Understanding the role of technology in health information systems

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ABOUT THIS SERIES

HIS Knowledge Hub’s Working Paper Series is the principal means to disseminate the knowledge products developed by the Hub in a user-friendly format and as easily-accessible resources. Working Papers are intended to stimulate debate and promote the adoption of best-practice for HIS in the region. The Series focuses on a range of knowledge gaps, including new tools, methods and approaches. Generally, working papers contain more detailed information than a journal article, are written in less-academic language, and are intended to be of practical relevance to countries and a range of development partners.

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ABSTRACT

Innovations in, and the use of emerging information and communications technology (ICT) has rapidly increased in all development contexts, including healthcare. It is believed that the use of appropriate technologies can increase the quality and reach of both information and communication. However, decisions on what ICT to adopt have often been made without evidence of their effectiveness; or information on implications; or extensive knowledge on how to maximise benefits from their use. While it has been stated that ‘healthcare ICT innovation can only succeed if design is deeply informed by practice’ (Sanderson 2007: 4), the large number of ‘failed’ ICT projects within health indicates the limited application of such an approach.

There is a large and growing body of work exploring health ICT issues in the developed world, and some specifically focusing on the developing country context emerging from Africa and India; but not for the Pacific Region. Health systems in the Pacific, while diverse in many ways, are also faced with many common problems including competing demands in the face of limited resources, staff numbers, staff capacity and infrastructure. Senior health managers in the region are commonly asked to commit money, effort and scarce manpower to supporting new technologies on proposals from donor agencies or commercial companies, as well as from senior staff within their system. The first decision they must make is if the investment is both plausible and reasonable; they must also secondly decide how the investment should be made. The objective of this paper is four-fold: firstly, to provide a common ‘language’ for categorising and discussing health information systems, particularly those in developing countries; secondly, to summarise the potential benefits and opportunities offered by the use of ICT in health; thirdly, to discuss the critical factors resulting in ICT success or failure, with an emphasis on the differences between developed and developing countries; and fourthly, to introduce evaluation frameworks and models used in developed countries to assess the plausibility of ICT projects in health. Overall, this paper aims to illuminate the potential role of information and communication technologies in health, specifically for Pacific Island Countries and Territories (PICTs).
Information and Communications Technology (ICT) has been referred to as a 'key instrument' in healthcare delivery and public health internationally (Drury 2005: 38). When designed and implemented effectively, ICT can improve access for geographically isolated communities; provide support for healthcare workers; aid in data sharing; provide visual tools linking population and environmental information with disease outbreaks; and is an effective electronic means for data capture, storage, interpretation and management. In this context, ICT for health refers to any tool that facilitates the communication, processing or transmission of information by electronic means for the purpose of improving human health (Bukachi & Pakenham-Walsh 2007).

In the developed world there has been enormous investment in health ICT since the late 1960s and this has expanded dramatically over the last 10 years. Obvious examples are the Canadian Health Infoway (www.infoway-inforoute.ca), the United Kingdom’s National Program for Information Technology (NPfIT) which is the world’s largest civil information technology investment program (www.connectingforhealth.nhs.uk) and the HealthConnect program and subsequent National e-Health Transition Authority programs in Australia (www.nehta.gov.au). Each of these programs, and many others, have carried out substantial policy research within e-Health, particularly in the areas of benefits and benefits realisation. Despite this there is still a remarkably small evidence base of rigorously evaluated health ICT interventions available to support informed investment decisions. For the developing world, this evidence base is even smaller.

On a global level, there are many organisations and institutions working to support this field of work. The World Health Organisation (WHO) hosts the Global Observatory on e-Health (www.who.int/kms/initiatives/ehealth/en) to respond to the limited systematic research that has been carried out to inform e-Health policy and practice. In 2005 a global survey was carried out to describe e-Health activities and action areas being undertaken at a country level. A key finding was the urgent need for guidance in implementing health technologies (WHO 2006); however no follow-up survey has been undertaken, nor have any practical recommendations been released. Another initiative is a global concept named ICT4D,
which relates to the application of Information and Communication Technologies for Development (www.infodev.org/ict4d). The World Bank has also established infoDev (www.infodev.org), a financing program, and convenes discussions to support information sharing on ICT4D, and to help reduce the duplication of efforts and investments. Within the Pacific Region, there are limited strategic initiatives relating specifically to health technologies (Network Strategies 2010). However, an activity that may have an overarching impact is the Pacific Rural Internet Connectivity System (PacRICS), which was established in 2008 by the Secretariat of the Pacific Community and the Pacific Island Forum Secretariat to provide two-way internet connectivity (www.pacrics.net).

However, while the assumption is made that technology can and does have a positive effect in healthcare; the evidence-base supporting its practical use is slender (Wootton 2009). In reality, many decisions on the adoption of new healthcare technologies are made in the absence of information on implications of its use (Kazanjian & Green 2002). Decision-makers are often unaware of the information they lack, and rarely obtain feedback on the consequences of their decisions; be it feedback on the effectiveness, costs, ethical, legal or social implications of technology (Kazanjian & Green 2002; Wootton 2009). Aside from the paucity of research on evidence for making informed decisions; available information on the selection of new technologies is often unstructured and unclear, and further compounded by the increasing number of technologies, and their increasing complexity (Chan & Kaufman 2010; Ruder et al 2008). There are a number of specific problems with the use of ICT that are generally better understood: costs associated with hardware and software, availability of broadband and mobile networks, the development of user interfaces and applications in languages other than English, and ongoing maintenance costs, to name a few (Wootton 2009). However, broader knowledge on the social, political and economic constraints (also referred to as the ‘soft’ barriers), is often lacking in considerations of technology innovations in healthcare (Ruder et al 2008).

In response to this evident knowledge gap, a literature review on past health information technology implementations in the region was conducted by the HIS Knowledge Hub. This paper presents initial findings from the review. There are four main research questions this paper aims to address:

1. What are the potential opportunities and benefits of ICT in assisting health information systems?
2. Why do health ICT technology investments succeed or fail?
3. Can a common ‘language’ for categorising and discussing Health Information Systems in the Pacific be developed?
4. What tools, models and frameworks are available to evaluate ICT in health?

PACIFIC ISLAND COUNTRIES AND TERRITORIES

The Pacific Region is a diverse area in terms of geography, populations, cultures, economies and politics, and includes 22 Island countries and territories, with an estimated population of nine million people (SPC 2009). The Pacific Islands are separated into three sub-regions of Melanesia (west), Polynesia (southeast) and Micronesia (north), based on their ethnic, linguistic and cultural differences (SPC 2009). Health outcomes in the Pacific region are varied in each of these sub-regions, with infectious diseases continuing to be a major health concern in some countries, while changes in lifestyle, urbanisation and diet have changed the epidemiology of other countries and caused a rapidly increasing burden of non-communicable disease (Smith 2004; Lum Ön et al 2009). With the diversity in history, economics, loyalty (to different colonial power structures) and culture in populations of the Pacific, it is unsurprising that their healthcare systems, which are inherently socially-based, are also diverse (Finau 1994). The degree of organisation and sophistication varies widely both between and within countries: from welfare state systems in Micronesia, to developing country systems in Melanesia, and transitional systems in the larger Polynesian islands (Smith 2004; Finau 1994).

While infrastructure may be the cornerstone of development (increasing access to knowledge and linking isolated rural communities); as discussed by Keke (2007), most Pacific Island Countries and Territories have weak institutional frameworks with limited coordination and management of staff and infrastructure. Overall, what can be said about the Region is that it is characterised by remoteness, dispersed and small total populations and vast ocean distances (apart from Papua New Guinea) and limited human resource and institutional capacity – especially in relation to ICT (PIFS 2002a; PIFS 2002b; Network Strategies 2010). It is these characteristics that have led to the growing agreement that ‘ICTs offer huge potential for social and economic development in the Pacific’ (Network Strategies 2010: ii). However it is these very same characteristics that make ICT exceptionally difficult to implement and sustain among PICTs.
ICT IN THE PACIFIC

Countries and Territories making up the Western Pacific Region are commonly grouped according to their level of development, as defined by per capita income. As such, countries such as New Zealand, Australia, Japan and Guam are usually grouped as ‘high income’; Malaysia, American Samoa and Palau ‘upper middle income’; the Philippines, Fiji and Kiribati ‘lower middle income’; and Cambodia, Papua New Guinea and the Solomon Islands are generally grouped as ‘low income’ (Lansang et al 2006). While per capita income is likely to be a good predictor of the level of sophistication in health ICT that a country can support at the current time; an important marker of the long term need for complexity and sophistication in the use of ICT in health, is a country’s total population. A large country such as Papua New Guinea, with its population of over six million (World Bank 2008), requires a relatively complex HIS; however a country such as Tokelau, with a population of less than 2,000, can adequately operate its health system with relatively simple tools. While Fiji, with a population of just under 840,000 (World Bank 2008) may require a scaled-down version of the overall system that would be suited to Papua New Guinea; it is unlikely that a country such as Tuvalu (10,000 people) would require a scaled-down version of Fiji’s system, and even less likely to require a system modelled on that of Papua New Guinea. Overall, at a certain point in size, there is likely to be an almost quantitative step change in system requirements for ICT.

Despite country-level differences in terms of both income per capita and total population, one of the most visible changes to the use of ICT in the Pacific has been the dramatic uptake in the use of mobile phones. With liberalisation of the telecommunications sector for a number of countries, the availability and affordability of mobile services has improved considerably (though penetration remains low when compared to other developed countries) (Network Strategies 2010). The growth of mobile cellular subscriptions has rapidly outpaced growth in fixed telephone lines and estimated internet users. Between 2000 and 2009, for example, the number of mobile cellular subscriptions in Samoa increased from 1.42 to 84.43 per 100 inhabitants; while fixed lines increased from 4.83 to 17.84, and Internet users from 0.57 to 5.03 (ITU 2010). A similar pattern has also emerged for Fiji, and to a lesser extent, the Cook Islands. An important limiting factor to the use of new technologies in the Pacific, and in developing countries in general, is the lack of competition among service providers, especially for countries with small total populations. State-owned monopolies, such as those within the Federated States of Micronesia and Kiribati, continue to restrict the opening-up of ICT markets within the Region, stalling development and inflating prices (Network Strategies 2010).

HEALTH INFORMATION SYSTEMS

The aim of this section is to provide a common language for talking about Health information Systems. The first question is what we do mean by a Health Information System (HIS); as the term is used with two very distinct meanings. The restricted meaning refers to systems that capture and report aggregated health statistical information. This is the meaning that, for example, the Health Metrics Network (HMN) and World Health Organization (WHO) traditionally use. WHO (cited AbouZhar & Commar 2008: 1) define HIS as integrated efforts to, ‘collect, process, report and use health information and knowledge to influence policy making, program action and research’ and further states that they are essential to the effective functioning of Health Systems worldwide. For the purposes of this paper we will refer to such systems as Routine Health Information Systems (RHIS). RHIS, such as those operated through health information departments or national statistics offices, provide information on risk factors associated with disease, mortality and morbidity, health service coverage, and health system resources.

The broader meaning of HIS refers to any system that captures, stores, manages or transmits information related to the health of individuals or the activities of organisations that work within the health sector. It is this broader meaning of Health Information Systems that is used in this paper. This extended definition incorporates such things as district level routine information disease systems, disease surveillance systems but also includes laboratory information systems, hospital Patient Administration Systems (PAS) and human resource management information systems (HRMIS) for health workers.

The following diagram (Figure 1) illustrates the typical components of such an extended Health Information System. The dashed box to the right of the diagram displays the components of a ‘traditional’ HIS for a ‘developing country’, these include;
• A routine health information system capturing aggregate activity data from paper forms via ‘district’ level reporting to be eventually recorded in an electronic system at the ‘provincial’ and/or national level
• Notifiable disease reporting system (possibly using both routine reporting and sentinel sites)
• Disease registries.

There is significant academic literature regarding the implementation of such systems, particularly in Africa, but few robust quantitative evaluations of their benefits. Over recent years there has also been significant research published on the impact of new technologies such as the use of mobile phones to improve the operation of these ‘traditional’ systems.

Figure 1: Components of an extended HIS

The remainder of the diagram illustrates the components that may make up the electronic HIS environment of many developed countries. Of course many HIS environments will not include all such components and where they do exist, they will have been implemented over an extended period of time building on earlier developments and dependencies. The diagram illustrates a number of key elements of the differences between the HIS environments:

• Investment in departmental (auxiliary) systems to support acute care, such as radiology and Laboratory Information Systems, initially the prime purpose of these is to manage work flow efficiently
• A focus on systems that store, transfer and use information on individual patients for prospective clinical decision making rather than on aggregated information used for policy and monitoring
• A focus on sharing information between health care providers to enable continuity of care, reducing duplication and improving patient safety
• Richer integration of information available from multiple sources to inform policy and management decisions.

1 The terms ‘district’ and ‘province’ are used here generically to refer to geographic administrative units, Fiji for example use the terms Sub-division and Division.
It can be expected that countries in the Pacific will be looking to adopt and implement such systems over time. The rate of adoption will vary from country to country but will be driven by factors such as:

- Changes in disease patterns, the shift from communicable to non-communicable and chronic diseases, requiring changes in patterns of care and supporting systems
- Increased expectation of stakeholders, this includes both increasing expectations from patients and possibly more significantly increasing demands from clinicians.

This extended Health Information System is composed of a large number of individual systems. In the past many of these have been isolated, ‘stand alone’ systems but intersystem communication for data sharing and integration is increasingly the norm. Such communication of clinical data progresses through a number of distinct stages. Initially data is communicated in a form understandable by humans but not by the machines (a facsimile is a simple example of this) and later moves to full semantic interoperability where transmitted data can be used by the receiving system for things such as computerised decision support. Individual systems include:

- **Patient Administration System (PAS).** Basic component of a hospital computer system which records patient details, all admission, discharge, ward allocation and transfer, treating clinicians and outpatient attendance. Coding of diagnoses and treatment options allows for the analysis of hospital and national disease burden. Usually one of the first systems to be installed in starting to ‘computerise’ a hospital.
- **Laboratory Information System (LIMS).** Primary purpose is to manage the flow of samples through a pathology laboratory. This requires the electronic registration of samples as they flow through the laboratory and the interaction with all laboratory machines to electronically capture the results. The secondary purpose is to provide the results to clinicians in a timely and convenient manner.
- **Electronic Medical Records (EMR).** Facility or organisation-based records of all patient interactions. Includes details of patient problems, diagnoses, investigations, test results, treatments and prescribed medicines. Usually requires input from auxiliary systems such laboratory information systems.
- **Electronic Health Record (EHR).** Sometimes termed a Shared Electronic Health Record (SEHR). Includes details from multiple organisations and care settings to provide a complete longitudinal patient medical history. Information is usually a summary from the contributing EMRs. Available to all healthcare providers delivering care to a patient.
- **Management Information System (MIS).** The intention of such a system is to bring together and present in an integrated manner all the information needed to manage and plan the health system. Ideally this includes health system activity data, human resource, financial, supply, disease incidence and demographic information. Few health systems in the world would have such an ideal MIS.

**OPPORTUNITIES AND BENEFITS**

In the developed world there have been two key drivers for investment in health ICT. The first is the ever increasing burden from chronic disease, often with complex co-morbidities, on the health care system with costs increasing significantly faster than population or GDP growth. In Australia, for example 80% of the burden of disease is now from chronic diseases (including cancers) (AIHW 2003). The treatment and management of such chronic disease continues over an extended period of time and is performed by multiple health care providers in multiple settings. The second key driver is the recognition of the need for greatly improved quality and safety in the delivery of health care. This recognition has been driven by such things as the National Institutes of Medicine report *To Err Is Human* (Kohn et al 2000) which estimated that in hospitals alone, between 44,000 and 98,000 Americans died each from medical error.

Both of the these factors have led to very significant investments in the development of systems to enable the sharing of structured data to provide more complete and timely information for clinical decision making. These have included such things as the development of local electronic medical records, secure messaging to interface systems and shared longitudinal electronic health records. There has been the expectation that these developments would lead to major
savings in cost and increases in patient safety. In the United States, for example, a RAND Corporation Study (Hillestad et al 2005) estimated that it would take 10 to 15 years to establish a full e-Health system but such a system would then deliver savings of $81 billion dollars per year as well as delivering greatly improved quality of care. In Australia, the projected cost of implementation of the national broadband network is $42 billion, but in its submission to the NBN Senate Select Committee, iSoft (2009), an Australian medical software company, estimated the cost savings for integrated health records to be of the order of $8-$10 billion annually, and emphasised the importance of broadband in realising the full e-health system.

Yet, as noted previously the quantitative evidence-base to support particular investments is small. The U.S. based Centre for Information Technology Leadership (CITL) reviewed a sample of studies from academic, industry, and provider sources, aiming to answer the question: What are the demonstrated benefits of a given system or application? They found few concrete answers, noting that:

“There is very little hard evidence demonstrating the value of specific HIT investments”;

“A good deal of the current literature is conceptual. Rather than discuss demonstrable benefits of HIT, about one-quarter of sources did not address specific benefits at all. Instead, these largely theoretical works discussed value assessment frameworks or barriers to value realization. Benefits like cost containment or outcomes improvement were mentioned with little if any supporting primary data”;

and

“Existing evidence is not sufficient to clearly define “who pays for” and who benefits from HIT implementation in any organization – except those …that are responsible for paying for and delivering all the care for the defined population” (Walker 2006).

While there has been limited rigorous quantitative analysis of the benefits from specific ICT investments in the developed world there has been even less for the developing world. There has been a significant level of published literature over recent years around such things as:

- Use of mobile phone technology for disease surveillance
- Low cost technologies for clinical video case conferencing
- Open source technology for the development of routine health information systems and the use of technologies such as hand held PDAs to improve the efficiency and timeliness of systems.

It is likely over the next decade that the major ICT investments in health in the developing world will be in:

- Hospital patient administration systems (PAS) to optimise the use of scarce resources, hospital bed-days and clinicians
- Logistics system to help manage the distribution, storage and distribution of drugs and medical supplies, and to reduce loss through retention of out-of-date drugs and pilfering
- Simple information transfer systems (referrals and discharge) to support continuity of care as patients move between primary care settings and acute care
- Extension of access to routine health information systems to lower geographic levels so data can be entered closer to source and a wider range of users can access information directly
- Pathology, radiology and pharmacy information systems to manage the work flow in these areas and subsequently provide information to clinicians and support continuity of care.

The following table (Table 1) lists examples of health ICT investments describing the types of initiatives, their benefits and dependencies. This is not intended to be an exhaustive list but does cover a wide spread of the types of investments that could be made in health ICT.
Table 1: Health ICT investments

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<th>Investment</th>
<th>Description</th>
<th>Benefit</th>
<th>Dependencies</th>
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| Electronic decision support on drug ordering   | Prescription entered electronically and sent to dispensing (pharmacy) system and possibly drug administration tracking system. Provides immediate electronic advice to prescriber on alternatives and potential interactions and side effects | Reduced cost of drugs and reduced risk of adverse event from drug – drug interaction                                | 1. Data entry terminals widely available at point of ordering  
2. Electronic laboratory and pharmacy systems  
3. Standardised drug coding  
4. Standardised, secure electronic messaging  
5. Electronic medical record with standardised coding of patient history and allergies |
| Coordinated care SEHR                          | Central repository that contains summary information from multiple source systems. Enables healthcare providers to have a complete view of current problems and treatments | Reduced duplication of diagnostic tests. Enables earlier treatment of emerging problems and reduces hospitalisation stays | 1. Source systems such as GP, primary care and hospital  
2. Standards for data recording  
3. Standardised, secure electronic messaging |
| Hospital patient administration system (PAS)    | Records patient admissions to acute care hospitals                                                                                           | Allows local management of hospital bed usage and contributes to overall analysis of burden of disease and health system costs | 1. Availability of local area network and terminals at admission desk, ward and management offices  
2. Staff capacity  
3. National data warehouse / management information system |
| Electronic transfer of laboratory results       | Secure transfer of results to clinician who ordered tests and other interested clinicians. Initially message is at the human readable level only but later moves to automatic transfer of system-interpretable data | Quickly and more reliable availability of pathology results. Reduction in duplication of tests and unnecessary tests. Eventually electronic decision support for the ordering and interpretation of pathology tests | 1. Compatible systems in laboratory and remote sites  
2. Affordable, reliable wide area communications  
3. Agreed messaging standards |
| Laboratory information system with auto-tracking | A laboratory information system (LIMS) is one of the key clinical auxiliary systems. Its primary purpose is to manage the workflow of samples through the laboratory. It can enable clinician access to results | Efficient work flow in the laboratory. More timely availability of results. Distribution of results to clinicians across different sites and settings. Storage of results for later review and time trend analysis | 1. Basic implementation has no dependencies other than local network, reliable power within the laboratory and staff capacity to maintain the various machine interfaces 2. Local network and interface to patient administration system to obtain patient identifier details |
| Web based entry and reporting of routine health information at sub-national levels | Network system that enables entry of data from local / district level directly into single national repository with immediate reporting and comparison of performance indicators | Eliminates duplicate entry of data and provides much more timely availability of meaningful local reports | 1. Robust and affordable wide area communication networks. Does not need to be real time wide band 2. Human capacity to manage system and monitor data and training of users in interpretation and use of data |
| Simple telemedicine case conferencing | Use of slow scan video equipment to provide video conferencing and diagnostic imaging over low band width networks. Clinician from referral hospitals can provide specialist advice at local and district facility level | Enables specialist medical consultation at local level, may reduce need for patient transfer to other facilities | 1. Organisational commitment of specialist time to be available on scheduled basis 2. Wide spread distribution of simple video and audio equipment 3. Robust and affordable wide area communication networks |
| Mobile phone notification of disease outbreaks | Programmed mobile phone notification of occurrence of disease. Usually from sentinel sites rather than all sources | Faster and more complete notification of disease occurrence | 1. Wide spread mobile phone coverage 2. Low cost programmed mobile phones 3. Central agency with capacity to rapidly react to disease outbreaks. |

**ICT PROJECT FAILURE**

While the potential health and financial benefits from the use of technological innovation in health are large, the risks are also substantial. A World Bank Study conducted in 2005 found, for example, that the majority of public sector ICT applications in developed countries were either partial or total failures (cited UNAPCICT 2010). Furthermore, in his report
on e-Government projects for development, Heeks (2008) states that 35% of such projects are total failures, 50% partial failures, and only 15% are considered successful. A study by Gheorghiu (2006) found that 70-80% of all information technology and information systems fail. Similarly, Kaplan and Harris-Salamone (2009) reported international failure rates of major health IT projects of between 30% and 70%. Such figures are found repeatedly throughout the academic and industry literature. There is a far smaller literature base on the developing world, but intuitively one would expect the failure rates to be at least as high as in the developed world. The International Development Research Centre (IDRC) (www.idrc.ca) noted a significant failure rate (up to 50%) in the small scale telemedicine projects it had sponsored and in general, an inability to demonstrate improved patient outcomes from the projects.

DEVELOPED WORLD EXPERIENCE

Given the high failure rate and the very visible and often politically embarrassing failure of many health ICT projects, there has been substantial academic and industry research on the factors that cause such projects to fail. Health systems are significantly different from other information system environments, due to their complexity, lack of one single ‘owner’, and ‘hyper turbulent’ and ‘information sensitive’ nature (Earth Institute 2010; Al-Ahmad et al 2009: 100). Common failure factors for health ICT projects thus include:

1. Lack of senior management sponsorship (Earth Institute 2010; Bukachi & Pakenham-Walsh 2007; Johnson 2006; Dorsey 2000)
2. Lack of engagement of clinicians and other end users (Elder & Clarke 2007; Johnson 2006)
3. Inadequate specification of requirements (Lucas 2008; Gauld 2006)
4. Insufficient time and resources allocated to organisational and process change
5. Inadequate understanding of the complexity health domain by IT companies (Al-Ahmad et al 2009)

These factors are discussed briefly below. Success factors, i.e. what leads to project success, can be defined easily as the converse of these; however a number of studies have also researched this area in depth (see, for example VWC 2009; UNAPCICT 2010).

1. Lack of senior management sponsorship is often cited as the number one cause of project failures in ICT, and this is particularly the case in health ICT projects. In the 10 years since Dorsey (2000) published his report stating that almost every study to-date had identified top management support as a key factor in project success, it would appear that very little has changed. Any worthwhile project causes disruption within an organisation and challenges existing interests and practices. If senior management are not committed to the project and unwilling to undergo the difficulties involved in overcoming the internal and external barriers then the project is almost certain to fail.

2. Lack of engagement of clinicians and other end-users remains a critical factor in the ultimate success or failure of an ICT project. In their research on lessons learnt from telehealth projects, Elder and Clarke (2007) remark that the fundamental issue pervading the continued failure of ICT projects in health is the lack of focus on the end-user. The internal dynamics of clinical organisations are quite different from those of other businesses. In a bank for example, management can enforce the introduction of new systems even if the end-users are opposed. In a clinical setting, doctors who have not been engaged in the introduction of new technology, who feel the systems waste their time or affect patient safety, can refuse to use the technology and often have the organisational power, even if informal, to have their wishes implemented.

3. Inadequate specification of requirements. In some studies this is listed as the number one cause of ICT project failure. If the technical and functional requirements of the system are not completely and clearly specified and linked to the benefits that the new technology is supposed to deliver then the project can easily be a technical success but a business failure. Correct requirements specification will also elucidate the dependencies of the project on other systems and projects.

4. Insufficient time and resources allocated to organisational and process change. The introduction of new ICT systems usually requires the introduction of new ways of working, new staff skills, new roles and may require organisational restructure. In general, people are resistant to such changes especially if they feel threatened by them. To successfully
overcome such resistance so that the new technology will deliver the anticipated benefits requires effort into business process analysis, stakeholder communication and user training. The amount of time and effort needed for these activities is very often underestimated.

5. Health information systems are complex. They not only deal with complex clinical information technologies, medical science, research and practices (Al-Ahmad et al 2009), but are often fragmented, disorganised and do not operate or progress as a coherent whole (HMN 2011). Frequently, technology companies coming into the health domain underestimate its complexity and proceed on the assumption that if something has worked in another domain then it should be possible to achieve the same in health.

6. The under-investment in human resource capacity-building is a critical factor in the continued failure of ICT projects in health. As discussed by the UN agency on ICT for development (UNAPCICT 2010), many proponents of ICT mistakenly assume that such projects are only about hardware, networking, software and applications; however a substantial amount of human activity is required when dealing with ICT.

DEVELOPING WORLD SITUATION

Health ICT projects in the developing world face all of the issues and challenges of projects in the developed world plus having their own specific risk factors. Some of these risk factors are common across the sector and others are more specific to particular regions. In their discussion on the past, present and future of telehealth, Elder and Clarke (2007) provide us with an all-too common scenario: a pioneering telehealth project is established in Uganda to enhance access of rural patients to doctors in urban hospitals through online consultations. However due to challenges with equipment, infrastructure and connectivity, no online consultations are ever made, and despite the considerable investment made to the project, no direct benefits to the health of the rural population were observed. They go on to describe this project as typical of its time: donor-driven, overly ambitious, lacking in adequate planning and capacity (human and technological) and too expensive to be widely adopted in resource-poor settings (Elder & Clarke 2007). Despite this story dating back 10 years, and the ‘bitter’ experience of the countless other failed ICT projects (Lucas 2008), we are still in the position of having limited knowledge on what works, how it works and how much it costs; with limited actual evidence on the impact of ICT in health (Earth Institute 2010).

One of the most common causes of ICT failure is the temptation to ‘leapfrog’ certain aspects of the development path, in an attempt to decrease the gap between developed and developing countries (Avgerou 2008). While technology offers an attractive means to bypass some processes in the accumulation of human or system capabilities, this approach is inherently risky for developing countries as few, if any, technologies are so well specified that they only need to be installed and turned on to work – most require a process of learning and adaption from the people and systems who will use them (Steinmueller 2001). Furthermore, technology rarely stands independently; rather, it is embedded in a system of complementary technologies and capabilities and requires three key elements for success: (1) people, (2) process, and (3) technology (UNAPCICT 2010; Steinmuller 2001; Cleverley 2009).

If ICT is to be used to provide information at the right time and when required, key elements must be understood including what to collect; where to collect; whom to report to; and how the information will be used and by whom (Sinha 2010). Poorly planned ‘interventionalist’ behaviour that ignores user needs, fails to understand host capacities, demands action, neglects cultural constraints and ignores the local knowledge base, will only result in failure for health technologies (Rodrigues & Risk 2003). Furthermore, the technology needs to be appropriate to the capacity and maturity of the health system, and this includes both human and technological maturity, as ‘if you automate a mess, you’ll get an automated mess’ (HMN 2011).

PACIFIC ISLAND COUNTRIES AND TERRITORIES

In their conclusions on Pacific ICT capacity and prospects, the Pacific Islands Forum Secretariat (PIFS 2002a) remark that Pacific Countries and Territories continue to face the same issues and challenges: no or limited access to phones; high telecommunications costs and charges; a poor supply of skilled persons to manage and operate the technology; outdated legislation; and limited ongoing financial support. Overall, four key challenges to the successful implementation of ICT initiatives in the Pacific have been identified: (1) telecommunications infrastructure; (2) human capacity and training;
(3) affordability; and (4) appropriateness.

**Telecommunications infrastructure**

In their work on telemedicine and telehealth in the Pacific, Bice et al (1996), conclude that the state and cost of telecommunications and information infrastructure is one of the major barriers to the implementation of ICT in the region. They further remark that this problem is not unique to the Pacific, but rather a common barrier faced by rural and remote communities in developed countries, as well as other geographically dispersed populations. Overall, limited and unequal access, the high costs involved with both purchasing equipment and accessing its services, insufficient bandwidth, and an overall low investment in infrastructure networks make it extremely difficult to implement effective ICT projects (PIFS 2002a).

This sentiment is echoed in Chetley (2006) when he discusses ‘connectivity’ and its role as an important constraint to the introduction and successful implementation of ICT in the health sector, and also in the work of Khazei and colleagues (2005) in their discussion of telehealth in Tanna Island, Vanuatu, and the stark reality that basic public health needs and infrastructure remain a higher priority than any telehealth or other e-Health applications. PATIS in Fiji (Kerrison 2004); the use of video-conferencing in the Marshall Islands (Callahan et al 2005); the scanning of death certificates (Gamage 2010) and use of SMS-based health promotion in Sri Lanka (Abusayeed 2010) all relied heavily on an adequate supporting infrastructure. PATIS has encountered issues with the reliability and quality of phone lines used to transmit data and an intermittent power supply. The limited infrastructure system in the Marshall’s ultimately led to the downfall of the video-conferencing project. Furthermore, without the relatively sophisticated infrastructure systems of Sri Lanka, scanning of death certificates and the use of SMS simply would not have succeeded.

**Human capacity and training**

A second key finding is the impact of human capacity and training, as any technology will be insufficient if people do not understand how to put it into effective use (BRIDGES 2010). Trained human resources for health are a major problem in healthcare systems in most developing countries, and particularly a problem in small Pacific nations (Chetley 2006). The limited human resources and capacity available in the Pacific region, both in terms of technical skills in how to use ICT, as well as high-level technical support skills to ensure set-up and maintenance, has resulted in a high reliance on external resources and experts (PIFS 2002). Such a reliance on external capacity drives ICT costs upwards, and also produces significant retention problems and a lack of locally-qualified personnel. However, it is not only the recipient country that needs capacity development and training in the use of ICT. As demonstrated in Vanuatu (Khazei et al 2010), international e-Health consultants must know what local resources are available and have an understanding of the conditions of the country they are providing information to (for example standard treatment protocols and availability of various drugs and diagnostics). Overall, while technology can provide a link to information and knowledge, the critical factor in all ICT initiatives is human resources and capacity (Rodrigues & Risk 2003; Keke 2007).

**Affordability**

The affordability and use of technology is another key issue to emerge from previous experiences with ICT in the Pacific. If an intervention is to succeed, people and organisations need to be able to afford to obtain and access the technology; however expensive hardware and the high cost of telecommunications and internet connectivity remains a major barrier in developing countries, especially in remote communities (BRIDGES 2010). While affordability represents an immediate problem, this will shift to issues of sustainability in the long-term, and as such, realistic choices about introducing costly ICT in poor communities must be made. If people and organisations cannot afford ICT now, then subsidised projects will not succeed if long-term steps are not taken to improve the economic situation (BRIDGES 2010). When planning ICT projects, there are often a large range of costs which are not considered in project proposals. These include initial costs such as infrastructure development (servers and networks), training and process change management and ongoing costs such as licence fees, technical support, system upgrades and ongoing training.

Bice and colleagues (1996) also discuss affordability issues in relation to ‘appropriate expenditures’: while it is common for the majority of funding to be allocated to the purchase of ICT equipment there are other important factors requiring funds such as training and education and maintenance. Other less visible issues related to affordability and cost relate to how to value and assess the cost of medical consultations and other services across the region.
Appropriateness

The appropriateness of the technology or equipment itself is the fourth key finding, and it covers a broad range of topics related to the actual item of technology. As an example, only a limited number of ICT software applications have been developed in languages other than English. This is an especially important barrier in countries with small sub-populations who speak a number of different local dialects, as working in the field of ICT may require considerable working knowledge of a common language (such as English) (Bice et al 1996). If ICT are to be meaningful, they must be locally relevant, and this extends to educational materials, health information and environmental data produced through e-Health initiatives (BRIDGES 2010). Electronic equipment must be suited to a tropical climate (including high humidity and sand/dust contamination) (Khazei et al 2005). The example of telepathology in the Solomon Islands demonstrates the difficulty in replacing specialised equipment, especially in remote and isolated areas. Furthermore, the video-conferencing phones used as part of the e-Health project in the Marshall’s were discontinued, and the use of Rapid SMS in Vanuatu encountered major issues when over 100 mobile phones were stolen and could not be replaced easily.

EVALUATION TOOLS, METHODOLOGIES AND FRAMEWORKS

A number of evaluation tools, methodologies and frameworks have been developed to address a seemingly contradictory situation (see Drummond et al 2008; Kazanjian & Green 2002; Wotton 2009; Chan & Kaufman 2010; Ruder et al 2008). On the one hand, there are a host of academic articles and agency reports promoting the substantial contribution of ICT to improved health care in developing countries. While on the other hand, a solid evidence-base supporting such claims remains absent. Frameworks offer guidance on the technology selection process, and help to both conceptualise a problem and identify suitable approaches for addressing it. In this context, a technology selection framework facilitates decisions pertaining to the development or acquisition of technology; a difficult task considering the knowledge needed to guide such initiatives is often not available (Chan & Kaufman 2010). Overall, selection frameworks assist by reducing the amount of trial and error and wasted resources in e-Health interventions, through focussing on a wide range of factors including infrastructure support, workforce skills, accessibility and affordability of equipment, cultural relevance and perceived value of ICT in healthcare (Chan & Kaufman 2010).

Health Technology Assessments (HTA) refer to real-world decisions on the value (in terms of benefits, risks and costs) of technology investments in health, including their validity, reliability and generalisability (Drummond et al 2008). Overall, a HTA is a ‘policy analysis, studying the medical, economic, social and ethical implications of development, diffusion and use of health technology’ (Drummond et al 2008: 245) concerned with answering ‘is the technology worth it’ (Figure 2).

Figure 2: Conceptual framework for the evaluation of health information technologies (adapted from Drummond et al 2008; Kazanjian & Green 2002)

The Real Access – Real Impact Criteria designed by BRIDGES (2010) offers a framework for the analysis of all issues around ICT access and use, including anticipating or detecting why certain e-Health projects have failed, and highlighting how and why other projects can succeed, as outlined below:

1. Physical access to technology
2. Appropriateness of technology
3. Affordability of technology and technology use
4. Human capacity and training
5. Locally relevant content, applications and services
6. Integration into daily routines
7. Socio-cultural factors
8. Trust in technology
9. Local economic environment
10. Macro-economic environment
11. Legal and regulatory framework
12. Political will and public support.

Overall, the Real Access – Real Impact Criteria provide us with an exceptionally detailed framework for assessing the application of ICT in healthcare among developing countries. The idea of using a framework to guide the selection of ICT is also mirrored in the work of infoDev. In 2006 infoDev published a framework on the role of ICTs in the health sector of developing countries (Chetley 2006). The framework remarks that while ICTs have the potential to improve the health and wellbeing of poor and marginalised populations, combat poverty and encourage sustainable development and governance, most e-Health initiatives have insufficient evidence to establish their relevance, applicability or cost-effectiveness. This makes it extremely difficult for the governments of developing countries to determine investment priorities. Eight constraints and challenges (The 8 C’s - connectivity; content; capacity; community; commerce; culture; cooperation; and capital) have been identified as important barriers to the introduction and successful implementation of ICT in the health sector of developing countries.

MATURITY MODELS

The concepts of ‘maturity’ and ‘adaption’ in Information Systems (IS) and Information Technology (IT) are well-known in the business literature, with early ‘maturity models’ dating back to the 1970s (Wetering & Batenburg 2009). Maturity in this sense refers to the state of an organisation’s effectiveness in performing tasks and how well organisational behaviours, practices and processes can impact on outcomes (Crawford 2006). Overall, maturity models reflect the characteristics of an organisation as they move through different stages in a change cycle, providing conceptual guidelines on essential requirements and components at each stage, including key success drivers and indicators (Duffy 2001; Kim & Grant 2010). In defining the different stages of development and growth, maturity models are able to analyse organisations; recognise when and why they should move forward; provide insight into the actions needed; and establish goals for achieving and measuring progress (Wetering & Batenburg 2009; Duffy 2001; Sharma 2008).

Due to their holistic nature maturity models are an important managerial tool, and while they have been used extensively in information system development, especially software development, they offer important insight into health information systems (Kim & Grant 2010; Wetering & Batenburg 2009; Crawford 2006). Sharma (2008) describes an ‘electronically immature healthcare organisation’ as one that is reactive, with personnel focussing on solving immediate crises; with no objective basis for judging product quality or solving process problems; and has unpredictable healthcare product quality. Further, Haux (2006) has proposed seven different stages in the development of HIS:

1. Shift from paper-based systems to computer-based processing and storage and increased data processing
2. Shift from local to global information system architectures
3. HIS used by professionals and patients/consumers
4. Data used for patient care and administration, and also increasingly used for healthcare planning and clinical research
5. Shift of focus from technical HIS problems to change management and strategic information management
6. Shift from alpha-numerical data to clinical images and data on a molecular level
7. Steady increase in new technologies for continuous monitoring of health status.

Each stage of a maturity model represents greater expectations and complexity of environments, as well as tracking improvement and transformation over time and the capabilities at each stage (Wetering & Batenburg 2009; Sharma 2008). While critiques of maturity models have highlighted the limitations of using a strictly linear assumption in regards
to system development (Kim & Grant 2010; Moon 2002), a key strength in such models is their ability to highlight the multiple stages in a change cycle, as well as the multiple factors involved (including human, technological, process and organisational) (Duffy 2001). This is of high relevance when considering ICT investments in health systems, as it is extremely difficult to ‘leapfrog’ one or two stages; often resulting in unsustainable development and the inappropriate use of technology.

**DISCUSSION**

Overall, information and communication technologies have a potentially major role to play in health information systems. Technology in healthcare can improve access for geographically isolated communities; provide support for healthcare workers; aid in data sharing; provide visual tools linking population and environmental information with disease outbreaks; and is an electronic means for data capture, storage, interpretation and management. Such possibilities are especially important in the Pacific; a region that is characterised by remoteness, dispersed and small total populations and limited human resource capacity.

However, key issues have emerged in the implementation of ICT in the region: telecommunications infrastructure remains a major limiting factor in the success of many ICT initiatives in the Pacific (and developing countries in general). It is vital that aspects such as electricity systems, phone lines and internet connectivity are taken into consideration before implementing any new technology. Furthermore, human capacity and training are fundamental aspects of any ICT initiative. The affordability of the technology (and use of it) must also be assessed in terms of initial and ongoing costs such as licence fees, maintenance and support costs. Any ICT initiative that is heavily reliant on external funding is unlikely to be sustainable over the long term. Additionally, the exceptionally high cost of many telecommunications services in the Pacific remain a significant limiting factor to their use. There are also important hidden costs associated with technology, including maintenance, upgrades and replacing broken equipment, which need to be assessed.

Judgements must be made on the appropriateness of the technology itself. Moreover, the tropical climate of the Pacific region is damaging to equipment, such as computer hard-drives that require climate-controlled and dust-free environments. Appropriateness also refers to the anticipated benefits of the technology in comparison to its costs. While ICT initiatives have the potential to support health information systems, any project or new policy must have an appreciation of the context and challenges of the implementation environment. These factors are highlighted in the numerous evaluation tools, methodologies and frameworks available on the appropriate and effective use of ICT in health. Overall, maturity models are a potentially effective tool that senior managers in health could use to assist them in making decisions on whether to invest in information and communications technology. Maturity models offer a means to classify different systems in terms of their current level of sophistication (in terms of human and technical capacity) and provide a pathway of development for health information systems in the region.

**Further research**

As discussed previously, the objective of this paper is to provide a common language for categorising and discussing HIS; summarise the benefits and opportunities of ICT in health; discuss the critical factors resulting in success or failure; and introduce evaluation frameworks and models used in ICT assessments. Results from the literature have highlighted the great diversity in ICT projects in the region, and also the great challenges in implementing appropriate, sustainable initiatives. Building from this work, a second paper will examine how maturity models and other tools may be able to assist senior managers in health in deciding on if an investment in ICT is both plausible and reasonable, and also how the investment should be made. It is envisioned that part of this research will include the development of a maturity model for health information systems in the Pacific region, to help developing countries ‘locate’ where their systems lie in the continuum of the management and use of information.
ANNEX 1 - METHODOLOGY

Stage one: Consultative meetings

Data was initially collected through two key regional consultative meetings. Both meetings provided the opportunity for knowledge and experience to be shared among a broad community of interested stakeholders, global experts and representatives from across the Pacific. The Pacific Health Information Network (PHIN) Meeting was held on 29 September – 2 October 2009 in Nadi, Fiji. The goal of the PHIN meeting was to provide an opportunity for networking and knowledge sharing for operational HIS staff on individual country activities, in the areas of HIS policy, mortality and morbidity coding, and the use of ICT in health. Following this meeting, the Pacific Health Information System Development Forum was held on 2-3 November 2009 in Brisbane, Australia. The goal of the forum was to identify and understand current practices and challenges within HIS in the Pacific region, to enable partner countries to actively contribute to, and build a common vision of how best to build capacity for HIS in the Pacific. Detailed information about the two meetings and the key findings can be found in Issues and Challenges for Health Information Systems in the Pacific, Working Paper Number 7, 2009 (available online at www.uq.edu.au/hishub).

A qualitative group methodology with key questions from the Health Metrics Network Frameworks and Standards for Country Health Information Systems (2008) was used to frame discussions throughout the two meetings. During the discussions held at the PHIN Meeting and Forum, a number of common issues and challenges for HIS in the Pacific emerged, covering:

- Improving data integration and sharing
  - Better use of technology to increase data sharing
- Increasing analytical skills among data producers
- The potential for regional approaches to HIS
  - Cost of information technology
- Strategies for advocacy for HIS
- The role of health surveys
- Use of institution-based data
  - Transmission of data in geographically isolated areas.

While a number of the issues and challenges are broadly related to the use of ICT, such as increasing the analytical skills of data producers through training in software applications and developing strategies for the advocacy of HIS that include the use of ICT, three challenges relate specifically to the use of technology in health. Results from these initial discussions provided the background and impetus for the final stage; a comprehensive literature review.

Stage two: Comprehensive literature review

The first part of the literature review aimed to address the following two questions:

1. How has information communication technology been used and could be used to successfully assist health service delivery?
2. What are success and failure factors investors should be aware of (e.g. software, costs, hardware, etc)?

After initially reviewing a number of key articles, a literature search strategy was developed using a combination of the following key words:

- “Information and communications technology” OR
- “Health information technology” OR ICT OR “Health information systems” OR “Health informatics”

AND
“e-Health” OR
“Electronic health record(s)” OR “Electronic medical records” OR “Electronic records” OR EMR OR EHR OR Ehealth OR Telehealth OR Telemedicine OR Teleradiology OR “Medical informatics” OR “Mobile phones” OR “Hand held computers” OR PDA.

These terms were searched alongside the following terms:

“Developing country” OR
“Developing nations” OR “Third world”

AND

“Pacific” OR
“Pacific nations” OR “Pacific region” OR Fiji OR Tonga OR Samoa OR (specific Island names).

No language restrictions were applied, although most databases or sources had an English-language focus. Databases accessed include: Medline, Science Direct, Scopus, Web of Science, PsycINFO, Dissertation & Theses Full Text (Proquest), Google Scholar, Google. Organisational websites such as The World Bank and World Health Organization were also accessed. Data sources included: bibliographies, mapping or scoping exercises, systematic reviews, research studies, review articles, policy discussions, case-studies with wider policy implications or discussion of lessons learned, published international agency and government policy statements, published editorial and opinion-based materials with policy implications.

The second part of the literature review was developed to investigate what tools, methodologies and frameworks are available to evaluate health information technologies. This had a number of sub-questions, including:

• How can you evaluate health information and communication technologies?
• What tools, methods and frameworks are available to evaluate health information and communication technologies?
• What tools, methods and frameworks are available to evaluate information and communication technologies in general?
• What health information and communication technologies have worked well? What have failed?
• What are the realities/practicalities of implementing health information and communication technologies in the Pacific?
• What factors might impact on the implementation of health information and communication technology?

The literature search strategy was developed using a combination of the following key words, and followed the same process as described above:

“Information and communications technology” OR
“Health information technology” OR ICT OR “Health information systems” OR “Health informatics”

AND

“e-Health” OR
“Electronic health record(s)” OR “Electronic medical records” OR “Electronic records” OR EMR OR EHR OR Ehealth OR Telehealth OR Telemedicine OR Teleradiology OR “Medical informatics” OR “Mobile phones” OR “Hand held computers” OR PDA

AND

“Health technology assessment” OR
Evaluation OR Assessment OR Tool OR Method(s) OR Approach OR Barrier(s) OR Challenges.
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