 1), provided an example to illustrate the scenario. Approximately, seven categories of information systems were implemented in the organization and the systems have been installed with various application-specific technologies and platforms (operating systems, hardware, databases and applications). In that context, integration represents one of the most urgent priorities in order to implement an integrated telemedicine system.

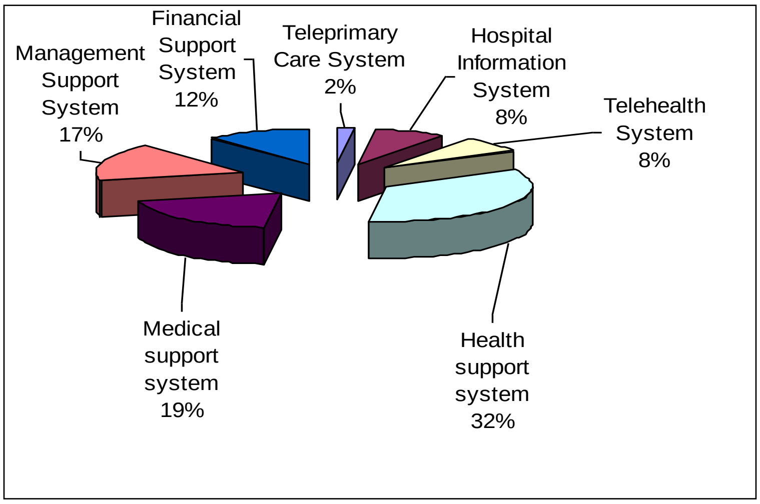

Figure 1: The Categories of Health ICT Projects in Public Healthcare Facilities

The efforts of collecting, integrating and generating centralised patients' health records from the existing disparate HIS 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 existed, few were interoperable. The different technologies, and the fragmented setup of ICT infrastructure and solutions led to challenges for achieving solution integrity between applications and services and, finally, for gathering and generating the LHR centrally. Malaysian public healthcare facilities are also faced with the same situation where the information systems operate independently with a variety of technology platforms (refer to Table 4) but unable to share patient medical records with one another [45]. Uncoordinated planning, legacy and proprietary systems with limited or no networking capabilities present major challenges to systems integration. 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 LHR can be synchronised across healthcare facilities and among HIS applications; and it can be maintained seamlessly and continuously.

Table 4: Software and Middleware Used in Health ICT Project

Application Name	Programming language	Operating system	Database	Application Networking	Web/Application Server
Tele-Primary 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 2EE -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

8. Specific Findings of Telemedicine Approach in 5 Selected Countries

This section reviews the telemedicine approaches of several selected countries. The most suitable approaches, experiences and best practice therein could be used as part of the proposed framework. The countries involved in this review include Singapore, Taiwan, Hong Kong, Canada and the UK.

8.1 The Taiwan Context

Telemedicine development in Taiwan has proliferated since 1990 and was officially launched in 1995 under the National Information Infrastructure (NII) project [46]. 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 includes support for clinical training and continuing medical education (CME) to healthcare professionals and medical assistants such as nurses and paramedics. The CME programme is a prominent telemedicine application in Taiwan. Integrated Service Digital Network (ISDN) and broadband telecommunication networks were commonly used for the telemedicine programme with the bandwidth range of between 128kbps to 2mbps. The implementation approach of telemedicine in Taiwan was carried out in three stages namely; initiation (such as reliability, availability, performance and data voluminousity), promotion (tested or piloted) and evolution (obtained data and assessment) research [47]. Taiwan's telemedicine approach is predominantly focused on clinical services and CME services but less attention is given for linking and integrating the services with the patient's EMR. This "bottom-up" orientation is their current approach to promote the telemedicine services but lacks effort on overall strategy.

8.2 The Singaporean Context

The objective of the telemedicine initiative in Singapore is to curb ever-escalating healthcare costs, increase efficiency in medical care, promote health and empower Singaporeans to manage their health [48]. A store-and-forward method (through the internet) is the main approach in delivering telemedicine services in Singapore. The *OphthWeb* is a pioneer telemedicine system in delivering optometric treatment services and a testing ground for generating the electronic medical records (EMR) for Singaporeans before applying to other clinical specialties [49]. 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 easy access to the telemedicine applications at low cost and in a convenient manner. There are specialized areas which utilise telemedicine technologies, such as tele ophthalmology (which is considered to have less risk compared to other specialties). Tele ophthalmology 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 lifestyle or wellness programmers to the citizens. On the other hand, continuing medical education (CME) plays an important role in keeping medical professionals current with changes in medicine generally and in areas relevant to their specialties [50]. The geographical expanse and the population size require proportionately little investment in the required telecommunication infrastructure. The majority of telemedicine services and e-health applications in Singapore used high-speed broadband backbone (Singapore ONE) with the bandwidth range of up to 622mbps [51]. As such, the internet is a suitable technology for implementing telemedicine applications in Singapore and this enables patient health records to be shared across and between healthcare stakeholders and is accessible by patients anytime and anywhere via the internet.

8.3 The Hong Kong Context

The mission of telemedicine initiatives in Hong Kong is to both improve healthcare delivery and to make better health information available to healthcare professionals and to patients [52]. 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 [53]. The approach of telemedicine in Hong Kong is to start with medical informatics initiatives where the computerisation of the Hospital Authority is a focus. By way of example, after the Hospital Authority (HA) was established in 1991, there were three phases of information system projects to be developed. These were the establishment of a patients' database, the development of clinical systems for generating central electronic patient record (EPR) and integration of healthcare information systems [54,55].

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. Most of the telemedicine technology is based on a store-and-forward approach using broadband internet access with bandwidth size from 384kbps and above. 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 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, thus not requiring a high cost for installing an adequate broadband telecommunication infrastructure. Countries like Malaysia however would incur a high cost for providing such infrastructure and a flexible solution has to be constructed for connecting all healthcare centres seamlessly.

8.4 The Canadian Context

Canada has been a world leader in applying telemedicine/telehealth technology to mitigate healthcare challenges. In 1997, *Health Canada* placed a high priority on the convergence of electronic health records (EHR) and telehealth as both are critical and integrated components of Canada's health infostructure [56]. Since 1998, more than 100 hospitals subscribed to the telehealth services and telehealth had performed over 10,000 consultations on over 70 specialities or clinical disciplines [57]. According to [56], telehealth services provided today are typically poorly integrated with 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 that really need it. Most importantly, the contextual clinical data related to patients are not captured electronically as part of telehealth encounters.

Hence, Canada's telehealth applications have moved towards total integration with EHR-based solutions (interoperable EHR) to provide the ability for telehealth to share consistent and comprehensive EHR information across its geographical territory [56]. The majority of telecommunication technologies used in telehealth applications is ISDN lines with a bandwidth range from 128mbps to 2mbps. The use of internet communication in telehealth applications is still low and the efforts towards web-based applications are becoming a major approach especially for realising the National EHR solution initiative [57]. The Canadian effort and approach on gathering, integrating and sharing relevant patient health information between health services across care setting and disciplines is a proactive action. However, this bottom-up approach that will integrate the 40,000 existing clinical information systems [56] is a tremendous challenge to be faced and addressed.

8.5 The United Kingdom Context

The UK's telemedicine services started in 1992 at the Royal Victoria in Belfast for managing minor injuries through an ISDN 128 Kbps line [58]. 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. The telemedicine services were not able to integrate into existing healthcare delivery system that led to integration issues. From 1999 onwards, the National Programme for IT (NPfIT) initiative was established for the NHS [59] and a strategic plan was developed for the effective use of information and communication technologies to create and share a long-life electronic health records for everyone. 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 patient's life-long clinical records. The patient's clinical record was a main component of NPfIT that integrated other NPfIT components (such as electronic booking and electronic transmission of prescriptions) and all GPs locally and nationally, enabling mining of clinical records [60]. NHS Clinical Record Services (CRS) became a framework for validating the patient's demographic and clinical history before the treatment was given to the patients.

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 [61]. 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 different in cultural identity, health system, stakeholder organisation and the readiness of broadband infrastructure across healthcare facilities. The total cost of 12 billion pounds 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 cost effective solution.

9. Where Malaysia Stands

The five country-specific examples of telemedicine approaches 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 is 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 is one of the crucial key areas for developing a knowledge-based society by way of the *Vision 2020* mission [62]. In 1997, the Malaysian government produced the *Telemedicine Blueprint* (subsequently renamed Telehealth) for supporting the future of the Malaysian healthcare system. The focus of the system will be on people and services, using telehealth and ICTs as the key enablers to provide an accessible, integrated, high-quality and affordable healthcare system [63].

The Integrated Telehealth pilot projects involved four components [64] namely:

- Mass Customised Personalised Health Information and Education (MCPHIE)
- Continuing Medical Education (CME)
- Teleconsultation (TC)
- Lifetime Health Plan (LHP).

Figure 2 illustrates the interplay amongst components within the telehealth applications; the LHP system forms the backbone for integration into the other three applications (CME, MCPHIE and TS) to form an integrated solution.

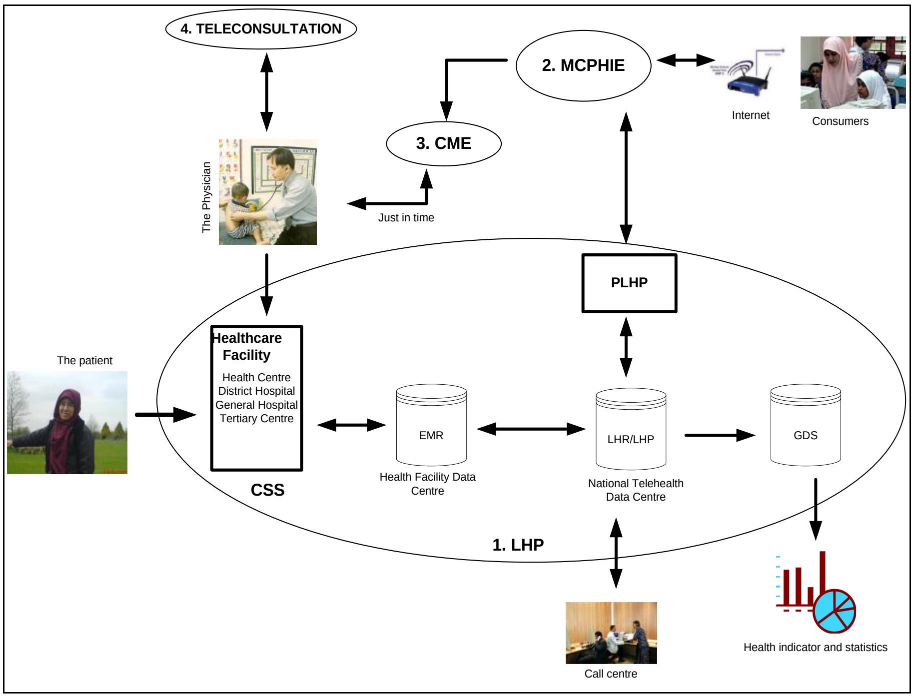

Figure 2: The Four Components of the Telehealth Application

The LHP is a backbone of the Malaysian Integrated Telehealth system that consists of three main components namely Clinical Support System (CSS), Personalised Lifetime Health Plan (PLHP) and Group Data Services (GDS) [10,65]. CSS is an administrative tool to support healthcare facilities to create the electronic medical records (EMR) and finally collate and generate a summary lifespan of EMR called lifetime health records (LHR). PLHP is a service to deliver health plans and care plans generated from the LHR. GDS is a data mart to deliver data-mining services and generate relevant reports [63,66]. CME offers just-in-time significant information to support decision-making relating to the patient being treated. MCPHIE offers a selection of relevant patient information about the disease that can be further personalised by the doctor and home consumers. Teleconsultation (TS) services could be called upon if expert opinion needs to be obtained.

All of the above applications using store-and-forward and internet technologies as a telecommunication medium for delivering the telemedicine services. The virtual private network (VPN) is used to link all referral hospitals and health centres. The spectrum VPN bandwidth requirements ranged from 2 mbps from the hospital to the data centre to 64 kbps from the health clinics to the hospital and 100 mbps for the local area network (LAN) of the hospital [63,67]. The medical records are hosted in two areas: one centralised database residing at the telehealth data centre and another that is linked to the many distributed databases at the various hospitals. All distributed databases contain detailed medical records that are captured online and in real time via web-based CSS application at every individual health centre. These distributed databases are then linked up to the centralised data centre whereby any information residing at the various distributed data centres may be retrieved by an attending healthcare provider or the patient as required.

10. Lessons and Recommendations

It was noted from the literature that telemedicine approaches vary among countries. The variation is due to different cultures, socioeconomic conditions and politics of those countries. However, the healthcare scenarios and the development of telemedicine system might be similar and, the experiences and lessons could be learned and shared by other countries. Recommendations of the Implementation approach to guide future LHR in Malaysian context of telemedicine in both the short and medium time frames are proposed below:

10.1 Broadband for Health Network

Malaysia should provide dedicated telecommunication network infrastructure for 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/programs was an effective approach to provide fast and large bandwidth (between 128 Kbps and 2 Mbps) of networking for the implementation of telemedicine system. By way of example, the N3 Network is a great approach for providing and supplying the telecommunication infrastructure to mitigate both current and future requirements of UK's health ICT initiatives [61,68]. The 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. The telecommunication network for Malaysian telemedicine system was one step behind where the narrow bandwidth is still in use for transporting the medical information. In addition, the network infrastructure setup was provided and maintained by various vendors that led to network integration and maintenance issues (see Table 5). The Ministry of Health Malaysia through its information technology strategic planning (ISP - 2006 – 2010), targeted to provide network link to all hospitals across the country by the year of 2006 [63,69]. This telecommunication infrastructure should also provide to all health centres as well due to the fact that the health centres provide primary care to the patients and crucial source for generating EMR.

Table 5: A variety of telecommunication network used in telemedicine system

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	

10.2 Focus on the Development of EMR and LHR

We learned from the Canada and the UK approach towards electronic healthcare where the EMR based medication is their current approach to achieve a seamless access to patient information and health records. On the other hand, the Hong Kong approach in developing and implementing telemedicine system incrementally nationwide started with the ICT infrastructure establishment. The computerisation of Hospital Authority to generate centralised patient medical records that can be accessed and shared by healthcare provider 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 of Malaysia by implementing the crucial CIS in all healthcare centres for collecting the EMR and finally generating the LHR repository. The LHR collator that might be a critical component of LHR repository should be given priority to be developed and implemented. LHR collator should be scalable and interoperable enough to collate patient's episodes from various systems and healthcare facilities. The establishment of standard integration framework for collecting EMR and generating the LHR is crucial for the success of the telemedicine system [70,71]. (See Table 6 for telemedicine development approach comparison)

10.3 Focus on Crucial Functions

The healthcare sector was complex which involved various clinical specialties and disciplines. To computerise and include all specialties in one short in telemedicine implementation is impossible and highly unachievable. As we have already known that ICT application implementation involved a series of processes and requires resources and time. Incremental approach in developing and implementing the telemedicine applications mitigate the resources and time constraints. However, the wrong choice of crucial functions to be included in telemedicine system would bring user acceptance and integration issues. The Malaysian telemedicine system should focus on crucial functions towards collecting as many EMR as possible for generating patient lifetime health records. The most clinical workflow that patients went through every time they visited the healthcare provider was registration and, clinical consultation and diagnosis. These two business functions (administration and clinical) exist in all healthcare levels – primary, secondary, tertiary and reference centres. We proposed the two crucial functions; patient registration system and clinical information system to be the focus and included in the Malaysian telemedicine system for maintaining LHR seamlessly and continuously. We learned from other countries' experiences that the development of disparate system in 'silos' would bring integration issues and would not sustain the telemedicine system in the long term. See Table 7 for integration characteristics comparison in the five selected countries.

Table 6: Telemedicine development approach comparison

Development approach	Singapore	Hong Kong	Taiwan	UK	Canada	Malaysia
National agenda and initiated by the Government	No	No	No	Yes	Yes	Yes
Support & drive by National Telemedicine policy and strategy	No	No	No	Yes	Yes	Yes
Starts and initiates from research & development project by research organizations/institutions	Yes	Yes	Yes	No	Yes	No
Implementation approach through pilot run and transformed into production	Yes	Yes	Yes	Yes	Yes	Yes
The programs/services are developed by specialties independently	Yes	Yes	Yes	No	Yes	No
Consolidate and integrate from fragmented services/programs into integrated one	No	Yes	No	Yes	Yes	Yes
Integrate with Electronic Health Record infrastructure for sharing the health information	Yes	Yes	No	Yes	Yes	Yes
Provide dedicated telecommunication infrastructure for health network services/programs	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 7: Telemedicine integration characteristics comparison among five countries

Integration characteristics	Singapore	Hong Kong	Taiwan	U.K.	Canada	Malaysia
Use of central EMR as a base 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 existing healthcare facility instead of creating a new telemedicine centres 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 existing application system such as healthcare information system and 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

11 Discussion and conclusion

Three unique factors were concluded from the literature search and the case study conducted at the Ministry of Health Malaysia. Firstly, it is noted that the Malaysian telemedicine strategy is derived through the National's agenda of vision 2020 that has been initiated and committed by the Government of Malaysia. Secondly, the Malaysian integrated telehealth components are mainly based on EMR and LHR repositories for delivering the services. Thirdly, and uniquely, Malaysia's telehealth is designed and customised to suit Malaysian circumstances and consists of an integrated system made up of four major components (as described in Table 6). 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 was CME and MCPHIE (albeit referred to by different names) and even LHP. However, what was evident was 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 is 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 is critical because it is the source of information for other health record structures such as LHR and LHS. Therefore, the integrity and the continuous upkeep of the LHR need 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 integrated LHR and developing suitable framework is crucial both for the progress and success of the project.

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