Implementing Burundi's national e-health enterprise architecture: past, present and future

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Background and purpose: The Ministry of Health (MoH) of Burundi initiated in 2014 the development of a national e-health enterprise architecture aiming to reclaim its leadership in this field and to better align existing and future ICT implementations in the health domain with the strategic options defined by the National Plan for Health Development (PNDS). **Methods**: The Open Group Architecture Framework (TOGAF) was used as a method for developing Burundi's e-health enterprise architecture. A first part of the study consisted of a detailed analysis of regulatory documents and strategic plans related to the Burundian health system and health informatics development. In a second part, field visits and semi-structured interviews were organized with a representative sample of relevant health structures throughout the country. Thorough analysis of human resources, business processes, hardware, software, communication and networking infrastructure provided both a baseline and a target e-health situation. Finally, a strategic document was developed for planning the way forward for filling the functional and technical gaps that had been identified.

Results: the preliminary study demonstrated the donor driven unequal distribution of hardware equipment over health administration components and health facilities. Internet connectivity was problematic and few health oriented business applications had found their way to the Burundian health system. Paper based instruments remained predominant in Burundi's health administration. The study also identified a series of problems introduced by the uncoordinated development of health ICT in Burundi such as the lack of standardization, data security risks, varying data quality, inadequate ICT infrastructures, an unregulated e-health sector and insufficient human capacity. The later architecture development effort resulted in the production and validation of a national e-health strategy for Burundi for the period 2015-2019 (PNDIS). This strategy has been put into implementation by the Ministry of Public Health and Fight against Aids since 2015 with the help of the country's development partners.

Conclusions: the results demonstrated the challenging situation of the Burundian health information system but also revealed a series of important opportunities for the future: a political will to reclaim MoH leadership in the health information management domain based on the PNDIS, the readiness to develop e-health education and training programs and the opportunity to capitalize the experiences with DHIS2 deployment, results based financing monitoring and evaluation with OpenRBF and hospital information management systems implementation based on OpenClinic GA.

Keywords: e-Health enterprise architecture, TOGAF, Health information systems, Burundi

1 Introduction

In 2005, the Ministry of Public Health and Fight against Aids (MoH) of Burundi has developed a National Health Policy covering the period 2005 to 2015 [3]. This policy was later translated by the MoH and its technical and financial partners into a series of objectives and resulted in the National Plan for Health Development 2011-2015 [1]. Amongst the objectives were the reinforcement of the National Health Information System and the restoration of MoH's leadership in the field of health information management. Therefore, a number of priority actions have been identified:

- The development of an e-health strategic plan for strengthening the national health information system
- The development of an integrated and competitive health information management system
- The development of effective tools for planning, monitoring and evaluation
- Increasing the availability of ICT tools (hardware, networks and software) at all levels of the Burundian health system
- The promotion of data driven research activities in the health sector

Integrating e-health in the national health policy yielded from the beginning enthusiasm from the donor community and in the course of the past decade, a growing number of ICT tools have found their way to the Burundian health sector. But most often, these tools have been introduced for supporting specific projects lead by NGOs and foreign technical and financial development partners. The majority of the chosen hardware and software solutions almost systematically served very well the individual project objectives, but inter-project coordination and interfacing remained almost inexistent. Doing so, sometimes successful e-health tools remained isolated in silo-projects where they only yielded a fraction of their potential benefits. Without corrective action, the Burundian health sector threatened to evolve towards a cacophony of divergent health informatics implementations that did not integrate with a coherent national health information system development strategy.

In order to cope with this threat, in 2014, the MoH initiated the development of a national e-health enterprise architecture with financial support of the Belgian Technical Cooperation. The Open Group Architecture Framework (TOGAF) [2] was chosen as the reference methodology for developing this architecture. During the first phases of the architecture development cycle, an initial analysis of human resources, business processes, hardware, software, communication and networking infrastructure related to health information management, had to be established. This paper describes the objectives, methods and findings of this preliminary analysis, leading to the development of Burundi's national e-health strategy [14].

2 Materials and Methods

The main objective of the preliminary analysis was to provide a reliable estimation of the existing human and material resources and the issues related to health information management in Burundi. This study was part of a complete e-health enterprise architecture development cycle according to the TOGAF methodology, and therefore its output had to address a number of expectations defined by TOGAF. In summary, the analysis focused on providing answers to the following questions:

- What are the MoH's business needs in terms of health information management?
- Which health information management applications have already been implemented in the field and to what extent do they address specific business needs?
- What data is being collected today by the MoH and what is the quality of it?
- Which technologies (software, hardware, and networking) are used today in the health domain in Burundi?
- What are the important health information management problems in Burundi today?

A first part of the study consisted of a detailed analysis of a number of regulatory documents and strategic plans related to the Burundian health system implementation and health informatics development [1,3,4,5,6].

In a second part, field visits and semi-structured interviews were organized with a representative sample of relevant structures of the MoH throughout the country. For the sake of completeness and

standardization, a study-specific interview guide has been developed and was systematically used by the interviewers. After an introduction on the purpose of the interview, representatives of each structure have first been questioned about the mission, the mandate and the vision of their organization, the objectives, the functions and the roles fulfilled and the way their work is organized. After that, a detailed analysis was made of health information management related human resources, ICT solutions and non-ICT (paper based) instruments at their disposal and finaly an inventory was made of existing procedures for exchanging health information with other (MoH or non-MoH) organizations. Finally, an analysis was performed of health information management problems, expected benefits, potential threats and the perceived importance of health ICT for each component of the organization.

The preliminary study was then used as a starting point for the development of a national e-health enterprise architecture for Burundi. Using the TOGAF toolkit, the architecture team developed therefore the future target (i) business- , (ii) application- , (iii) data- and (iv) technology architectures for the MoH and consolidated these in a national e-health strategy for the period 2015 to 2019. This document was submitted to the MoH for final validation in 2015.

3   Results

3.1   Field visits and interviews

The study of regulatory documents and strategic plans took place in October and November 2014. After that, a series of field visits and interviews have been organized with 39 relevant MoH and -related structures in the Bujumbura region:
- The permanent secretary and all MoH directorates
- Major health programs (malnutrition, HIV, malaria, vaccinations, tuberculosis)
- Donor agencies and technical partners (Belgian Technical Cooperation, European Union, German Cooperation, Unicef, Japanese Cooperation, Gavi fund)
- Health facilities (third level reference hospitals, public and private clinics, health centers)
- Educational institutions

In the period from November-December 2014, the e-health architecture development staff also visited 5 other provinces (Muramvya, Gitega, Ruyigi, Kirundo and Ngozi). In total a sample of 5 provincial health offices (29%), 5 health district administrations (11%) and 12 hospitals (18%) have been analyzed by the study, representing an overall coverage of more than 15% of all MoH structures.

3.2   Hardware

The study showed that computer hardware has most often been supplied to the MoH within the scope of donor-driven intervention programs. There was no organization-wide management of computer equipment and therefore distribution of hardware over the different MoH directorates, provincial or district administrations and hospitals was very heterogeneous: some structures which were supported by several donors were very well equipped; others remained without any computer hardware at all. Under impetus of national and provincial policies, a growing number of health centers in Burundi had also started buying computer hardware with their own funds, unfortunately without having a clear idea of how to integrate these new tools into their existing business processes.

Generally speaking, hardware specifications were quite standard: desktop PCs with Windows XP and Windows 7 operating systems, of which a large number had limited functionality due to computer virus infections (there is no budget available for keeping antivirus software databases up to date and many of the PCs have no access to Internet for performing updates anyway). PCs were almost systematically accompanied by uninterruptible power supplies (UPS), but due to the lack of battery maintenance, the protection offered by these UPSs was minimal.

Many of the executive staff made use of laptop computers which in about half of the cases were their personal privately-owned equipment.

Most of the MoH structures owned one or more printers and many of them were individual printers that were not shared in a network. Toner and ink cartridge supply was often problematic due to

unavailability of toner cartridges on the Burundian market or absence of a budget for this kind of operational costs.

Files and documents were commonly transferred from one computer to another using USB memory sticks, which constitute an infamous source of virus infections.

3.3 Networks

At the central level (Bujumbura region), most of the MoH structures had a local network (wired or Wi-Fi) at their disposal. Often, these networks were connected to the Internet thanks to donor funding, which unfortunately is always limited in time (and sometimes also in data volume). Few large structures (central MoH site, Military Hospital) had been connected to the national optical fiber network that offered reasonable Internet connectivity, but for most of the medium-sized and small health facilities prices for this kind of service remain prohibitive. Internet bandwidth offered by local ISPs in Bujumbura on the other hand, was poor and unstable although considerable improvement had been seen in the past few years. Installation of Internet connections was also uncoordinated, resulting in some structures accumulating several (poorly performing) parallel connections on the same site: 4 different wired Internet connections have been identified at the national blood transfusion site, without taking into account the numerous individual 3G-USB modems offered by donor programs. Remarkably, in spite of the generally poorly performing Internet connectivity, most MoH structures at the central level stated that an Internet connection had become indispensable for their activities.

Outside Bujumbura and the provincial capitals, the situation was completely different. Wired Internet connections were almost systematically unavailable and performance of 2G and 3G wireless data networks was poor. Some donor agencies (such as EU) had equipped MoH structures with VSAT connections, which have the advantage of providing stable and reliable bandwidth. Unfortunately, they come at rather high operational costs and therefore their use is subject to data volume limitations, causing the Internet connection being unavailable part of the time due to inappropriate use (downloading of movies or audio) which can consume all of the monthly foreseen VSAT credit in only a few days.

3.4 Software

Almost all of the end user computers ran on Microsoft Windows operating systems (XP, version 7 and 8) accompanied by Microsoft Office applications, with the exception of a number of desktop and server computers at the directorate of the national health information system, which ran on Linux Mint or Ubuntu.

Although health specific software implementations remained rare, a clear tendency towards web-based business applications was noted, often based on Linux/Apache, MySQL databases and PHP or Java developments:

- In 2014, the MOH started pilot implementations of the DHIS2 data warehouse in Bujumbura, Ngozi and Muramvya as a replacement for the outdated MS Access based GESIS health data collection solution. Further extension of DHIS2 to the other provinces were scheduled after a detailed evaluation of this pilot experience.
- iHRIS human resource information system deployment also started end 2014 with the first implementation pilots scheduled for early 2015.
- Hospital information system (HIS) implementations remained exceptional (less than 10% of the hospitals), with all of the health facilities in our study sample running OpenClinic GA [13]. The majority of the HIS solutions were concentrated in third level reference health facilities.
- OpenRBF has been implemented for monitoring results based financing (RBF) programs at the central and provincial levels.
- Joomla and Drupal seemed to be the most popular solutions for dynamic website content development

Additionally, some successful m-Health applications (the RapidSMS based KIRA Mama project [11] and SIDA-info [12]) also provided promising results.

Epi-Info and SPSS were the leading statistics software solutions. General and analytical accounting systems are not uncommon in the health sector structures of Burundi: Asyst and QuickSoft (local development), SAGE Saari, Popsy, and Banana were used by half of the health facilities while Tompro had been recently introduced for project-oriented accounting at the central MoH level.

3.5   Paper based instruments

The vast majority of the provincial and health district administrations were using ICT-tools for reporting health data to the central level (GESIS), but a number of hospitals and almost all health centers still relied on paper based instruments for routine data collection. Information was written down in registers by peripheral health center- or hospital staff and sent on a monthly basis to the health district administration (emergency surveillance information was sometimes reported more quickly using SMS). Health districts then forwarded compiled health facility data to the provincial level, where eventually provincial reports were sent to the central level in Bujumbura.

A minimum of 25 registers must be permanently kept up to date by each health center and an amazing average number of 75 registers are in use in an average district hospital. Additionally, donors and health intervention programs sometimes claim parallel and redundant reporting from the health facilities and district administrations they support, which represents an impressive administrative overhead.

Paper based instruments were also predominant for health record keeping in the vast majority (90%) of the hospitals, which all faced health information quality issues.

3.6   Health information management problems detected

Over the past 10 years, the existing health sector ICT landscape of Burundi has been growing organically, with the majority of the project-oriented solutions being brought in by donors and health programs. This happened in an uncoordinated way, leading to:

- **Lack of standardization**: health information representation is hardly standardized and very few international classifications or coding systems are taken into account (with the exception of some of the DHIS2 and OpenClinic GA modules).
- **Data availability risks**: many databases are hosted in donor countries outside Burundi, with real data accessibility risks for the MoH. Also, many MoH agents use personal computer equipment without appropriate backup procedures or anti-virus protection.
- **Data protection risks**: data access rights are not formally organized according to the role that individual agents fulfill in the health administration; usually people have full access or no access at all to the information.
- **Varying data quality**: multiple reasons explain the poor quality of some data collected in the field. There is (1) the lack of intrinsic motivation with MoH staff members who don't produce data for their own purpose; (2) the important administrative burden caused by redundant health data collection processes; (3) the fact that many MoH agents don't have the necessary qualifications for producing reliable data; (4) the absence of personal consequences linked to the production of erroneous information; (5) donors focusing on project health data which compromises the global and systemic collection of data that is not linked to financial benefits (RBF) and finally (6) the frequent staff turnover at all levels of the health system (on average key personnel doesn't stay longer than 1 year in the same position).
- **Varying data promptness**: the lack of reliable (electronic) communication instruments delays the transmission of health information between different levels of the health system.
- **Lack of data completeness**: data is sometimes being considered a factor of power and the lack of perceived personal interest in information sharing interferes with effective and systematic communication of data in the health sector of Burundi.
- **Defective and insufficient computer equipment**: a number of MoH structures have no access to appropriate ICT hardware and due to the lack of maintenance procedures, many of the existing equipment has become defective. Computer virus infections also constitute a major problem for the MoH administration.
- **Inadequate ICT infrastructure**: today, access to stable electric power is out of reach for many MoH structures, even in the larger cities. UPSs have been provided with most of the computers, but their batteries are often defective and don't provide any protection against power failures

(sometimes power failures can last for several days, which heavily compromises the reliability of electronics in every day's work). Affordable high bandwidth Internet is unavailable for most of the MoH components. Donor project-funded Internet connectivity is always limited in time and does rarely bring a sustainable solution.

- **Unregulated e-health market**: although e-health solutions are considered "medical devices" by WHO, neither standards nor regulations have been put in place for introducing ICT-tools into Burundi's health system. E-Health solutions deployment therefore escapes from any health authority control.
- **Lack of health applications**: most of the software solutions deployed in the health sector are generic office applications, statistical analysis applications or aggregate data reporting instruments. Too few health specific application implementations such as hospital-, laboratory-, radiology- or pharmacy information systems have found their way into Burundi's health system.
- **Insufficient human capacity**: human resources constitute a major problem for introducing e-health solutions in Burundi: on one hand, qualified staff who are capable of effectively using ICT-tools in their work environment are missing in many of the MoH structures. On the other hand, there is a plethora of unmotivated and underqualified staff occupying positions in the MoH administration preventing young and better qualified workers from being recruited. Additionally, health-ICT related training and education opportunities are not aligned to the needs expressed by the different directorates and health facilities.
- **Organizational problems**: the organizational structure of the MoH reflects in no way the important transversal role of ICT in today's healthcare. The statute of ICT professionals of MoH is far from attractive, demonstrating the fact that they are considered an administrative burden rather than a valuable asset of the organization.
- **Ineffective dissemination of information**: the absence of a reliable communication network limits the dissemination of regulations, good practice guidelines and policies from the central MoH level to the peripheral structures.

3.7   Towards a national e-health strategy

The TOGAF methodology, after applying some simplifications, enabled us to quantitatively and qualitatively estimate the status of health ICT tools deployment in Burundi's health sector, based on a representative sample of administrative structures, health facilities, education- and research institutions. The preliminary study results more or less confirmed the challenging situation of the Burundian health information system [4,5,7,8], but they also revealed a number of opportunities for the future [9,10]:

- There seemed to be a political will to reclaim MoH leadership in the health information management domain by enforcing compliance with international consensus and standards for all future e-health initiatives, with the MoH in a regulator/gatekeeper position.
- The human resources deficit in health informatics was huge and many of the country's education institutions should collaborate on national and international levels to provide necessary and appropriate ICT training, undergraduate and postgraduate health informatics programs. The readiness to do so seems to exist on the side of the Burundian academic institutions and the donor community.
- DHIS2 implementation got substantial support from the government and donor agencies. Extensive training programs have started in December 2014 and a lot of enthusiasm exists to make the implementation of a flexible national health information data warehouse happen.
- Hospital information management system implementations have been successful in several hospitals (University Teaching Hospital of Bujumbura, Military Hospital of Kamenge, Prince Louis Rwagasore Clinic, CMCK, CNAR), This provided clear evidence for the feasibility of HIS implementation in Burundi.

The challenge remained to capitalize the experiences from the success stories and to integrate them into a new coordinated, well adapted and appropriately funded e-health strategy for the country in the next 5 to 10 years. Therefore, the output of the preparatory study was used as a starting point for the further development of an e-Health Enterprise Architecture for Burundi's MoH (PNDIS), of which a first draft was presented in a stakeholder workshop in Bujumbura on December 10th 2014. A first part of the PNDIS defines a business architecture, an application architecture, a data architecture and a technology

architecture for Burundi's future e-health developments in the public sector. A second part identifies opportunities of capitalizing existing strategic solutions. A third part provides an implementation plan and a budget. Based on this architecture exercise, a number of high priority recommendations have been forwarded by the architecture development team to the Burundian stakeholder community:

- The creation of a national MoH datacenter in Bujumbura that centralizes shared databases and applications and provides a professional infrastructure with stable electricity, access control, data backup and redundancy. *This recommendation was put into practice early 2017 with the collaboration of Lumitel, a national telecom provider.*

- The development of a multi-technology (optical fiber, 3G and VSAT) VPN-based health care intranet connecting central, provincial and district level structures. *Here also, Lumitel has engaged in provisioning of internet and VPN connectivity to public health administration and care structures based on a priority list established by the MoH.*

- The implementation of a number of shared generic applications for the public health sector: accounting software, workflow management, a unique central website, a virtual library, a geographic information system and an MoH owned mail server (preventing the loss of valuable information when staff using gmail.com of yahoo.fr accounts leave the organization). *These applications have been scheduled for progressive implementation in the MoH datacenter, starting with a national MoH collaboration server.*

- The implementation/strengthening of a series of health specific business applications such as DHIS2, iHRIS, OpenRBF, OpenClinic GA HIS, LMIS and a series of health resource registries (including a facility registry). *With the help of the Belgian development agency and guided by the national e-health strategy, the MoH has made substantial progress in this domain. From end 2014 till today, the DHIS2 data warehouse has been progressively deployed to all health districts, replacing the former GESIS national health information system. Since 2014, Burundi remains one of the most successful implementation of results based financing and the OpenRBF information system has played an important role in the management and monitoring of RBF activities in the country. Finally, in the period from 2014-2016, four new OpenClinic GA implementations of a standardized national hospital information management system have been piloted in 4 hospitals in Bujumbura, Ngozi, Muramvya and Kirundo. Since end 2016, after successful evaluation of the pilot phase, the MoH has started rolling out OpenClinic GA to other public health facilities in Bujumbura, Bubanza, Mukenke, Karusi, Gitega, Cankuzo and Bururi. Several private hospitals in Bujumbura, Ruyigi and Kigutu have joined the MoH in this implementation.*

- The implementation of tablet- and smartphone-based patient oriented health data collection tools in health centers and at the community level (KIRA Mama and SIDA-Info). *This recommendation is yet to be implemented.*

- The implementation of an SMS-to-IP gateway enabling health facilities that have only access to plain GSM and SMS connectivity to participate in the country's electronic data collection mechanisms. *The first pilot implementations for this solution will be implemented in 2017 and piloted in 5 health centers.*

- The development of 3 health informatics teaching programs to cope with the important human capacity building needs: (1) a Master in Health Informatics program in collaboration with neighboring universities from Kigali, Bukavu and Lubumbashi, (2) a specialization program in applied health informatics for health professionals and (3) the creation of a biomedical technician bachelor program. *These educational plans have been further elaborated in collaboration with Université Lumière and the National Institute for Public Health in Bujumbura and the first cohorts of students will be enrolled in 2017.*

- The creation of an autonomous health informatics directorate at the MoH with 4 departments in charge of (1) standardization and regulation, (2) health informatics infrastructure management (datacenter and intranet), (3) health informatics education and promotion and (4) helpdesk and support functions. *This recommendation shall have to wait to be integrated in a larger reorganization plan of the MoH, which is a difficult administrative and political exercise. Meanwhile, the bulk of the proposed functions of this new directorate are filled in by the actual Directorate of the National Health Information System (DSNIS).*

4   Conclusions

After a first successful application for the development of a national e-health strategy in DRC in 2014 [15], the TOGAF toolkit also confirmed its status of a comprehensive and practical instrument for capturing and describing status, needs, opportunities and solutions in complex systems such as the e-health domain in Burundi. A preliminary e-health status assessment demonstrated the challenging situation of the Burundian health information system but also revealed a series of important opportunities for the future: a political will to reclaim MoH leadership in the health information management domain based on the PNDIS, the readiness to develop e-health education and training programs and the opportunity to capitalize the experiences with DHIS2 deployment, results based financing monitoring and evaluation with OpenRBF and the fast extension of hospital information management systems implementation based on OpenClinic GA. Burundi's national e-health strategic plan has proven to be a useful enabler for the MoH in coordinating its numerous e-health activities and for making impressive progress with nationwide deployment of a number of core e-health applications. Beyond initial expectations, the national e-health strategic choices have also been adopted by a growing number of private sector stakeholders.

The focus for future PNDIS implementation in Burundi is on improving systems interoperability (OpenRBF, DHIS2, OpenClinic GA), extending the implementation of the hospital information systems to new public hospitals, introduction of new applications for diagnostic and therapeutic support (quality of care improvement) and the introduction of a limited number of new applications such as a national asset inventory and maintenance management system and electronic health registries for health centers.

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