D4D in public health: An overview of some relevant projects

Marc Nyssen
Emeritus professor "Medische Informatica"
Vrije Universiteit Brussel

Frank Verbeke
CEO Post-Factum

Summary:

D4D stands for "Digital For Development". Digital developments touch all of us, but in low-and-middle income countries, this usually is not considered a priority. Although the World Health Organization has recommended member countries to develop appropriate electronic health strategies, many countries in the Global South lagged behind because more immediate needs such as minimal medical staff, equipment and medication took up all available resources. However, thanks to the continuing efforts of partners such as the Belgian Development Cooperation, the impact of supporting digital applications has been clearly demonstrated. Digital applications allow better knowledge of what happens in hospitals and health centers, thereby improving patient care, management as well as finances.
In this paper, we highlight a number of applications in health care: hospital management systems, clinical decision support solutions in health care centers and hospitals, inventory and maintenance management of medical devices and infrastructure and reporting. Also emphasis is put on education, aiming at making local actors self-supporting.
This paper will focus on different projects, but mainly in the context of Enabel interventions.

Keywords:

D4D [Digital for Development] , e-health, GMAO, CMMS, HIS.

Introduction

Digital for development (D4D) comprises all information and communication techniques, aiming to contribute to the development of lower and middle income countries. D4D projects encounter several challenges that must be handled to make success possible. To name a few: careful planning with realistic goals and taking into account actual procedures and local regulations; equipment to be deployed must be adequate and harsh environments of varying power, high temperatures and moister levels; guidance and educating the personnel.

In the health care system, these challenges are increased by the constraints of the working environment of most health care institutions, where the personnel shortage often leads to heavy workloads, so the introduction of computers and networks must alleviate the work, improve the quality and satisfaction of the health care workers at all levels.

In this paper we will highlight our approach to tackle these challenges.

My (MN) first involvement in cooperation was in the 1990's with the University of Cape Town, developing a distance learning component for a postgraduate program in hospital equipment management, targeting the health sector of South Africa and the Western Cape more particularly. This cooperation was funded by Flanders and led to an "Own Initiative" project at VLIR-UOS. The "Sizanani" project successfully supported distance learning for more than seven years (between

1998 and 2005), diminishing the need for the students, mostly active health care professionals, to make long displacements to Cape Town, far from their work-place in order to complete their studies.

In 2009, the 2-year Europaid project "Eb@lé Santé" was approved. This project aimed at the introduction of ICT solutions in major university teaching hospitals of DRC: in Kinshasa, Lubumbashi, Kisangani and Bukavu, making use of the existing Universitic network, which was established by VLIR-UOS and CIUF. Eb@lé Santé introduced the OpenClinic GA hospital management system in these hospitals which were involved as partners in the project, taking into account central patient registration in 2 or 3 selected medical departments of each of the participating hospitals. Moreover, a link was established with the RAFT project of the Université et Hôpitaux de Genève (Antoine Geissbuhler), enabling weekly tele-consultation and teleconferencing sessions on medical topics and experiences, relevant to low- and middle income countries, predominantly in Africa.
The Eb@lé Santé project demonstrated the feasibility of the introduction of information and communication technology in African health care. Initially, it was hoped that about 10.000 patient registrations would be made during the 2 year project period, but in the end,about 30.000 encounters have been registered. Also, we noted through the "Global Health Barometer" monitoring system, that patient encounter registrations continued swiftly even after the end of the Europaid project as shown in Figure 1.

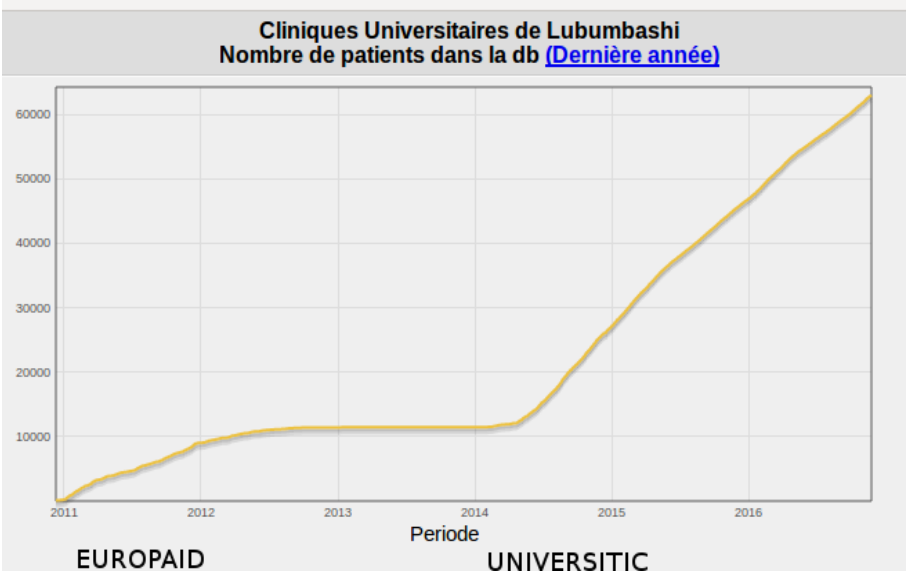

Figure 1: number of patients, registered in OpenClinic GA database (db) at Lubumbashi University Hospital; notice the continuous growth, particularly in 2014, 2 years after the Eb@lé-Santé project finished

The Eb@lé-Santé project not only demonstrated the feasibility of successful deployment of ICT tools in Sub-Saharan public hospitals, but we also learned about the need for longer-term involvement: two years were too short to obtain full results and up-take by the beneficiaries.

BTC-CTB / ENABEL framework for actions in digital health

The then called BTC-CTB (Belgische Technische Cooperatie- Cooperation Technique Belge) defined its three points "Digital for Development" (D4D) strategy as described in [Federal Public Service Foreign Affairs, Foreign Trade and Development Cooperation (2016)] and resumed as follows:

1. Better use of data and information
2. Digital for inclusive societies
3. Digital for inclusive and sustainable economic growth.

For health care, a "5 + 1" approach was taken:

1. Country level: quality information through the DHIS2 (District Health Information System, version 2 reporting of aggregate health data) data warehouse, open access to data and support for national e-health plans
2. At the health facility level: improving management, patient administration and operational performance
3. For the health professional: collect data and keeping the patient records in a standardized way, enabling mobile health care and monitoring
4. At community level: awareness rising, providing feedback and early warning, as well as performance based financing
5. At the patient level: comprehensive patient applications, enabling money transfers, patient centered text messages and monitoring of physical activity

The +1 approach item resides in the capacity building of digital skills and the introduction of computer assisted decision making.

To implement a streamlined collaboration with NGO's, BTC- CTB (later called ENABEL) launched calls for "framework collaboration contracts" typically spanning 4 years and offering expertise in specific scientific/technical fields. In the field of "biomedical engineering and e-health" a consortium was formed, led by the medical informatics department at VUB and colleagues from the " Institute of Tropical Medicine", as well as NGO's and social profit companies such as Bluesquare, AEDES, Close The Gap, Post-Factum and 3E. Since January 2013, the consortium was actively involved in a multitude of biomedical engineering and e-health projects in Sub-Saharan Africa, mainly DRC, Rwanda, Burundi, Senegal, Guinea and Niger. The initial consortium underwent some minor modifications as time progressed but a major change happened in 2019, when the AEDES consultancy company and Bluesquare decided to start a separate consortium, with SAVICS joining the original consortium.

Both consortia were contracted by ENABEL in different types of projects, in accordance with the domains and regions as decided in the bilateral collaboration programs between the Belgian government and the partner countries and always in close collaboration with the partner country Ministries, in our case most often the Ministry of Health.

Table 1 shows an overview of the project types in which we participated in the past 10 year period: 2013 - 2023.

TYPE OF ACTIVITY	FIELD	COUNTRY
Strategic documents	National e-health and maintenance management	DRC, Burundi, Rwanda, Niger
Hospital digitalization	Design/implementation/ deployment/follow-up	DRC, Burundi, Rwanda, Niger, Sénégal, Mali, Tanzania, Ethiopia, Peru
Health center digitalization	Design/implementation/ deployment/follow-up	Burundi, Sénégal, Mali

Clinical decision support	Design/implementation/ deployment/follow-up	Burundi, Rwanda, Mali, Ethiopia, Peru
ICT for inventory & maintenance support (CMMS-GMAO)	Implementation/ deployment/follow-up	Rwanda, Burundi, Niger
E-Health education	Technical and master programs	Rwanda, Burundi, Niger, DRC, Guinea, Mali, Benin, Peru
Carte sanitaire	Health resources mapping	Niger, Benin, DRC
Android apps (SPT)	Clinical decision support	Burundi
Covid19 call center	Implementation/ deployment/follow-up	Bénin
Waste treatment management	Implementation/ deployment	Guinée
PBF portal	National / management	Burundi, Rwanda, Benin

Table 1: Project type overview

An important side-result of the framework programs is the increasing involvement of native African experts. In 2016, the first consortium counted 3 Africans on a total of 39 (8%), now in 2023 there are 12 African experts on a total of 38 participating (31%).

Strategic plans

Frank Verbeke and Gustave Karara elaborated the e-health strategy for DRC. This strategy was agreed upon by the Ministry of Health and later validated by the Congolese Government. Implementation of this strategy was slow and is still on-going due to the needs for funding by different donors.

For Rwanda and Burundi, several e-health related strategy documents were produced, assisting the countries' Health Ministries in defining consistent strategies and implementation plans to introduce and deploy information and communication technologies in their health care systems, mainly the public health institutions but also reaching out to private institutions.

Also Senegal and Niger benefited from strategic advice of the BTC-CTB / Enabel consortia.

Just to mention a few examples:

- Strategic plan for hospital maintenance in Burundi
- Development of sustainability plan for health care in Rwanda
- Telemedicine in Benin
- eHealth strategy development in Niger
- Strategic plan for hospital maintenance in Niger
- Digitalisation of the health system in Tshopo and Sud-Ubangi (DRC)
- The Burundi PNDIS (Plan National de Développement de l'Informatique Sanitaire)
- Assistance Santé Numérique (Senegal)

These strategic plans proved to be highly valuable and, although not all fully implemented, they were essential as backbones for coherence in the digital health investment policies of the countries involved.

Implementation and deployment projects: ICT in Hospitals and health centers

The open source package "OpenClinic GA" designed by Frank Verbeke is the main software tool used in the implementation of the ICT deployments in hospitals and health centers. OpenClinic GA is a complete hospital management system, comprising the full patient medical record, the hospital

administration, including financial management and health insurance reimbursement, medical imaging (PACS), direct links with the laboratory equipment, pharmacy management, reporting via DHIS2 and summary aggregate data transmission to the "Global Health Barometer" data warehouse authorized by the health facility management. As there was no equivalent software available (neither commercial, nor open source) , Frank Verbeke had the courage to write a really modular hospital management system, based on the patient-centric electronic health record concepts developed in Belgium and allowing international contributions by making the source code available on the "sourceforge" web-site.

OpenClinic GA is currently deployed in more than 1000 health institutions world-wide, ranging from small health centers up to hospitals with 1000+ beds.

Based on experience, a complete methodology was developed to maximize success in the specific Sub-Saharan environment:

- an "in situ" maturity and needs analysis performed in collaboration with the health institution leading to a detailed implementation plan;
- a hardware strategy based on on-premise "low-power" servers and autonomous solar power solutions, with power-over-Ethernet (PoE) compatible wireless router stations and secure wireless connections linking the laptop workstations in the wards and the administration to the central servers;
- on-site training sessions for ICT staff, administrative and medical staff;
- remote support over secure VPN connections.

If the health facility management accepts, OpenClinic produces a daily "aggregate data report" that is sent to a central data warehouse called the "Global Health Barometer" where technical and aggregate data are stored and made accessible through a web page shown in Figure 2

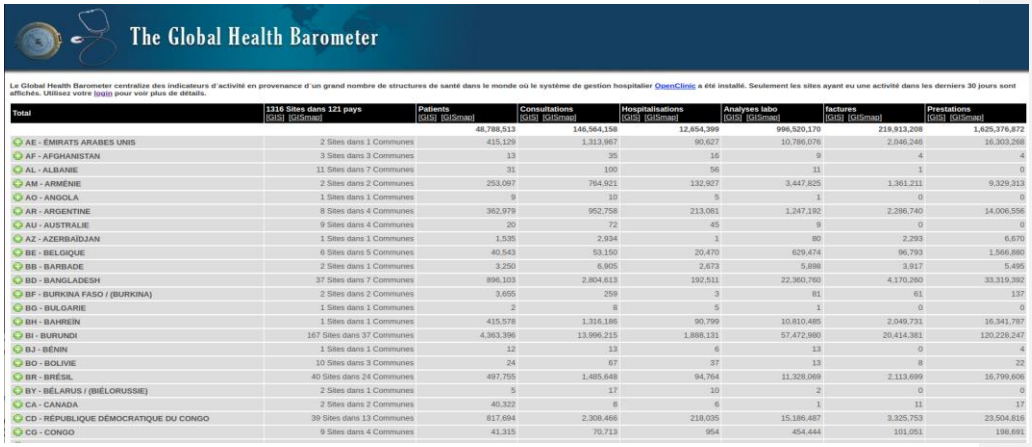

Figure 2: Global Health Barometer overview page at https://www.globalhealthbarometer.net

Downloads and deployments of OpenClinic GA, as well as contributions of others to the open source software go far beyond the Enabel projects, but the latter benefited in a systematic way from it, enabling extensive deployments, mainly in Rwanda and Burundi but also in Mali, Senegal, DRC, Tanzania, Ethiopia, Niger and Peru.

The OpenClinic GA data collected in several countries allowed Gustave Karara to study the degree of medical coverage in these countries, contributing to the methodology for follow-up on the goal of

"universal coverage", as published in Karara et Al, 2017 and regarding the health care "burden" on patients in Karara et Al, 2019.

Recently, PhD studies were made, regarding the digitalisation of the referrals and counter-referrals, between entities of the health sector: between health centers and hospitals, between district hospitals and reference hospitals in order to improve the quality of the information transferred along with the patients, as described by Kalume et Al 2022.

Implementation and deployment projects: ICT in maintenance of hospital equipment

Hospital equipment and medical devices are essential resources for the health systems. To assist and improve the acquisition, management and maintenance of health care infrastructure and equipment, the WHO has produced a book on medical devices, offering recommendations, guidance and good practices. For the projects on ICT-assisted maintenance we mainly followed these WHO recommendations.

In Rwanda, the Ministry of Health and mainly, the Biomedical Department "RBC" (Rwanda Biomedical Centre) had started deploying the computerized maintenance management system (CMMS) MEMS funded by the Clinton Foundation. Enabel initiated an evaluation of the implementation in Rwanda, resulting in a number of recommendations which were unfortunately not all followed-up. Although the MEMS database covered about 90% of the medical equipment in the public hospitals, little or no feedback returned to the maintenance personnel in the health facilities. The central inventory was remarkably up-to-date but the impact on improvement of the maintenance was minimal. We recommended to activate the weekly preventive planning schedules that could have been sent automatically to the maintenance teams, taking into account their specific equipment, to guide their maintenance work, but unfortunately this advice was not followed.

In 2016 Enabel asked for a study towards a computerized maintenance management system for the health care system in Burundi. After a feasibility study, requirements were defined and an "Open Clinic GA" module was developed for the management of not only medical devices, but also infrastructure (buildings, electricity, water provisioning) and vehicles (ambulances, motor bikes, cars).

As in Rwanda, the inventory management modules in the health facilities communicate with a nation-wide database, situated at the Ministry of Health in Bujumbura, which keeps the inventory and characteristics of the device types (such as requirements for preventive maintenance, periodicity of inspections, etc. ...).

Due to the lack of a freely usable and appropriate device nomenclature, it was decided to built a nomenclature, covering the needs of Burundi (or in fact any Sub-Saharan country, linked to WHO's ICD-11, as reported by Van Laere et Al, 2017.

In Burundi, the deployment was performed in two provinces and an evaluation in 2018 showed the benefits: important improvement of the equipment availability, less down-time and accurate keeping of the inventory.

Following this evaluation the Minister of Health decided to deploy the "GMAO" in the whole country. Therefore in 2019, Enabel initiated a study to probe the users concerning desirable improvements, based on their 2 year field experience in the first phase pilot provinces. These improvements were then implemented and deployed country-wide as of 2021.

Education and training projects

Master in medical Informatics in Rwanda

Thanks to Rockefeller Foundation funding, the engineering school of the University of Rwanda: Kigali Institute for Science and Technology (KIST) was able to initiate a master program in medical informatics in 2021. A number of field experts among which Frank Verbeke and myself were asked to propose a course program for a 2 year master. We based the program on the recommendations of the International Medical Informatics Association (IMIA) and courses started in 2011. The program was successful in drawing in about 25 students in the first and second year, but in 2013 the authorities decided to move the master program from the engineering school KIST to the nearby nursing school "Kigali Health Institute" (KHI). In 2015, we were asked to update the study program and a revised curriculum was submitted and accepted by the academic authorities and published afterward [Wrightet Al 2015].

Finally, in 2019, the program was moved to the Centre for Excellence in Biomedical Engineering (CEBE), attached to the University of Rwanda. CEBE combines education, research and development in the fields of biomedical engineering and medical informatics.

Computer assisted maintenance in Burundi

Complementing a strategic study and recommendations, followed by deployment, training sessions were developed to guide the users with the computer assisted maintenance system in Burundi. From the start, two inventory management platforms were deployed: an "operational" server and database and an "acceptance" environment, enabling testing of updates and running training sessions in a very realistic environment, without affecting production data.

Medical informatics at the master in Public Health at UGANC in Guinée

The Public Health department at the "Université Gamal Abdel Nasser Conakry" (UGANC) started a number of e-health related courses, supported by Enabel in Conakry. These courses add specific public health informatics competences to the masters in public health core program, preparing students for future digital health challenges in the Guinean health system.

Data-center management in Burundi

In order to improve the efficiency of health data self-management and at the Ministry of Health in Burundi, the authorities proposed to set up a data-center for health that is expected to house all the public health care data of the country.
Enabel joined the authorities to accomplish this effort, first by a study to evaluate the candidate applications, modalities and dimensioning of the infrastructure to be set-up.
A one week course was developed, focusing on the theory and practice of data-center management.

CISA1 and CISA2 medical informatics training in Burundi

As Burundi opted for the broad deployment of health facility information systems in the public health system, ranging from small health centers up to large national reference hospitals, a major need for ICT expertise was created. Enabel proposed a series of digital health training modules designed to guide both users and technicians to come to grips with hospital information systems and other health related ICT applications. Some of these courses focused on building programming capacity in order to adapt or add functionality to existing open source health care applications.
These training modules were named CISA1 (generic e-health training) and CISA2 (health profession targeted training)? CISA stands for “Certification en Informatique de Santé Appliquée”.

Creation of the Digital Health Campus in DRC and the Center of Excellence for Research and Training in Health Informatics (CERFIS) in Burundi

Digital health data can be a very valuable source for national health policy development and monitoring and evaluation of health systems. Unfortunately, many low income economies lack the necessary human resources for developing and conducting high quality research programs based on structured digital information which is routinely collected. As a solution, several initiatives have been launched aiming at strengthening national and regional research competences in public health informatics.
In 2019, with funding from PATH (formerly known as the Program for Appropriate Technology in Health) is an international, nonprofit global health organization), the VUB assisted an inter-university consortium of the schools of public health in Kinshasa, Lubumbashi and Bukavu with the creation of the Digital Health Campus of DRC (Campus de Santé Numérique, CNS). The CNS took profit of a previous collaboration program between the same Congolese universities and the Institute of Tropical Medicine in Antwerp (RIPSEC project). In 2021, the Digital Health Campus was officially recognized as an essential component of DRC's national e-health strategy (Plan National de Développement de l'Informatique de Santé 2021-2024). Since 2019, the CNS has an active MoU with VUB, enabling exchange of academic staff and students at masters and doctoral level in the field of digital health.
Enabel and VUB furthermore assisted the National Institute of Public Health (INSP) in Burundi with the creation of a Center of Excellence for Research and Training in Health Informatics (CERFIS), an initiative similar to the CNS project in DRC. The CERFIS was formally set up in 2022 and signed an MoU with VUB in 2023. It will host a master 2 program in public health informatics starting in September 2023 and has already become a strategic research, monitoring and evaluation partner for Enabel and other donors in Burundi. It hosts the beforementioned CISA 1 and CISA 2 training programs and recently started to provide training modules for continued professional education in digital health for the Burundian public health workforce.

Evaluation and impact studies

Impact of the introduction of Hospital Information Systems

As soon as 2012-2013 Enabel launched impact studies to evaluate the impact of the digitization of the health care institutions on the quality of care. The first study was performed in Rwanda and published in 2013 [Verbeke et Al 2013]. This study evaluated several operational parameters of 5 hospitals that were equipped with the OpenClinic GA and compared these parameters, one of which the case-load to the national averages (see Figure 3). Case-load evolutions were taken with as a base reference (100% in the left column the year before ICT deployment and in the right column compared to the national average).

	3 years out-patient case load evolution	
	OpenClinic group	National average
CHUK	107,02%	102,80%
Nyamata	91,78%	81,62%
Rwamagana	105,99%	81,62%
Gihundwe	103,33%	81,62%
Ndera	122,81%	100,91%
Mean	106,19%	86,91%
	p=0,047*	

*single factor ANOVA comparing 3 years evolution of OACO for study group hospitals to Rwandan average

Figure 3: comparing outpatient case-load (the number of cases with which a hospital is concerned at one time) evolution over three years, left column compared to 100% level, the year before ICT introduction, the right column shows load evolution for each hospital compared to the national average.

Also, an improvement of per in-patient income (the total income of the hospital, divided by the number of in-patient days) was observed in all related hospitals. As shown in figure 4, with as base-reference the in-patient income the year before ICT installation; a stabilization occurs 3 years after the deployment of ICT in the hospitals. (Ndera data were not available over 3 years).

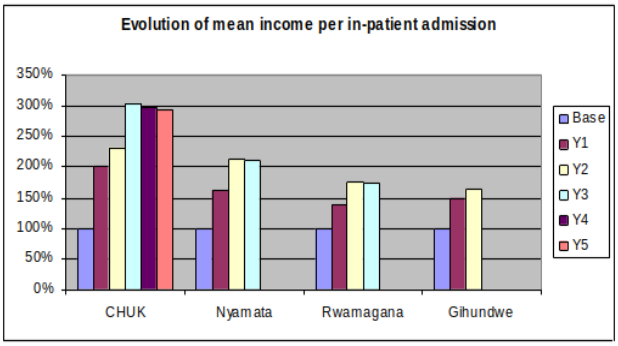

Figure 4: improvement of mean in-patient income over time- Y1, 2, 3 = 1, 2, 3, ... year(s) after ICT deployment,

Impact of the introduction of ICT in equipment management

In Burundi, Enabel conducted an impact study to evaluate the impact of the introduction of ICT in the management of hospital equipment maintenance CMMS [Computer assisted Maintenance Management System, French: Gestion de la Maintenance Assistée par Ordinateur - GMAO], 3 years after the start of the deployment in the provinces Muramvya and Kirundo . [Beniacoup et Al, 2021]. The study evaluated the evolution of several parameters comparing to a baseline taken right before the introduction of the CMMS in January 2017. The study provided evidence for a notable improvement of the number of preventive maintenance interventions, the quality measured by the success rate and the shortening of the duration of the interventions.
On figure 5, we clearly see the increase in operational equipment over time.
In Rwanda, the CMMS deployment was less successful, the feedback to the maintenance personnel was not activated, so only the inventory function is in place. The report Enabel 2019 relates this.

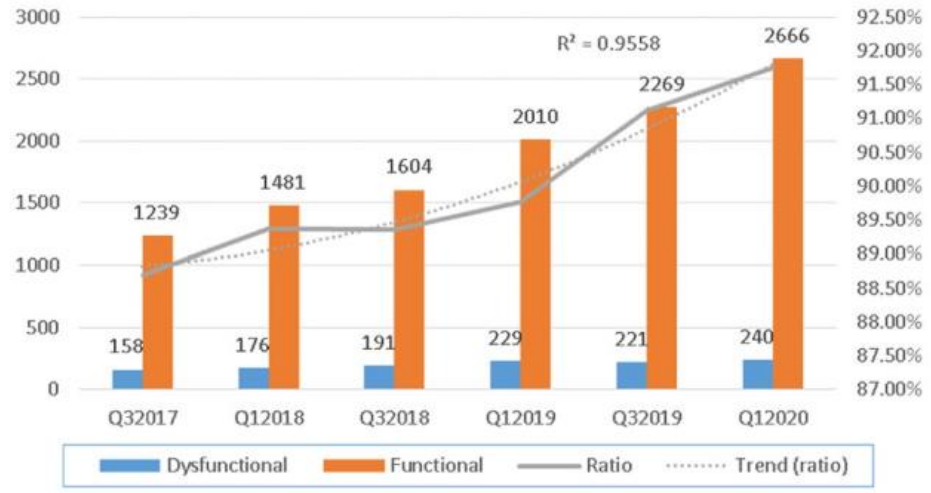

Figure 5: increase of functional medical devices after introducing CMMS in two Burundian provinces

After this study, the Burundian authorities decided to deploy the OpenClinic GA CMMS in all public Hospitals of the country.

Discussion

When appropriate measures are taken to comply with the environment (low power servers, mostly wireless connections, solar panels and sufficient battery capacity, rugged installation racks, comprehensive guidance and help-desk), information and communication technology projects can be highly successful in Sub-Saharan Africa.
Next to the methodology, based on experience and data, the expertise of the teams, involved in the planning and in the deployment are of utmost importance, as well as close collaboration with the local and national authorities, usually the Ministry of Health.
Year after year, we also see an increasing number of local African experts joining our project consortium, generating a multiplying effect and improving the sustainability and success rate of the projects.
Completed deployment projects have also created opportunities for local "spin-off" initiatives such as companies, offering maintenance services.

Conclusions

The Belgian Development strategy has proven to be visionary and successful as demonstrated by impact studies which showed (and quantified) the improvements resulting from the introduction of ICT in health care.

Thanks to the excellent collaboration with the local authorities (mostly Ministries of Health, Ministries of Education, universities and institutes, hospitals and health centers) and of course the resident representatives of Enabel, the consortia of NGO's could realize an impressive impact on the Sub-Saharan health care systems thanks to appropriate ICT solutions.

Sustained efforts with increasing involvement of local experts bear fruits!

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