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Hospital Information Management Using Open Source Software: Results of the MIDA Project in 3 Hospitals in Rwanda

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Background and Purpose: The health sector in many developing countries, especially in sub-Saharan Africa, suffers since a long time from poor health information collection and analysis systems. This study evaluates the results of 3 projects financed by the Migration for Development in Africa-Great Lakes (MIDA GL) program in 3 Rwandan hospitals: Kigali University Teaching Hospital (CHUK), Neuro-psychiatric hospital Caraës-Ndera (NPH-CN) and Gihundwe district hospital (GDH). These projects aimed to empower hospital staff in collecting and analyzing hospital information by using OpenClinic, an open source hospital information management system.
Methods: The first analysis at CHUK used the results of a CAP (competence, ability, practice) survey addressed to healthcare staff in using OpenClinic, in 2010 and 2012. The second method analyzed results of NPH-CN and GDH in the OpenClinic software utilization between 1/1/2011 and 31/12/2012.
Results: Results showed that routine OpenClinic utilization increased by 20% (from 36.0% to 56.3%) at CHUK between 2010 and 2012 and skills levels increased significantly in admission (+9.2%) and laboratory (+10.0%) departments where the training programs were run. The results obtained from the hospitals of Gihundwe and Ndera showed that the 2 hospitals almost doubled their income one year after implementation and indicators like case load, encounter load and numbers of provided health care deliveries continue to increase linearly, demonstrating the continuity of OpenClinic utilization. Clinical modules however have not yet been well adopted in Ndera and Gihundwe: reason for encounter documentation and diagnostic coding are not being performed systematically.
Conclusion: The MIDA GL funding allowed 3 Rwandan hospitals to implement the OpenClinic tool easily and to improve its utilization by gathering and centralization of health information in real-time. The improvement of user skills level in OpenClinic enabled them to take ownership of the tool proving the need for regular staff training and evaluations in the OpenClinic utilization.

Keywords: MIDA, Empowering healthcare staff, OpenClinic utilization, Hospital information system, Rwanda

1 Introduction

The health sector in many developing countries, especially in sub-Saharan Africa, suffers since a long time from poor health information collection and analysis systems. Different causes can be identified: lack of financial resources, insufficient skills and bad performing tools for collecting and analyzing information.

First of all, the investment in health information in developing countries, particularly in Africa, remains too low. It is estimated that working health information systems require at least US$ 0.53 per

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capita in low-income countries and US$ 2.99 per capita in high-income countries [1]. Those figures may be on the low side. A study in Sierra Leone estimated the cost of running a complete system of health information at US$ 1 per capita per year [2].

Secondly, many developing countries suffer from shortage of staff with relevant training and skills in statistics, epidemiology, demography, public health and informatics: partly because too few people has been trained, and partly because of the inability of the public sector to retain qualified staff with low remuneration levels compared to the private sector. Another cause of the lack of skilled human resources in many parts of Africa is the mass exodus of leaders and university graduates. Political instability, armed conflicts, unemployment and poor governance are all incentives to emigrate to regions deemed more developed and stable. This brain drain is for many African countries a major obstacle to sustainable development, particularly for the health, education and rural development sectors [14].

Thirdly, paper-based systems continue to dominate in health information collection. According to the second Global Survey on eHealth conducted by WHO in 2009, nearly 90% of the responding countries reported relying on paper-based individual patient records at the health facility level, and less than 30% of countries reported using electronic records. At the subnational level, where aggregate patient information is essential for resource management, paper-based systems are prevalent in almost 60% of the responding countries, while slightly over 40% of countries report that their aggregate patient information is digitalized and can be transmitted electronically [3].

In Rwanda, the collection of information is most often done manually, at the end of the month by counting cases from registers. This work proves to be an important administrative burden because many instances require reports: ministries of health, vertical health programs, international organizations, etc. Also, the numbers of health indicators being collected is very high. The Rwandan Ministry of Health reports serve a range of donors with 890 separate health data items, 595 relating to HIV and malaria alone [4]. Since 2006, ICT-tools have been systematically introduced for organizing the Rwandan health information system. In 2008, a study has identified four types of systems for collecting and centralizing health information [5]:

1. Public Health Informatics, to evaluate population health, to monitor health trends, and to create a responsive surveillance system. Eventually, this becomes the National Health Information System (NHIS).
2. Electronic Health Records such as OpenMRS (Open Medical Records System) [15]
3. Mobile e-Health systems using mobile technology (SMS) to gather clinic level information on infectious diseases through mobile phones using Voxiva's TRACnet software.
4. Telemedicine – Information and communication technology used to deliver health and healthcare services, information and education to geographically separate parties

The major problem of these solutions is the lack of interoperability as each program has been developed in isolation from the others.

Meanwhile things have improved under impetus of the desire to create a national system for centralization of health indicators. Several systems currently exist within the health management information system (HMIS). Health facilities with internet connection use short messages (SMS) and Health information Systems (HIS) data stored remotely on a central server and others without internet connection fill electronic forms and put them on a stick. These files will subsequently download at the central server. If it appears that the electronic transfer of health information to the central level was a giant step forward towards more complete data gathering, the gains are however less spectacular when we look at the quality of the collected information. Data are mostly not collected in real-time but are manually compiled from several registers and then copied to electronic reports afterwards.

A new experience of real-time gathering and centralization of health information began in late 2007 at the Kigali University Teaching Hospital (CHUK), a national referral hospital in Rwanda. The information system that was implemented in this hospital has been completely tailored to local user requirements. The initially narrow-scoped set of ICT-tools has been progressively evolved to an integrated hospital management system under the name OpenClinic (OPEN system for Comprehensive heaLth facility INformation management in low Income Countries) [16]. Currently, the software runs in some 20 public and private hospitals in Africa, including 10 hospitals in Rwanda [6].

This open source software, which is focused on integrated patient record management, aims to generate predefined sets of indicators based on secondary use of routinely collected clinical data.

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Generated indicators relate to the hospital activities, user performance, health facility income, health insurance and reason for encounter- and diagnostic coding using international classifications such as ICD-10, ICPC-2, DSM4, LOINC etc… [6].

At the hospital level, information collected are important because they also allow to determine hospital performance indicators and hospital self-management that Government currently requires to public Rwandan hospitals in contracting policy using Performance Based Financing (PBF)-programs [7]. Today's hospital managers are being asked to derive performance indicators for their health facility, which are focused on the optimal use of hospital capacity, such as case load, admission load, length of stay, bed occupancy rate, cost effectiveness, disease costs etc. They are also called to report on the efficiency of the hospital, staff performance, procedure costs etc. [8] Part of a prospective global budget funding, a budget in balance becomes an important criterion for judging management quality. For private hospitals, profit may even be the primary performance criterion.

Therefore, it is crucial for the hospitals not only to report for the national health information, as required, but also to report on hospital performance, via solid measurements. Information collection that contributes to indicators and appropriate measurements requires skilled staff and computer tools for collecting, centralizing and analyzing health information indicators in real-time.

Concerning staff skills, Rwanda is a country that has experienced a significant loss in human lives and important brain drain due to the genocide and war in 1994. But if the brain drain is among many factors contributing to the underdevelopment of certain African regions, currently in Rwanda, the policy of the Ministry of Foreign Affairs and Cooperation through its Diaspora Directorate judge these movements as an opportunity to promote economic and social development using migrant intellectual potential acquired in the host countries [17].

This is why Rwanda benefits the projects from the Migration for Development in Africa (MIDA) program initiated by the International Organization for Migration (IOM) to develop synergies between Great-Lakes migrants' profiles and Rwandan country needs in the areas of health, education and rural development. Mida GL program aims to develop public and parastatal institution human capacity in knowledge and skills using migrant competences in Great Lakes countries (Rwanda, Burundi and RDC) [14]

Thus, in the health sector, the MIDA Great Lakes (MIDA GL) Phase IV (2009-2012) program supported 3 Rwandan hospital projects in health informatics capacity building. Those hospitals are:

- University Teaching Hospital of Kigali (CHUK), the greatest reference hospital (450beds) located in Kigali-city,
- Neuro-Psychiatric Hospital-Caraës Ndera (NPH-CN), 280 beds, a mental health reference hospital located in Kigali-City, 15 km from the center. It is a private facility runs by the Brothers of charity.
- Gihundwe District Hospital (GDH), 180 beds, located near the border with RDC at the most southern point of Lake Kivu, in Western province.

The CHUK project was to create a continuous training and research center in health informatics

The proposed project of NPH-CN was to develop an electronic dictionary coding diagnosis (Thesaurus) using International tri-classified (ICD-10, DSM-4 and ICPC-4) codification for disease cases encountered in mental health [18].

The project of GDH aimed to improve the management of patients and finances, including staff expenses.

The three hospitals currently implement the hospital management information system using OpenClinic software. CHUK was the first to use OpenClinc from early 2007. The last 2 hospitals have implemented the system in the framework of the MIDA GL phase IV program. GDH started in December 2010 and NPH-CN in August 2011

The implementation process of the hospital management tool was followed. This process includes the steps that have been implemented in other hospitals where OpenClinic runs [6] including a period of training and follow-up and a period of maintenance and assistance.

To implement the OpenClinic system, GDH has received funding for the administrative part of the system, which includes modules for patient identification (ID); admission, discharge and transfer (ADT), financial management and reasons for encounter (using ICD-10 and ICPC-2 codes). The NPH-CN received funding for the implementation of all modules including new developments thesaurus tri-classified diagnosis coding, ICD-10, DSM-2 and ICPC-4.

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MIDA GL program financed each project up to € 50,000. 60% of the funding was used to pay experts from Diaspora who came to support partner institutions, especially for human capacity development. 7 MIDA experts followed one another at the 3 hospitals to support them in the implementation of these projects. They made in total 24 missions of each 30-day average over 3 years MIDA GL program.

This research focuses on the results of the 3 projects in the field of empowering healthcare professionals in collecting and analyzing health information using the OpenClinic over a 3 year period, during which they were supported by the MIDA GL program.

The overall objective is to evaluate the results achieved in the implementation of the MIDA GL projects in 3 Rwandan hospitals, focusing on the empowerment of healthcare hospital staff in health informatics in order to allow them to improved collecting and analyzing hospital information by using the Openclinic tool. As specific objectives, the study:

- Analyzes healthcare staff competence, ability and practice (CAP) in using OpenClinic system at CHUK
- Analyzes efficiency in using OpenClinic at Ndera and Gihundwe hospitals.

According to the MIDA GL program schedule, the 3 projects have been implemented from 1/1/2010 to 31/12/2012. We will focus on the period when the project began in an each institution until 31/12/2012.

2 Materials and Methods

Based on the elaboration of the 3 projects we have developed 2 types of analysis:

- The first analysis uses the results of a CAP (competence, ability, practice) survey addressed to healthcare staff in using OpenClinic software at CHUK between 2010 and 2012.
- The second was to analyze the results of NPH-CN and GDH in the OpenClinic software utilization between 1/1/2011 and 31/12/2012.

Under the MIDA GL program in its 4th phase, several activities were carried out in hospitals CHUK, NPH-CN and GDH to support these 3 hospitals to build their healthcare staff capacity in health informatics. These activities sum up to:

- Purchase and install computers
- Install and configure the local network
- Install and configure a hospital management system (OpenClinic software)
- Train in health informatics: epidemiology, statistics, general computer and OpenClinic software utilization;

The vast majority of the hospital staff (specifically the staff from hospitalization and lab departments for the CHUK) has been included in the MIDA GL project. They have been, primarily, trained in OpenClinic utilization.

We focused our analysis to the impact of the OpenClinic software utilization. To do this, we used the results of the CAP survey in CHUK and the results achieved by GDH and NPH-CN in OpenClinic implementation. The results of those indicators were derived from the statistics module of OpenClinic and from the Global Health Barometer (GHB) centralized indicators [19]. The GHB performs fully automatic health & performance indicator extraction from local databases and merging of the resulting data into a single central database.

The CAP surveys were conducted in the CHUK in August 2010 and August 2012. A sample respectively of 69 and 96 healthcare staff (OpenClinic users) responded to the questionnaire. Epi Info 3.5 was used to enter and analyze the survey data. This survey allowed us to measure several indicators:

- The software utilization level expressed in terms of OpenClinic daily utilization by the healthcare staff
- The satisfaction level of healthcare staff in OpenClinic utilization
- The general skills level of healthcare staff in OpenClinic software utilization, expressed by grouping variables related to the utilization, perception and satisfaction, and by departments

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To measure the efficiency in OpenClinic utilization as a health information system in the hospital management, we used statistics obtained from OpenClinic systems installed at NPH-CN and GDH sites and from the statistical indicators centralizing in the GHB. The following measures were used:

- Comparison of incomes by healthcare delivery groups during 2 years of OpenClinic project implementation.
- Evolution of the number of a representative sample of recorded data to assess the extent and quality of data collected.

3 Results

3.1 CAP survey results

The MIDA GL project trained more than 300 people in the utilization of computer applications, in particular the OpenClinic system, which has become a tool for daily work at the 3 hospitals.

According to the GHB, in 2012, 791 OpenClinic users are configured at the CHUK, 147 at NPH-CN and 81 at GDH. Among CHUK users, 69.2% were female and 30.8% male.

According to the CAP surveys conducted in 2010 and 2012 at CHUK, the sample was represented respectively by 69 and 96 OpenClinic users. Hospitalization and laboratory department's staff represent respectively 52% and 20% of all potential OpenClinic users staff.

The survey also showed that in 2010, 26.1% of respondents were male against 72.5% female. And in 2012, 28.6% of respondents were male and 71.4% female.

On the level of utilization the percentage of daily users of the system increased between 2010 and 2012, from 36.0% to 56.3%.

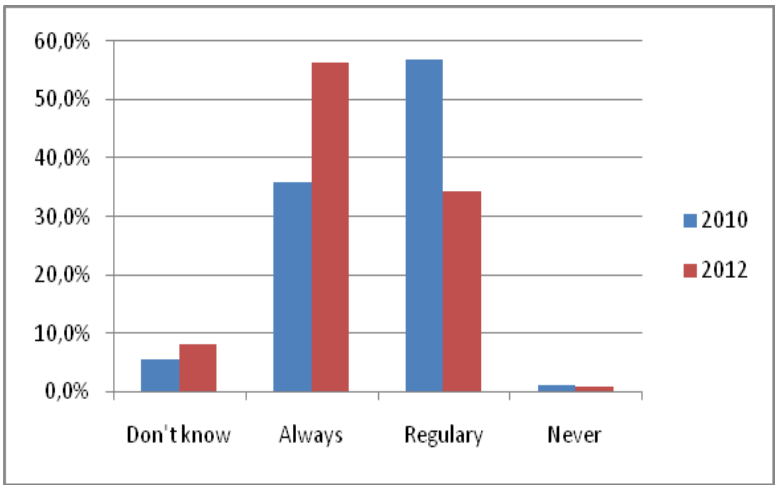

Fig. 1. OpenClinic daily utilization level at CHUK in 2010 and 2012

We also noticed looking in the CHUK OpenClinic database that the number of OpenClinic users increased between 2010 and 2012. It went from 600 to 790 between December 2010 and December 2012. The majority of news users are those who work in the hospitalization and lab departments.

The survey showed that while in 2010, 34.8% of users estimated that the system helped them to fulfill their tasks; this has increased to 45.3% in 2012.

Regarding the degree of satisfaction in the OpenClinic system, in 2010, 84.1% of respondents were satisfied (17.4% very satisfied) against 5.8% who are not happy. In 2012, 84.4% of respondents were satisfied (21.9% very satisfied) against 3.1% who are not happy.

To determine staff skills in OpenClinic, we combined variables related to the utilization, perception and satisfaction in OpenClinic. The graph below summarizes the level of general OpenClinic skills level by CHUK departments in 2010 and 2012.

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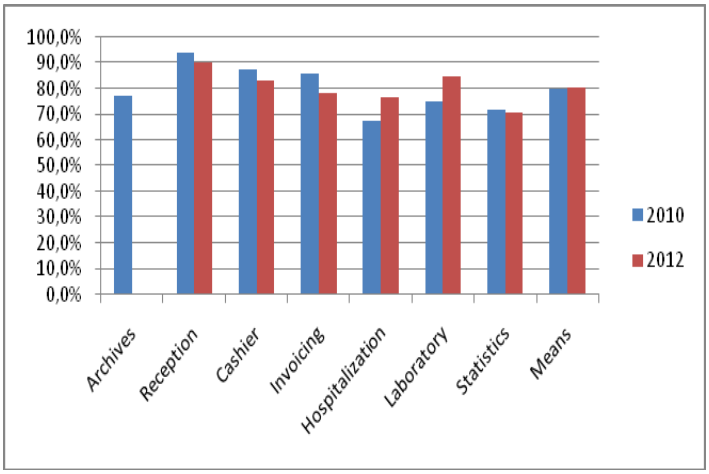

Fig. 2. OpenClinic skills level at CHUK departments in 2010 and 2012

The general OpenClinic skills level average is 80% (SD = 9.2%) in 2010 and 81% (SD = 8.3%) in 2012.

The level of skills in OpenClinic utilization have greatly increased in hospitalization and lab departments between 2010 and 2012, respectively, from 67.5 to 76.7% and from 75.0 to 85.0%. This is justified by the profile of the staff who attended the training provided within the framework of the MIDA GL project at CHUK.

3.2 Efficiency of the system

The efficiency in the system is based on the revenue gain recorded and the volume of information stored in the Openclinic system at NPH-CN and GDH.

Hospital incomes recorded in OpenClinic consist in payments of the patient and the insurer, under the health insurance policy. In Rwanda, the costs of patient care are covered by the patient himself, his insurer and sometimes an additional insurer.

As our 2 hospitals have begun to improve by using OpenClinic billing software from the 2nd (at GDH) and 3rd (at NPH-CN) quarter in 2011, we decided to compare the incomes recorded for the 4th quarters of 2011 and 2012.

We noted that the income for the quarter nearly doubled from 133 million to 206 million between Q4 2011 and Q4 2012 at NPH-CN. We noted the same trend at the GDH. Looking also the income generated by the 2 hospitals in 2011 and 2012, we noted a significant increase in revenues. If we take the GDH, we noted that within the 4 last years, its revenues tripled!

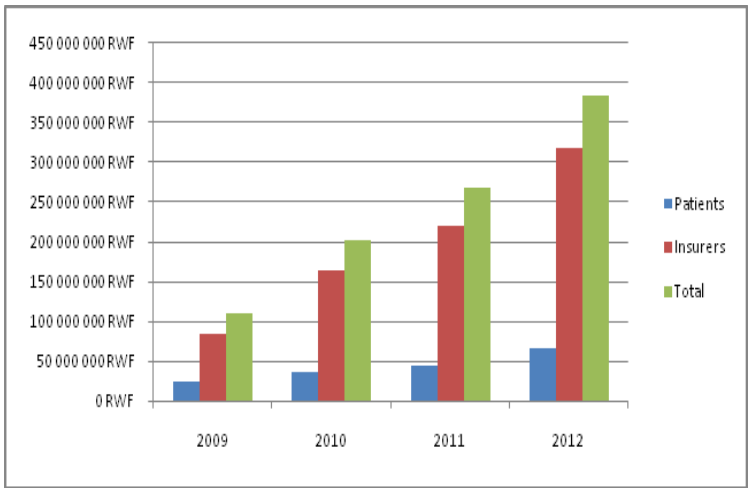

Fig. 3. GDH incomes evolution from 2009 to 2012

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GDH revenues increased compared to 2009: +83% in 2010, +141% in 2011 and +246% in 2012. The computerization of patient records might explain increases in the last 2 years.

We analyzed the evolution of the indicators from their systems regarding the number of patients and the number of encounters.

At GDH, between 2011 and 2012, the number of patients in the database was 53,261 of which 66.9% are female and 33.1% male. The distribution by gender is statistically different ($p<0.00$). The GHB showed that the children less than 5 years represented 9.3% of the patients at the end of fin 2012.

At NPH-CN, the data base contained late 2012, 50,599 of which 50.4% are female and 49.6% are male. The proportion of women was not statistically different than the proportion of men ($p=0.45$). The GHB showed that the children less than 5 years represented 5.4% of the patients at the end of fin 2012.

The number of the encounters increased in a constant way at the 2 hospitals. It exceeded the 55.000 at HDG and 50.000 at HNP-CN at the end of 2012.

The "in-depth" analysis of encounters is summarized in **Table 1**. The table shows the number of consultations and hospitalizations per year registered in Gihundwe and Ndera hospitals for 2011 and 2012.

Table 1. Patient encounters at HDG and HNP-CN in 2011 and 2012

	HDG			HNP-CN		
	2011	**2012**	**Total**	**2011**	**2012**	**Total**
Number of new admissions	6 023	6 616	12 639	1 915	3 321	5 236
Median of number of admissions days	6	8	6	11	10	10
Number of consultations	19 762	20 735	40 497	11 101	34 271	45 372
Number of outpatient	12 621	13 022	25 643	4 269	8 517	12 786
Encounter by patient	1.6	1.6	1.6	2.6	4.0	3.5
Total of encounters	**25 785**	**27 351**	**53 136**	**13 016**	**37 592**	**50 608**

The median of admission distribution days is 6 at GDH and 10 at NPH-CN. On average, the patient performs 1.6 encounter in consultation at GDH and 3.5 in NPH-CN for the two years.

The GDH meets a problem of encounter management of encounter. The staff of hospitalization department let the patients in the OpenClinic hospitalization contact, after their effective discharge. That gives aberrant bed occupancy rate.

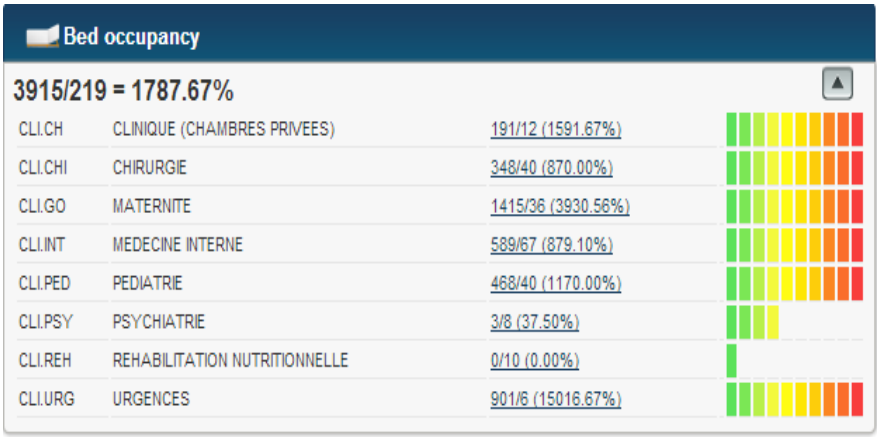

Fig. 4. Bed occupancy at GDH on 31/12/2012

And on the level of medical results, stages still remain to be crossed by the 2 hospitals because the (amongst others) encoding of reasons of encounter using international codification (ICD10, ICPC2 or DSM4) is not regular at GDH and had not started yet at NPH-CN at the end of 2012.

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4 Discussion and Conclusion

After these case study results on utilization of the OpenClinic system as a hospital management system in CHUK, NPH-CN and GDH, we observe the important role of users when they are well trained in the utilization of IT tools. Indeed, these IT systems become daily work tools and the empowering of users leads to the quality of results.

From the experience of CHUK OpenClinic users, we evaluated the capacity, ability and practice of those healthcare staff and found that users are adapted to the tool by the training they received. Thanks to the MIDA GL program, the level of OpenClinic utilization increased from 36.0% to 56.3% for daily users at CHUK. We found that the majority of new users came from the hospitalization and laboratory departments. Indeed the OpenClinic system is implemented in phases. The “boom” in utilization is achieved when the majority of hospital staff is involved. At CHUK, targeting hospitalization and laboratory’s staff in OpenClinic training allows to increase significantly the number of empowered users.

The level of user satisfaction has also increased from 17% in 2010 to 22% in 2012 for the very satisfied users. It has been shown that low levels of user satisfaction in the context of the implementation of such a project should always be considered as cause of failure [9].

The level of skills in the OpenClinic implementation brought together the utilization, perception and satisfaction of users. At CHUK, we noted that, although the average skill level has remained stable (around 80%) between 2010 and 2012, it at least increased in hospitalization (+9.2%) and laboratory (+10.0%) departments to respectively 76.7% and 85.0% in 2012. The increase of user skills level in an ICT tool allows them to take ownership of the tool [9].

After the analysis of users empowering in OpenClinic utilization, we demonstrated the effectiveness of OpenClinic using in Ndera and Gihundwe hospitals. To do this, 2 key performance indicators were measured between 2011 and 2012:

- The evolution of incomes
- The evolution of certain indicators such the number of patients and the number of contacts.

We used some measurements of endogenous performances of hospital activities without taking account of the "outcome measures" related to the health of the patient. These measurements can be tools for permanent evaluation of the users, incomes and internal activities [11]. The evaluated activities are performance and output indicators concerning particularly curative services drawn from the quarterly data of the hospitals of districts [12].

Some indicators, particularly financial, show improved performance management in the 2 hospitals through the utilization of OpenClinic as hospital management system.

On the revenue side, we found that incomes of the 2 hospitals have significantly increased during the past 2 years. Comparing the 4th quarter of 2011 and 2012 for the two hospitals, we found that incomes doubled to NPH-CN and increased 50% to GDH. One might think that this increase is directly related to increased encounters (visits and admissions) in the same period. The proportion increasing of encounters was 41% at HDG and 4% at HNP-CN between Q4 2011 and 2012. This increasing cannot alone explain the increase in incomes recorded which almost doubled. Here, we have evidence of the real impact of the OpenClinic utilization. The "OpenClinic" effect in the increasing of revenue has also been shown to CHUK where the hospital has doubled its revenue one year after the implementation of OpenClinic [10].

The trend indicators between 2011 and 2012 as the number of patients, the number of contacts and the number of registered services, etc. show continual activity in using OpenClinic at GDH and NPH-CN. This is in line with observations made in other hospitals where the system is implemented.

The management of the encounters in admissions and the utilization of the OpenClinic medical module are the 2 objectives which could not be fully reached within the framework of project MIDA implemented in the 2 hospitals, Gihundwe and Ndera. The reasons are related to the lack of time for physicians to use the system but are also due to patients' records which are not being available in time to the staff working in computerized medical record department. Another reason for this is the doctors’ writings are not easily readable to complete the medical records [13].

This research has shown that with the MIDA GL program, Rwandan hospitals, CHUK, GDH and NPH-CN were able to implement the OpenClinic software, hospital management information system.

The CHUK was the first hospital to implement this system early 2007. The CAP surveys 2010 and 2012 have shown the need for users training in OpenClinic utilization. The hospital staff becomes more

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empowered through training and Openclinic utilization. A user training and user ICT-assistant must be a continuous process that doesn't stop after a few years of OpenClinic implementation if the hospital management information system should become a continuously staff evolving application.

This research also showed that using OpenClinic as a hospital information management tool allowed GDH and NPH-CN to increase their performances and has quantified the resulting increases. This has been proven by the ability of the hospital to follow its health indicators day by day and its financial situation improved as the incomes have doubled one year after OpenClinic implementation.

The funding by MIDA GL allowed 3 Rwandan hospitals to implement the OpenClinic tool easily and to improve its utilization. Challenges still remain in terms of the implementation of the patient's medical record starting with the proper management of discharged patients admitted in the system and the systematic record of the reasons for encounter and diagnostics after hospitalization.

We cannot say that the MIDA GL projects in the 3 hospitals have been 100% successful, but this approach of training and capacity building using the migrant skills allowed participating hospitals to improve their management system.

There are indeed elements that lead us to advocate for sustained and continuous training in medical informatics and in particularly, OpenClinic utilization. OpenClinic software gradually becomes a tool for hospital management in several African countries, especially in Rwanda where the number of hospital users, both public and private, increases. Currently, 12 hospitals and clinics use this system in Rwanda [9].

Compared to the major project of the Ministry of Health in Rwanda to collect, centralize and analyze health information, the contribution of the MIDA GL program was useful in 3 hospitals in Rwanda but it is a drop in the ocean, taking into consideration the immense needs in these area. What is safe and interesting is that the technique of collection and centralization of health information in real-time at the hospital level has already proven in the 3 hospitals funded by MIDA GL and other twenty hospitals in the region.

Analysis and implementation of different systems of health information gathering currently existing in Rwanda for their integration would be very useful to join the energies developed all sides and thus regulate the field of e-Health in Rwanda.

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