Developing integrated health information systems in low income countries: An enterprise architecture approach

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Prof. Dr. M. Spiess

Dekan

To my lovely wife Glory the love of my life

My daughter Orley, and my sons Harry and Larry

…. you kept me going when I had nothing left in me…..

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The image on the cover is a model developed at PATH (Program for Appropriate Technology in Health) with contributions from the author of this dissertation

Summary

In the last half-century the world has witnessed dramatic gains in health status. These are occurring in developing countries now but started in Europe and other wealthier countries around the global in the late 19th century and early 20thcentury. These improvements were partly attributed to increasing in education and income of the population which resulted in more hygienic living conditions and nutrition later in the 20th, expansion of health and public health services by governments and biomedical innovations.

Sub-Saharan Africa still carries most of the global burden of disease with low life expectancy at birth with majority of deaths occurring to children under the age of 5 years. Infectious diseases are the major contributors to the disease burden in sub-Saharan Africa that affect the poorest in addition to noncommunicable diseases. The health system is a major determinant in reversing this burden in sub-Saharan Africa. Health systems in sub-Saharan Africa are weak and need to cope with simultaneous communicable and noncommunicable epidemics. Health information systems play a significant role in steering health system strengthening and documenting progress as it provides reliable information on health determinants, health system performance and population health status. Despite its importance, health information systems in many developing countries are weak, fragmented and often focused exclusively on disease-specific programme areas. Integration of health information systems will provide the basis for public health professionals to look at the health system from different viewpoints.

Enterprise architecture (EA) is a management tool that provides means for aligning information systems with organisation's mission, goals and objectives. EA is used to develop a comprehensive description of all of the key elements and relationships of an organization and its alignment with an organization's mission, goals, and strategic objectives with information

systems. EA can be used as a method for designing health information systems in terms of a well defined set of building blocks, and showing how the building blocks fit together and how they communicate with each other. This research aims to study the potential of EA as a strategic methodology that can be used to systematically gather and document health information system requirements to design a unified comprehensive health information system that integrates data from diverse sources at all levels of the health system for localised evidence-based decision making and health systems strengthening.

This research used qualitative method to collect primary and secondary data. Primary research data was collected through in-depth interviews with key stakeholders and observation and discussions in workshops and meetings. Secondary research include desk research by searching for published and unpublished research outputs, white papers, reports, user manuals and training materials.

Gathering and documenting requirements and processes that facilitate systematic design and development of health information systems that are usable, integrated, interoperable and sustainable are practices neglected by Ministries of Health and donor partners in health systems strengthening. In response, this thesis presents original studies on the potential use of an EA approach to strengthen health information systems in low income countries.

EA is a systems science approach that is widely used in software design in developed countries. It is common to see, in developing countries, the application of EA to be focusing on developing eHealth or HIS architecture in silos with little attention paid its application in the context of the health system. This thesis shows developing countries would benefit more from EA by applying it to simplify the complexity of the health system through guiding a systems thinking approach to

describe processes, personnel, information systems, data and sub-systems their alignment and how they are all intended to complement health systems goals and strategic direction. In the process of developing EA developing countries should use the opportunity to reassess the current processes, indicators and data usage and take a decision to either eliminate processes that are no longer required or rationalise them.

Developing countries has realised the potential of ICT in improving healthcare delivery and availability of information for evidence decision making. Despite this realisation many HISs in developing countries are chaotic characterised by silo systems unable to communicate with each other. EA approach facilitates the design of integrated HISs by describing HIS in a more systemic holistic way.

Zusammenfassung

In den letzten fünfzig Jahren hat sich der Gesundheitszustand der Weltbevölkerung dramatisch verbessert. Während sich dieser Fortschritt heute vor allem auf Entwicklungsländer beschränkt, begann er in Europa und anderen wohlhabenden Ländern auf der ganzen Welt schon im späten 19. und frühen 20. Jahrhundert. Solche Verbesserungen sind teilweise der höheren Bildung und dem höheren Einkommen der Bevölkerung zuzuschreiben, welche hygienischere Lebensverhältnisse und Ernährungsgewohnheiten im 20. Jahrhundert zur Folge hatten, aber auch erweiterten Gesundheitsdiensten durch Regierungen und biomedizinischen Erfindungen.

Afrika südlich der Sahara trägt nach wie vor den grössten Teil der globalen Krankheitslast mit einer tiefen Lebenserwartung bei der Geburt und der höchsten Todesfallrate bei Kindern unter 5 Jahren. Infektionskrankheiten sind neben nichtansteckenden Krankheiten Hauptbestandteil der Krankheitslast, die die ärmsten in Afrika südlich der Sahara trifft. Das Gesundheitssystem ist ein bedeutender Einflussfaktor, wenn es um die Reduktion dieser Krankheiten in Afrika südlich der Sahara geht. Gesundheitssysteme in Afrika südlich der Sahara sind schwach und kämpfen gleichzeitig mit Epidemien ansteckender und nichtansteckender Krankheiten. Gesundheitsinformationssysteme spielen eine wichtige Rolle bei der Verbesserung der Gesundheitssysteme und helfen, den Fortschritt zu dokumentieren, da sie verlässliche Informationen zu Gesundheitsfaktoren, Effizienz des Gesundheitssystems und den Gesundheitszustand der Bevölkerung liefern. Obwohl sie so bedeutend sind, sind Gesundheitsinformationssysteme in vielen Entwicklungsländern schwach, bruchstückhaft und oft nur auf bestimmte betroffene Gebiete beschränkt. Die Vernetzung der Gesundheitsinformationssysteme würde es für Angestellte des Gesundheitswesens ermöglichen, das Gesundheitssystem von verschiedenen Blickwinkeln her zu betrachten.

„Enterprise architecture“ (EA) ist ein Führungsinstrument, das es ermöglicht, Informationssysteme mit dem Auftrag und den Zielvereinbarungen einer Organisation zu vergleichen. EA entwickelt eine umfassende Beschreibung aller Schlüsselelemente und Beziehungen einer Organisation, um das Informationssystem auf den Auftrag und die strategischen Ziele der Organisation auszurichten. EA kann zur Entwicklung von Gesundheitsinformationssystemen mittels genau definierter Bausteine verwendet werden und zeigen wie die Bausteine zusammenpassen und miteinander in Verbindung stehen. Die vorliegende Forschungsarbeit untersucht die Möglichkeiten von EA als strategische Methode zum systematischen Sammeln und Dokumentieren von Anforderungen eines Gesundheitsinformationssystems. Dadurch soll ein umfassendes, einheitliches Gesundheitsinformationssystem entwickelt werden, das Daten von verschiedenen Quellen auf allen Stufen des Gesundheitssystems zusammenführt, um eingegrenzte, evidenzbasierte Entscheidungen und die Stärkung des Gesundheitssystems zu fördern.

In dieser Forschungsarbeit wurden qualitative Methoden verwendet, um primäre und sekundäre Daten zu sammeln. Primäre Daten wurden durch Tiefeninterviews mit den wichtigsten Interessenvertretern erhoben, sowie anhand von Beobachtungen und Diskussionen in Workshops und Sitzungen. Die sekundäre Datenerhebung beinhaltet Schreibtischarbeit wie die Suche nach publizierten und nicht-publizierten Forschungsergebnissen, Weissbüchern, Berichten, Bedienungsanleitungen und Schulungsunterlagen.

Das Sammeln und Dokumentieren von Vorgaben und Prozessen, die das systematische Designen und Entwickeln von Gesundheitsinformationssystemen, die anwendbar, umfassend, kompatibel und nachhaltig sind, vereinfachen, wird von den Gesundheitsministerien und Geberpartnern bei der Stärkung der Gesundheitssysteme vernachlässigt. Die vorliegende Arbeit präsentiert

Originalstudien zur möglichen Anwendung von EA, um Gesundheitsinformationssysteme in einkommensschwachen Ländern zu stärken.

EA ist eine systematische, wissenschaftliche Herangehensweise, deren Anwendung im Softwaredesign in entwickelten Ländern weit verbreitet ist. Üblicherweise wird in Entwicklungsländern EA bei der Entwicklung von eHealth oder der Architektur von Gesundheitsinformationssystemen in Silos angewendet, wobei der Verwendung im Zusammenhang mit dem Gesundheitssystem wenig Beachtung geschenkt wird. Die vorliegende Arbeit zeigt, dass Entwicklungsländer mehr von EA profitieren würden, wenn sie es zur Vereinfachung von Komplexitäten im Gesundheitssystem anwenden würden. Durch einen „Systems Thinking"-Ansatz könnten Prozesse, Personal, Informationssysteme, Daten und Subsysteme beschrieben und angepasst werden, um Ziele und strategische Richtung des Gesundheitssystems zu ergänzen. Während der Erarbeitung des EA sollten Entwicklungsländer die Gelegenheit nutzen, ihre Prozessabläufe, Indikatoren und Datenanwendungen zu überdenken, und überholte Prozesse zu eliminieren oder zu rationalisieren.

Entwickelte Länder haben das Potential der Informations- und Kommunikationstechnologie erkannt, um die Gesundheitsvorsorge und die Verfügbarkeit von Informationen für evidenzbasierte Entscheidungen zu verbessern. Trotz dieser Erkenntnis sind viele Gesundheitsinformationssysteme in entwickelten Ländern chaotisch und zeichnen sich durch Silosysteme aus, die nicht interagieren können. Der EA Ansatz vereinfacht den Aufbau von integrierten Gesundheitsinformationssystemen in einer systematischeren, umfassenderen Art.

Abbreviations

AFRO	WHO African Regional Office
AIDS	Acquired Immune Deficiency Syndrome
CCHP	Comprehensive Council Health Plan
CHMT	Council Health Management Team
CRDM	Collaborative Requirements Development Method
DHA	District Health Accounts
DHS	Demographic and Health Surveillance
DPLO	District Planning Officer
DSS	Demographic Surveillance Sites
EA	Enterprise Architecture
FBIS	Facility Based Information System
GAVI	Global Alliance for Vaccines and Immunisation
GFATM	The Global Fund to Fight AIDS, Tuberculosis and Malaria
GHI	Global Health Initiative
H-ADM	Health Architecture Development Method
HDSS	Health and Demographic Surveillance System
HEA	Health Enterprise Architecture
HIS	Health Information Systems
HIV	Human Immunodeficiency Virus
HMIS	Health Management Information System
ICT	Information and Communication Technology
IDSR	Integrated Disease Surveillance and Response
IT	Information Technology
LGA	Local Government Authority
LGRP	Local Government Reform Program
MDG	Millennium Development Goals
MESI	Monitoring and Evaluation Strengthening Initiative
MoFEA	Ministry of Finance and Economic Affairs
MoHSW	Ministry of Health and Social Welfare

NCD	Non-communicable diseases
NETTS	National Expansion of TEHIP Tools and Strategy
NFT	National Facilitation Team
NIMR	National Institute for Medical Research
NSS	National Sentinel System
PATH	The Program for Appropriate Technology in Health
PHC	Primary Health Care
PMORALG	Prime Minister's Office Regional Administration and Local Government
SAVVY	Sample Vital Registration with Verbal Autopsy
SPD	Sentinel Panel of Districts
SSA	Sub-Saharan Africa
TEHIP	Tanzania Essential Health Intervention Project
TOT	Training of Trainers
UCC	University Computing Centre
WHO	World Health Organisation
ZTC	Zonal Training Centres

Chapter 1

Introduction

1 Introduction

"There are four revolutions currently underway that will transform health and health systems. These are life sciences, ***information and communication technology****, social justice and equity; and systems thinking to transcend complexity" Julio Frenk– 2008*

In the last half-century the world has witnessed dramatic gains in health status. These are occurring in developing countries now but started in Europe and other wealthier countries around the global in the late 19th century and early 20thcentury(Kaula et al. 2009;World Bank 1993). These improvements were partly attributed to increases in income of the population which resulted in more hygienic living conditions and nutrition later in the 20th century. Other reasons for these improvements included increasing education, expansion of health and public health services by governments and biomedical innovations, for example, vaccines and antibiotics. These improvements resulted in significant gains in the well-being and reduced economic burden(World Bank 1993).

Sub-Saharan Africa (SSA) carries 24% of global burden of disease despite having only 14% of global population (WHO AFRO 2011). In SSA life expectancy at birth was 53 years in 2008 with almost 20% of deaths occurring to children under the age of 5 years (WHO 2011). Despite dramatic reduction of child mortality rate from 180 per 1,000 live births in 1990 to 140 per 1,000 live births in 2009 these rates are still unacceptably high and most of the causes are preventable or treatable (United Nations 2011). Neonatal mortality remains high and is not declining. In 2009 it was reported that 40% of all under five deaths occur in neonatal period(WHO 2011). Infectious diseases, including tuberculosis, malaria and HIV/AIDS, account for almost 80% of the disease burden mainly affecting the poorest(WHO 2004). The Millennium Development Goals (MDG) Report of 2011 reported that almost 90% of all malaria deaths occur in Africa.

SSA remains highly affected by HIV/AIDS,in2009 it accounted for an estimated 69% of new global HIV infections and causes 75% of global AIDS deaths(United Nations 2011).In addition to communicable infectious diseases, noncommunicable diseases (NCD) are increasing becoming a major burden in SSA (Dalal et al. 2011;Holmes et al. 2010). The burden of chronic NCD, such as diabetes, hypertension and cancer has been increasing rapidly in SSA where in 2004 it is estimated that 25% of a ll deaths were caused by NCD (Dalal, Beunza, Volmink, Adebamowo, Bajunirwe, Njelekela, Mozaffarian, Fawzi, Willett, Adami, & Holmes 2011).

Health systems in SSA need to cope with simultaneous communicable and noncommunicable epidemics. The health system is a major determinant in reversing this burden in SSA. Despite its importance health systems in developing countries remain weak and too fragmented to be able to deliver the required interventions and quality of service to those in need (Travis et al. 2004). It is widely known that there is a need to strengthen health systems in SSA in order for these countries to be able to deliver high quality and equitable health services, and be able to generate information for evidence based decision making(de Savigny and Adam 2009;Swanson et al. 2010;Travis, Bennett, Haines, Pang, Bhutta, Hyder, Pielemeier, Mills, & Evans 2004;WHO 2000;WHO 2004).Health information systems play a significant role in steering health system strengthening and documenting progress as it provides reliable information on health determinants, health system performance and population health status(de Savigny & Adam 2009)

1.1 Health Systems

Compared to other social systems a health system faces particular challenges, including its complexity, high costs associated with the health care and the threat to people's health and socio-economic well-being. The health system has to deal with wider variety of problems, from relief

of pain and treatment of diseases and emotional disorders to advice that in the past people used to seek from other sources, for example on diet and sexual behaviour(WHO 2000).

The World Health Report 2000 produced by WHO provided for the first time a framework to help countries to understand and measure the performance of their health systems. This report was the first attempt by WHO to analyse the role of health systems and suggest how to make them more efficient, accessible and responsive to everyone regardless of their location or social economic status(WHO 2000).The report presented the first definition of the health system and defined the health system as "*all activities whose primary purpose is to promote, restore or maintain health*". In this report the WHO has identified the four functions of a health system: 1) stewardship; 2) financing; 3) resources generation; and 4) service provision and mentioned three fundamental objectives of the health system: health improvement; responsiveness to expectation; and financial protection against ill-health(WHO 2000). Health information systems despite the significant role they play in generating evidence used to steer and measure how far a health system can meet those objectives, was missing from the 2000.

In 2007, WHO released a Framework for Action which expanded the definition in The World Health Report 2000 to "*a health system consists of all organisations, people and actions whose primary intent is to promote, restore or maintain health*"(WHO 2007).The Framework identified six building blocks that make up the health system based on the function defined in the WHO report of 2000. The six building blocks are: leadership and governance (stewardship); financing; information; health workforce; medical products, vaccines and technologies; and service delivery (WHO 2007). The building blocks, which this time included information, provide a convenient way of exploring the health system and identify important attributes essential to the strengthening of the health system (See Figure 1-1)

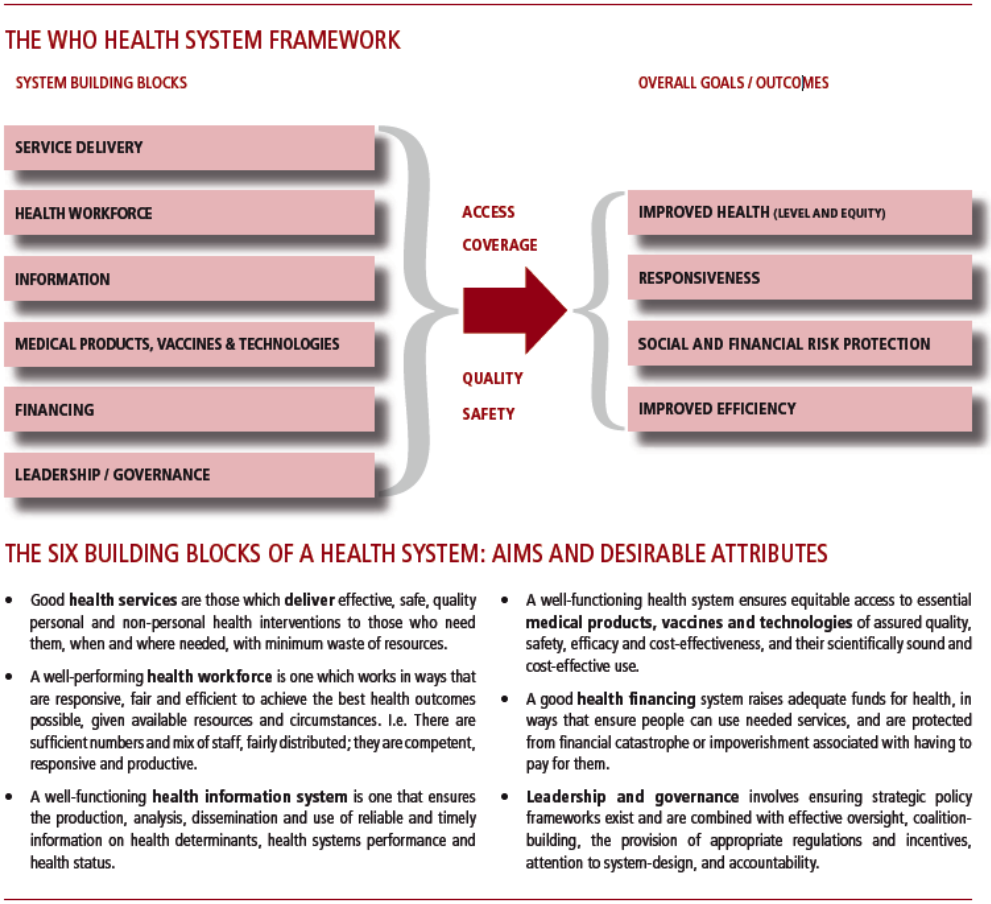


Figure 1-1: WHO Health System Framework Building Block

(Extracted from WHO 2007 - Everybody's business: strengthening health systems to improve health outcomes.)

In 2000, the World Health Report 2000 reported the enormous gap between the potential of health systems and their actual performance despite the existence of interventions that have a potential of reversing the spread of epidemics and saving lives at reasonable cost (WHO 2000). It has been recognised that public expenditure in health does not necessarily translate into improved health status (Filmer and Pritchett 1999). Instead strengthening the health system may achieve better health outcomes than increasing financial investment into fragile health system(de Savigny & Adam 2009;Frenk 2010;Nsubuga et al. 2010;Swanson, Bongiovanni, Bradley, Murugan, Sundewall, Betigeri, Nyonator, Cattaneo, Harless, Ostrovsky, & Labont 2010;Travis,

Bennett, Haines, Pang, Bhutta, Hyder, Pielemeier, Mills, & Evans 2004). As shown in Figure 1-2, two countries with almost Swaziland and Maldives with almost similar income per capita have very different life expectancy Swaziland with life expectancy of 48 years compared to Maldives with 77 years life expectancy. Also the figure shows the difference in income per capita between Nicaragua and Kuwait countries with very different income per capita but they have the same life expectancy of 74 years. The assumption is that the higher the income per capita the higher the health expenditure and the better the health system the higher the life expectancy.

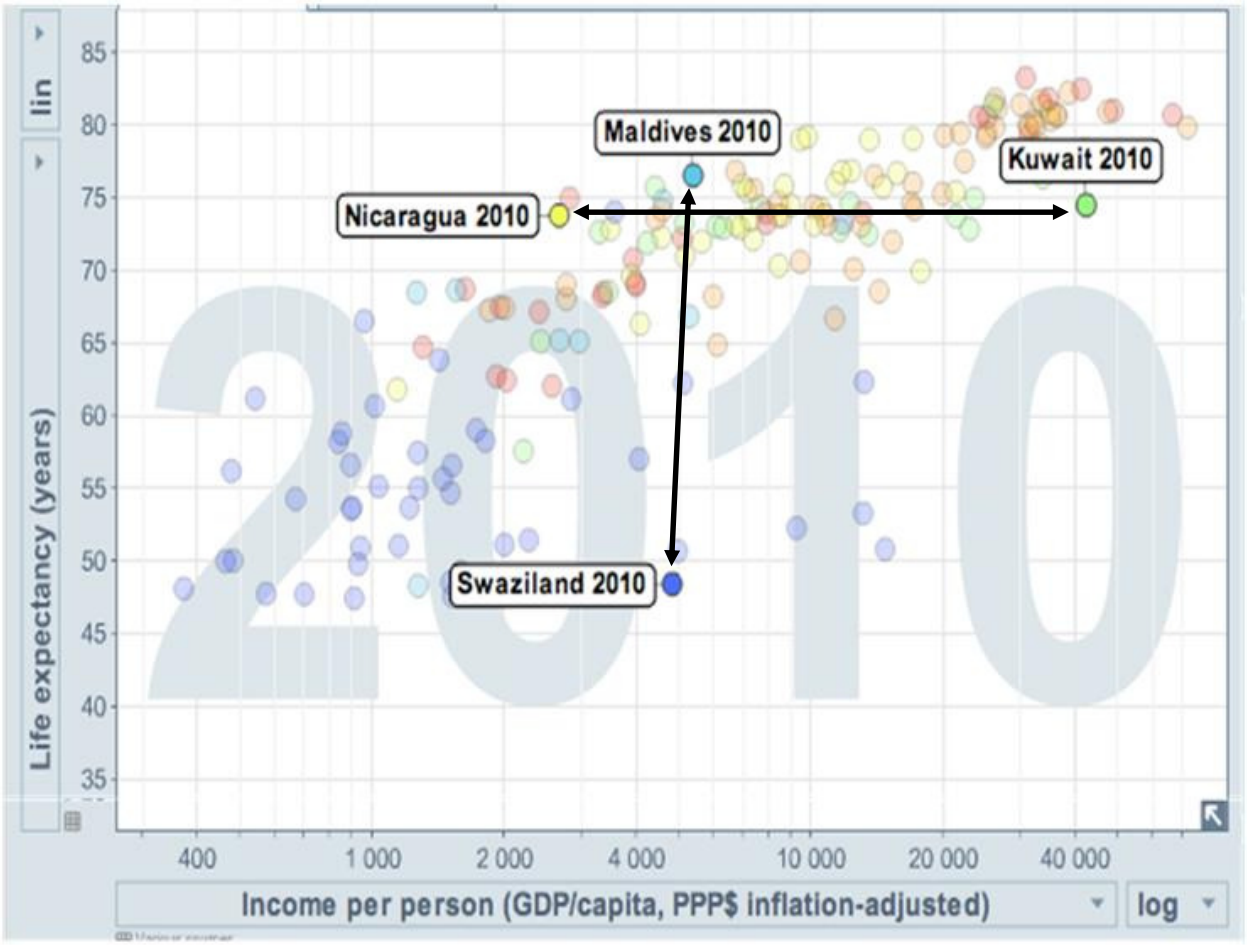


Figure 1-2: Life expectancy vs income per capita (2010)

Global Health Initiatives (GHI), such as Global Alliance for Vaccines and Immunization (GAVI), Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) and the World Bank,

are now investing in health systems strengthening as they see it as essential to improve population health and attaining MGDs (Balabanova et al. 2010;de Savigny & Adam 2009;Sundewall et al. 2011;Swanson, Bongiovanni, Bradley, Murugan, Sundewall, Betigeri, Nyonator, Cattaneo, Harless, Ostrovsky, & Labont 2010;Warren 2011). However, the term health system strengthening remains a vague concept with no clear definition and consensus on the strategies for health system strengthening (Marchal et al. 2009;Sundewall, Swanson, Betigeri, Sanders, Collins, Shakarishvili, & Brugha 2011;Swanson, Bongiovanni, Bradley, Murugan, Sundewall, Betigeri, Nyonator, Cattaneo, Harless, Ostrovsky, & Labont 2010).

Systems thinking originated in early 1920s in fields such as biology and engineering and applied in fields like computing (Rothschild et al. 2005). Systems thinking is an approach to problem solving that views "problems" as part of a wider dynamic system(de Savigny & Adam 2009). Health systems is a complex system and WHO Health System Framework provide a convenient way of simplifying this complexity by describing it as consisting of six building blocks, of which their interaction and relationship to each other is what constitutes a system instead of each building block as its own sub system (de Savigny & Adam 2009). The systems thinking approach can be used in strengthening the health system by providing a way of diagnosing and discovering system problems and provide a practical guide toward finding system solutions to systems problems(Haines 2007). The Flagship report from the Alliance for Health Policy and Systems Research pointed out that it is crucial to understand the relationships and the dynamics of the building blocks when designing and evaluating system level interventions of health systems. It put forward "Ten Steps of Systems Thinking" in order to provide guidance on applying system thinking in strengthening health systems(de Savigny & Adam 2009).

1.2 Health Information Systems

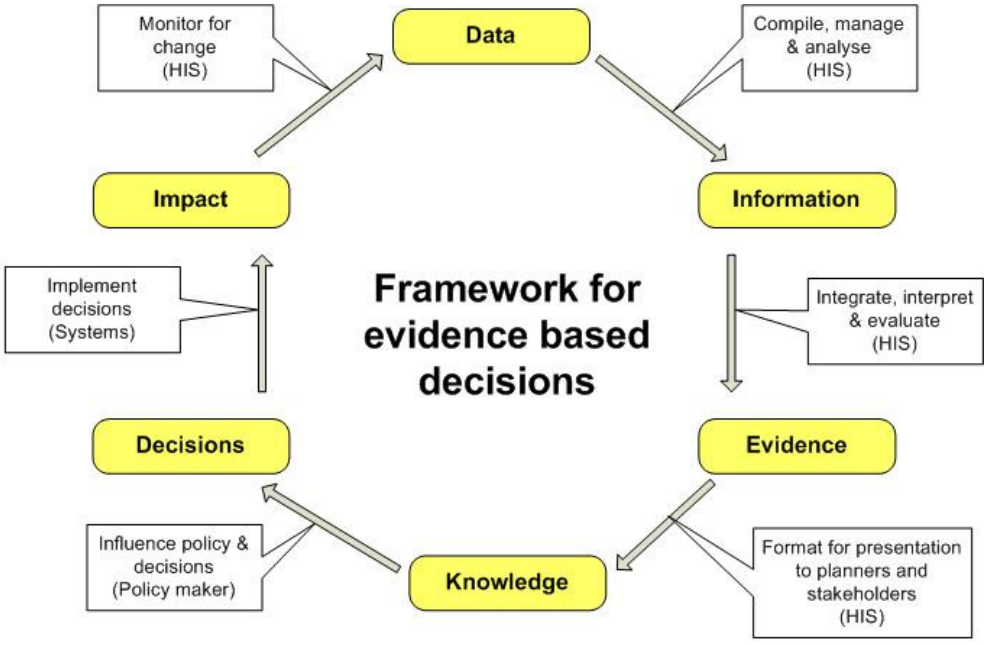
"It is not because countries are poor that they cannot afford good health information;

it is because they are poor that they cannot afford to be without it"

Health information systems (HIS) are critical in making sure accurate health information is timely and available to decision makers to enable them to allocate resources appropriately, track progress and performance of the health system, evaluate impact of interventions and make strategic decisions that may save lives and enhances population health(Stansfield et al. 2008). However, HIS in many developing countries are weak, fragmented and are often focusing on vertical disease-specific program monitoring and evaluation but inadequate in providing information needed to facilitate evidence-based decision making(AbouZahr and Boerma 2005;de Savigny and Binka 2004;HMN 2008;Lippeveld et al. 2000).The demand for a better evidence to measure progress towards MDGs and performance based financing required by GHI has resulted in increasing demand of reliable health information from already overwhelmed HISs unable to cope with existing demand (Braa et al. 2007;Lippeveld, Sauerborn, & Bodart 2000).

In health systems strengthening, one of essential foundations is reliable and timely information of health information(HMN 2008). For this to be achieved there is a need to have a stronger health information system described as *"an integrated effort to collect, process, report and use health information and knowledge to influence policy-making, programme action and research*"(Lippeveld 2001).The description above emphasises the important point that HIS is not about collecting and storing of data. For health information to be useful there is no shortcut, the collected data needs to be organised and analysed for it to become information and then transformed to evidence which will eventually be transformed and become new knowledge in

order to influence decisions(See Figure 1-3) (de Savigny & Binka 2004). These are all functions of the HIS.



Modified from: de Savigny D, Binka F: Monitoring future impact on malaria burden in Sub-Saharan Africa. *Am J Trop Med Hyg* 2004, 71: 224-231.

Figure 1-3: Framework for evidence based decisions

HIS should be able to facilitate localised evidence-based decision making at all levels of the health system from the point of collection. Most often lower levels of the health systems are only seen as data providers instead of active consumers(Sahay and Lewis 2010).Health information systems face many problems that hinder their effectiveness. As a result "*they are seen as management obstacles rather than as tools*"(Lippeveld, Sauerborn, & Bodart 2000). Some of these problems are:

- Fragmentation: caused by donor agencies and national programs developing their own health information systems to fulfil their needs;

- Lack of standardisation: caused by the lack of agreed standardised health information system framework that should be used as a guide in the development of health information systems;
- Poor data quality: caused by different issues such as lack of technical skills required collecting the required data and analysing the data as well as motivational issues.
- Lack of utilisation: no transformation of data to information for use in decision making
- Overlap and duplication

1.3 Health Information Systems Reforms in Developing Countries

Most health information systems, in both developed and developing countries, in practice are complex and fragmented(AbouZahr & Boerma 2005). This is caused by the way they have been developed and evolved over time, in piecemeal fashion, in response to donor pressure or requirements of disease specific initiatives(HMN 2008). The end result is often an HIS that is highly complex, dysfunctional and non-interoperable, incapable of responding to the basic needs of the health system and its stakeholders. Health information systems reform is needed if they are to become functional and capable of linking information from different sources in a meaningful and effective way.

HIS is an integral part of the overall health system so reforms in HIS should be linked with health systems reforms and vice versa(Lippeveld, Sauerborn, & Bodart 2000). Health sector reforms have been taking place in developing countries in the 1990s and early 2000s (Lambo and Sambo 2003). In almost all these developing countries reforms in the health sector did not go together with serious efforts to reform and strengthen health information systems. For example decentralisation of the decision making to the districts was not followed by enhancement in the

capacity for the districts to generate and analyse data at the district level (AbouZahr & Boerma 2005). In order for health information systems reforms to be successful they should be integrated into broader efforts to strengthen the overall health system involving stakeholder from all levels of the health system.

The Health Metrics Network (HMN) was launched in 2005 to help countries and partners improve health by improving the availability and use of health information to support evidence-based decision-making at country level and below. HMN is the first global health partnership that focuses on two core requirements of health system strengthening in low and middle-income countries: First, to address a vision of an information system that addresses the health system and its component parts as a whole, rather than specific diseases and programs; and second, to concentrate efforts on strengthening country leadership for health information management and use. In order to meet these requirements and advance global health, it has become clear that there is an urgent need to coordinate and align partners around a harmonized plan to develop country health information systems(AbouZahr & Boerma 2005;Stansfield et al. 2006;Stansfield, Orobaton, Lubinski, Uggowitzer, & Mwanyika 2008). Using its global acceptance HMN has a potential to use both top-down and bottom-up approaches in making sure that globally standardised health information system frameworks are developed, agreed and tested(HMN 2008).

According to the HMN Framework (2008), the goal of HMN is to increase the availability, quality, value and use of timely and accurate health information by catalyzing the joint funding and development of country health information systems. It is intended that this goal should be achieved by:

- Developing and elaborating upon the harmonized HMN Framework for country health information systems.
- Supporting developing countries in adapting and applying the HMN Framework to improve their health information systems; providing technical support; and acting as a catalyst to secure funding.
- Improving the quality, value and use of health information by developing policies and offering incentives to enhance the dissemination and use of such data at local, regional and global levels.

One of the main functions of the health information system is to bring together data from different sources catalytically, to share and disseminate the insights resulting from integration to the many different audiences and to ensure rational, effective and efficient use of health information(HMN 2008;WHO 2005). Bringing together data from different sources should enable decision makers to use information generated by other sectors to identify factors, outside the health sector, affecting the health of the population.

Integration has been an important aspect of information systems for decades. Lack of integration of different information systems makes the ability to make coordinated and sector-wide responses to business problems almost impossible(Goodhue et al. 1992). According to Goodhue et al. (1992), standardisation of data definitions and structures through the use of common field and record definitions, structures and rules is essential for data integration. In the commercial world there have been several attempts to look for ways to integrate fragmented information systems through defining common standards for common services, shared information storage, common terminologies and shared technical platforms(Sahay et al. 2007). However, until now

there has never been a single solution that is acceptable to all and the issue of integration remains elusive for health information systems (Chilundo and Aanestad 2004).

1.4 Enterprise Architecture

The enterprise architecture field started in 1987 after the publication "A Framework for Information System Architecture" in the IBM Systems Journal(Zachman 1987). This Framework described a new way of simplifying the increasing size and complexity of the implementation of information systems that came about due to advancements of technology. In this framework, Zachman suggested the use of a "logical construct (or architecture)" for defining and controlling interfaces and integration of different components of the system. Zachman pointed out that decentralisation of computing facilities without architecture results in chaos so the concept of information system architecture is becoming a necessity in order to establish order and control in the investments of information systems (Zachman 1987). The approach that Zachman originally described as an information system architectural framework is what today is known as enterprise architecture (Sessions 2007).

The need for enterprise architecture came about as businesses were looking for a way to deal with major problems in Information Technologies (IT). Some of these problems were increasing complexity of information technology systems and difficult in getting better return on IT investment (Jonkers et al. 2006;Sessions 2007;Urbaczewski and Mrdalj 2006;Winter and Fischer 2007;Zachman 1987). According to Sessions (2007) "*The more complex the system, the less likely it is that it will deliver maximum business value. As you better manage complexity, you improve the chances of delivering real business value*".

Enterprise architecture (EA) is a management tool that provides means for aligning information systems with organisation's mission, goals and objectives (Armour et al. 1999;Harmon 2003;Ross et al. 2006). It is used to produce a comprehensive description of all of the key elements and relationships of an organization (Spewak 1993) and its alignment with an organization's mission, goals, and strategic objectives with information systems (Harmon 2003;Ross, Weill, & Robertson 2006).EA can be used to describe the methods for designing health information systems in terms of a well defined set of building blocks, and showing how the building blocks fit together and how the communication between the building blocks can be achieved. Since its development in 1984 the EA approach has been applied by many companies, governments and other institutions worldwide in order to improve their business process, e.g. US Department of Defence, Massachusetts Institute of Technology, commercial firms like BP (British Petroleum), Intel and Volkswagen. Global organizations such as the World Bank are viewing EA as a way of enabling broad reforms in the public sector in developing countries especially in eGovernment(World Bank 2008).

EA approach can be used to simplify the complexity of health information systems by allowing for important interrelationships to be identified, including which components need to be aligned to which parts and in so doing reduce the risks and incentives of fragmentation, duplication, and lack of interoperability. Furthermore, insights from governments and commercial organizations have shown that well-developed enterprise architectures reduce the risk of costly mistakes from applying diverse information and communication technologies in an unplanned and unstructured manner. Broadly the government sector has emerged as one of the largest adopters of enterprise architecture while public health has yet to really benefit from this trend(Stansfield, Orobaton, Lubinski, Uggowitzer, & Mwanyika 2008).

There are a number of frameworks that are in use today but the most commonly used are (Sessions 2007); The Zachman Framework for Enterprise Architecture, The Federal Enterprise Architecture Framework (FEAF), The Gartner Methodology and The Open Group Architectural Framework (TOGAF). These methodologies were designed to address specific needs in developed world although they may overlap or address similar views (Urbaczewski & Mrdalj 2006). These frameworks are in their initial stages of being used in low income countries.

The Zachman Framework for Enterprise Architecture: Zachman framework first published in 1987 and is considered as one of the pioneers of enterprise architecture(Urbaczewski & Mrdalj 2006;Zachman 1987). The Zachman framework provides a way of organising artefacts (design documents, specifications and models) in two dimensions. The first dimension is based on six perspectives or views: Planner, Owner, Designer, Builder, Subcontractor, and User. The second dimension is based on the descriptive focus of the artefacts: what, how, where, who, when, why(Sessions 2007;Urbaczewski & Mrdalj 2006). Zachman does not provide a step-by-step process for creating a new architecture (Sessions 2007).

The Federal Enterprise Architecture Framework (FEAF): This framework was first published in 1999 by the US Federal Chief Information Officers Council. FEAF was developed in response of Clinger-Cohen Act of 1996, which directed the development and maintenance of Federal Enterprise Architecture to maximize the benefits of IT within the US Government(The Chief Information Officer Council 1999). FEAF took a perspective that an enterprise is built by segments and a segment is a major line-of-business functionality. These segments are developed individually and considered to be their own enterprise within Federal Enterprise (Urbaczewski & Mrdalj 2006). There are two types of segments; core-mission-area segments and business-services segments. FEA is considered as the most complete of methodologies as it has both

comprehensive way of organising artefacts like Zachman and an architecture development process like TOGAF (Sessions 2007) .

The Gartner Methodology: is an enterprise architectural practice used by Gartner one of the best known IT research and consulting companies in the world (Sessions 2007). Gartner believes success in enterprise architecture is about bringing together business owners, information specialists and technology specialists and unify them behind a common vision that drives business value(Sessions 2007). Gartner view enterprise architecture as a strategy and not engineering and the most important thing to them is where an organisation is going and how it will get there.

The Open Group Architectural Framework (TOGAF): TOGAF was first developed in 1995 and it is now in its 9th edition. TOGAF is publicly available and free to use. The most important part of TOGAF is its Architectural Development Method which is a process for creating architecture(The Open Group 2010). TOGAF is viewed as complementing Zachman by providing a process for creating artefacts that you can categorise using Zachman (Sessions 2007). TOGAF divided and enterprise architecture into four categories;

1. **Business architecture** - describes the processes the business uses to meet its goals
2. **Application architecture** - describes how specific applications are designed and how they interact with each other.
3. **Data Architecture** - describes how the enterprise data sources are organised and accessed
4. **Technical Architecture** - describes the hardware and software infrastructure that supports applications and their interactions

Developing countries are now using the enterprise architecture approach to design and implement their health information systems. Different countries are in various stages of developing their health enterprise architecture with the aim of identifying and describing different components of their health information systems, their relationships and how information can be shared between them.

1.5 eHealth

eHealth is about harnessing the power of ICT to improve the health system. In this work eHealth is defined as *"the use of information and communication technologies (ICT) in health care delivery and public health"*. There is no universally accepted definition of the term eHealth (Eysenbach 2001;Oh et al. 2005;Pagliari et al. 2005). However, most definitions include the concept of applying electronic technology in health (Bates and Wright 2009;Drury 2005;Gerber et al. 2010;Mitchell 1999;Oh, Rizo, Enkin, & Jadad 2005;Pagliari, Sloan, Gregor, Sullivan, Detmer, Kahan, Oortwijn, & MacGillivray 2005). In these definitions some viewed technology as a tool and others as an instance of eHealth itself, but it is clear that eHealth is more than a mere technological development (Eysenbach 2001;Pagliari, Sloan, Gregor, Sullivan, Detmer, Kahan, Oortwijn, & MacGillivray 2005).

The term eHealth has been in use since 1999, highly influenced by the surging interest in the field of eCommerce (Mitchell 1999). The need for a new term came after it was recognised that telemedicine, remote diagnosis and treatment of patients by means of ICT(BASHSHUR 1995), as the use is more cost-effective if it is part of an integrated telecommunication and information technology in the heath sector(Della Mea 2001). The term eHealth then started to be used to "describe the increasing use of electronic communication in the health sector" (Mitchell 1999).

eHealth is seen as one of the factors that have a potential of improving the health of the population and the health system (Bates & Wright 2009;Blaya et al. 2010;Chetley 2006;Drury 2005;Kirigia et al. 2005;Oh, Rizo, Enkin, & Jadad 2005;World Health Organisation 2006). eHealth provide means of making sure that the right information is available to the right person, at the right place and at the right time for evidence-based decision making. Most often eHealth is used to refer to application of ICT to the healthcare sector, where it is perceived that quick wins can be achieved, instead of taking systemic view that may bring reforms to the health system(International Telecommunication Union 2008).

1.6 Tanzania's Health Systems

1.6.1 Health systems strengthening

The health sector in Tanzania has gone through four waves of reforms and is presently in a fifth wave. The first wave was pre-independence between 1923 and 1960. There was no political administrative promotion of equity in financing and provision of health services and resource allocation. The inequity was due to the geographical location especially rural or urban area(Semali 2003). The second wave undertaken post-independence of Tanganyika in 1961, which was the beginning of decentralisation. Local governments were made responsible for revenue collection and provision of health services. Inequity in health financing remained an issue in this wave caused by the decline of budget allocation to health(Semali 2003). In the third wave, which took place in 1972, the Government of Tanzania, following the advice of McKinsey and Co. who were commissioned to study the government administration, decided to abandon decentralisation and instead implement deconcentration(Nyerere 1972).Central government took over some functions of the local government including health facilities and the personnel

(Government of Tanzania 1982a;Government of Tanzania 1982b). As a result there was an overlap of local and central government functions (Semali 2003). The fourth wave, which started 1993, saw the return to decentralisation, after it was observed that the central government was unable to provide health services in rural areas (Chiduo 2001). In order to increase efficiency and bring decision making closer to the communities and improve accountability of the health services it was decided to re-decentralise in order to give budgetary control to the district level. The central government remained as a facilitator and key player in policy formulation, regulation and quality control (Chiduo 2001). The fourth wave came with a goal of improving the health and well being of all Tanzanians and further deepening of the decentralisation which started in wave three (Mapunda 2001). The government allocation to health declined further and has an impact on the quality of health care (Semali 2003).A current fifth wave, started in 2004, came as a result of increased funding from the government and global health initiatives such as the GFATM. The increase in funding resulted in selective strengthening of the health system which became evident by child survival gains in Tanzania which increase their prospects of meeting MDG 4 (Masanja et al. 2008).

1.6.2 Tanzania's Health Information System

The health information system can be seen as having two types of data sources, population-based and institution-based (HMN 2008). .

- **Institution-based** data is generated from administrative or operational activities taking place in the health facilities and other institutions inside and outside the health sector, for example agriculture. Institution based data sources include; individual records, service records and resource record.

- **Population-based** data is generated from defined population and may cover the whole population or representative samples of the population and they may be either continuous or periodic. Population based data sources include; censuses, civil registration and population surveys

1.6.2.1 Institution based

Health Management Information System

History

The Health Management Information System (HMIS) is a facility-based health information system that is used to collect data from health facilities. The history of HMIS dates back to 1986 when the pilot testing was done in Mbeya Rural districts. The pilot was further developed and expanded in 1993, with assistance from Danida, to cover the whole of Mbeya region(HERA 2000). The system was then given a Swahili name MTUHA "*Mfumo wa Taarifa za Uendeshaji wa Huduma za Afya*" for Health Management Information System (HMIS). The nationwide introduction of the first version of HMIS took place between 1994 and 1997 which covered all health care services and health programs. All health facilities regardless of the ownership are required to use this system to report to the district health authority.

The goal of HMIS was to optimise the performance of health services at all levels of the administration through timely provision of necessary and sufficient information needed by the health managers to monitor, evaluate and plan their activities (HERA 2000). To achieve this goal the system needed to be reliable, integrated, decentralised, functional(HERA 2000). HMIS was designed to provide information for the explicit purpose of supporting decision-making at local

and central levels. Although HMIS is well established it has limitations that makes it necessary to handle the indicators it generates with caution when making decisions (MOH 2008). According to The Health Sector Performance Profile Report for 2006/07 the following are the problems HMIS faces(MOH 2008):

- Selection bias in terms of coverage: this is because HMIS is facility based and not all people seek health services from health facilities;
- Underreporting, incompleteness, untimely
- Lack of analysis capacity at all levels which result in poor data quality.

The first release of the HMIS software was implemented at Regional level (HERA 2000). This initial release of the software was entirely in English, it was later changed to Swahili after it was realised during the testing phase to be challenging to users with limited understanding of the English language (Nyamtema 2010;Smith et al. 2008). The top-down design and implementation and lack of user involvement lead to inappropriate design decisions and report generation challenges. Never the less this approach was also used in the design and implementation of the revised version of the HMIS software (HERA 2000;Smith, Madon, Anifalaje, Lazaro-Malecela, & Michael 2008).

HMIS data from health facilities, collected using manual forms were sent to the district level where they were aggregated and then sent to the regional level. At the regional level the data was then entered into a computer system and the computer generated reports were sent to the national level. In 1997 the reporting was done on a monthly basis, but in 1998 it was realised that the monthly reporting was unrealistic so instead quarterly reporting was adopted at all levels.

The communication problems were to blame for this change. Despite this change health facilities were still instructed to calculate monthly rather than quarterly figures locally(HERA 2000).

The current system

There are four levels in the structure of Tanzania's Health Management Information System (HMIS), including health facilities, district, regional and national levels (Kimaro and Nhampossa 2007). In the decentralisation the districts, apart from being responsible for implementing Primary Health Care (PHC), serve as a hub for the flow of data from the community to the national level (Kimaro & Nhampossa 2007). Vertical programmes had separate and parallel systems for data collection, analysis and reporting (Mwangu 2003). The HMIS was established to address the problem of having parallel systems which were regarded as fragmented, top-down-oriented and providing unreliable data and information with limited useful feedback. To support the agenda of health reforms through decentralisation the HMIS was intended to cover all levels of the health sector, including all vertical programs and private facilities (MOH 1993).

The Ministry of Health and Social Welfare (MoHSW), with a consortium of partners, in October 2007, developed a proposal to strengthen the HMIS in Tanzania and the proposal resulted in an initiative named Monitoring and Evaluation Strengthening Initiative (MESI). The broad-based consortium led by the MOHSW is driving the development of the MESI and is seeking to address some of the shortcomings from previous attempts by making sure it is an MOHSW owned and led program. The initiative seeks to harmonize indicators, refine strategies, and accelerate progress for the use of data for rational decision making(MoHSW 2010). But Tanzania's HMIS is driven very much by a program monitoring routine rather than systems monitoring.

Integrated Disease Surveillance and Response (IDSR)

In 1998 the Ministry of Health adopted the Integrated Disease Surveillance and Response (IDSR) strategy developed by the World Health Organization Regional Office for Africa (WHO AFRO) (Rumisha et al. 2007). The adoption of this strategy was aimed at strengthening communicable diseases surveillance in the country by collecting information that will assist in quick detection and response of epidemics and providing evidence for decision making at all levels of the health system. In 2001, with technical support from National Institute of Medical Research (NIMR), the Ministry of Health started a pilot implementation of IDSR in 12 selected districts (Rumisha, Mboera, Senkoro, Gueye, & Mmbuji 2007). Although IDSR has been adopted as a national strategy in Tanzania since 1998, it has not been effectively rolled out in most of the country, apart from the pilot implementation done in the 12 districts (MOH 2004). It is intended to support international concerns over emerging diseases rather than health information system strengthening.

Planning and reporting database

The Government of Tanzania, with technical support from the University Computing Centre (UCC), developed software to be used in all councils in Tanzania. The software, named PlanRep (meaning Planning and Reporting Database), was designed to enable local authorities to plan and submit their plans electronically to the central government. PlanRep integrates plans, budgets, expenditures and burden of disease in order to enable local authorities to improve their planning.

1.6.2.2 Population based

Demographic and Health Surveys (DHS)

Tanzania has been relying on community based health information for population census and since 1992 the Demographic and Health Surveys (DHS) (MOH 2008). Population census covers the entire population and provides highly disaggregated data, but it runs too infrequently (every 10-15 years) to meet contemporary information needs and rarely contain cause of death data. Population census in Tanzania is done less than every 10 years so they have a potential of missing some vital events occurred in the population which may result in under estimation of some of the indicators, for example Under 5 Mortality Rates and Infant Mortality Rates. Demographic and Health Surveys (DHS) are nationally-representative household surveys that provide data for monitoring and impact evaluation indicators in population, health, and nutrition on a regular basis.DHS data are used for assessing demographic and health dynamics of the population. DHS is based on a sample of households selected in different parts of the country and interviewed using a standard questionnaire to capture information about households and household member and their basic characteristics(Vaessen et al. 2004). DHS surveys are done every 5 years which make it less sensitive to rapid changes in coverage and impact of interventions and likely to underestimate some of the indicators, for example neonatal mortality or child mortality (de Savigny & Binka 2004).

Health and Demographic Surveillance Systems (HDSS)

The Ministry of Health developed a National Sentinel Surveillance (NSS) system which is responsible of coordinating sentinel registration systems activities in Tanzania. Sentinel system is used for monitoring of vital events based on the continuous registration of all births and deaths and determination of causes of those deaths in areas of a national population purposively selected for programmatic or practical reasons. The most common methodology used in sentinel registration systems is through Health and Demographic Surveillance Systems (HDSS) sites.

The HDSS provides continuous longitudinal household based information on the health of the population, the burden of disease and health service use at community level. The HDSS is used to bridge the data gap that exists in resource constrained countries by providing all-cause and cause specific mortality data (Osman et al. 2006). A HDSS monitors a dynamic cohort for births, deaths, cause of death, fertility and migration. The cohort is first determined by a single initial census of all individuals in the sentinel demographic surveillance area (DSA). The initial census geo-locates all households by global positioning satellite (GPS) and captures core information on all residents who intend to reside in the DSA over the next four months. It records the names, sex, age, dates of birth, and civil relationships of everyone in each household, assigning each of them unique and permanent alphanumeric identifiers and registers them as *de facto* members of the HDSS.

So far there are 5 sites currently running in Tanzania. These sites are Ifakara HDSS, Rufiji HDSS, Kigoma/Ujiji HDSS, Magu HDSS and Korogwe HDSS. The goal of NSS according to the National Health Policy (2003) is "*to have an adequate number of districts incorporated in the system in order to arrive at reliable National Information*". It was established to harness the potential of the county's community-based longitudinal health and demographic surveillance initiatives. It is the fact that individually HDSS sites may be considered as not representing the real picture of the health status of the country population (HMN 2008). However, if data from different sites can be pooled together so that they can be compared and contrasted they may increase their national representativeness (MOH 2004).

Sentinel Panel of Districts (SPD)

Tanzania is establishing a new platform for health monitoring, evaluation and research namely Sentinel Panel of Districts (SPD). These are nationally representative sample of 23 districts, sampled by National Bureau of Statistics, which will be used as a platform to provide sustainable source of reliable national data to meet the monitoring needs of different stakeholders and for impact evaluation and research. SPD has population-based arm that will collect demographic data to generate cause specific mortality estimates through SAVVY (SAmple Vital registration with Verbal autopSY). The facility-based information system (FBIS) arm collect health service statistics from approximately 20% of all health facilities in the country using HMIS and later on through custom modules introduced to track indicator currently not collected by HMIS (Ifakara Health Institute 2011).

In the efforts of making sure there is equitable delivery of quality health services, the Government of Tanzania applied for a Global Fund Round 9 grant with the aim of addressing four of six health systems building blocks. The building blocks addressed were; information system; health workforce, medical products, vaccines and technology; and leadership and governance. In their proposal the Government of Tanzania proposed five intervention areas; increasing health workforce production; improving workforce attraction and retention; strengthening the use of quality health information for planning; strengthening procurement, storage, and quality assurance; and improving systems governance and stewardship. The MoHSW and TEHIP further assisted UCC to add health functionality to PlanRep.

1.7 Gaps

The literature shows evidence of agreement that HISs play a significant role in steering health system strengthening by providing reliable evidence on health system performance and

population health status. However, most HISs in developing countries are complex and fragmented and are seen as management obstacles rather than tools. This is caused by the way they have evolved overtime. HIS reforms are necessary to ensure they are capable of responding to basic needs of the health systems and its stakeholders. This can be done by making HIS interoperable capable of bringing together data from different sources for evidence-based decision making. There is no single solution for designing and developing integrated HISs and the issue of integration remain elusive for health information systems.

eHealth is about harnessing the power of ICT in health. For eHealth solutions to be effective they need to be designed and developed by involving end users and everyone likely to be effected by the system. However, there is very little research that uses a systematic collaborative methodological approach to identify and document user needs in the health domain. Despite the existence of software design methods there was no evidence of documented systematic methods for gathering and documenting HIS requirements for LIC

Enterprise Architecture has the potential to minimize the complexity of the HIS by providing an HIS-design methodology. This methodology will provide a way of describing HIS as a set of building blocks, the interaction between, and synergism of, the building blocks. Despite its potential, there is no evidence of EA application in the context of global health to strengthen health systems and health information systems.

Chapter 2

Objectives

2 Objectives

2.1 Rationale

The Health Information System (HIS) plays an important role in ensuring that reliable and timely health information is available to enable evidence-based and strategic decision-making that has potential for saving lives and enhancing health. Despite its importance, health information systems in many developing countries are weak, fragmented and often focused exclusively on disease-specific programme areas (HMN 2008). Integration of health information systems will provide the basis for public health professionals to look at the health system from different viewpoints.

To have sustainable health development and improved health outcomes, strengthening health systems, including health information systems, is essential. There is a greater need to think of a health system in its totality rather than disease-specific programme areas. Designing and developing integrated and standardized health information system is a step in the right direction. In a typical health system in a developing country each vertical health program implements its own information system to suit the needs of the individual program they support with little regard as to how this is integrated with or benefits the overall health information system (Braa and Humberto 2007). Lack of integration creates redundancy and additional workload for health workers which is caused by repetition of data collection and reporting (Sahay, Monteiro, & Aanestad 2007). If existing health information cannot provide a required indicator efforts should be made to introduce it in the existing system instead of developing a separate information system. When systems are designed and developed in an architected way, extending the system

might not end in duplication of efforts as all components would have been identified and how they communicate with each other.

In the efforts to improve the health of the population, public health workers and specialists collect data using a wide variety of methods. The analysis is then done in order to provide a meaning to the vast amount of data collected. Despite the fact that the collected data is either about an individual or about a geographical area, these data are collected in incompatible formats which make aggregation of the data difficult or close to impossible. Sometimes even the way some of the indicators are calculated may differ, if HIS is developed collaboratively with users from different levels of the health system their needs will be identified and a system will be developed that carter for the needs of all stakeholders.

There is a broad consensus that an integrated health information system will strengthen the health system and enable evidence-based decision making (Aanestad et al. 2005;Sahay, Monteiro, & Aanestad 2007). However, health information system strengthening has not had any substantial impact, many authors have given different reasons for this: political (Sahay, Monteiro, & Aanestad 2007) and managerial issues (Smith, Madon, Anifalaje, Lazaro-Malecela, & Michael 2008); approaches that are data led instead of action-led (Aanestad, Monteiro, Kimaro, Macombe, Macueve, Mukama, Muquingue, & Nhampossa 2005;Lippeveld, Sauerborn, & B odart 2000) and a lack of standardisation (Aiga et al. 2008;Luic et al. 2006). Other authors mentioned a lack of success due to integration being regarded as a purely technical issue (Chilundo & Aanestad 2004).

Although much research has been done in the area of health information system integration, there are some gaps in the research. First, most of the research is done from an information

system point of view and very few look at it from a public health or health systems point of view (Chilundo & Aanestad 2004). Second, integration is done mainly using information from existing health information systems and no attempt has been done to streamline these systems. Third, most research has been done from a specific health information system perspective, DHIS (Aanestad, Monteiro, Kimaro, Macombe, Macueve, Mukama, Muquingue, & Nhampossa 2005;Sahay, Monteiro, & Aanestad 2007) and HMIS (Smith, Madon, Anifalaje, Lazaro-Malecela, & Michael 2008) and very few have looked at integration in general (Chilundo & Aanestad 2004). Fourth, there is no research that has been done to develop a methodology that will be used to gather and document HIS requirements and to develop a globally common health information system framework which will be used as a blue print that countries can use to develop country specific integrated health information systems (Aiga, Kuroiwa, Takizawa, & Yamagata 2008). The objective of this research is to address the above mentioned gaps in the research.

2.2 Objectives

2.2.1 Goal

To study the potential of Enterprise Architecture as a strategic methodology that can be used to systematically gather and document HIS requirements to design a unified comprehensive health information system that integrates data from diverse sources at all levels of the health system for localised evidence-based decision making and health systems strengthening.

2.2.2 Specific Objectives

1. To identify and assess the computerised health planning tools currently in use, their usefulness in enabling evidence-based decision making and investigate how they were designed and developed
2. To assess the potential of enterprise architecture in designing integrated health information systems
3. To evaluate how eHealth strategy can be linked with eHealth system architecture
4. To develop a systematic approach that can be used to develop and implement health information systems

Chapter 3

Methodology

3 Methodology

This research used qualitative method to collect primary and secondary data. Primary research data was collected through in-depth interviews with key stakeholders and observation and discussions in workshops and meetings. Secondary research include desk research by searching for published and unpublished research outputs, white papers, reports, user manuals and training materials

A case study approach was used to examine the introduction and use of PlanRep. The approach was used because the focus of the study was to find out how PlanRep was designed and developed and why it was introduced. According to Yin (2003), a case study is also used if a researcher wants to understand contextual conditions of the phenomenon under study. In this research the intention was to understand contextual issues that may have an impact on the successful implementation of PlanRep (Yin 2003). In-depth interviews were held with PlanRep users from five districts, trainers from the Zonal Training Centres (ZTCs) covering the chosen districts, and individuals who designed and developed the PlanRep software. The agency representative who conceived and commissioned the development of PlanRep was also interviewed as was the person responsible for PlanRep at PMORALG and the Ministry of Health and Social Welfare (MoHSW).The five districts were purposely sampled using the following criteria; a district with previous knowledge of CCHP Sure; a district with previous knowledge of DHA tool; a district with low donor support; a district furthest from the capital; a district with the strongest plan, based on the MoHSW criteria. The interviewed were conducted in Swahili and then translated into English for analysis. To complement the interviews secondary data in the

form of training reports, user manuals, guidelines and implementation reports were obtained and reviewed.

To research the potential use of enterprise architecture in health the review of literature was done. A systematic search of literature was done to gather peer reviewed literature from databases, grey literatures, white papers, reports, conference proceedings and research reports. There was limited literature on the application of enterprise architecture in health so literature covering application of enterprise architecture in other sectors was also considered. To expand literature search reference list of each article was reviewed in detail to find additional articles and approaching experts and organisations working on enterprise architecture.

In the process of developing the systematic architecture rational approach presented in Chapter 6 I attended TOGAF 8 certification course and became TOGAF 8 Certified Practitioner. The aim was to develop expertise on TOGAF method and enterprise architecture in general. After finishing the development and review of the systematic architecture rational approach we applied the approach to gather and document requirements for a mobile phone application in Tanzania. Lessons learned and feedback obtained from this experience was used to refine the approach.

Chapter 4

The Case for National Health Information System Architecture; a Missing Link to Guiding National Development and Implementation

4 The Case for National Health Information System Architecture; a Missing Link to Guiding National Development and Implementation

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4.1 Abstract

Developing countries and the global network of donors, programs and nongovernmental organizations (NGOs) have agreed that health systems need to become stronger if gains in health are to be achieved and sustained. Existing data collection and use is fragmented, disease specific, inconsistent and often of poor quality. A major factor contributing to this current situation is that the burden of data collection falls to health workers and that this burden is excessive. What is needed is a national health information system that is capable of supporting day-to-day management, long-term planning, and policy development for the entire national health system. Front line health workers who bear the burden of data collection should benefit from the availability of information for decision making in a well designed health information system. A national health information system is comprised of multiple and diverse functions and applying what has been learned from other sectors facing similar challenges is valuable. One such practice developed over the past 20 years to guide planning, development and management of complex systems in all sectors including, government, commercial, and NGOs is the development of enterprise architecture. Enterprise architecture is proposed as the next level of elaboration of the Health Metrics Network Framework to provide countries with a technical road map to strengthening their national health information system. A well thought-out and collaboratively supported reference architecture enables country health information systems to be built and implemented using consistent standards for data collection, management, reporting and use. The components of the enterprise architecture will be adapted from or collaboratively generated with the global disease programs whose buy in and endorsement is crucial to its success. Investments in health information systems can be aligned and leveraged around such an architecture to build

stronger core health information systems supporting better local health services management, health policy and ultimately stronger health systems.

Keywords

Health information systems, public health informatics, HIS, health systems, enterprise architecture, global health, integrated data systems

4.2 Introduction

A national health information system (HIS) plays an important role in ensuring that reliable and timely health information is available for operational and strategic decision making that saves lives and enhances health. Despite its importance for evidence-based decisions, health information systems in many developing countries are weak, fragmented and often focused exclusively on a single disease-specific program area (HMN 2008). There is a broad consensus in the literature that strengthening of national HIS is desirable (Stansfield, Walsh, Prata, & Evans 2006). An integrated HIS will provide the basis for public health professionals to look at the health system from broader more comprehensive points of view (Sahay, Monteiro, & Aanestad 2007).

To have sustainable public health development and improved health outcomes, strengthening health systems, including health information systems, is essential. A common vision of a national HIS allows for leveraging the gains in tools and methods achieved in vertical disease-specific programs and maintaining the effectiveness of those systems to build a stronger integrated foundation addressing the entire health system. Introducing a well described and coherent set of best practices for promoting data integration and use is a step in this direction. In a typical health

system in low resource settings vertical programs often implement their own information system to meet their specific needs without consideration of how this information is integrated with the overall health information system (Braa & Humberto 2007). Absence of integrated information and use effectively ensures duplication and places a heavy burden on health workers caused by redundant, fragmented and inconsistent methods and instruments for data collection, aggregation and reporting (English et al. 2006). It is the peripheral health workers that often collect routine data and prepare reports. There are many examples of information and communication technology being introduced that show great promise in strengthening health information systems but these efforts too often are fragmented in design and implementation are typically not systematic or scalable (Lucas 2008). It is envisioned that stakeholder groups when engaged in a collaborative process see that many current program specific systems have common components and building towards a common architecture within the HIS leverage the impact of these investments and development resources. It also helps identify areas where interoperability between the components of the system is required or desirable, and can help classify the potential approaches for such interoperability points.

4.3 Health Metrics Network

Health Metrics Network (HMN) was launched in 2005 to help Ministries of Health, stakeholders and partners improve global health by improving the availability and use of health information to advance evidence-based decision-making. HMN is the first global health partnership that focuses on two core requirements of health system strengthening in low and low-middle income countries: first, to address a vision of an information system that embraces the entire health system and its component parts as a whole, moving beyond specific diseases and programs and

secondly, draw attention to and invest in country leadership and ownership in strengthening health information management and use. In order to meet these requirements and advance global health, it has become clear that there is an urgent need to develop a common view and align partners around a common plan to develop country health information systems (HMN 2008).

4.4 A Framework for Health Information System Strengthening

The HMN Framework draws on a set of guiding operating principles that have evolved through the active participation of over 65 countries and numerous partners to date. The principles which provide the direction for the development of the Framework are as follows:

1. Routine use of better information is associated with better health outcomes and a strengthened national HIS is one essential mechanism for delivering capacity.
2. Fostering country leadership and ownership is necessary for sustaining gains in health, strengthening health systems and the enabling health information system.
3. Country requirements and implementation challenges must be thoroughly understood and directly addressed for a national HIS to be effective.
4. Improving health, health policy and health system performance requires national, broad-based stakeholder consensus and stakeholder commitment.
5. Health information system strengthening requires a long term strategic plan with short term pragmatic action plans that build on successive coordinated incremental steps.

4.5 An Architectural Approach to Health Information System Strengthening

Ministries of Health and their stakeholders have begun to voice the need for a more detailed technical elaboration of the HMN Framework to support focused investments and the

mobilization of a wider pool of leaders and advocates of health information. Building on its global acceptance as an organizing framework for health information systems the application of enterprise architecture principles appear to serve the purpose of describing and documenting the requirements and characteristics of a national HIS. It will help to communicate its benefits as a national HIS inclusive of all public health and disease programs to accelerate adoption. It will also serve to create a platform for purposeful investments that will ultimately improve health outcomes and promote greater health system efficiency and effectiveness.

Enterprise architecture (EA) is a comprehensive description of all of the key elements and relationships that make up an organization (Spewak 1993). It is used to define the alignment of an organization's mission, goals and objectives with information systems (Harmon 2003).EA can be used to describe the methods for designing health information systems in terms of a well defined set of building blocks, and showing how the building blocks fit together and how the communication between the building blocks can be achieved. Since its development in 1984 the EA approach has been applied by many companies, governments and other institutions worldwide in order to improve their business process, e.g. US Department of Defence, Massachusetts Institute of Technology, commercial firms like BP (British Petroleum), Intel and Volkswagen. Global organizations like The World Bank are viewing EA as an enabler to broad reforms in the public sector (World Bank 2008).

An EA approach to health information systems development allows for important interrelationships to be identified, including which components need to be aligned to which parts and in so doing reduce the risks and incentives of fragmentation, and duplication, and lack of interoperability. Furthermore, insights from governments and commercial organizations have

shown that well-developed enterprise architectures reduce the risk of costly mistakes from applying diverse information and communication technologies in an unplanned and unstructured manner, while they accelerate the evaluation and adoption of emergent technologies in a way that benefit the whole system. Broadly the government sector has emerged as one of the largest adopters of enterprise architecture while public health has yet to really benefit from this trend (Saha 2009).

The HMN Framework provides a sound basis to design a reference EA for a national health information system to guide development of heath information systems better able to meet immediate country requirements and support continuous improvement in health systems. The EA will also serve as a global repository for lessons learned, standards and tools that any country, donors, developers, and partners worldwide can use to strengthen health information systems. In addition, the EA will help describe the current state of a country's HIS, and provide a roadmap of maturity levels and steps for growth over time that countries can use to inform their plans for HIS investments. The EA architecture for national health information systems will be most powerful if widely disseminated as a public good and is co-developed by experts, practitioners and users from across the globe. Ultimately the EA process will produce a Reference HIS Enterprise Architecture that will serve as a foundation for a national implementation and as a foundation for the development of multinational tools. An EA is not a static documentation of the system rather it allows for a long term aspiration vision while enabling practical stepwise progress that is informed by continuous experience and feedback.

4.6 The Role of the Enterprise Architecture in Alignment and Consensus Building

The EA for a national HIS will describe the fundamental organization of the system embodied in its components, standards and the principles governing its design and evolution (The Open Group 2010). It will provide a unifying and coherent structure that leads to a common understanding and provides guidance for conceptualizing, building or contributing to a national health information system. It should provide a description of key actors, their primary information needs and the logical data management processes; what existing processes could be improved and what new processes could be supported, how it would work in the operational environment; and what technologies would be required. The process for developing the EA will out of necessity involve the many stakeholders within countries and the network of partners. This the process of creating the EA will bring together for the purposes of aligning and inspiring a shared vision for national health information systems.

National governments are addressing development of many functions of government that are advancing in their use of ICT, including transportation, finance, statistics, education, defence, agriculture, and natural resources. An important consideration in an EA for health is the degree to which a national function or enterprise architecture has been established and to what extent the national HIS is expected to relate to such architecture. The national HIS EA can be instrumental in defining the relationship to other ministries as well as reflecting standards and principles of a national strategy or EA to the extent it exists.

4.7 National HIS Enterprise Architecture Domains

There are a range of alternatives for developing an EA including The Zachman Framework, The Open Group Architecture Framework (TOGAF), the Federal Enterprise Architecture and the Gartner Methodology (Sessions 2007). Each of these methods has strengths and weaknesses and none are really complete as they exist today. This white paper does not attempt to decide which methodology is the best fit for addressing national health information systems in resource constrained settings. Rather, we will present the common elements that serve to introduce the core elements of EA. In the practice of developing an EA the most common approach is often a blend of existing methods that address the specific challenges of the enterprise setting. This blended approach holds promise for developing the Reference National HIS Enterprise Architecture (Sessions 2007).

Commonly there are layers or domains of an architecture that are subsets of an overall enterprise architecture (The Open Group 2010). Four layers are commonly defined in a general model of an enterprise architecture. For developers and implementing partners to have sufficient guidance these four domains provide distinct granularity. Together these four domains make up our initial enterprise architecture for a national HIS.

Table 4-1: HIS Enterprise Architecture Layers

Architecture Domain	Deliverables	Representative Questions Addressed
1. Organizational Architecture	• Business domains • Business functions • Business processes • Governance, Policy, Resources	• Who are key decision makers, what are their roles and behaviours insofar as decision making is concerned? • What are the essential questions that as users must be able to answer for strategic and day to day decision making? • What core business processes, i.e. health services delivery, laboratory, pharmacy, are necessary to support decision making? • What policies and laws are necessary to support the initial

		development and implementation of a national HIS? • What resources are necessary to establish the minimum capacity for a sustainable HIS? • Who will be responsible for the maintenance of the integrity of the national HIS?
2. Data Architecture	• Data model • Metadata dictionary • Classification standards and systems	• What are the essential core and common data necessary to support information and evidence for decision makers? • What data sources contain these data and what can be linked for use from existing operational systems? For example the national census, vital registration or surveillance systems? • What is the link between essential minimum data sets and global programme M&E?
3. Applications Architecture	• Software applications • Interfaces between applications • User interfaces	• What are the initial key applications a minimal national HIS must be able to deliver? Examples include standard data collection instruments, data communication services, data analysis and modelling, report generator, GIS. • What applications are best included within a single platform design versus those applications that are best maintained as separate operational systems? • How will applications that have a requirement to be linked be able to do so? • How should the user interface work?
4. Technical Architecture	• Hardware platforms • Local and wide area networks • Operating system • Interoperability	• What are the requirements for information to be captured, data entered, tagged, communicated, managed and disseminated? • What is the minimum information and communication technology capacity needed across the country to support access to the applications and dissemination of information? • How will new classes of electronic devices, communication networks and related ICT be leveraged over the next 5 to 7 years?

4.8 Scoping the Enterprise Architecture Program of Work

An important step in developing the enterprise architecture is to establish the initial scope. A scope allows for the careful consideration and definition of what is appropriate and of the highest priority. Again there are various approaches to creating an EA. TOGAF like other approaches provides a methodology for developing an EA. The Architecture Development Method (ADM) is useful in the discussion of the importance of scope and how one might blend different models (The Open Group 2010). There are four main dimensions in which scope may be defined and limited:

- Enterprise scope or focus: what is the full extent of the enterprise and how much of that enterprise should the architecture focus on?
- Architectural domains: a complete enterprise architecture description should contain all four architecture domains (business, data, applications and infrastructure) but resource constraints will impact the extent of the architecture even if the full enterprise is limited.
- Vertical scope or level of detail: how much of architecture is enough before implementation activities including system design, system engineering and system development can begin?
- Time horizon: what is the time horizon for a complete architecture and do resource constraints require intermediate *Target Architectures* to be defined that enable implementation activities to begin?

Establishing the initial priorities as informed through collaboration with Ministries of Health and their stakeholders will serve as a context to understand the dimensions of EA. Business domains are another critical element in scoping the EA. Business domains are clusters of coherent business functions, over which meaningful responsibility can be taken in business processes, i.e. pharmacy, laboratory or facility operations. Below is an initial Health Domain Model comprised of an initial set of business domains that identified by global health experts and country stakeholders that serves as a starting point for the scoping process (PATH 2008). It is important to reinforce the principle that the enterprise architecture is intended to enable a foundation platform capacity what might be called "core and common" across the health system. It is the foundation upon which continuous improvement will be based and expanded capabilities created. It is a starting point for what we hope is a long, dynamic and innovative future.

Table 4-2: HIS Domains

Business Domain	Business Processes	Archetypical Users
Facility Based Services	Patient registry Individual health record Registration of death	Patient/guardian/parent Chief health officer Physician

	Registration of birth Classification of disease Classification of symptoms Classification of procedures Notification of reportable diseases Disease outbreak detection and reporting	Nursing Officer Community health worker Trained birth attendant MCH worker District health manager Director of primary health care
Community Based Services	Registration of death Registration of birth Migration (In and Out) Demographic Surveillance System Disease outbreak detection and reporting	Community health worker Community leader District medical officer National Health Manager
Diagnostic Services	Collect and register specimen Determination of results Associate result to patient Notification of reportable diseases Classification of disease Patient Registry	Chief health officer Physician Nursing Officer Surveillance officer Laboratory technician
Supply Chain	Central stock monitoring Facility stock monitoring National demand forecasting District demand Forecasting Stock threshold alerting & notification Distribution and logistics management Service delivery monitoring Service delivery forecasting	Chief health officer Facility health manager District health manager District store manager Provincial health manager Pharmacist Central store manager District store manager
Human Resources in Health	Taxonomy of health workforce Recruitment, credentialing, hiring of health workers Monitoring deployed workforce Reporting priorities for recruitment & training	National health manager National finance manager Provincial health manager District health manager Facility health manager
Environmental Services	Water quality and access mapping Sanitation resources and access Environmental conditions & history of natural disasters & events Classification of monitoring procedures Routine environmental monitoring	Chief health officer Physician District health manager Provincial health manager National surveillance officer
Management & Planning	Access to health protocols & research Aggregation of routine data Linking of routine and population data Budget & expenditure reporting Analysis and representation of data Monitoring of urgent health events	Chief health officer Physician District medical officer Provincial medical officer Global M&E officer Community health worker

	Disease outbreak detection and reporting MDG and M&E reporting	
Finance Resources for Health	Patient fee for service collection Health insurance enrolment Health services insurance settlement National and sub-national budgeting National and sub-national expenditure tracking National and sub-national revenue tracking	Chief health officer District health manager Provincial health manager National health finance officer National treasury finance officer
Knowledge and Information Resources	Access protocols for care delivery Access to research and authoritative source materials Delivery of skills development courseware	Chief health officer Community health worker Physician National director of nursing National health manager Facility manager
Infrastructure Resources	Physical assets inventory Existing asset replacement forecasting New asset investment forecasting Physical asset maintenance management	National health director Provincial health manager District health manager Facility manager

4.9 Conclusion

This paper presents the case for an enterprise architecture for guiding the development and evolution of health information system. The incredible surge in health funding has created a plethora of fragmented tools, methods and practices for data collection and analysis that have placed a counterproductive and unsustainable burden on front line health workers. There is a growing consensus that this burden not only causes poor data quality it also diverts critical health resources from patient care responsibilities. The challenge of how to improve the current situation is one that an enterprise architecture can help address. By providing an architecture that is scalable, flexible and resilient donors, governments, NGOs and commercial suppliers can contribute to the development of tools and methods that reuse components and leverage core and common data and standards that reduce not add to the burden of data collection. A model

architecture of a national HIS will provide a foundation for countries that are developing their own national health information system as well as for developers of tools used in many countries. The enterprise architecture provides the missing link to guide development and implementation of national health information systems. Improving health system performance through the consistent use of an EA will be the blue print for better health outcomes resulting from the routine use of better information from stronger national health information systems.

Chapter 5

Innovative district health planning in Tanzania: The Implementation and Evaluation of Computerised Planning and Reporting Tools

5 Innovative district health planning in Tanzania: The implementation and Evaluation of computerised planning and reporting tools

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5.1 Abstract

5.1.1 Background

Increasing investments in health often translate into improved health outcomes for the population, when allocated to cost-effective interventions. There is evidence that providing simple tools for budgeting and mapping priorities that help district health planners allocate resources strategically can contribute to the improved health of a population. This study examines the introduction and use of such a tool, PlanRep, in Tanzania. PlanRep is a local government planning and reporting tool designed to assist local government authorities (LGAs) in performance planning, budgeting and, projecting revenues and expenditure. PlanRep was developed to help district planning officers reduce the reporting burden by simply clicking a button to enter and retrieve data and prepare the requested reports.

5.1.2 Methods

A case study approach was used to examine the introduction and use of PlanRep. This involved in-depth interviews with key stakeholders, and reviewing secondary data from training and implementation reports, manuals and materials. In-depth interviews were held with the representative from the agency that conceived and commissioned the development of PlanRep, the software developers who designed and developed the PlanRep software, the person responsible for PlanRep at the Prime Minister's Office Regional and Local Government (PMORALG) and the Ministry of Health and Social Welfare, trainers from the Ministry of Health Zonal Training Centres (ZTC) covering the chosen districts, and PlanRep users from five selected districts.

5.1.3 Results

The idea for PlanRep was conceived in 2003 and by 2007 PlanRep was being used by all local government authorities in Tanzania as the official planning and reporting tool. PlanRep was developed to help district planning officers reduce the reporting burden by clicking a button to enter and retrieve data and to prepare reports. Respondents indicated the PlanRep health sector module to be the most advanced of the PlanRep modules and a model for other sectors as it is capable of generating additional analyses, displays and reports that can be generated. These 'extras' were reverse-engineered into PlanRep from the MoHSW TEHIP District Health Accounts (DHA) tool.

5.1.4 Conclusion

PlanRep is a remarkable innovation and to the authors' knowledge, no other country operates such an omnibus tool. It is a single unified tool used by all decentralized sectors. PlanRep simplifies reporting and increases the level of participation in the planning process, by giving a greater sense of ownership of these plans. PlanRep has positively changed the way district planners carry out planning and reporting activities and when fully utilised, it has the potential to revolutionalise district planning process. Nevertheless users reported many suggestions for ways in which it can be improved.

5.2 Introduction

In low-income countries, a number of tools and approaches have been developed to guide district planners allocate resources at the planning stage. The burden of disease (BOD) and cost-effectiveness have been the primary criteria for identifying priorities in many of these tools

(Baltussen and Niessen 2006;Kapiriri et al. 2003). In Tanzania, a district health profile tool that converts burden of disease from sentinel surveillance into burden shares addressable by cost-effective interventions to enable the district to identify priorities (de Savigny et al. 2008), was developed with the aim of repackaging population health information from the Health and Demographic Surveillance Sites (HDSSs) in a way that would be easily understood by district officials.

It has been shown that increasing national wealth and donor assistance for health interventions does not necessarily translate into improved health of the population (Green 1995;WHO 2001). Instead, allocating resources to high burden diseases with cost-effective interventions in accordance with population health needs is key (World Bank 1993). In Tanzania it has been shown that providing district health planners with simple tools to guide the allocation of resources in more strategic and innovative ways could significantly contribute to improved population health (de Savigny, Kasale, Mbuya, & Reid 2008). These tools and experiences are being scaled-up nationwide through further development and application of computerized applications, customized for decentralized planners in Tanzania via PlanRep. This paper explores the development of the PlanRep application.

In a decentralised administrative environment, the responsibility for planning and allocating resources lies with the local government authorities (LGA) or agency (Gilson et al. 1994). In 1995, the Ministry of Health of the United Republic of Tanzania developed National District Health Planning Guidelines with the objective of "*improving the planning capabilities at the district level*" (MOH 1998).

Health sector planning and budgeting for Tanzanian districts of several hundred thousand people is a complex undertaking (de Savigny et al. 2001;MOH 1998). One of the most detailed components of any district health plan, in Tanzania called Comprehensive Council Health Plan (CCHP), is the budget. District budgets often exceed 25 pages of details and can contain in excess of a thousand budgeted items or activities, with hundreds of sub-totals, and dozens of major line items. These budgets are often assembled from detailed operational activities aggregated to provide total figures. At the end of the process, it is difficult for the Council Health Planning team to see the proportional content of their budgets and plans. Since resource allocation within budgets reflects, to a large extent, the priorities of the CCHP, it is important that the Council Health Planners examine the final product of their plan in terms of how they have allocated limited resources. Easy comprehension and analysis of District Health Budgets was mainly impeded by the overload of numerical information. This prompted the Tanzania Essential Health Intervention Project (TEHIP) in 1997, to start working together with the Council Health Management Teams (CHMTs) in two districts in Tanzania, Morogoro Rural and Rufiji districts, to develop a simple tool for analyzing Council Health Plan budgets and expenditures.

It is one thing to make a plan, it is quite another to implement it. Often the planning process stops too early (Gilson, Kilima, & Tanner 1994). The resources eventually made available do not always coincide with what was requested in the plan. Once the resources arrive, the original plan is often set aside, and implementation is carried out depending on resources received (Green et al. 1997). Hence, there is a need at the beginning of implementation phases to adjust the plan according to the actual confirmed resources. This should be done by the partner-investors in the plan. At the end of the year, partners should reflect on how closely the ambitions of the adjusted

plan met the objectives of the original plan. The District Health Accounts (DHA) Tool (referred to as DHA for the remainder of the paper) was designed to overcome these challenges by providing a graphical interface; i.e. to convert numbers into graphics.

DHA is a computer-based tool developed in Microsoft Excel™ with Visual Basis for Application (VBA), created to simplify the complexity of district planning processes and the CCHP. It does this by integrating budgeting, costing and intervention in relation to the addressable burden of disease into a single tool and display the plan and budget in a series of analytic graphics for district planners to compare the burden of disease with their budgets. The tool is easy to use and designed for people with limited computer skills. This tool was among those developed by TEHIP, whose goal was to "*... help local authorities fix the gross technical and allocative inefficiencies that characterized health care delivery in two rural Tanzanian districts...*" (de Savigny, Kasale, Mbuya, & Reid 2008). Prior to the development of DHA in 1997, it was difficult for district health management teams to examine how they had allocated their resources in terms of systems and services, capital and recurrent investments, prevention and curative services, and for essential interventions targeting the local burdens of disease (de Savigny, Kasale, Mbuya, & Reid 2008). The DHA was selected for inclusion in the larger planning and reporting tool used by local government authorities (LGAs) in Tanzania, known as PlanRep.

PlanRep is a local government planning and reporting software designed to assist LGAs in planning, budgeting, and projecting revenue from all sources, as well as tracking funds received, physical implementation and expenditure. PlanRep, toggle between Swahili and English, caters for all sectors and departments in the council. Moreover, it contains the tools required for preparing the CCHP (PMORALG 2009). Compared with other sector-specific sections, health is

the most advanced component of PlanRep, as it can generate additional reports and graphics that provide extra information to health planners to guide the allocation of limited resources.

The purpose of this paper is to examine the development and implementation of PlanRep, to explain what problems PlanRep was designed to resolve, how it was developed and rolled out, and to show how PlanRep is used in the districts. This case study attempts to determine whether PlanRep resolved the problems for which it was designed, whether it has changed the way district planners prepare their plans and track implementation, and to identify what is needed in future tool designs.

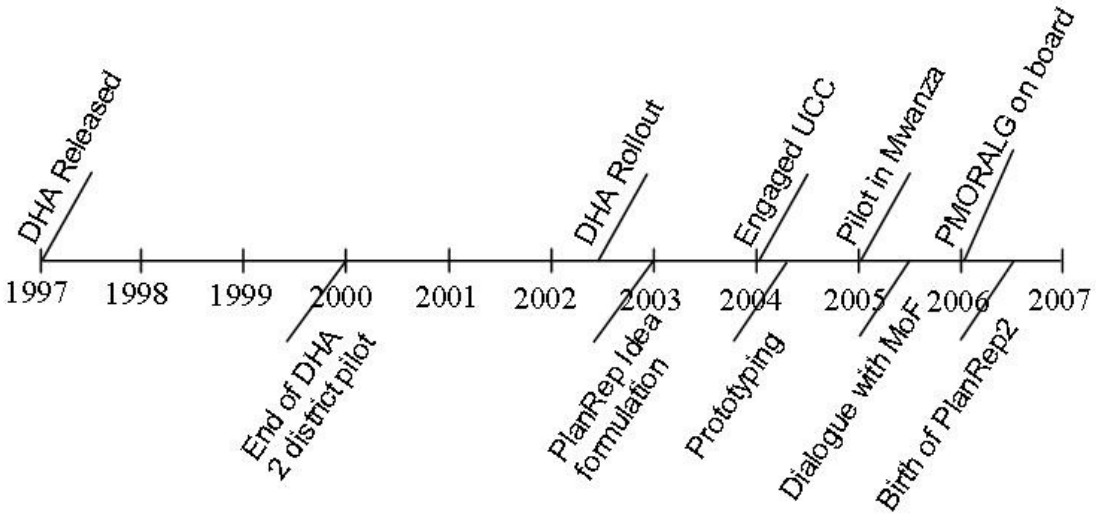


Figure 5-1: PlanRep development milestones.

PlanRep is software used for planning and reporting by all sectors in all local governments authorities in Tanzania. PlanRep provide easy to use user interface in Swahili and English. PlanRep was commissioned by the Local Government Ministry and was entirely designed and developed by Tanzanian software developers. It has since evolved and is now 'owned' not only by the Local Government Ministry but also by the Ministry of Finance and Ministry of Health, and mandated for use by every local authority for planning and budgeting. PlanRep system

enables all local authorities to create a performance budget framework; link it to the National Strategy for Growth and Poverty Reduction; link each activity to a responsible person; and calculate projected revenue from Central Government, own sources and the community.

5.3 Methodology

A case study approach was used to examine the introduction and use of PlanRep. This involved in-depth interviews with key stakeholders, reviewing secondary data from training reports, manuals and materials, and implementation reports. In-depth interviews were held with PlanRep users from five districts, trainers from the Zonal Training Centres (ZTCs) covering the chosen districts, and individuals who designed and developed the PlanRep software. The agency representative who conceived and commissioned the development of PlanRep was also interviewed as was the person responsible for PlanRep at Prime Minister's Office Regional Administration and Local Government (PMORALG) and the Ministry of Health and Social Welfare (MoHSW).

Five out of the 128 districts were purposely sampled as follows:

a) A district with previous knowledge of CCHP Sure [1];

b) A district with previous knowledge of DHA tool;

[1] Computer based planning tool based on Microsoft Excel developed by the Tanzania-German Programme to Support Health, helping health planners avoid calculation errors, allocate the planned amount to cost centres and take care of ceilings. The tool will enable planners to concentrate on the quality of plans, without spending a lot of time on the formal aspects of planning (TGPSH 2009)

c) A district with low donor support;

d) A district furthest from the capital;

e) A district with the strongest plan, based on the MoHSW criteria;

In these districts, the authors interviewed the main PlanRep user in the district. These were District Planning Officers in District (a) and (e), a District Dental Officer in District (b), the Acting Municipal Treasurer in District (c), and a member of CHMT in District (d). The interviews were conducted in Swahili, and recorded and then transcribed. We analysed the interviews to identify the main points and themes of the discussions.

National trainers from ZTCs covering the chosen districts, the inventor from LGRP and a representative from the University Computing Centre (UCC), the developer of the PlanRep software, were also interviewed.

The user and training manual were reviewed, as were the follow-up reports obtained from ZTCs.

5.4 Results

5.4.1 The Idea

The analysis revealed that the idea of implementing PlanRep arose in 2003, when the Government of Tanzania, through the Local Government Reform Programme (LGRP), was trying to improve the way local government authorities (LGAs) report on their progress. In doing so, they determined that the first step was to design a simple computer software application that could be used to enter the vision, mission, objectives, targets and activities, of all sectors. Once the plan and budget were entered, the council could then update the progress of each activity and

the resources that had been used. Using this information, the council planning officer could then report on the progress of each activity or generate any other report by clicking a button. Furthermore it was revealed by respondents that at district-level, apart from reducing planning and reporting burden to district planners the database, used by all sectors, would allow the data that had been entered to be forwarded to the national level for cross-district analysis. The intention was for PlanRep to complement council business process instead of introducing bottlenecks.

According to the respondents, up until this point, some sector ministries (and their donors) were frustrated by the reports coming from PMORALG, as they were not getting the reports they wanted, and those they did receive were quite often inconsistent or inaccurate. PMORALG reports gave different answers to the same questions at different times. As a result, some sector ministries and their donors were forced to bypass PMORALG and collect the information themselves.

5.4.2 From Idea to Implementation

Respondents mentioned that in the process of translating the idea into reality, LGRP first analysed the business process of local government authorities by looking at the charts of accounts, planning and budget guidelines, and the reports that needed to be generated for each sector. Only after this, did the process of developing the software begin.

It was revealed in the interviews that at the same time (2003), the Government of Tanzania was in the process of deploying a commercial financial accounting software package in all districts.

The software, known as EPICOR^{TM2}, was to be used specifically for accounting purposes and not for planning. The planning system needed to be interoperable with the accounting software so that the districts could easily transfer data between the two.

In early 2004, at the recommendation of a local government consultant, LGRP contacted UCC to start the process of developing the planning and reporting software. UCC is a limited company wholly owned by the University of Dar es Salaam, providing information and communication technology (ICT) consultancy to government ministries, departments and agencies, local government authorities, businesses, non-government organisations and the university itself. LGRP described how they envisaged the software and UCC developed a series of prototypes and presented them to LGRP for feedback.

> *We used to sit down with the software engineers from UCC, in a small hotel conference room, trying to explain to them what we wanted the software to do. They would go away and develop something and then show it to us in order to find out if they had captured exactly what we had described.* (LGRP respondent)

It was reported in the interviews that at the end of 2004 LGRP decided to pilot test the PlanRep prototype, PlanRep0, in eight local government authorities in Mwanza region. They brought together the sectoral department heads from these LGAs and provided an introduction to the system, showing them how to enter their district plans and the types of reports that could be generated. For many of the participants, it was the first time they saw what a computer could do apart from secretarial word processing. The potential of having a tool that would enable them to

[2] An accounting software used by the Government of Tanzania as an Integrated Financial Management System (IFMAS)

simplify the planning process was good news to all. This pilot confirmed to LGRP that PlanRep had the potential to make a difference. As mentioned in the interviews:

> *… we were amazed at the enthusiasm of these people. Some people had never operated a mouse in their lives. As you know most of us civil servants use the computer as a high speed typewriter, so if you see that you can use this high speed typewriter as a management tool it is an amazing discovery…. so we were encouraged that this was something worth doing*. (LGRP respondent)

5.4.3 Development of PlanRep

The developers of PlanRep used prototyping as software development methodology. This means that after ascertaining all the requirements, a software engineer designs a system and lets the users test it to obtain their feedback. The developer then uses the feedback to refine the system. The main purpose is for the users to see and test the ideas of the software developer as to how the intended system should look and operate.

> *…we used to design the software and then show it to the people from local government, after which we asked them whether what we had done made sense or not and which parts needed to be modified. We then did the modifications and show them to the client. So we improved the system as we obtained feedback. We continued doing that until we had met all the requirements.* (UCC developer)

Microsoft Access™ was used as the platform for PlanRep, on account of the availability of software programmers who could maintain the system and the ubiquitousness of Microsoft Access™ in all district offices.

To gather the requirements, respondents revealed, UCC software engineers first contacted the MoFEA, the main consumers of reports. They also communicated with the Commissioner of Budgets for local government authorities to understand budget guidelines and the types of reports they would need. After analysing the needs of all parties, the PlanRep development and implementation started.

PlanRep1 was released for wide use in the 2005/2006 financial year. It was later replaced by PlanRep2, after it was found that PlanRep1 did not reflect the reality of how local government authorities do their planning and budgeting. The main reason for this discrepancy was that the requirements used to develop PlanRep1 were specified and prototypes evaluated by MoFEA and LGRP, report consumers, and did not include input from other sector ministries and LGAs, the end users. Only when end-users started using PlanRep did these shortcomings come to light.

> *..because our initial interest was to simplify the reporting of LGAs to MoFEA, who were more interested in things that consume resources, unlike councillors and PMORALG who were interested in the service details. As a result, after we had installed the system, we realised that it did not reflect real-life day -to -day usage as we initially thought* (UCC Developer)

The PlanRep development team discovered DHA at a health-planning workshop facilitated by TEHIP. They were impressed with the way it helped health planners improve their strategies through its graphical interface. A decision was made to reverse engineer DHA into PlanRep so that health planners could have access to the extra tools and reports provided by the DHA tool from within PlanRep. Combining the two tools would enable health planners to use two tools at the same time and expand the functions available to them. The DHA tool developer explained to

the PlanRep development team how the tool worked and the basic principles behind it. The PlanRep developers then included these features in PlanRep.

> *… the health section is the most advanced section of PlanRep, which is the main reason why the DHA tool was included in PlanRep. We needed to do some extra work in order to reverse engineer the DHA tool into PlanRep, but it was worth the effort*. (UCC Developer)

According to the respondent, UCC developers performed their own in-house pre-test before presenting the system to end-users. Currently, there is no dedicated team of testers from LGAs to perform a thorough test of the application before release. When updated version of the software is released, UCC uploads it to PMORALG's website and sends an email to all PlanRep focal persons in each LGA to notify them. The PlanRep focal person can be a DPLO, an accountant, or a statistician. PMORALG also has ICT specialists in all regions, responsible for providing technical support to PMORALG sponsored systems, including PlanRep, as well as LGA offices in their respective regions. In LGAs with unreliable or no internet access, these ICT specialists would download the new release from the internet and then physically take it to the LGAs for installation.

According to the respondent, a new release could be the result of a new feature or a bug fix. The severity of the bug would determine whether or not it was necessary to release a new version of the application or whether it could wait and be updated at a later date.

> *We get reports of bugs from different sources, for example end users or trainers who encounter some bugs during training sessions.* (UCC Developer).

However, proposed new features must be approved by a Change Control Group set up to review the suggested changes. The Group consists of representatives from PMORALG, MoFEA, MoHSW and UCC, and meets once a year or when the need arises. Approved changes are communicated to UCC, who in turn implements them and releases a new version of the PlanRep. A specific set of criteria guides the Group's decision about requested changes.

> *...the group normally discusses each request to see if it contributes to the main principle forwhich PlanRep was invented or if it helps the LGAs to plan better or more efficiently.If these criteria are met then the requested change will be approved otherwise the change will be rejected* (UCC Developer)

5.4.4 Training

Respondents recalled that in 2006, UCC software developers and PMORALG Department of Management Information System conducted the first five-day training of trainers (TOT) session. A number of TOT workshops followed, with the aim of providing enough trainers to form a National Facilitation Team (NFT), responsible for training end users in their respective geographical locations. The current NFT is composed of PMORLAG and ZTC staff, ICT specialists from regional secretariats, and practitioners from selected LGAs.

To reduce costs and logistical complexity of trainings, PMORALG decided to utilise one of the NFT members, a ZTC, which is located in each of the six zones of Tanzania. The training centres, established by MoHSW, form an important link between MoHSW, the regions and districts in translating and implementing national policies.

ZTCs are mainly responsible for training users of the health sector of districts in their zones on PlanRep. They received funding from the National Expansion of TEHIP Tools and Strategy (NETTS), a MoHSW project. ZTC, on behalf of the NETTS project, arranged seven days of training for at least three health management team members from five districts at a time. These training sessions were conducted with technical support from UCC master trainers.

All interviewees, including both users and trainers, agreed that one week of training in PlanRep was not enough, due to the lack of basic computer skills among most participants. As a result, trainers had to combine computer orientation with the PlanRep training. Some of the participants had attended computer training courses in the past, but they did not use computers in their normal working environment and thus more likely to forget what they had learnt due to lack of practice.

> *…you meet someone who has received basic computer training in the past but when they go back to their work station they do not use a computer for a long time. Therefore when they come to us we have to start from scratch and to take him/her through the process very slowly. But if someone is conversant with computer usage one week is more than enough for PlanRep training* (PlanRep Trainer)

Following the trainings, follow-up visits were organised to test the knowledge retention of participants by asking them about various aspects of PlanRep, having them perform a certain task and observing how they perform it. Follow-up visits were very useful in uncovering critical issues that might have prevented users from using PlanRep post-training.

> *.. we went to one district and when we asked them about PlanRep they told us that they haven't been able to open it because they had forgotten the password. This shows that it is only during planning when they remember the existence of PlanRep* (PlanRep Trainer)

Some of the districts use those who have been trained in PlanRep to train their fellow workers. This has served to increase the number of PlanRep users in local government authorities and helped users conducting the training to build confidence and expertise.

PMORALG are working toward making PlanRep training affordable and sustainable. One strategy is to increase the number of NFT members able to provide training to end users in LGAs to increase the number of people trained in PlanRep. There are also plans to provide basic computer training to districts, according to their needs.

5.4.5 Use

The analysis revealed PlanRep was made available to all districts for the 2005/2006 budgeting year. However, not all local government authorities used the application, though they had been trained. The initial low usage of PlanRep, according to the respondent, was due to the fact that the MoFEA had not made it mandatory for local government authorities to submit their plans and budgets using PlanRep, causing those that did to have doubled the amount of work, to prepare plans and budgets for submission to MoFEA in Excel and to PMORALG with PlanRep. In the 2007/2008 financial year, MoFEA endorsed PlanRep and made it mandatory for local government authorities to submit their plans and budget using PlanRep. As a result, PlanRep usage increased to 100%.

Interviewees agreed that PlanRep has changed the way they do planning in a positive way. Before PlanRep was introduced, budgeting and planning was a manual process. Districts received guidelines from the MoFEA and used either a spreadsheet or word-processing application to manually prepare their plans and budgets. For health, some districts were using either the CCHP Sure tool or the DHA tool. The health department prepared their plans, either handwritten or word processed, and submitted them to the planning department, which was then responsible for entering the plans on a spreadsheet in a format that, most of the time, was unique to that particular district. This process was time consuming, tedious, idiosyncratic and prone to errors.

Hard copies of the plans were then printed and submitted to MoFEA and line ministries. The lack of a standardised tool or format caused a lot of problems when MoFEA tried to aggregate district plans at the national level, despite the existence of planning and budgeting guidelines.

> *… it was a difficult process as sometimes you spent a lot of time in front of a computer. Because after heads of departments have submitted their plans in different formats we have to enter all of them on an Excel spreadsheet.* (PlanRep User)

PlanRep's introduction and use enabled each department in the district to prepare its own plan and budget, with guidance and support from the district planning department. This increased the level of participation by district teams in the planning process and fostered a sense of ownership of these plans. The plans are submitted in electronic format to the planning department who will consolidate them to create a comprehensive district plan. An electronic copy of the comprehensive district plan is then locked to prevent further changes and exported to the regions,

where they in turn aggregate the council plans into a regional plan. After locking and exporting the regional plan, it is sent to MOFEA and PMORALG for use at the national level.

According to the respondents, PlanRep helps district planners improve their plans by providing graphical outputs to enable them to review their plans and budgets by clicking a button. These reports are sometimes used to guide planners on how well resources have been allocated in relation to intervention addressable burden, support versus service provision and preventive compared to curative services.

> *… I am now able to see the proportion of resources I allocate for each intervention. This has helped me to improve the way I do my planning, because now I am able to know in which intervention I need to put more resources, enabling me to plan strategically. Also after entering my plan I can crosscheck against the given ceilings based on the guidelines and then adjust where necessary. This has made a big difference to the way I plan and budget.* (PlanRep User district level)

Progress tracking is a feature of PlanRep that allows users to track physical implementation. Although, this feature is not widely used at the district level, a few found it very useful as it further simplified report generation. According to one respondent, users could benefit from this feature by entering progress and expenditure data.

> *… after entering your plan and starting implementation, you can start entering progress and expenditure data. Then at the end of a reporting period you click a button and generate your report based on what you had entered*. (PlanRep User)

Apart from PlanRep Micro, designed to work at the district level, there are two other versions of PlanRep: PlanRep Meso and PlanRep Macro that are designed to work at regional and national levels, respectively. PlanRep Meso targets Regional Secretariats (RASs) and allows them to aggregate all the budgets of the LGAs in their region for revenue and expenditure comparison and analysis. PlanRep Meso could be an excellent vehicle for increasing RASs' ability to support planning reviews and district level planning workshops. However, it is not yet in use as training is yet to be provided. PlanRep Macro allows PMORALG to aggregate plans nationally for analysis and to view a breakdown of information by region or district. It is currently used by PMOLARG.

5.4.6 Features

PlanRep is available in Swahili and English and enables the user to enter a strategic plan as a component of a Medium Term Expenditure Framework (MTEF), consisting of objectives, targets, activities and inputs, as shown in Figure 5-2. The PlanRep health module enables users, during the planning stage, to associate indicators with objectives, targets with poverty reduction strategies, activities with health interventions, funding sources, priority area and inputs with the Government Fiscal System (GFS codes) to mention a few. The health module also generates different types of reports including graphics that map expenditures to needs (i.e. burden of disease), as shown in

Figure 5-3, and budgets according to guidelines and ceilings, as shown in Figure 5-4. PlanRep also allows users to enter expenditures to compare expenditures with budgets.

Figure 5-2: PlanRep2 date entry screen

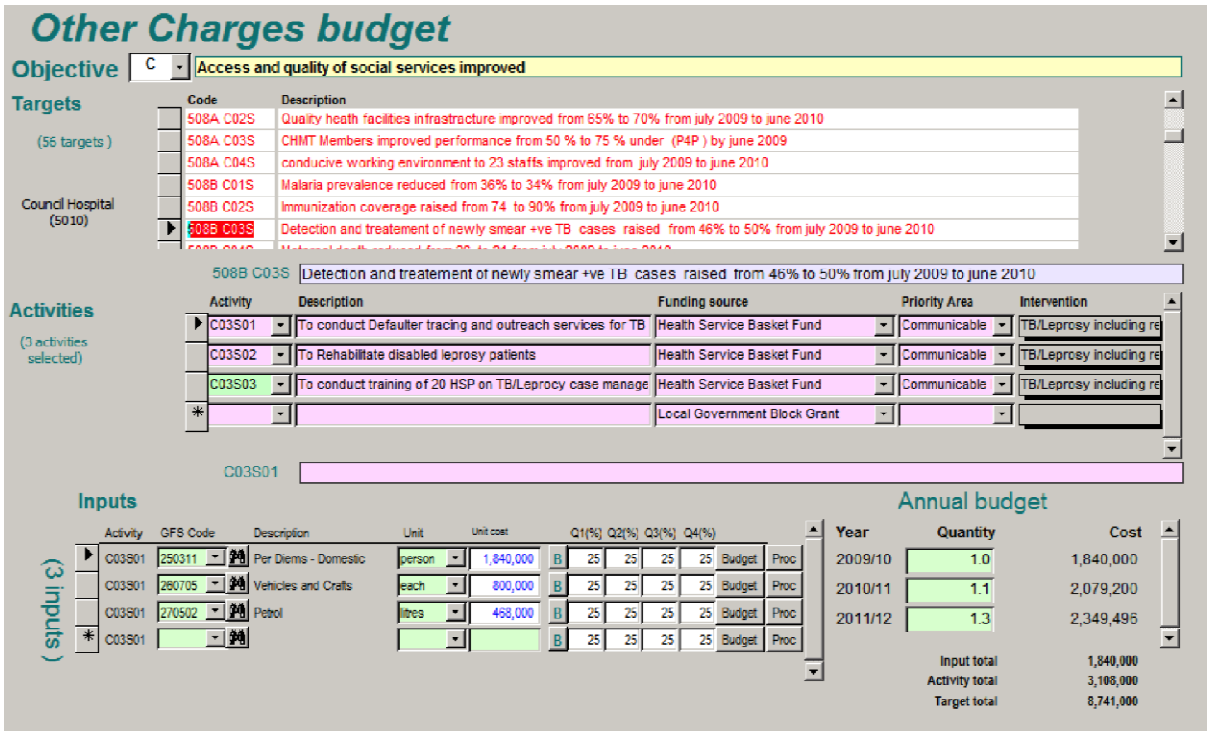


Figure 5-3: Mapping of budgets to burden of disease

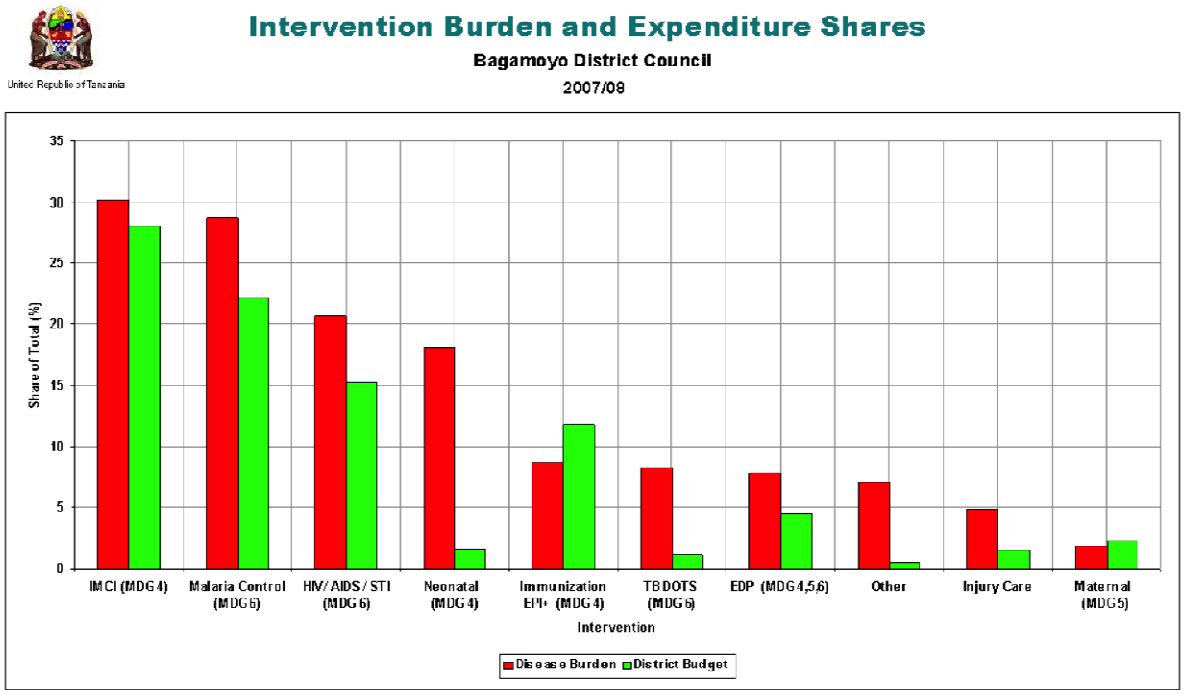
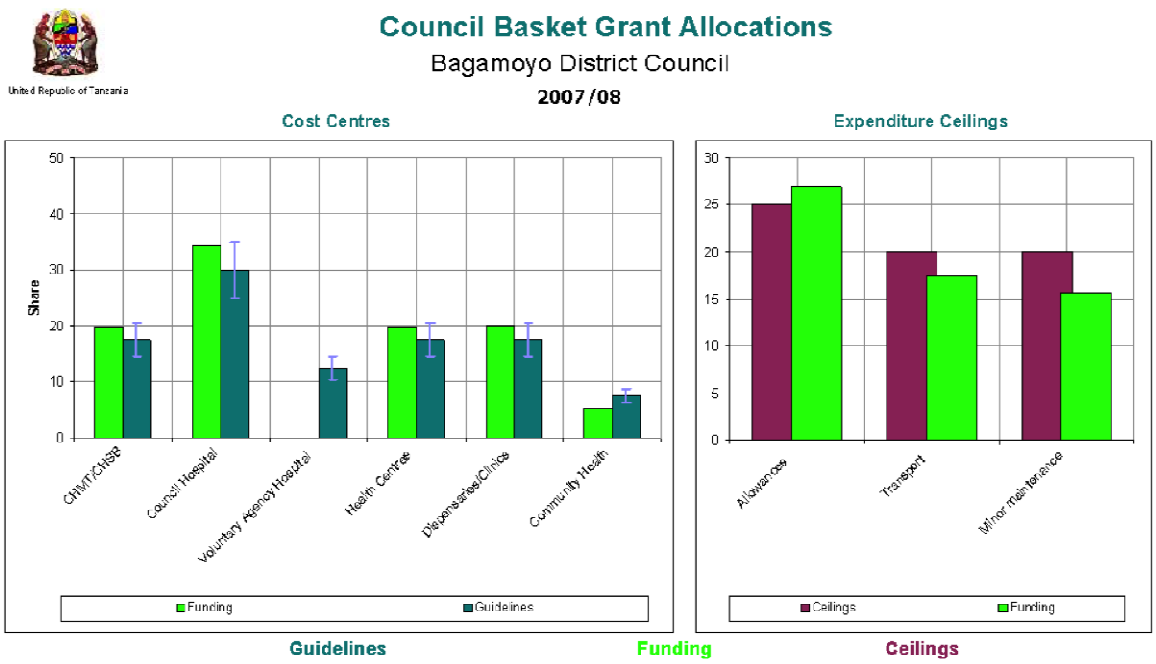


Figure 5-4: Comparison of budgets against guidelines



5.4.7 Limitations of PlanRep

Despite its potential, PlanRep has some issues that may have a negative effect on its success. These issues were raised by respondents interviewed and cited as critical to the success and sustainability of PlanRep.

One of the major problems of PlanRep is that it cannot generate all the reports needed by sector ministries. As a result, local government authorities have to generate these reports by other means, resulting in duplication of effort. However, efforts are underway to harmonise the reports required by stakeholders, including donors, so that PlanRep can generate general reports of use to all stakeholders. This would give districts a greater incentive to enter progress and expenditure data and use PlanRep to generate reports.

Interoperability between PlanRep and Epicor, the accounting system, is one of powerful features of PlanRep, however, this feature is not working properly. Priority should be given to improve

this feature that enables PlanRep budget data to be exported to the Epicor accounting system and Epicor expenditure data to be imported into PlanRep.

Harmonising PlanRep with CCHP requirements is another challenge of the PlanRep health module. At the moment, reports generated by PlanRep are not in the format required by CCHP, Harmonisation of codes, for example cost centres and GFS codes, is a challenge that needs immediate attention.

5.5 Discussion

A great deal of progress has been made since 2003, when PlanRep was first conceived. There have been two major releases of PlanRep, MoFEA has adopted it as the exclusive tool for submitting district plans, and all local government authorities in Tanzania are using it. There is hope for PlanRep's sustainability in the long run.

PlanRep was designed with the aim of resolving the planning and reporting problems that sector ministries and local government authorities were facing and reducing the planning and reporting burden on district planners. All local government authorities are using PlanRep for planning and budgeting, but very few are using it to generate quarterly implementation reports. One of the reasons for this is that local government authorities do not enter information on physical implementation, funds received and expenditures. Strategies need to be put in place to ensure that this purpose is fully realised. One such strategy would be to make sure Epicor-PlanRep interoperability is perfected.

PlanRep has revolutionised the way local government authorities do their planning and budgeting. Individual departments are now fully involved in the planning process as they can

enter their own plans instead of having the DPO do it for them. The DPO is instead free to concentrate on making sure the plans are prepared according to the guidelines. With regard to health, all districts have access to the extra tools and reports imported from the DHA tool. Simplifying the preparation of plans and budgets enables health planers to focus on developing innovative interventions instead of worrying about getting the calculations right in the Word document.

PlanRep's features, when used properly, offer the potential to generate a rich set of information. But, PlanRep's features are under-utilised and this may diminish the success and promise of the software. According to a PMORALG respondent, although the local government authorities submit their annual budgets entered in PlanRep, only a few enter their expenditures and use PlanRep to generate reports. Harmonising reports and including reports required by different stakeholders could increase the use of PlanRep for reporting.

Some of the PlanRep users interviewed were keen to learn more about PlanRep on their own by downloading the user manuals available online. In the five districts we visited, the two users who took the initiative to learn PlanRep before attending the training course were the same ones who tried to maximise PlanRep's features by entering expenditures and generating quarterly reports. This indicates that PlanRep use depends on individual initiative. Thus, measures should be put in place accordingly to ensure greater use of PlanRep. PMORALG, the custodians of PlanRep, are responsible for its sustainability and making sure it is functional and continuously updated. According to PMORALG, there are strategies in place to achieve this. One of the strategies is building the capacity of PMORALG staff to provide technical support to end users. It is essential that local government authorities receive the appropriate computers and skills training to ensure the continued use of PlanRep.

5.6 Conclusion

The PlanRep Tool is a remarkable innovation and to the authors' knowledge, no other country operates such a comprehensive tool. It is a single unified tool used by all decentralized sectors. This kind of district level database, using a common structure for all sectors, allows scaling up of data compilation, with or without aggregation, to the regional and national levels for cross-district analysis.

PlanRep is meant to alleviate the reporting burden of the District Planning Officer (DPO), makes it easier for each department in the district to prepare their own plans and budgets, in a way that is consistent with one another. This not only simplifies reporting on development projects, but also increases the level of participation of district workers in each sector in the planning process and engenders a better sense of ownership of these plans.

The PlanRep software development process needs to be strengthened. A version control system and a dedicated, objective software testing team are required to reduce the number of bugs, instead of depending on developers to fully test features that they developed themselves.

5.7 Competing Interests

The authors declare that they have no competing interests.

5.8 Authors' Contributions

HM and DD conceived the study, HM drafted the manuscript. All the authors participated in the design of the study, and design, interpretation and preparation of the manuscript. All authors have read and approved the final manuscript

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Chapter 6

The Rational systems design for health information systems in low-income countries: testing an enterprise architecture approach

6 Rational systems design for health information systems in low-income countries: testing an enterprise architecture approach

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6.1 Abstract

Low-income countries (LIC) with their funding and implementing partners are increasingly recognizing health information systems (HIS) as an essential way to strengthen and support health systems. There is tremendous potential for innovations in information and communication technologies to assist health managers, health workers and patients. Yet individual technologies and software applications are often developed without specifying how they will interact and communicate with existing and future information systems. Furthermore, they are developed without giving adequate attention to the needs the information system is supposed to address, resulting in software applications that do not effectively meet user needs. There is a lack of documented systematic methodology for gathering and documenting requirements for developing HIS. This paper introduces a systematic, architected and rational approach (SARA) for the design and development of health information systems. SARA, based on Enterprise Architecture approach, represents a portfolio of practices, tools and methods that can be easily and appropriately adapted and applied in the design phase of health information system development. This paper will present early efforts to develop this portfolio including lessons learned from applying SARA in Tanzania.

Keywords
Health information systems, health management information system, enterprise architecture, eHealth, systematic architected rational approach

6.2 Introduction

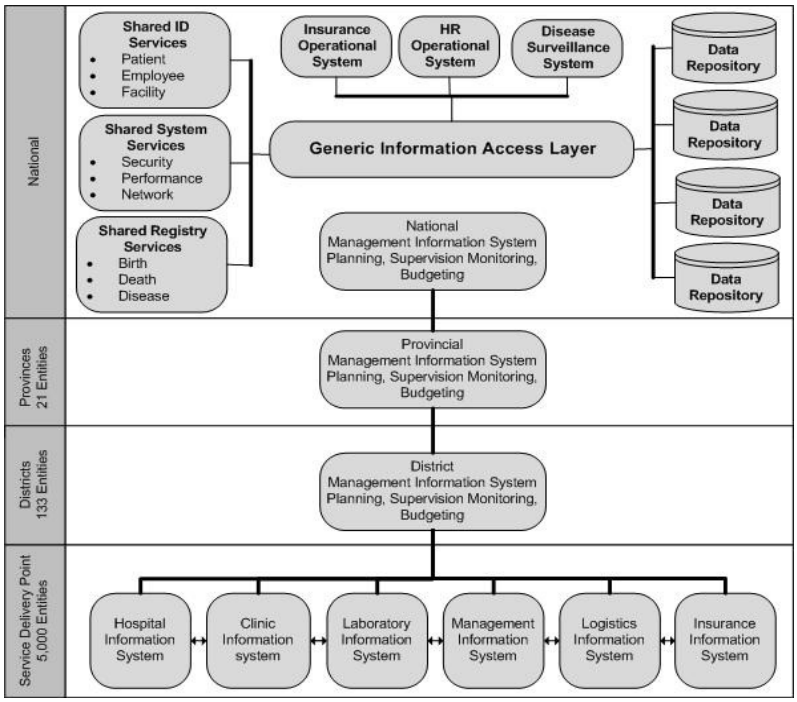
Ministries of health in low- and middle-income countries have widely recognized the value of strengthening health information and health information systems (HIS). According to the World

Bank, low income countries (LIC) are countries with gross national income (GNI) of $995 or less and middle income countries are with GNI US$996 and US$3,945 (World Bank 2011).Recent national and global efforts have drawn attention to the importance of seeing health information as being generated by an integrated and comprehensive health information system and not just disparate monitoring and evaluation methodologies (HMN 2008).World Health Organization (WHO) sees health information systems as an integral building block or sub-system in the overall health system (WHO 2007). More recently, WHO has promoted systems thinking for strengthening health systems, which puts emphasis in understanding the context and looking for connections between the components of the system (de Savigny & Adam 2009). Despite significant investments in HIS in most countries, especially those with limited resources, HIS are still highly fragmented and often do not adequately support management functions and evidence-based decision-making beyond disease-specific program areas. The result is that the national health information system falls short of being an integrated "system" and does not evolve in a systematic way. An integrated HIS that bring together data from vertical or disease-specific sources will enable the data from all levels of the health system to be aggregated and analysed in totality (Sahay, Monteiro, & Aanestad 2007;WHO 2005).

Modern innovations in information and communication technologies (ICT) have tremendous potential for strengthening HIS in LIC (Chandrasekhar and Ghosh 2001;Lucas 2008)**.** However, if designed and developed without the active involvement of stakeholders of health systems and the actual end users in requirements definition, this potential is often not realized, according to Gartner, without active collaboration in defining and managing requirements efficient and accurate delivery of information systems is impossible (Gartner Group 2008). User involvement is critical in understanding what the users do and what they need, also to create a sense of

ownership that is essential to the success of any system (Schlotzer and Madsen 2010). HIS design and implementation is complex due to heterogeneous nature of the health system and its complex dynamics as shown in Figure 6-1 (Saha 2011).HIS is made up of a number of components that they need to work together at different levels of the health system. These components may be running different solutions, some may be paper based and with different operating models based on different standards. All these components will need to be able to talk to each other and exchange information. This complexity can be simplified if they are designed in an architected, manner that is by breaking it down into components or domains, identifying their interrelationships, and according to specific principles and guidelines guiding its design and development. An architected approach allows for rigorous design and implementation of a more robust HIS.

Figure 6-1: Tanzania Reference HIS Architecture



Enterprise Architecture (EA) is a well-described methodology for aligning information systems with an organization's mission, goals, and objectives. It is used to produce a comprehensive description of all of the key elements and relationships of an organization (Spewak 1993) and its alignment with an organization's mission, goals, and strategic objectives with information systems (Harmon 2003;Ross, Weill, & Robertson 2006). EA methods can be applied to describe and design HIS in terms of building blocks, showing how these building blocks fit together and how the links and communication between the building blocks can be achieved. Global organizations such as the World Bank are viewing EA as a way of enabling broad reforms in the public sector (World Bank 2008).

There are numerous EA frameworks. One of the most standardized, and accepted is The Open Group Architecture Framework (TOGAF). Now in its ninth release, TOGAF was first made available in 1995 by a vendor and technology agnostic consortium with a strong focus on how ICT can support business objectives and requirements (The Open Group 2010). TOGAF provides its proven step-by-step method for developing and maintaining enterprise architecture (Harrison and Varveris 2004). It covers four levels of architecture: business, data, application, and technology infrastructure. At the core of TOGAF is the Architecture Development Method (TOGAF ADM) that describes a generic, highly adaptable method for developing enterprise architecture (Rees 2011). TOGAF ADM provides set of tools, common vocabulary and methods for defining an information system as set of building blocks and the description of how they fit together. What EA and the ADM provide is assurance that the technology supports and serves the mission and strategic objectives of the organization; not the other way round by defining an architecture before making ICT solutions (Brooks 2009). ICT industry has for many years struggled with ICT failures and the global health has much to gain from the rich body of

knowledge produced with large investments of money, time, and resources (The Standish Group 1995).

The software engineering community agrees that the first step of designing or developing any system should be a systematic elicitation, analysis, and documentation of the requirements (Gartner Group 2008;Smith et al. 2007); it is more expensive to modify the system once it is developed than it is to revisit and modify the requirements or design (Schlotzer & Madsen 2010). A systematic approach to HIS design and development follows a series of logically connected steps in order to identify a problem, and then document, and design a preferred solution (de Savigny & Adam 2009;Tyre et al. 1995). One example of a systematic way of eliciting requirements is found in the TOGAF business scenario provided in Box 1 (The Open Group 2010).

Systematic design refers to a design process that looks not only at the problem to be overcome, but also at the particular context and environment, and other systems that are part of a problem. An intimate understanding of the context can only be achieved by involving stakeholders in an in-depth analysis of the problem area. The process also requires understanding of the separate and interlinked systems, not just what they are and what they do, but how they work together.

Experts in HIS in LIC provide various perspectives. Braa focuses on the role of standards and gateways in integrating systems (Braa, Hansthen, Heywood, Mohamed, & Shaw 2007). Heeks examines the source of failure in the development and deployment of software systems in LIC, concluding that there are often significant gaps between the designers' views and the on-the-ground reality (Heeks 2006). A small number of researchers draw attention to the importance of paying attention to design before development. Krickeberg proposes a set of principles to guide

the development of Health Management Information System (HMIS) (Krickeberg 2007)and Kimaro focuses on the role and challenges of user participation in the design of HIS (Kimaro and Tollman 2008). Other authors emphasize the need for user involvement in specifying user requirements and although these approaches are for developed countries, they are relevant to this case because they talk about design and development of health related information systems (Kuziemsky and Lau 2010;Schlotzer & Madsen 2010).

Box 1: TOGAF Business Scenario

The business scenario is a complete description of a business problem that enables individual requirements to be viewed in relation to one another in the context of the overall problem. Business scenarios provide a language with which the solution development community can link business problems and technical solutions.

There are seven steps that make up the overall development process:

1. Identifying, documenting, and ranking the problem driving the scenario
2. Identifying the business and technical environment of the scenario and documenting in scenario models
3. Identifying and documenting desired objectives
4. Identifying the human actors and their place in the business model
5. Identifying computer actors (computing elements) and their place in the technology model
6. Identifying and documenting roles, responsibilities, and measures of success per actor
7. Checking for "fitness-for-purpose" and refining only if necessary

The documentation of a business scenario should be thorough and contain all of the important details about the scenario. It should capture and sequence the critical steps and interactions between actors that address the situation. The process of creating the business scenario involves three phases that flow through each of the seven steps outlined above; gathering, analyzing, and reviewing.

Careful selection of appropriate technologies and software applications follows from a well thought out blueprint or EA that describes the "system-as-a-whole", as it is today and how it should evolve over a reasonable timeframe, like five to seven years. Further it should describe the individual components, the timing of their introduction, related projects, and how they fit together in a manageable and sustainable system. Finally, consideration of the capacity of the health system to manage HIS over the long-term must be rational. A rational approach will consider the level of complexity, amount of technology change, skills, and capacity required to manage and support the HIS as a whole as well as the individual components and projects. This calls for balancing the scope and speed of implementation of a national HIS with the human and financial resources available to manage and sustain it.

The aim of this paper is to introduce an approach adapted from TOGAF framework to provide guidance that countries and solution providers can use to design and develop integrated HIS. It advocates for a systematic approach that reflects the strategic direction set by policymakers and stakeholders. This approach can be used at national level to design HIS or an information system to provide a solution to a specific problem or at a health facility to design an information system.

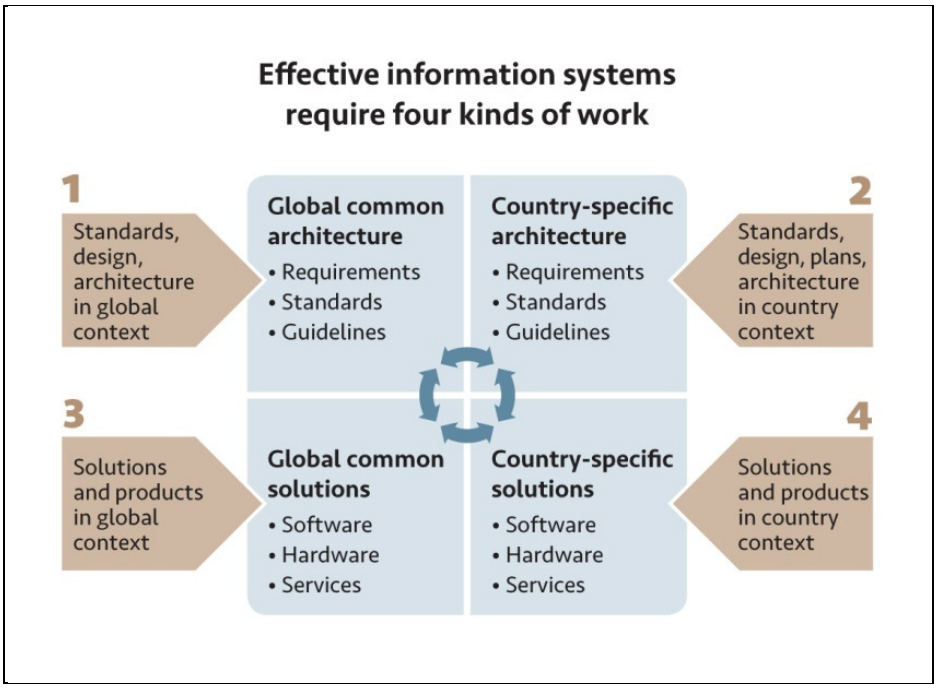
6.3 A Systematic Architected Rational Approach (SARA) to HIS Design

Our approach is adapted from the TOGAF framework, which provides a flexible and adaptable Architecture Development Method (ADM) that can be used to gather and document requirements (The Open Group 2010). Some parts of TOGAF ADM are adopted and others are modified to develop a systematic approach relevant to the development of HIS for LIC, and that leads toward a systematic architected rational approach (SARA) to HIS design and implementation, in general. Our approach is generic and flexible, which means it can be tailored

to suit a specific context. For example, the order of the steps and applicability of other steps may depend on the maturity of the country HIS or the complexity of system that is being developed. The idea is to move away from being prescriptive and instead provide guidance that countries can use to develop and implement integrated HIS. The proposed approach encourages collaborative design and development of HIS architecture that is consistent, reflects the needs of stakeholders, employs best practices, and gives due consideration both to current requirements and to the likely future needs of the health system (The Open Group 2010).

Figure 6-2is a framework representing the relationship between common and easily shared architecture and designs versus a country specific architecture and plan for implementation**.** The experience of the authors in public health systems in the U.S. and other settings with abundant resources, as well as those that are resource constrained is that well developed and documented architectures, especially user and system requirements, are very valuable to country efforts to strengthen HIS. There is a strong relationship between the common and country specific work, as each can inform the other. Country experience validates and improves architectural artefacts that can contribute to making common architectures more robust and useful. In the same way, stated requirements lead to solutions and these can either be common solutions that are useful to many or specific to a single country scenario. The power of common solutions is in its potential for providing cost savings and reducing the risk of failure. Many projects have already been implemented with many more underway; each one of these has the potential to inform common solutions that could be shared with many.

Figure 6-2: Framework of global common and country specific architecture and solutions.



6.3.1 Systematic approach

Step One

The initial step of the systematic approach is to gain a thorough understanding of the selected HIS functional domain. A functional domain is defined as a natural collection of functions like those represented by a supply chain, human resources, and facility health services. After the selection of the functional domain, a landscape analysis needs to be completed to prepare a foundation of knowledge, and a draft functional business process model. This step focuses on gaining a thorough understanding of the domain and understanding of who is performing the work, the work that they perform, and discrete activities that make up the logical workflow in order to determine requirements.

In this initial stage, convening a steering group of stakeholders, including policymakers and selected technical people, is a valuable enterprise. One of the responsibilities of this group is to

establish principles that will be used to guide the development and implementation of the HIS plan and the system itself. This process also helps to understand the perspectives of stakeholders, securing their buy-in and support, and developing a shared sense of ownership and responsibility to support the overall process and eventually the developed system. These principles help guide decision-making especially in the face of competing alternatives and priorities.

Step Two

Step two is to establish a baseline inventory of existing systems within and that interact with the functional domain. This inventory should mention what systems are in place and their weaknesses and strengths. Next an assessment of the effectiveness and satisfaction with existing systems can help highlight the areas where improvement is most needed. The Health Metrics Network (HMN) has developed an instrument to guide countries in conducting self assessment of health information systems capabilities. These first two steps, which use techniques adapted from preliminary and architecture vision phases of TOGAF ADM, can help establish a solid planning foundation by understanding what is in place today, its function, its current status, and how well the health system takes advantage of these existing tools.

Step Three

Step three is the mapping of existing HIS capabilities and systems to the strategy of the health system. The strategy of the health system includes the goals, objectives, and measurable outcomes to be achieved. Mapping the strategy to the existing baseline capability leads to a greater understanding of the gaps in performance and the priorities for HIS development. Baseline capabilities are also known as an “as-is” state and the future state is known as the “to-be”. Gap analysis is done to identify what needs to be done in order to move from the as-is state

to the to-be state. Like the development of principles, the engagement of stakeholders (especially policymakers) in gap analysis helps to develop a shared understanding of the opportunities available to the Ministry of Health (MOH) by applying ICT. This step uses technique adapted from TOGAF ADM architecture vision phase.

Step Four

Step four, using technique adapted from business architecture phase of TOGAF ADM, is the development of requirements based on gaps and needs identified in the previous steps. Everyone who is likely to be affected by the system, such as policymakers, information technology experts, health care managers, and providers who will be the actual users of any systems, and subject matter experts should be involved. Involvement of these stakeholders is critical in making sure that there is common understanding and general consensus on what the system is expected to do. The stakeholder engagement process helps in identifying different perspectives of the system from different user types. Their involvement in the requirements gathering stage helps to narrow the gap between the system designers' view and the reality on the ground (Heeks 2006). Two types of requirements are determined at this stage. First are the user requirements that stipulate the software functionality necessary to meet specific user needs. Second are the system requirements, which are largely those characteristics that users do not see but are essential, such as security, data interoperability, and support for environmental constraints like limited electricity and network connectivity. User and system requirements can be gathered in one or more facilitated workshops with subject matter experts and those who do the work on a daily basis. However, the most important aspect is user involvement in the process as it is essential to have an accurate understanding of the real user requirements and questions that the system is expected to address.

6.3.2 Architecture

Using an architected approach helps to complete the process of putting all of the discrete components and projects into a manageable form that is easy for stakeholder, donors, and system suppliers to understand. This is the stage that helps to move from functional requirements towards developing technical specifications to be used by system suppliers to design and develop software and hardware solutions for HIS. The relationship and communication between HIS domains will be identified at this stage. Stansfield et al. (2008) identified a set of clusters, called domains, which provided one way of describing core functional domains of the health system. This initial Health Domain Model continues to be improved by global health experts and country stakeholders. It is comprised of a set of functional domains and serves as a very effective starting point for simplifying the complexity of the HIS (PATH 2008).

Designing and implementing an effective HIS requires a need to look at the HIS as a whole system instead of looking at it from disease or domain specific point of view (de Savigny & Adam 2009). This approach will reduce the risk of fragmentation, duplication, and lack of interoperability as all interrelationships and alignment of domains will be identified at design stage (Stansfield, Orobaton, Lubinski, Uggowitzer, & Mwanyika 2008). It is critical to first know how the system that is being developed fits into the country's health information system by identifying interoperability and information needs that the system is expected to address. All efforts need to be made to reuse what already exists in order to reduce duplication.

TOGAF business scenarios are part of a technique that is used to identify and understand the requirements in an architected "system-as-a-whole" way (The Open Group 2010). This technique outlined in Box 1 provides the means to describe the functional process, the organization, and

technology environment, the people and components that execute the scenario, and the desired outcome. It also helps to bridge the communication gap between the solution providers and customers by providing a language that can be understood by both. Emphasis is put on the use of non-technical language and visual models, including workflow diagrams to represent functional processes. The use of a small set of symbols that are easy to explain is a core part of the methodology.

6.3.3 Rational Approach

EA provides a mechanism to describe the current state and the target state or architecture and a strategy to enable the transition from current state to target architecture (Brooks 2009). A rational approach to HIS design is one where each decision can be justified based on contextual factors and each decision can be shown to be an effective way to move from present situation to a future situation or target architecture (Brooks 2009;Parnas 2009). It is important to consider and understand contextual technical and non-technical factors or local environments when designing and implementing HIS in resource constrained countries. An obvious example is the availability of electricity to power computers and recharge mobile devices. Another example is the availability and reliability of communication networks. HIS designers and implementers need to understand the local context and constraints in terms of human resources capacity, culture, infrastructure, and political landscape. Cultural differences have an influence on the design and use of HIS (Kuldeep and Niels 1990) Values of the HIS designer will be explicitly or implicitly reflected into the system (Kuldeep & Niels 1990); one of the reasons is that human beings are often influenced by a preconceived design idea acquired on related projects, which may lead to poor HIS adoption and misalignment when the system is deployed (Kuldeep & Niels 1990;Parnas 2009). It is very risky for HIS designers and developers to assume that knowledge

gained in one setting is directly applicable in another without careful consideration of the local context.

6.4 Applying SARA

We now present a case study showing how SARA was applied to develop integrated user and system requirements for improving tuberculosis (TB) case detection and referral and district program supervision in Tanzania.

6.4.1 Purpose

The TB Control Program intended to investigate the role of mobile technology in improving the detection and referral of people suspected to be infected by TB. Additionally, this effort sought to improve the effectiveness of supervision of service delivery for patients with TB. User requirements represent the foundation that should lead to appropriate design and development of HIS tools. To begin the process a two day workshop (Box 2) was held to document the requirements with participants who represented four levels of the TB program in Tanzania (national, zone/region, district, and facility).

Box 2: Workshop Timetable

Day 1	Day 2
Session 1: How do things work today? • Overview of workshop objectives • Introduction of participants • Vision, strategy, and goals of TB program • Describe current workflow and information flow. • Describe users and their place in workflow.	Session 3: How to make things work better? • Review and refine scenarios and models from Day 1. • Identify what success looks like to users. • What and where in the workflow do changes need to be made? • Describe improved workflow and

• Describe technical capacity and systems.	information flow. • Elaborate details of improvements, tasks, and data. • Validate roles and responsibilities in new models.
Session 2: What are the problems and where do they occur? • Identify problems that need to be addressed. • Describe context where these problems exist. • Elaborate details of problems. • Describe relationships between users and systems. • Describe success if problems are resolved.	Session 4: What should be done first? • Identify key stakeholders and viewpoints of success. • Describe one to three objectives to achieve new model. • Confirm objective measurements, time, and resources. • Review, refine, and prioritize requirements to achieve objectives.

6.4.2 The systematic approach

The facilitating team started the systematic process by doing background research on TB case management. Preparation for the requirements gathering workshop started by identifying potential participants. In order to ensure representation of a diverse group of stakeholders, we involved people at all levels of the health system in Tanzania. Participants from the National TB Program, TB officers from the regional and district levels, and TB nurses from health facilities in both rural and urban settings were included as it was critical to ensure that perspectives from different user types were captured.

The review of the National TB and Leprosy Program strategic plan set the stage for the identification of requirements. Participants identified strategic objectives that are relevant as a guide to identify user and system requirements to improve case detection, referral, and

supervision of TB suspects. Guided by these strategic objectives, participants discussed the workflow of each identified process.

Participants identified four major processes in TB suspect and case management:

1. Identification of a TB suspect;
2. Referral of TB suspect to a clinic for specimen collection and testing;
3. Follow-up of TB suspect/case (pending diagnostic results) to disseminate results and initiate therapy for positive cases; and
4. Registration of a patient that has completed therapy in the Electronic TB Register (ETR).

Each process was analyzed in detail to identify people/stakeholders involved in the work, where the work takes place, instruments used for data collection and management, data produced, and action performed. For each process participants were asked to describe how the system currently works and identify any gaps. A solution will then be identified to cover the gap. In the end participants identified five primary gaps in the system that would be amenable to information technology intervention: referral, staff inadequacies, data, facility and/or infrastructure, and transportation.

6.4.3 Architecture

Participants discussed how they see this system fit into the overall HIS in the country and identified other systems involved in TB case detection, referral, and management. Participants identified the ETR as one of the systems that is used as a source of information for the national HIS. ETR is an electronic tuberculosis register used for TB surveillance, program monitoring and evaluation. Individual patient records are entered from the standard paper based TB registered and different patient lists and reports can be automatically generated (ETR .Net 2007).

ETR is the system that serves as the foundation of data used to inform policy and to monitor TB program performance at national and district level.

Activity diagrams were used to capture and describe activities performed in the identified workflows. These diagrams were used to describe flow and the events that cause decisions and actions to take place. The process was collaborative and workshop participants participated fully in the creation and modification of these activity diagrams. The process started by asking the participants about the activities that take place, the decisions that need to be taken, and the action(s) that follow each decision. Facilitators then drew diagrams, presented them back to the group, and asked the group to make modifications that are required. The exercise was repeated until participants felt that the diagram, in Figure 6-3, represented what happens in real life.

Using a non-technical approach to activity modelling was effective and allowed for participants new to this approach to grasp the concepts and symbols used. This does require the facilitators of the workshop to introduce the approach, concepts, and symbols. We used the ten symbols shown in Table 1 with their meanings:

Table 6-1: Table of symbols and definitions

Symbol	Definition
1. 	Pools: A group, department, organization or unit that contains multiple functional swim lanes (functional groups).
2. 	Swim Lanes: A functional individual or group. These are entities that perform or are accountable for designated activities in the process.
3. 	Start Event: A process mapping shape used to define the “start” of the process.

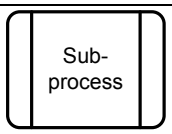
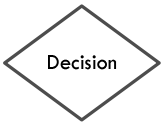
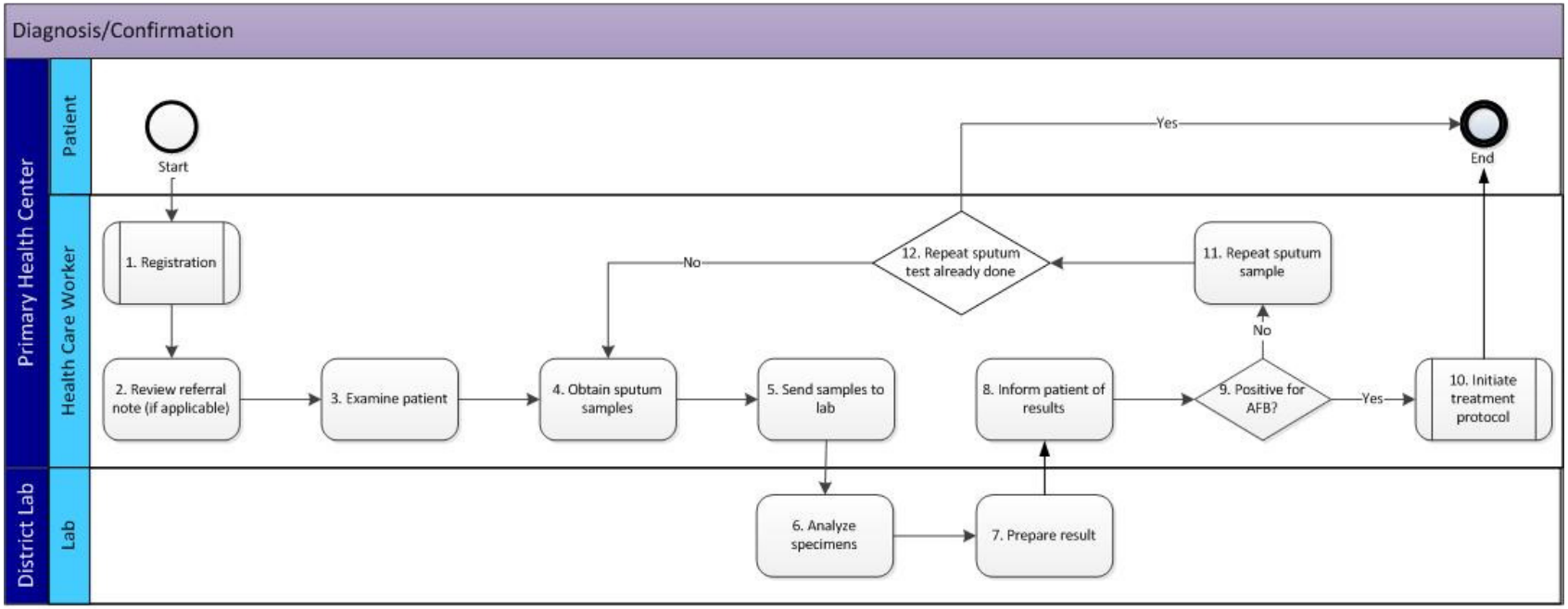
Symbol	Definition
4. 	End Event: A process mapping shape used to define the "end" of the process.
5. 	Sequence Flow: Depicts the flow of information or artefacts through the process from activity to activity.
6. 	Activity: An action performed by the functional individual or group.
7. 	Sub-process: A shape used as a call out to another process.
8. 	Decision: A required conclusion needed in the process. These are typically approvals or resolutions.
9.  Multi-page Connector	Multi-page Connector: A process mapping shape that links multi-page processes for ease of understanding.
10. 	Annotation: Notations made at the activity level.

Figure 6-3: TB Program Activity Diagram



Activity Details / Narrative

General Process Notes

Objective: The diagnosis of TB in suspected cases, which may be referred from the community via a CHW screening, or may present on their own as a result of symptoms/illness.

1. Registration

2. Review referral note (if applicable)

3. Examine patient

4. Obtain sputum samples

- Three samples need to be collected for diagnosis of pulmonary TB. The first sample is done on the spot. The patient is then given a container and instructions and asked to produce an early morning sample—which they will come in with the next day. When the patient returns, they are also asked to give a third sample at that time.

5. Send samples to lab

- The sputum sample must be properly labelled and be accompanied by an appropriate requisition.The specimens must be sent to the lab in a timely manner (within 4 days).

6. Analyze specimens

- The lab will test the specimens for Acid Fast Bacillis (AFB) using whichever technique they have.

7. Return to clinic for results

8. Inform patient of results

- This will be done by the clinician when the patient returns. If the patient does not return for the results- the patient needs to be tracked and informed of the results.

9. Positive for TB?

- If the sputum results are positive for AFB. Other diagnostic tests may also be done that are diagnostic for TB.

10. Initiate treatment

- This process includes the enrollment into a formal treatment regime, protocolised care, tracking and specialised monitoring.

11. Repeat sputum test

- If this is the first negative sample and the patient's symptoms are suggestive of TB, a second sample set should be done.

6.4.4 Rational

Facilitators and participants examined and discussed contextual factors that should be considered when designing the solution. The consensus of the work group was to consider a mobile phone based solution because of the availability of appropriate infrastructure and the community outreach based nature of the TB case identification and management. The infrastructure that exists at the district hospital and community based clinic levels vary widely. District hospitals have desktop computers, electricity (although power supply is intermittent), and mobile phones that are carried by all TB staff. This project was limited in scope to a small number of health workers as a pilot and as a result a full environmental landscape was not completed. There are important considerations when considering national level scale that are often not part of pilot projects. These include the system requirements to support a large number of concurrent users, large and variable transaction volumes, communication network capacity, user technical assistance, etc.

6.5 Discussion

This paper illustrates a systematic architected rational approach for HIS design and implementation. The approach places emphasis on the need for user involvement in the design process and to look at the HIS as collection of different components that need to work together, taking into account the local context when designing and implementing systems. The approach uses techniques from the first three phases of TOGAF ADM, preliminary, architecture vision and business architecture. The case study shows how the approach was used to capture and document requirements for improving TB case referral and management.

The authors agree with Kuziemsky (Kuziemsky & Lau 2010)that there is very little research that uses a methodological approach to identify and document user needs in the health domain. Despite the existence of software design methods the authors have found no evidence of documented systematic methods for gathering and documenting HIS requirements for LIC. A large number of HIS projects fail (or do not go beyond pilot phase) because they are designed and implemented without properly determined and documented user and system requirements. As a result systems are developed that do not reflect the real world needs of their users. Early involvement of those who are likely to be affected by the system will help to bridge the gap between end users, system designers, and developers. This enables developers to develop a system based on real needs instead of making wrong assumptions (Heeks 2006).

The recommended approach encourages deep and efficient engagement of stakeholders and end users at all levels of the health system. It enables an important technical discussion on the best technological solution to take place at the right time without compromising creativity or flexibility that can be caused by identifying the solution before analyzing and documenting the requirements of the health system and the local environment. The language used to document the requirements needs to be free of technical jargon and avoid the focus of physical technologies or solutions very early in the process. This approach enables users to concentrate on what and how they do their job, and the technical team can translate this information into requirements statements or diagrams that are easily understood and translated by non-technical people. This requirement gathering process gives an opportunity to review workflow and, where necessary, make improvements based on the gap that has been identified. It also enables stakeholders to discuss issues of integration and standardization of processes in order to avoid duplication of efforts and increase efficiencies.

The approach the authors put forward is adaptable and flexible so it can be made applicable to a local context. This is important as it assures that countries do not have to make their situation fit the approach; instead they can make the approach fit their local context. For example the activities do not have to be applied in a particular order and some steps can be skipped all together.

6.6 Conclusion

Enterprise architecture has a potential of simplifying the complexity of HIS and enable countries to design and develop a more integrated national HIS that more ably communicates with each other. TOGAF is a framework that is rich and complex and more work needs to be done in order to further develop a systematic architected and rational approach for HIS design. This systematic approach is essential in the design and development of systems that reflect what users do in order to reduce the risk of failure. However, more tests, refinement, and documentation of the methodology need to be done in order to simplify it so that countries can apply it to the design of their national HISs. Also, the approach can be used at the global level to develop generic requirements of the HIS functional domains identified earlier, so that countries can customize to suit their local needs.

There is an increasing acceptance of the use of enterprise architecture in Africa, along with initial attempts to use enterprise architecture to design HISs. However more needs to be done to establish a documented and tested methodology that empowers LIC to apply this methodology to gather and document their requirements, rather than global partners focusing on developing architecture for LIC to adapt. Finally research and evaluation is needed to show how more

integrated health information systems contribute to strengthening not just health systems but also population health and health equity.

6.7 Biographies

Henry Mwanyika

Henry Mwanyika has more than 9 years experience in ICT in the public and private sectors in Africa and abroad. Currently he is pursuing a doctorate on the use of enterprise architecture in health information systems strengthening at the University of Basel. He holds a BSc Computer Science and an MSc Business Information Technology Systems.

David Lubinski

David Lubinski has more than 30 years of experience in commercial, government, and nongovernmental organizations focused on health information systems. He leads the global HMIS program at PATH. Prior to this, he was chief technical officer for WHO's Health Metrics Network. He holds an MBA and a master's in public health policy.

Richard Anderson

Richard Anderson works with PATH's HMIS group on projects involving mobile and computing technologies. He holds a PhD in Computer Science from Stanford University and is a Professor of Computer Science and Engineering at the University of Washington leading research efforts on computing in low resource environments and educational technology.

Kelley Chester

Dr. Chester has 10 years of experience related to information technology and healthcare systems working with several community hospitals as well as with healthcare IT consulting firms. She

holds a doctorate degree in Public Health Leadership and master's degree in Biostatistics from the Jiann-Ping Hsu College of Public Health.

Mohammed Makame

Mohammed Makame, M.D., M.P.H., has more than 20 years experience as a clinician and more than 15 years in public health as an epidemiologist. He leads PATH's Tanzania country program, established PATH's TB/HIV Project which he led for 5 years, and was instrumental in scaling up TB/HIV services in Tanzania.

Don de Savingy

Don de Savigny, Head of Health Systems at the Swiss Tropical and Public Health Institute and chair of the WHO Health Metrics Network TAG, has 40 years experience in international public health, particularly in Africa. Recent work centres on system-level interventions aimed at health systems strengthening from a systems thinking perspective.

Matt Steele

Matthew Steele is a Senior Program Officer in Technology Solutions and Maternal Child Health and Nutrition at PATH. For the past two decades he has led projects and programs aimed at development and evaluation of technologies for improving management of important diseases in low resource settings.

6.8 Appendix 1: Health Architecture Development Method (H-ADM)

The following is the suggested step by step methodology considered as a starting point for developing Health-Architectural Development Method (H-ADM). This process is a combination

of TOGAF ADM (The Open Group 2010) and Collaborative Requirements Development Methodology (CRDM) developed by PATH (Program for Appropriate Technology in Health. 2010). It also based on my personal experience gained from workshops to gather requirement for logistic management information system in Senegal, Vietnam, Rwanda and Kenya (Program for Appropriate Technology in Health. 2010) and TB project presented in this paper. The diagram below (Figure 6-4) shows suggested steps and activities for the H-ADM;

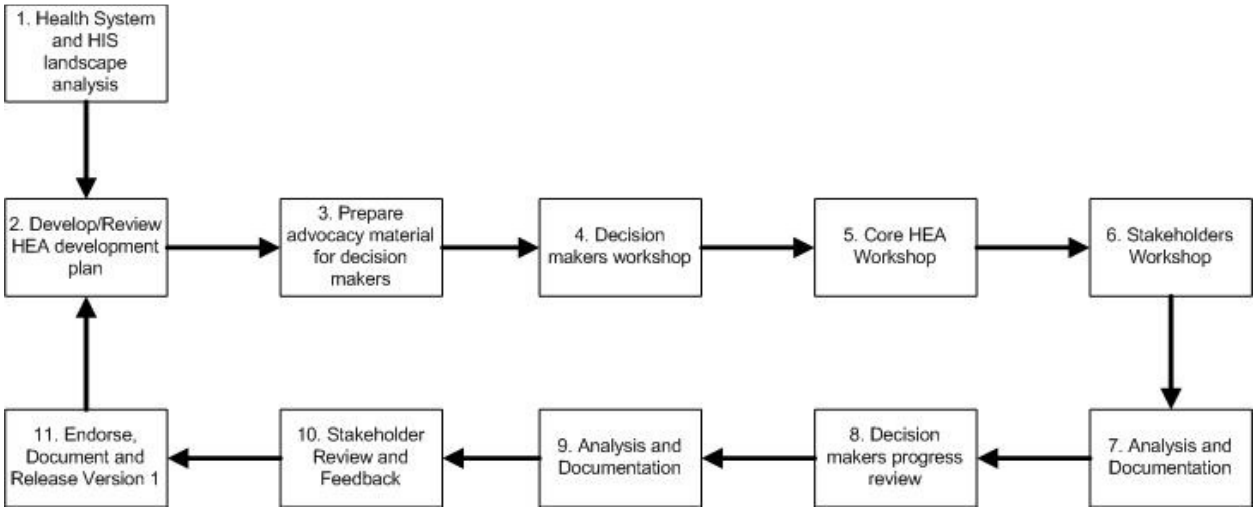


Figure 6-4: Health-Architecture Development Method (H-ADM)

Health Architecture Development Process

1. Health System and HIS landscape analysis
    - Review the current health system and health information system
    - Identify main components making up the HIS and their relationships
    - Identify governance structures for the HIS at all levels of the health system
    - Evaluate maturity stage of the HIS and initiatives currently underway
    - Identify potential champion of the HIS enterprise architecture (HEA) initiative
2. Develop/Review health enterprise architecture development plan

- Identify core HEA team members
- Prepare draft high level architecture diagram of functional domains and sub domains and their relationships of the current HIS
- Develop detailed activity plan of the architecture development framework
- Prepare maturity assessment results report

3. Prepare advocacy material for decision makers
    - Share the following information using non technical language
        - Progress so far
        - Identified current functional domains and sub domains, their relationships and stakeholders involved
        - How the HEA activity complement the health sector strategic plan
        - Resources required for the HEA activity
        - Scope of the HEA activity
        - Recommended core HEA team members including their roles and responsibilities
        - Draft HEA vision
4. Decision makers workshop
    - Decision makers provide discuss, provide feedback on
        - Formation of Governance board
        - Resource requirements and commitment
        - Detailed activity plan of the architecture development framework
        - Core HEA team formation and endorsement
        - HEA scope
        - HEA vision
5. Core HEA team workshop
    - Review progress made
    - Review feedback from decision makers workshop
    - Familiarise with H-ADM
    - Allocate roles and responsibilities to core HEA team members
    - Review HEA development framework and activities

- Review draft high level architectural diagram of functional domains and sub domains and their relationships
- Identify stakeholder workshop participants and their profile
- Prepare stakeholder workshop materials

6. Stakeholders workshop
    - Review HEA development process framework and activities
    - Review draft high level architectural diagram of functional domain and sub domain, identify major gaps and changes
    - Review and finalise HEA vision and scope
    - Develop current business architecture
        - Identify functional sub domains
        - Identify current processes
        - Identify actors for each process and their location and level
        - Identify data needed to be shared between components and processes
        - Identify information systems currently in use
    - Develop target architecture necessary to support HEA vision and the health sector strategic direction
        - Identify target functional domains and sub domains
        - Identify target processes for each domain and sub domain
        - Identify actors for each process and their location and level
    - Identify data needed to be shared between components and processes
    - Perform gap analysis
        - Identify gap between current business architecture and target business architecture
        - Identify new organisational structure
        - Identify processes that needs to be abandoned
        - Identify processes that needs to be changed
        - Identify new processes
        - Identify new data requirements
    - Identify prioritised activities to get to target architecture
    - Architecture requirements specification

7. Analysis and Documentation
    - HEA vision
    - Health sector strategies
    - Current architecture
    - Target architecture
        - Organising structure of functional domains
        - Functional domains and sub domains including their relationships
        - New identified processes including users who perform them
        - Data model for each functional domain and sub domains
    - Gap analysis results
    - Architecture requirements
8. Decision makers progress review (HEA Governance board)
    - Review the Architecture document and provide feedback
    - Review current status and next steps
9. Analysis and Documentation
    - Core HEA team review feedback from HEA governance board
    - Core HEA team update Architecture document
10. Stakeholder review and feedback
    - Review an finalise Architecture Document
11. Endorse, Document and Release Version 1
    - First Version of Architecture Document reviewed and endorsed ready for implementation

Chapter 7

The link between eHealth Strategy and eHealth Architecture

7 The link between eHealth strategy and eHealth systems architecture

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7.1 Abstract

The eHealth landscape in many developing countries is characterised by fragmented information systems silos that would benefit from developing an enterprise architecture to enable moving from eHealth silos to integrated eHealth systems. eHealth is about harnessing the power of information and communication technologies (ICT) to improve not just health systems but ultimately to improve population health and health equity. eHealth provides means for delivering the right information to the right person at the right time for decision making. There is a need for countries to formulate eHealth strategies that set out key directions for development and implementation of eHealth solutions and provide guidance in the systematic deployment, support and investment over time. eHealth architecture provides a description of sets of components and the relationship between them. The purpose is to identify system wide components required to be delivered by eHealth solutions by identifying functional components, their logical relation to each other and external systems and the dependencies that are required to deliver the eHealth solution. An eHealth architecture is an of an Enterprise Architecture (EA) in the health domain and has the potential to simplify the design, development, deployment and management of robust, forward looking, interoperable eHealth solutions that are consistent with an eHealth and health system strategy. Among other attributes, EA is both a methodology and management tool that provides a means for aligning information systems with an organisation's mission, goals and objectives. The application of EA can encourage stakeholder involvement and collaboration in an eHealth planning process and, in this way foster country ownership, leadership and accountability.

This paper provides a description on how eHealth strategy and eHealth systems architecture are linked to deliver robust interoperable eHealth solutions to strengthen national health information system.

Keywords

eHealth, eHealth strategy, architecture, system architecture, health information system, enterprise architecture, health systems

7.2 Introduction

eHealth is seen as one of the factors that has-the potential to improve the health of population and the performance of its health system (Bates & Wright 2009;Blaya, Fraser, & Holt 2010;Chetley 2006;Drury 2005;Kirigia, Seddoh, Gatwiri, Muthuri, & Seddoh 2005;Oh, Rizo, Enkin, & Jadad 2005;World Health Organisation 2006). There are multiple definitions of eHealth (Oh, Rizo, Enkin, & Jadad 2005), and in this paper we use a definition commonly used by WHO which define eHealth as *"the use of electronic information and communication technologies (ICT) in health care delivery and public health"*. eHealth provides the means of ensuring that the right information is available to the right person, at the right place and at the right time for evidence-based decision making. eHealth refers to the application of ICT in the healthcare sector where it has the potential to enable rapid improvements in healthcare service delivery as opposed to systematic changes brought about by reforms to the overall health system (International Telecommunication Union 2008). In reality, eHealth is concerned with harnessing the power of ICTs to improve the health system in the near term as well as to be scalable and sustainable over time.

According to WHO, the health system "*consists of all organisations, people and action whose primary intent is to promote, restore or maintain health*". The WHO Framework for Action identifies six building blocks that make up a health system (WHO 2007). The relationships and interaction between these building blocks is what makes a system from the individual building blocks (de Savigny & Adam 2009). Systems thinking, is a strategic approach to looking at a system as a dynamic whole instead of only the individual components that make up the system (de Savigny & Adam 2009). According to de Savigny and Adam (2009), the systems thinking approach can be applied to health systems to better understand the relationships and dynamics between the building blocks of the health system that work together to achieve a desired goal.

Enterprise Architecture (EA) is a well described methodology for defining the alignment of management information systems with an organization's mission, goals, and objectives. EA is both a methodology and management tool that provides a means for aligning information systems with an organisation's mission, goals and objectives and is consistent with application of the systems thinking approach to the information building block of a health system. Enterprise architecture is consistent with a systems thinking approach to the information building block.

Donors and international development partners have an increasing requirement for countries to produce reliable data for progress monitoring and evaluation (Delgado and Gorry 2008). This requirement translates into an increased data collection work-load on front line health workers (Stansfield, Orobaton, Lubinski, Uggowitzer, & Mwanyika 2008). In order to reduce duplication of efforts and inefficiencies, countries need to explore ways that health data and information can be better rationalised, coordinated and shared across the health system. There also need to provide guidance on eHealth hardware and software standards to be used.

The 58th World Health Assembly adopted a resolution on eHealth calling member countries to formulate long-term and cost-effective eHealth strategies (World Health Organisation 2005). These strategies are required to ensure efficient and effective use of the power of ICTs to improve the health system in both developed and developing countries. In order for an eHealth strategy to be effective it should be developed with the involvement of stakeholders from both public and private sectors as well as from all levels of the health system and should be consistent with country's health sector strategy (Stansfield, Orobaton, Lubinski, Uggowitzer, & Mwanyika 2008). The alignment of eHealth and health sector strategies is critical in making sure health sector goals and strategies that can be improved by eHealth are identified and the eHealth strategy is developed to support them (Finkelstein 2011).

Architecture is simply the description of a set of components and the relationship between them (Armour, Kaisler, & Liu 1999). Enterprise architecture (EA) is a methodology and management tool that provides means for aligning information systems with an organisation's mission, goals and objectives (Armour, Kaisler, & Liu 1999;Harmon 2003;Ross, Weill, & Robertson 2006). Organisations can use EA to analyse and define its structure according to defined viewpoints at the highest level of abstraction and identify ICT components that could be aligned within their current functions and future needs (Armour, Kaisler, & Liu 1999). Different aspects of enterprise architectures exist, including several different viewpoints, with the enterprise viewpoint representing the highest level of abstraction. System architecture is the conceptual description of a system that describes its components, their logical relation to each other and other systems and the principles governing their design, development and deployment. It includes the description of hardware, software and data including data structure and their integration (Armour, Kaisler, & Liu 1999;Blobel 2010). This view is essential in making sure that all components of the systems

are identified and it is understood how they support organisation functions and remain aligned to the health system strategic objectives.

Developing countries are embarking on a journey to use EA to strengthen their health information systems. Different countries are in different stages of developing their eHealth architecture with the aim of identifying and describing different components of their health information systems, their relationships and how information can be shared between them. This is in contrast with the way enterprise architecture has been traditionally used, aligning information systems with an organization's mission, goals and objectives (Armour, Kaisler, & Liu 1999;Ross, Weill, & Robertson 2006;Stansfield, Orobaton, Lubinski, Uggowitzer, & Mwanyika 2008). The application of EA in eHealth is still in its infancy as a result there is limited literature available at the moment.

As part of the process of designing and integrated health system an eHealth strategy, one can analyze current processes and decide whether they need to be re-engineered, rationalized or replaced. The implementation of eHealth solutions should be taken as an opportunity to redesign health systems processes to bring about improvements and optimizations instead of merely introducing automation to existing poorly performing processes. Existing processes may be inefficient and fragmented as a result of which the automation may not yield dramatic improvements (Hammer 1990).

This paper is a description of how eHealth strategy and eHealth systems architecture can be linked to deliver robust interoperable eHealth solutions and strengthen national health information systems. eHealth strategies set out key direction for development and implementation of eHealth solutions by providing the overall framework, principles and

direction to guide deployment and investment of eHealth solutions over a period of time. On the other hand, eHealth systems architecture translates activities identified in the eHealth strategy into set of functions that eHealth solution can support.

7.3 eHealth strategy development

As with any systems approach, the development of an eHealth strategy requires the involvement of key stakeholders, including government, non-government organizations and private organizations. Typically government stakeholders include the Ministry of Health and its stakeholders and programs, the Ministry in charge of Information Technology and regulatory agencies. However, this may vary depending on the structure of the government. Non-government organizations may include development partners, bilateral and unilateral organizations, universities, associations, etc. And private organizations may include private sector federations, telecommunication companies, software development companies etc. Bringing all stakeholders to the same table to discuss the development of an eHealth strategy is important in order to capture diverse viewpoints and to create the buy-in that is required from both those that will potentially play a role in the implementation of the strategy and those that will benefit from its implementation.

In practice, however, this exercise can be a daunting challenge. One of the challenges facing eHealth policy-makers is to engage stakeholders with diverse viewpoints and create a shared eHealth strategy that represents government's requirement while taking stakeholder views into account. This approach needs to take into account personal interests and the potential this has for creating bias. This calls for government leadership and strong guidance in order to mitigate these potential risks.

While an eHealth strategy is meant to address the country's priorities it is important that it describe all health sector business functions and how technology can potentially improve these functions within the foreseeable future. Prioritization may hence be addressed while setting the timeframe within which each eHealth intervention can be implemented. Various countries have varying needs and hence their priorities. This may largely be dependent on the strength of the healthcare system, the available infrastructure to support eHealth interventions and the availability of resources.

7.4 eHealth system architecture development

eHealth architecture provides a description of set of health information system (HIS) artifacts and the relationship between them (Armour, Kaisler, & Liu 1999). The purpose of eHealth system architecture is to identify system wide components required to deliver eHealth solutions by identifying their components, their logical relation to each other and other systems and their inter-dependencies. Components of the eHealth architecture can be grouped in three ways:

- **eHealth data**: describing major data items and data that will be shared between components. Data models are used as a description method.
- **eHealth applications**: describing tools and systems that will be used by users to interact with the system or for data processing
- **eHealth infrastructure**: describing computing infrastructure required to support eHealth solutions

There are several EA frameworks that can be used to develop eHealth architectures such as the Zachman Framework, The Open Group Architecture Framework (TOGAF), the Federal Enterprise Architecture, the Health Metrics Network and the Gartner Methodology (Stansfield,

Orobaton, Lubinski, Uggowitzer, & Mwanyika 2008). At global level currently there are attempts underway to apply an architectural approach to eHealth in low income countries. The Health Enterprise Architecture Framework (HEAF) is one of these attempts (Jembi Health Systems 2011). Lessons learned from these initiatives will inform the development of frameworks, methodologies and reference architectures for other countries to use.

The open source TOGAF, is one of the most standardized, and accepted EA frameworks. It provides a proven step-by-step method for developing and maintaining enterprise architecture. It covers four levels of architecture: business, information, application and technology infrastructure. At the core of TOGAF is the Architecture Development Methodology (TOGAF ADM) that describes a generic, highly adaptable method for developing enterprise architecture (Rees 2011). TOGAF ADM provides set of tools, common vocabulary and methods for defining an information system as set of building blocks and the description of how they fit together (The Open Group 2010).

The development of eHealth architecture is not a process that can be done all at once. The process requires the definition of iterative steps that build on each other and requires participation of individuals with different types of expertise from subject matter experts to ICT experts and decision makers. This paper does not provide step by step guidance on how to develop eHealth architecture. Instead it aims at outlining important aspect countries should take into consideration when developing eHealth architecture.

Involvement of stakeholders is one of the most important aspects in the process of developing eHealth architecture. Stakeholder viewpoints are vital in making sure the developed eHealth architecture has taken into consideration the needs of different stakeholder groups. They should

also be involved from the beginning of the process as their engagement at early stages of architecture development process is critical in obtaining alignment and buy in. Stakeholder experience and subsequent insight of potential obstacles can prove invaluable to the smooth progression to developing an eHealth architecture. As a result the developed eHealth architecture will be relevant to wider audience and create sense of ownership at all levels from frontline staff to decision and policy makers.

Simple and precise language in communication and in the documentation helps to avoid misunderstanding. When engaging stakeholders, decision makers and users it is recommended to avoid ICT technical language. Technical language during discussion is useful and essential if it takes place at the right time with the right audience. It is recommended to avoid technical discussion to take place too early in the process. When communicating with non-technical audience it is recommended to utilise visual models described in the language of health professionals, managers and users including workflow diagrams.

Taking a systemic view of the health system when designing eHealth architecture helps to understand how components of the health system function, interact with one another and the data that needs to be shared between these components. This also helps in determining interoperability, defined by TOGAF as "*the ability to share information and services*" (The Open Group 2010), requirements and how they can be managed. The architecture is key in identifying standards that will facilitate sharing of information and services between components. According to TOGAF, many organisations categorise interoperability as follows (The Open Group 2010):

- **Operational interoperability**: this defines how business processes are to be shared

- **Information interoperability**: this defines how information is to be shared
- **Technical interoperability**: this defines how ICT services like communication networks and databases are to be integrated and shared or at least connected to one another

In the eHealth architecture development process it should be understood and documented how each component of the architecture is mapped to the eHealth strategy. The mapping is important in identifying potential duplication, lack of standardisation and redundancy of components and processes.

7.5 Rwanda Example

WHO has been actively taking a lead in promoting the application of eHealth architecture in countries and this is critical in making sure there is consistent adoption of EA approach.

Rwanda is one of the countries that is drawing upon the EA discipline to strengthen their HIS. In October 2009, WHO organized a workshop in Kigali, the Rwandan capital, which brought together Ministry of Health officials working in the IT space, implementers, and health care workers from all domains of the health care system from Rwanda as well as neighbouring countries to participate in a 'peer assist' exercise. The MOH of Rwanda using their basic eHealth architecture of the national HIS as a starting point, invited practitioners from each of the 'building blocks' represented in the national eHealth architecture (Figure 7-1). This figure describes the main health information systems currently being used in Rwanda Each group, representing healthcare workers in pharmacy, clinics, district health offices, insurance, laboratories, etc. and in rotating bilateral teams, mapped out the minimum data sets each group needed from the other to accomplish the basic work of their functional area. Through several rotations, what emerged was the beginnings of interoperability profiles between various parts of

the national health information system. This process was innovative, engaging and encouraged creativity most importantly participation of multiple stakeholders was critical in creating sense of ownership of the end product.

This event launched a two year multi sectoral effort to document the use cases for interoperability and to implement a workable interoperability solution based on the national architecture. By November of 2011, an 'interoperability bus' was being constructed and implemented in order to have seamless flow of data between priority aspects of the agreed upon architecture (Figure 7-2). Figure 7-2 is a schematic depicting the elements of a national HIE that is designed to provide a technical implementation of some of the interoperability profiles elaborated at the WHO meeting, namely certain patient-based systems, community-based systems and aggregated reporting systems. This links the technical implementation in this Figure back to the elements of the national eHealth architecture depicted in (Figure 7-1 above).

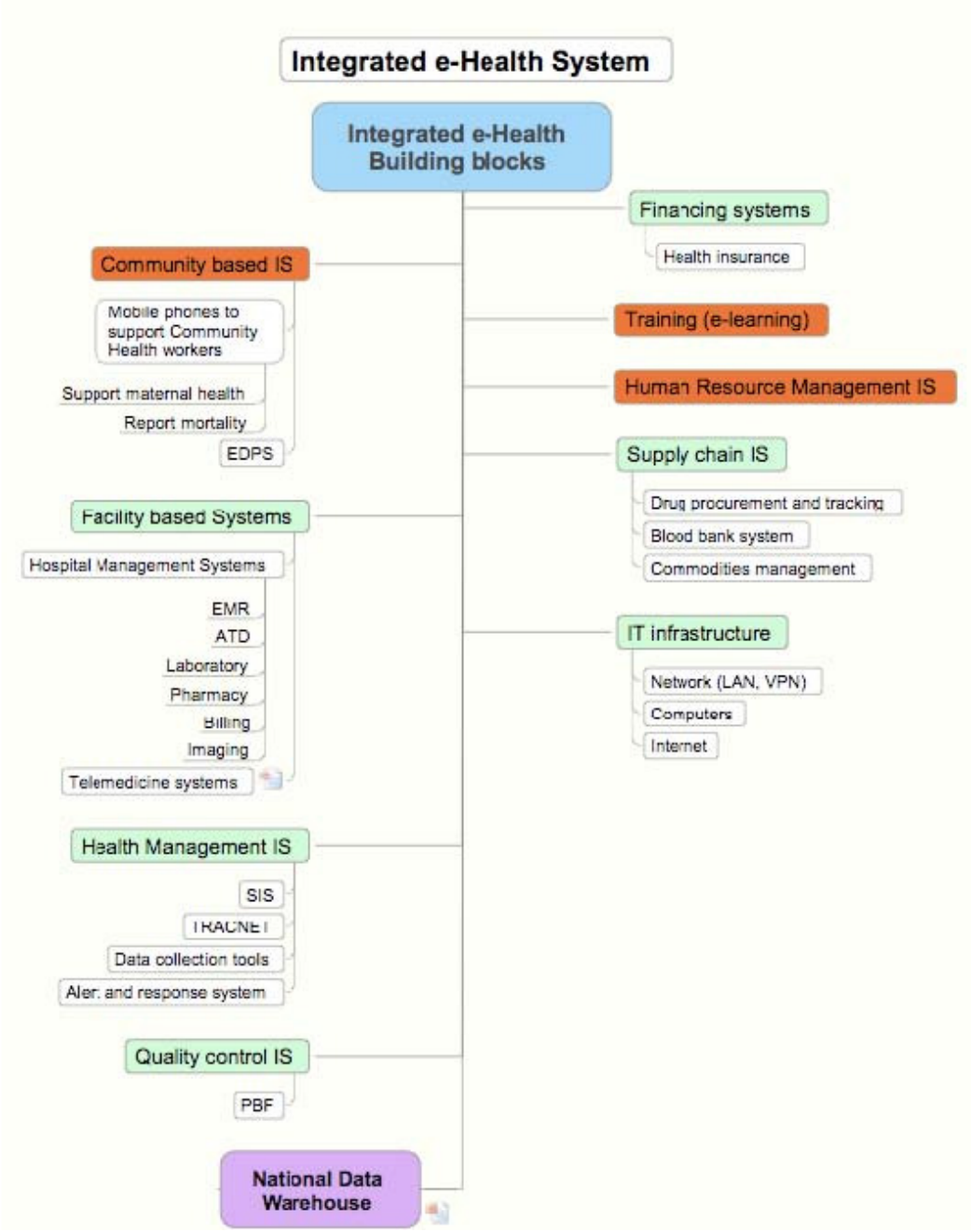

Figure 7-1 Rwanda eHealth Architecture (Source: Rwanda Ministry of Health)

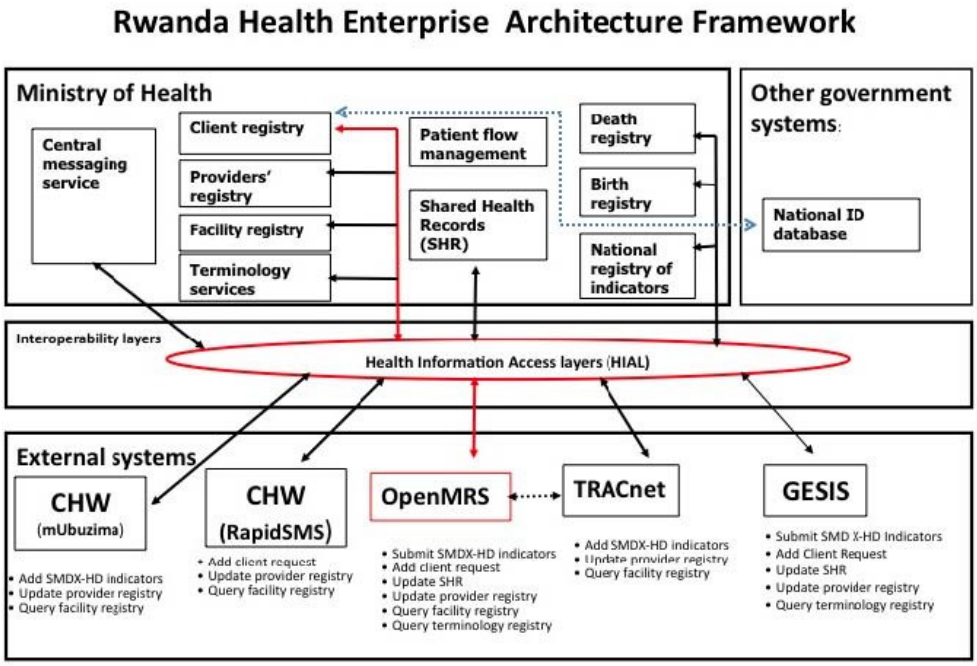

Figure 7-2: High level logical architecture of the Rwanda Health Information Exchanges and relevant point of care applications

(Source: Ryan Crichton – Jembi Health Systems)

7.6 Moving beyond strategy and architecture

The fact that excellent eHealth strategies and architectures alone do not save lives or improve health is not an epiphany. If these well documented strategies and well designed architectures are turned into eHealth solutions and are deployed to address the needs of end users they have the chance of impacting health system performance and saving lives. At the same time if eHealth solutions are designed and deployed in a way that is not systematic or architected, they may not address the needs of the end users. The eHealth architecture may also be used as a starting point to gather functional and system requirements to develop new solutions or to perform an assessment existing or off the shelf solutions.

The vision stipulated in the eHealth strategy will be realised if eHealth solutions are developed and rolled out in a systematic way. However, the health system is dynamic as a result of changing demographics and disease profiles. This may result in the need for the eHealth strategy to be updated in order to cope with the emerging issues or be flexible enough to cope with these changes. Having in place change management process will ensure changes or additions are managed in a cohesive way and the rational for these changes documented and communicated to all effected or interested parties.

There is a need to establish a mechanism at central level to ensure effective management and oversight of the eHealth strategy and associated architecture. This mechanism is also known as governance, and its main purpose is to provide assurance that eHealth solutions are designed and implemented in accordance with the principles and standards outlined in the strategy and architecture. It is also responsible for making sure the eHealth strategy and architecture evolves in a systematic way to respond to emerging health system demands.

7.7 Conclusion

There is agreement across many countries that technology can improve the way healthcare is delivered and also improve public health decision making and indeed many countries have implemented various technologies in order to harvest the anticipated benefits. Currently however, the eHealth landscape in many countries is characterised by discrete silo systems with significant barriers to the effective sharing of information amongst those systems. Among other challenges the lack of integrated or interoperable system contributes significantly to the difficulty in unlocking the potential of the various technologies that are being used. There is hence a need

for a clear strategy that defines each countries vision and priorities if such challenges are to be mitigated.

eHealth provides opportunities for health system strengthening by improving quality of data, modernising access and sharing of information and improving performance and efficiency of health information systems. However, these opportunities can only be realised if eHealth solutions are designed and implemented strategically and by looking at the health system in a systemic holistic way. Taking a systemic view will help in reducing fragmentation, redundancy and suboptimisation of efforts. This view may lead to increasingly use of eHealth architecture and the resulting solutions as means to bring about necessary reforms, stakeholder alignment and improvement to not just health systems but also population health and health equity.

The eHealth strategy and architecture will help developing countries move away from a status quo of moving ahead with eHealth innovation in a fragmented, unplanned manner without clear strategy on how they complement the health system and how their impact will be evaluated. In the process of developing eHealth strategy countries should take the opportunity to stand back and rethink of the processes and use the opportunity to rationalise or obliterate processes that are not working, the idea it to move away from computerising bad systems or introducing automation based on the needs of the past instead of the future.

eHealth architecture has the potential of simplifying the design and development of robust, future looking, interoperable eHealth solutions that are in line with a common and shared eHealth strategy. However, more efforts are needed to develop a simplified H-ADM (Health Architecture Development Methodology) to guide countries in the design and development of eHealth solution to realise their eHealth strategies. There is also a need for greater global coordination in

order to facilitate sharing of best practices between countries to accelerate capacity building, reusing effective tools and solutions which may bring cost savings and reduce the risk of eHealth project failure.

More than a planning approach, EA is a methodology which provides an open framework through which stakeholder groups within a complex information environment can articulate their viewpoints and information needs and ensure more than interoperability, but collaboration and alignment as well. In practice, this minimizes the risk of proliferation of fragmented systems, and allows for the possibility of greater economies of scale, and more importantly, new knowledge generated by the opportunities which emerge when different information sources are successfully integrated. This evolution of thinking from interoperability, to data sharing, to collaboration, to knowledge generation is a key ethos in the EA community and reflected in the culture of the participants (http://www.feapo.org/). Ultimately the reason why so much attention has been paid for the interoperability of health information systems, and the architecture that is required within a complex health information environment, is because health programs and health providers are interdependent, and to meet the ever increasing challenges faced by health systems, particularly in resource poor settings, program mangers, providers, and patients as well, need to have easier and increased access to useful health information across the health system in order to make the best possible to improve the general level of health in the community, the clinic, the district, national and globally. Ultimately, this is about people at different parts of the health system working together, and ensuring the software chosen reflects this need and manages the complexity of this challenge effectively.

Chapter 8

Discussion

8 Discussion

"We cannot solve our problems with the same level of thinking that created them"
- Albert Einstein

Gathering and documenting requirements and processes that facilitate systematic design and development of health information systems that are usable, integrated, interoperable and sustainable are practices neglected by Ministries of Health and donor partners in health systems strengthening. In response, this thesis presents original studies on the potential use of an enterprise architecture approach to strengthen health information systems in low income countries.

This chapter presents an overall discussion of the thesis and its findings.

8.1 Enterprise Architecture as Strategy

Enterprise architecture (EA) is a systems science approach that is widely used in software design in developed countries. The approach was first suggested to be used in Health Information Systems (HIS) strengthening in 2008 in the paper published as part of this thesis in Chapter4.EA is mainly associated with alignment of information systems with an organisation's goals (Ross, Weill, & Robertson 2006). EA has gained a reputation as an essential discipline to facilitate business transformation (Saha 2011). However, it is common to see, especially in developing countries, the application of EA to be focusing on developing eHealth or HIS architecture in silos with little attention paid its application in the context of the health system and this could be caused by the complexity of the health system (Moodley et al. 2011). Evidence from this thesis shows developing countries would benefit more from EA by applying it to simplify the complexity of the health system through guiding a systems thinking approach to describe

processes, personnel, information systems, data and sub-systems their alignment and how they are all intended to complement health systems goals and strategic direction.

eHealth is defined as *"the use of information and communication technologies (ICT) in health care delivery and public health"*. Some developing countries are starting to realise the potential of EA in developing integrated and interoperable eHealth solutions to strengthen their HIS. However, its application is far from being common place and its application is currently fragmentary with no easy to follow methodology for developing countries to use. As a result countries like Tanzania are struggling to understand how they can apply the approach, overcome its complexity and dedicate time and skills to developing an HIS architecture. This poses danger as developing countries may embark in the architecture development process in a wrong way and only come to realise when it is too late. As a result the experience may result in abandoning the EA discipline.

There is an initiative currently underway to apply an architectural approach in eHealth to develop Health Enterprise Architecture Framework (HEAF) for developing countries. The idea is to develop a framework that developing countries can use to develop their country specific architectures by providing a simplified methodology (Moodley, Pillay, & Seebregts 2011). This is an excellent initiative as long as it provides step by step methodology and tools for developing countries to apply and provide a platform for experience sharing. These are lacking and this thesis aims at complementing this initiative.

In the process of developing HIS EA developing countries should use the opportunity to stand back and reassess the current processes, indicators and data usage and take a decision to either eliminate processes that are no longer required or rationalise them. This process is also known as

business process reengineering (BPR). BPR is a technique used by businesses to rethink and radically redesign their business processes to bring improvements (Hammer 1990). When applied to HIS building blocks the BPR process recognises that HIS is comprised of specialised functional domains each responsible for carrying out a specialised task. These are presented in Chapter4. For that reason, the re-engineering focuses on re-designing the processes in a systemic way in order to achieve the greatest possible benefits to enable the health system achieve its objectives. Chapter5shows the evidence of what happens when developing and deploying a solution without taking the opportunity to rethink the current processes. PlanRep was designed with the aim of resolving planning and reporting problems local government authorities were facing. The opportunity was missed to redesign the whole planning and reporting process by harmonising reports required by stakeholders and change the way plans are reviewed and submitted to the national level as a result the system ended up creating extra burden to district planners.

The process of developing EA should be systematic and collaborative to ensure views of stakeholders and users from all levels of the health systems are taken into consideration when gathering requirements and developing the EA. This process should not be seen as a desk work that can be done by consultants interviewing a number of different stakeholders in isolation. Evidence from chapter 6 shows an application of the EA approach to gather requirements involving users from all levels of the health system. Users were involved in identifying gaps of the current system and a solution to cover the gap. Instead of expert consultants designing and imposing a solution without the involvement of stakeholders which may end up not resolving the real problem on the ground, the use EA approach resulted in improved workflow and designing of a solution that reflected the reality on the ground.

8.2 Using EA for eHealth

eHealth has potential for improving the way information is obtained, transferred, stored, processed and disseminated to different audiences scattered in different geographical areas inside or outside the country (Blaya, Fraser, & Holt 2010;Chetley 2006;Drury 2005;International Telecommunication Union 2008;Kirigia, Seddoh, Gatwiri, Muthuri, & Seddoh 2005;Pagliari, Sloan, Gregor, Sullivan, Detmer, Kahan, Oortwijn, & MacGillivray 2005;World Health Organisation 2006). However, this potential can only be realized if these eHealth solutions are designed and deployed in a coordinated and integrated manner in order to avoid fragmented silos in the already weak health systems commonly found in developing countries. Fragmentation and non interoperability of eHealth solutions can be found not only in developing countries. Developed countries have suffered and continue to suffer from fragmentation. For example the Canada Health Infoway was established to ensure different information systems are interoperable so that data can be shared between different legacy systems. Using EA approach the Canada Health Infoway successfully designed the information and communications infrastructure allowing the seamless sharing of information across the wide range of diverse systems composing the complex Canadian health system (Canada Health Infoway 2011). Another example is the United Kingdom National Health Services National Programme for IT. This ambitious but failed programme aimed at having a single mandated electronic patient record centrally accessed by General Practitioners and hospitals. After spending more than twelve billion pounds the UK government eventually abandoned it because EA approach was not used during design stage and there was insufficient involvement of stakeholders. As a result there was lack of “buy in” (NHS 2011).Most developing countries are in a better position as they do not have to deal with the inertia of well established legacy systems that are non-interoperable.

However, they need to ensure that interoperability is integrated at the heart of new eHealth solution conceptualization, design and deployment.

An information system that has multiple stakeholders with different requirements and interests. Involvement of all stakeholders during the design is essential, instead of involving only those providing the financial resources or the most powerful and influential. This was evident in the development of the planning and reporting database presented in chapter5. There are 4 types of users; districts; Local Government ministry PMORALG; sector ministries; and Ministry of Finance. The developer involved only the report consumers at every stage of the design and development. As a result when the finished product was made available to data producers for live testing it was realised that the software did not reflect the reality on the ground.

Stakeholders play an important part in the design of HIS. The systems thinking approach and Health Metrics Network (HMN) Framework alike emphasise the importance of early and continued stakeholder involvement in systems strengthening initiatives. The participatory design approach is considered as one of most effective ways of designing information systems in any settings. Participatory design originated in Scandinavia in the 1970s emphasises the active involvement of the end user in the requirements gathering and eventually design and testing of the system (Kimaro & Tollman 2008). As shown in chapter 6 participatory approach provided an opportunity for end users and system designers to share technical and contextual understanding that was critical in the design of the system.

Simplified communication between the end user and the designer helps to create understanding instead of confusion. Chapter 6 of this thesis shows how communication was simplified using visual models to facilitate the communication of technical content in a non-technical way.

Technical discussion cannot be avoided when developing eHealth solutions but at what point this discussion takes place needs to be well thought-out to avoid it taking place too soon or too late. This thesis provide evidence that "*kicking the can down the road*" might be a good technique in the early stages, because if the technical discussion is taking place too early it may suppress creativity as the focus will be shifted from finding a solution to the problem at hand to finding a problem that can be resolved with a solution at hand. As discussed in chapter 6 of the thesis, the technical discussion and the decision to use mobile phone solution was reached after going through processes, identifying gaps and analysing the working environment of end users.

Participation of stakeholders, policy and decision makers, end users and/or anyone who is likely to be affected by the system from early stages helps to obtain a "buy in" from them. As the development process continues stakeholders need to be updated on the progress made so that critical feedback can be provided. This process is also called prototyping in software engineering where the developer shares incomplete versions of the software being developed for feedback (Gordon and Bieman 1995). Continuous progress updates provides the opportunity for end users and decision makers appreciate the complexity or simplicity of what is being developed so that expectation can be managed. This is rarely done in low income countries HIS development.

Human resource capacity is considered as one of the bottlenecks that hinder developing countries to leverage the power of ICT. Most health workers in developing countries do not have basic computer skills (Kimaro & Tollman 2008). This is because most training institutions have been slow to offer basic computer training in the curriculum. This thesis points out this failure of dynamic efficiency in the education sector. Developing countries should build capacity of their

health workforce by making sure it gets basic computer training so that they are able to leverage the power of ICT in their professional work.

eHealth solutions may be as complicated as fully fledged electronic medical records or as simple as SMS based solution to send text messages to pregnant women reminding them to attend ANC clinic. The development and implementation of these eHealth solutions is likely to require multiple skills and perspectives (Mistrik et al. 2010). Specialised technical skills required to develop these solutions is said to be lacking in developing countries (Heeks 2006;Moodley, Pillay, & Seebregts 2011). This is said to be the case despite the fact that NGOs, commercial banks, private software and telecommunication companies are using local developers to develop and maintain complex systems. This thesis shows that local developers with specialised technical skills exists in developing countries but are not utilised by the government due to non competitive pay and lack of leadership. Donors will need to supplement governments to access this expertise competitively.

8.3 HIS Strengthening

In HIS strengthening efforts, a cliché is for people to start thinking about developing and deploying a computer based solution (Vital Wave Consulting 2009a). HIS strengthening is not merely computerisation of a paper based HIS in order to facilitate data collection, transfer, storage and analysis. Instead it should be accompanied with a comprehensive assessment of the existing system by identifying weaknesses and strengths of the system including data sources, collection tools, and indicators as well as data use culture.

The development of HIS should be a combination of both bottom-up and top-down. The national level will specify data required for decision making at national level and lower level, where data

is collected, should also be able to specify what they need for day to day decision making. Then through dialogue that involve stakeholders at all levels of the health system decision is made to identify the minimum data items that must be routinely collected and data items that can be collected through cross sectional surveys. The aim is to ensure a balance between supply of and demand for health information and instil data ownership to data producers and consumers at all levels of the health system. Figure 8-1shows the connection between supply of and demand for health information and their effect on the HIS. The aim is to get to the top right corner of the matrix where there is a high balance between supply of and demand for health information.

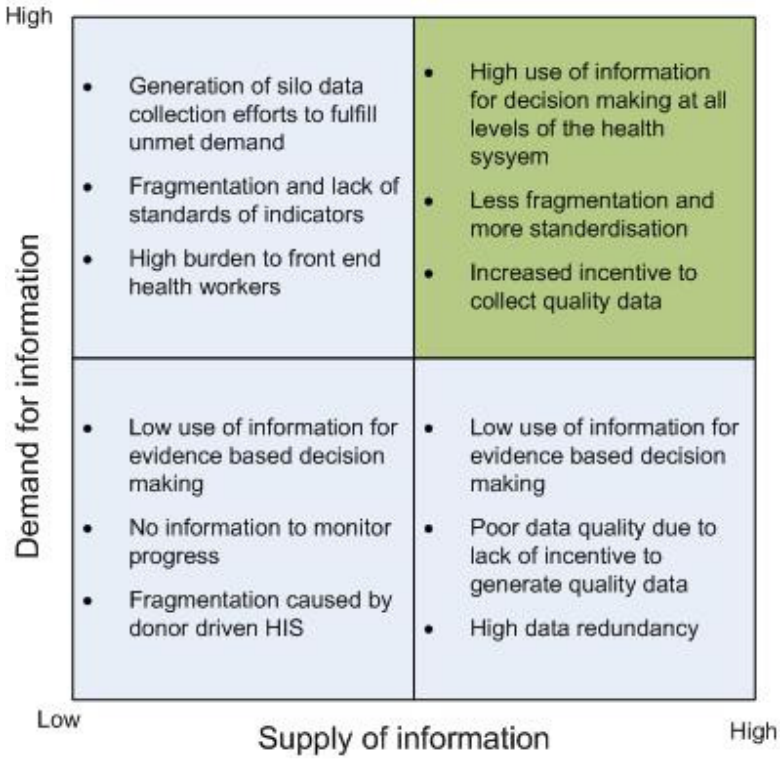

Figure 8-1: Supply vs Demand of health information

The introduction of mobile phones in health (mHealth)is likely to be influential in HIS strengthening in the near future (Kahn et al. 2010;Vital Wave Consulting 2009b). This is because

the mobile network coverage is increasing in developing countries (Vital Wave Consulting 2009b). In Tanzania availability of data services is improving due to the efforts done by the government to build the high speed fibre optic network backbone to connect all districts in Tanzania with fast internet connection. However efforts should be made to ensure these mHealth solutions are developed to scale and these efforts consolidated so that countries do not end up in a situation where they have one mobile phone to collect data for each disease for example one for Malaria another for HIV/AIDS and another one for TB. As discussed in chapter 6, during requirements gathering stage issues of interoperability with existing systems and scaling up were discuss and taken into consideration in the design of mobile phone application to improve TB case detection and management in the community..

World Health Organisation is calling member countries to formulate long-term and cost effective eHealth strategies to ensure countries leverage the power of ICT to strengthen their health system. As evidence in chapter 7 shows, development and implementation of eHealth strategy poses a challenge in countries with weaker leadership and poor coordination at national level. HMN framework highlights the important role of leadership and coordination in strengthening HIS (HMN 2008). The development of eHealth strategies needs to be lead by local champions who are committed and dedicated as it provides sense of ownership and continuation. These champions should to be locals, knowledgeable and either a decision maker or someone who can gain the attention of a decision maker. The example given in chapter 7 shows evidence from Rwanda, considered as a success story among developing countries when it comes to successful implementation of eHealth interventions. Rwanda developed eHealth strategy and national eHealth architecture by involving multiple stakeholders with strong leadership and coordination

from Ministry of Health at national level as a result there is an increasing alignment among donors and implementers of eHealth in the country.

8.4 Summary of Papers and Linkages

This thesis includes four publications covering objectives presented in chapter 0. The first paper in chapter 4 presented the case for using EA approach to guide the design and development of integrated national health information system. This paper suggested for the first time the use of EA for HIS strengthening in developing countries. The paper ended by presenting, as a starting point, a list of functional domains for health information system, processes and potential users. The second paper presented in chapter 5 examines the development and implementation of district planning and reporting database in Tanzania. This paper looks at how requirements were gathered and the approach used in the design and development of the database. The aim was to identify the approach used for gathering requirements, designing and implementing the system and the potential gaps. The third paper presented in chapter6 introduces the systematic architected rational approach (SARA) for HIS design and implementation. The approach is based on EA and places emphasis on the involvement of end users in the design of HIS. The paper presented a case study that shows how the EA approach was used to gather and document requirements to design a mobile phone application in Tanzania. The fourth paper presented in chapter 7 describes the need for linking eHealth strategy and eHealth architecture. The paper shows how eHealth strategy and eHealth systems architecture are linked to deliver robust interoperable eHealth solutions to strengthen national health information system. The paper presented important issues to consider when developing eHealth strategy and architecture. It emphasises the importance of stakeholder involvement and encourages countries to use the opportunity to reassess their business processes and redesign processes that are not working.

Chapter 9

Conclusion

9 Conclusions and Recommendations

The purpose of this thesis was to study the potential use of Enterprise Architecture (EA) as a strategic approach used to systematically gather and document Health Information System (HIS) requirements to design a unified comprehensive health information system that integrates data from diverse sources at all levels of the health system for localised evidence-based decision making and health systems strengthening.

EA is widely used in developed countries to provide means of aligning organisation's goals and objectives with information systems. Since it was first suggested to be used in HIS strengthening it has been commonly applied in developing eHealth solutions and HIS instead of strengthening health systems as a whole. EA provides ways to describe processes, information systems, organisation subunits so that they align to the goals and strategic direction of the health system.

Stakeholders and end users form all levels of the health system must be continuously involved in HIS strengthening process. Their continuous engagement and participation will bring broad perspectives critical in the design and development of eHealth solutions that reflect the reality and create sense of ownership that is critical to the successful design and development of any eHealth solution.

Developing countries has realised the potential of ICT in improving healthcare delivery and availability of information for evidence-based decision making. Despite this realisation many HISs in developing countries are chaotic characterised by silo systems unable to communicate with each other. EA approach facilitates the design of integrated HISs by describing HIS in a more systemic holistic way.

HIS strengthening efforts may bear fruits if the opportunity for computerisation is also used to reassess the current processes, indicators and data usage and take a decision to either eliminate processes that are no longer required or rationalise them instead of computerising bad non-working processes.

9.1 Recommendations

Donor partners should integrate their initiatives when providing support to developing countries. Donors should consider funding EA activities as part of health systems or HIS strengthening initiatives and encourage countries to reassess and improve their processes. This will yield fruitful results as donors will not be forced to bypass the weak HIS and establish another silo system to monitor progress.

Global EA experts should support countries to develop capacity in EA and encourage local ownership of the development process. EA experts need to understand and appreciate the local context instead of imposing solutions from developed countries. They also need to avoid the temptation of being technical too early in the process.

The potential of eHealth in health system strengthening has gained the attention of decision makers and donors. Countries should use the opportunity to bring improvements to their health systems and consolidate health system strengthening initiatives. Country leadership and coordination is critical in bringing together donors, implementing partners and resources to reassess and improve their processes. Countries should develop eHealth strategies to ensure they leverage the power of ICT in a systematic and strategic way.

More efforts should be made to develop a simplified Health-Architecture Development Method (H-ADM) to guide countries to develop their HIS EA.

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Appendix – Curriculum Vitae

Name: Henry Bethuel Mwanyika

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EDUCATION/QUALIFICATIONS:-

2008 – 2012 **PhD Epidemiology**
Swiss Tropical and Public Health Institute,
University of Basel, Basel Switzerland

2004 – 2005 **MSc. Business and Information Technology Systems**
University of Strathclyde, Glasgow UK

1997 - 2001 **BSc (Hons) Computer Science.**
University of the West of England, Bristol UK

WORK EXPERIENCE:-

2007 – Present **Ifakara Health Institute, Dar es Salaam Tanzania**
Research Scientist

Sept 2007 – Jun 2008 **University of Dar es Salaam, Dar es Salaam Tanzania**
Part-time Lecturer

Dec 2006 – June 2007 **Institute of Finance Management (IFM) Dar es Salaam Tanzania**
Part-time Lecturer

Oct 2005 – Sept 2006 **InPractice Systems Enterprise Solutions, Dundee, United Kingdom**
Software Developer

Jan 2002 –June 2004 **Adult Morbidity and Mortality Project (AMMP), Dar Tanzania**
Information Systems Officer

Aug 1999 – Sept 2000 **Lucent Technologies (UK), Malmesbury England**
Software Engineer

OTHER:

Feb 2011 - Mar 2011 **NORAD Norway/PATH (Seattle, USA):**
Consultant - Review of the Health Information System Program (HISP)

Feb 2011 **WHO AFRO**

Consultant - Technical Assistance to Liberia in the costing of Liberian maternal and newborn health roadmap

Aug 2010 **Swiss Development Corporation, Dar es Salaam Tanzania**

Consultant - Provide Technical Assistance to the Tanzania Ministry of Health and Social Welfare to review Comprehensive Council Health Planning (CCHP) & Reporting with the aim of strengthening Planning and Reporting Tool (PlanRep) and its integration in CCHP.

TRAINING/ WORKSHOPS ATTENDED:-

Sept 2011 **eLMIS strategy and requirements development workshop for Tanzania**

Aug 2011 **WHO-Health Metrics Network (Geneva):**

Member Expert Panel - Monitoring Vital Events Resource Kit meeting

Nov 2010 **mHealth Summit – Washington DC**

Speaker in Enterprise Architecture concurrent session

June 2010 **EA Experience Sharing Workshop - Vancouver, Canada**

May 2010 **eHealth Conference – Vancouver Canada**

April 2010 **Enterprise Architect Practitioner Certificate, The Open Group Architecture Framework - Bern Switzerland**

Nov 2009 **WHO-Health Metrics Network (GENEVA):**

Member Expert Panel - Development of HIS Strengthening Progress Tracking Tool

Sept 2008 **Technical Consultation on Prioritizing the Building Blocks of a National Health Information System - Seattle, USA**

July 2008 **Making the eHealth Connection: Global Partnerships, Local Solutions – Bellagio, Italy**