

Article

Rational Systems Design for Health Information Systems in Low-Income Countries: An Enterprise Architecture Approach

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Abstract

Low-income countries 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 article introduces a systematic, architected, and rational approach (SARA) for the design and development of health information systems. SARA, based on an Enterprise Architecture (EA) 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 article 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

INTRODUCTION

Enterprise Architecture (EA) is a discipline that is continually evolving. Most importantly, EA adapts to the business setting for which it is practiced, influenced by many variables such as the political, cultural, external environment, technical and business contexts. The intent of this article is not to provide a universal EA definition or approach, but to share what have proven to be successful EA practices undertaken by WA Police to establish an EA capability, covering three topics: Establishing Enterprise Architecture, Connecting with the Business, Connecting with Partners, and key learnings of each.

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). The 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 and 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 brings together data from vertical or disease-specific sources will enable the data from all levels of the health system to be aggregated and analyzed in totality (Sahay et al, 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 the heterogeneous nature of the health system and its complex dynamics as shown in Figure 1 (Saha, 2011). HIS is made up of a number of components that 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 inter-relationships, 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.

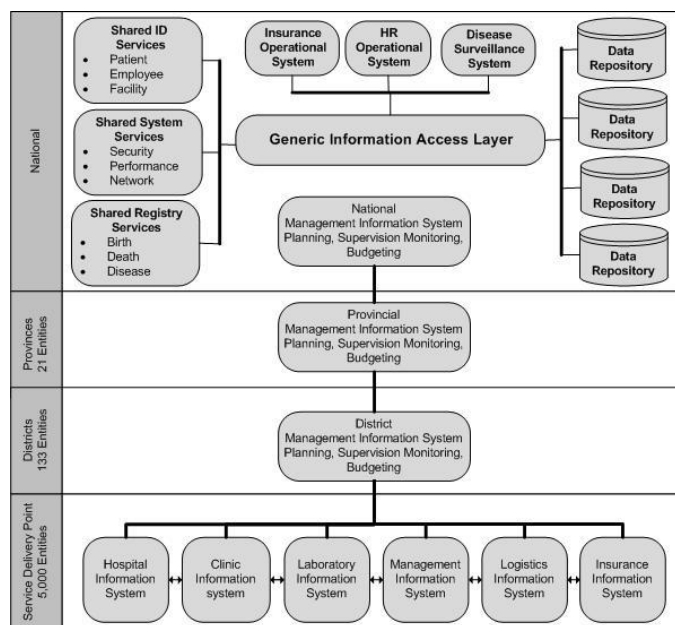


Figure 1: Tanzania Reference HIS Architecture

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 et al, 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 TOGAF®. Now in its ninth release, TOGAF was first made available in 1995 by a vendor and technology-neutral 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 EA (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 Methodology (ADM) that describes a generic, highly adaptable method for developing enterprise architecture (Rees, 2011). The TOGAF ADM provides a set of tools, common vocabulary, and methods for defining an information system as a 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 around by defining an architecture before making ICT solutions (Brooks, 2009). The ICT industry has for many years struggled with ICT failures and the global health community 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 in 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 and 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 and 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 the 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 et al, 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 (Kuziemy and Lau, 2010; Schlotzer and 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 article is to introduce an approach adapted from TOGAF to provide guidance that countries and solution providers can use to design and develop integrated HIS. It advocates a systematic approach that reflects the strategic direction set by policy-makers and stakeholders. This approach can be used at a 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.

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 2 is 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 US 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 artifacts 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.

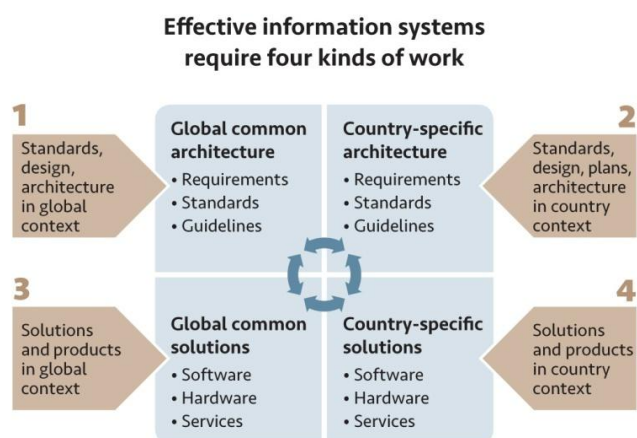


Figure 2: Framework of Global Common and Country-Specific Architecture and Solutions

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 HIS capabilities. These first two steps, which use techniques adapted from the preliminary and architecture vision phases of the TOGAF ADM, can help to 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 policy-makers) 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 techniques adapted from TOGAF ADM architecture vision phase.

Step Four

Step four, using techniques adapted from the business architecture phase of the 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 policy-makers, 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.

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 the core functional domains of the health system. This initial Health Domain Model continues to be improved by global health experts and country stakeholders. It comprises 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 a disease or domain-specific point of view (de Savigny and Adam, 2009). This approach will reduce the risk of fragmentation, duplication, and lack of interoperability as all inter-relationships and alignment of domains will be identified at design stage (Stansfield et

al, 2008). It is critical to first know how the system that is being developed fits into the country's HIS by identifying interoperability and information needs that the system is expected to address. All efforts need to be made to re-use 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.

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 the 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 and 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 and 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.

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.

Purpose

The TB Control Program is 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? <ul style="list-style-type: none"> • 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 • Describe technical capacity and systems | Session 3: How to make things work better? <ul style="list-style-type: none"> • 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 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? <ul style="list-style-type: none"> • 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? <ul style="list-style-type: none"> • 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 |

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
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.

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,

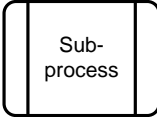
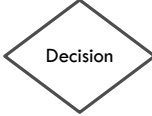


and evaluation. Individual patient records are entered from the standard paper-based TB registered and different patient lists and reports can be automatically generated (ETR .Net, 2007). ETR is the system that serves as the foundation of data used to inform policy and to monitor TB program performance 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 3, represented what happens in real life.

Using a non-technical approach to activity modeling 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 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. |
| 4 |  | End Event: A process mapping shape used to define the "end" of the process. |
| 5 |  | Sequence Flow: Depicts the flow of information or artifacts through the process from activity to activity. |
| 6 |  | Activity: An action performed by the functional individual or group. |

| | Symbol | Definition |
|----|--|--|
| 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: A process mapping shape that links multi-page processes for ease of understanding. |
| 10 |  | Annotation: Notations made at the activity level. |

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.

DISCUSSION

This article 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 a 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 the 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.

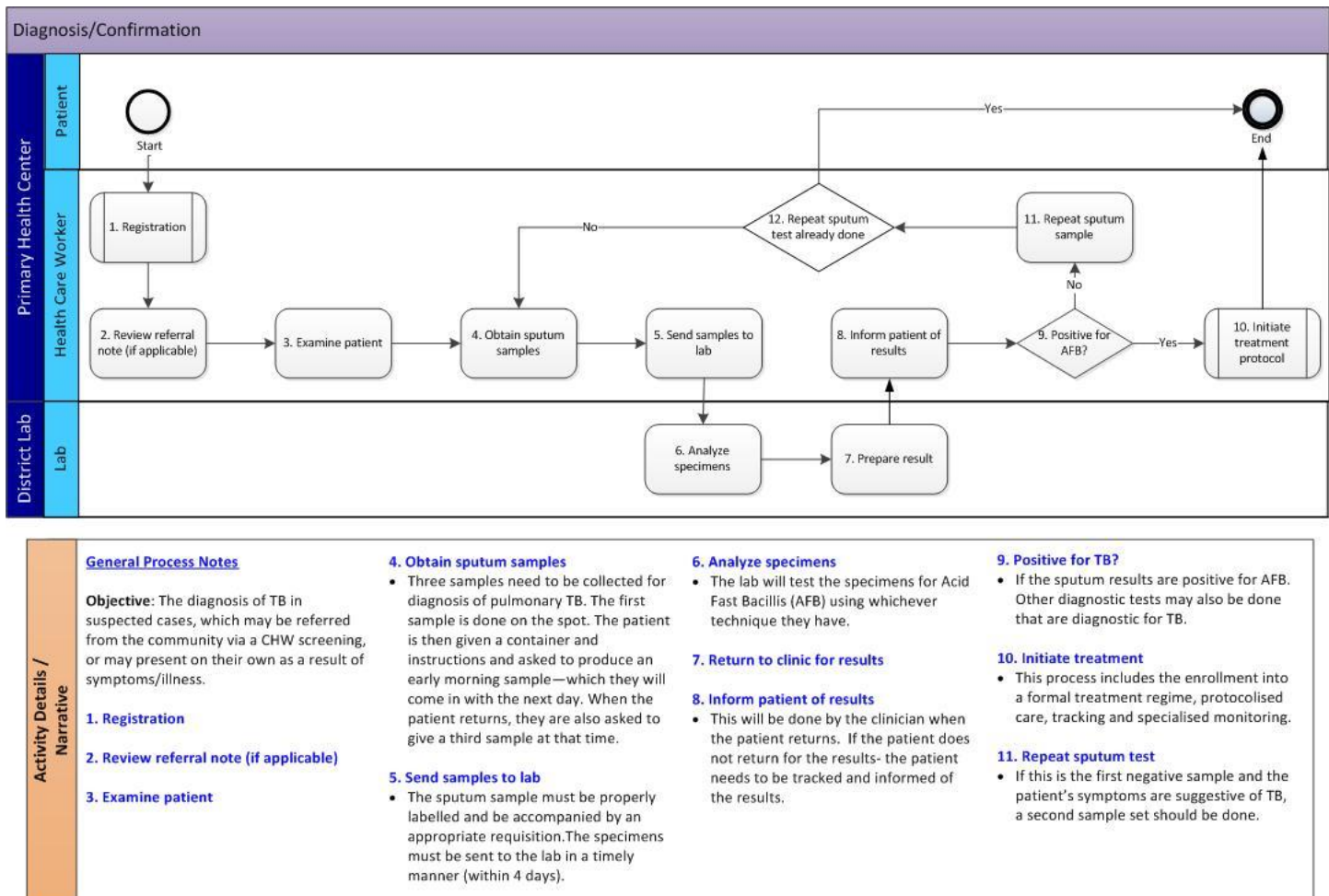


Figure 3: TB Program Activity Diagram

The authors agree with Kuziemy (Kuziemy and 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.

CONCLUSION

EA has the potential of simplifying the complexity of HIS and enabling countries to design and develop a more integrated national HIS that more ably communicates within itself. 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 EA in Africa, along with initial attempts to use EA 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 HIS contribute to strengthening not just health systems but also population health and health equity.

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