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Evaluating the Impact of ICT-tools on Health Care Delivery in Sub-Saharan Hospitals

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Abstract

This research explores to what extent Information and Communication Technology (ICT)-based information management methods can help to improve efficiency and effectiveness of health services in sub-Saharan hospitals and how clinical information can be made available for secondary use enabling non-redundant reporting of health- and care performance indicators. In the course of a 6 years research effort between 2006 and 2012, it was demonstrated that patient identification, financial management and structured reporting improved dramatically after implementation of well adapted ICT-tools in a set of 19 African health facilities. Real-time financial management metrics helped hospitals to quickly identify fraudulent practices and defective invoicing procedures. Out-patient case load significantly increased compared to the national average, average length of stay has been shortened in 15 of 19 health facilities and global hospital mortality decreased. Hospital workforce-evaluated impact of hospital information system implementation on local working conditions and quality of care was very positive. It was demonstrated that local sub-Saharan health professionals strongly believe in the importance of health information systems.

Keywords:

Hospital information systems, performance measurement, international classifications, sub-Saharan Africa.

Introduction

Many developing countries, particularly in the sub-Saharan region suffer from chronic difficulties to efficiently cope with major challenges in terms of public health. A number of important reasons are well known:

- A shortage of qualified caregivers[1][3]
- Insufficient financial resources and thus a structural reliance on foreign funding sources[4]
- Corruption and inefficient use of available resources with health care being identified amongst the top three corruption prone areas[5]
- A policy which is not always geared to the real health needs of the population despite numerous international efforts[6][7]
- An underpaid and thus unmotivated workforce[8]

Unfortunately and generally speaking, today it is very difficult if not impossible to get a complete and accurate image of the real health care needs (incidence and prevalence of diseases), the available resources (the care offered) and the performance of the existing healthcare systems in many low-resource countries. Quite often, an explicit framework defining the goals of a health system against which outcomes can be judged and performance quantified is not available[9].

The problem of the unavailability of reliable health information in developing countries is not new and has been one of the elements leading to the creation of WHO's Health Metrics Network in 2005. For several decades, attempts have been made to develop reporting instruments for central health administrations in order to collect and provide quantitative and qualitative information about health indicators relevant to their country. Unfortunately, the selection of these indicators has too often been dictated by the information needs of international or local vertical health programs[10] (HIV, malaria, tuberculosis, maternal and child mortality, sleeping sickness, etc) resulting in poorly- or non-integrated data collections (sometimes referred to as National Health Information Systems) that are rarely useful for making improvements to the existing health care system. Moreover, the reporting of such health indicators relies in nearly every country on redundant registration systems[10] (some health facilities have reported to deal with more than 20 different registries!), which heavily compromises the quality of the information provided: multiplication of registration procedures almost always creates a significant administrative burden for health facility staff who can rarely discover a direct personal interest in the reports they provide, leading to incomplete data registration, poor data quality or even reporting of fictitious data. In the end, based on qualitative criteria, many of the consolidated databases in national health information systems appear to suffer from very limited usability.

Many health sector managers and health policy makers in developing countries have expressed the need for a consistent set of techniques and methods that, with regard to health care status and performance documentation, could fill some gaps and solve some weaknesses of existing Sub-Saharan registration systems. With regard to this, several important challenges can be defined:

1. To what extent could information that was recorded for purposes of patient care be made available for secondary use aiming at reporting of health indicators? The main challenge of such an approach would be the improvement of data quality[14]. Reducing the burden of redundant administrative, financial and clinical registration processes would probably be an essential element in such strategy. As an interesting side-effect, one could expect that the direct use of care-related data might possibly reduce the risk of information faking and fraud.
2. How can care related data directly be integrated in customized feedback reports, enabling self-evaluation and performance improvement by health care providers and facilities[13]?
3. How could one conceive a hierarchical health indicator system that is preferably based on validated international coding and classification standards and that enables aggregation of indicators on multiple levels in order to simultaneously serve the needs of different stakeholders

(ministry of health, results based financing, health programs, research centers...)?
4. How to implement a manageable set of generic performance measurement instruments enabling peer-comparison with aggregated data of similar health structures?

Materials and Methods

Objectives

Our study explores to what extent ICT-based information management methods can help to improve efficiency and effectiveness of health services in sub-Saharan hospitals and how information, that was recorded for purposes of patient care, can be made available for secondary use enabling non-redundant reporting of health- and care performance indicators.

Study hypothesis

The study starts from the hypothesis that the performance in terms of efficacy, efficiency and productivity of sub-Saharan health facilities can be improved by implementing well adapted ICT-based health information management tools. The study also examines if structured performance measurement and evaluation can be effectively used as a care provider targeted feedback instrument to generate performance improvements.

Methods

The methodology of this study, which ran from 2006 till 2012, included several steps:

Business process analysis

The aim of the first step was to perform a business process analysis of a representative set of sub-Saharan health facilities, enabling identification of relevant health information management issues. A total of 30 health facilities were analyzed in Mali, Ivory Coast, the Democratic Republic of the Congo, Burundi and Rwanda. The set of health facilities was composed of 13 national reference hospitals (public third level health facilities), 9 district hospitals (public second level health facilities) and 8 private hospitals or clinics. Identification and analysis of relevant health facility information management business processes was performed using the following techniques[11]:

- Meyer's Rigorous Physical Diagrams[12] to document how various users and departments within the health facility exchange information (data flow diagrams)
- Timing Analysis Diagrams[2] to document timing and constraints (time constraint diagrams).
- Flowcharts (process flow diagrams)

Diagrams have systematically been developed based on semi-structured interviews with representatives of the most relevant health facility departments: hospital direction, patient registration and administration, finance department, the four main clinical departments (internal medicine, pediatrics, surgery, gynecology-obstetrics), pharmacy, lab, medical imaging, epidemiology and statistics.

Health information management issues inventory

Many issues related to health information management were identified in a second step. Patient identification procedures seemed to be poorly defined or implemented in many hospitals and the important concept of a unique hospital-wide patient record was systematically missing. Admission, discharge and transfer information was weakly documented in the vast majority of the sites. Financial and health insurance management procedures were complex and diverse in the countries that we analyzed. Moreover, reporting business processes repeatedly changed in the course of the 6 years of implementation needing frequent revisions of the documented logic. Presumably, business processes will undergo more changes in the future under impetus of new developments related to universal health coverage that have been started in many sub-Saharan countries. Medical records were poorly structured in most of the facilities before the advent of our information system implementation program. Clinical information was also split up in several departmental health records within hospitals, hindering a holistic approach of the patients' health status. Some clinical departments functioned as isolated information silos (e.g. most of the HIV departments) which had no considerable communication with other clinical entities in the hospital. The majority of hospital executives (27 of 30) reported great difficulty in getting a good idea of the daily operations of the institution. They confirmed that many items could not be adequately documented: collective (per service) and individual performance of staff, unauthorized absence, the cost of various services provided by the hospital, profitability of departments and health procedures, compliance of provided care with practice guidelines or scientific knowledge, patient satisfaction and many others.

Health metrics identification

In this phase, we defined a number of metrics for assessing the status of a series of important health information management issues that were identified above. These metrics measured input as well as output of health facilities related to:

- Patient identification problems
- Financial management, more specifically defective invoicing and direct payment & debt recovery
- Poor and unstructured clinical documentation
- Health worker and health facility productivity

A baseline assessment was performed on a representative set of Central African health facilities using the developed metrics.

Software toolkit development

In a next step we developed a comprehensive and integrated set of sophisticated yet simple to use ICT-instruments addressing the most important identified health information management issues. What initially started as an ICT-toolkit development project for supporting health facility staff in performing a limited predefined number of routine tasks, quickly grew out to the building of a larger than intended hospital information management system, which was called OpenClinic. The development approach being user-centric, many improvements have been brought to the software based on direct user-feedback. Many users also self-re-engineered their business processes based on new capabilities offered by the software, resulting in a long term iterative process. In the end, the software was put in the public domain (http://sourceforge.net/projects/open-clinic).

Field implementation

During the 2007-2011 period, a series of implementation projects based on developed OpenClinic modules have then been set up in a total of 19 health facilities in Rwanda, Burundi and the Democratic Republic of the Congo (DRC). All projects included the following phases:

- **Project management setup**: a high-level project management team was systematically created where any important decisions that might have a significant impact on the course of the project, could be made.

- **Identification of the project scope**: an answer was provided to the question "what is the precise purpose of introducing ICT-tools in the health facility?"
- **Functional analysis**: here we defined the business processes that had to be covered by OpenClinic and performed a functional gap analysis documenting mismatches between users' expectations and available software tools.
- **Technical analysis**: this summarized the technical requirements for implementing OpenClinic in each health facility based on the functional analysis results.
- **Training analysis**: described the expected amount of training that had to be provided in order to make users productive with the newly introduced tools.
- **Financial analysis**: a global budget had to be established taking into account the functional and technical gaps as well as the provisional training plan. Furthermore, costs related to technical assistance and maintenance during and after the project also had to be anticipated.
- **Key user selection:** for different subsets of required functionality, a number of *key users* have been recruited in each health facility. These *key users* tested initial (beta) versions of provided software modules and provided feedback to the development team.
- **Test environment setup**: a functional version of the developed tools was first being set up on a temporary server environment in each hospital.
- **Production environment setup:** when functional gaps had been filled and validated, the resulting software was released to a production system.
- **Training**: usually user training took place immediately after setting up the production environment.
- **Maintenance & assistance**: once a series of modules had been put into production, technical and functional assistance must be available when users run into problems. If no such support is available, there's very little chance that the software toolset will ever acquire the status of a real working instrument.
- **Monitoring, measurement and feedback**: a selection of performance metrics was systematically collected. Well documented results were then reported every few months to the hospital management.

Funding for the study set of health facilities has been provided by international donors and NGO's, but in some cases also by health facilities themselves (this was systematically the case for private health facilities).

Impact measurement

Continuous metrics-based productivity monitoring was performed using automatic nightly data-extraction and merging of the obtained extracts into a project data-warehouse, called *The Global health Barometer*. Periodic feedback was provided every three months to the health facility users. In the end, impact of the toolkit deployments and feedback procedures on health facility performance was measured by comparing post-implementation results to the initially obtained baseline data. Data envelopment analysis (DEA) has been used for this purpose using a selected number of metrics applied to eight hospitals in Rwanda and Burundi.

SPSS version 20 was used for statistical analysis. In statistical tests, p values < 0.05 were considered significant.

Results

At the end our study, the OpenClinic toolkit had been used for the registration of some 775.000 patient records, 175.000 hospital admissions, 1.350.000 out-patient visits and more than 8.000.000 delivered health services in Rwanda, Burundi and DRC. As such, the study sites provided substantial amounts of data for evaluating the developed set of productivity metrics and the research hypotheses that had been brought forward at the beginning of our study.

Impact evaluation

Significant impact has been measured on different aspects of health information management:

Baseline patient identification success ratios (numbers of existing patient records that were sucessfully retrieved) were obtained from a series of assessments performed in 2007 and 2011 covering some 27 health facilities in Rwanda and Burundi. Six of these health facilities have also started OpenClinic toolkit implementation at a later stage enabling pre- and post-implementation comparison. The overall success rate improved from an average 35,42% pre-implementation score to 97,68% after OpenClinic implementation (p=0,00019, single factor ANOVA test).

Compared to the average country values for similar health-facilities, out-patient case-load (OACO) had increased by 6,19% in the study group while the national mean had decreased by 13,09% (p=0.047, single factor ANOVA test)

Analysis of user-fee based hospital income showed a statistically significant increase for out-patient encounters by 46% in the second (p=0.033) and 53% in the third (p=0.019) post-implementation year. For in-patient admissions, the change appeared to be even more convincing with a statistically significant increase of 63% (p=0,003) after 1 year, 96% (p=0,0009) after 2 years and 130% (p=0,022) after 3 years of hospital information management system implementation.

In a number of cases, well documented feedback on suspicious metrics values helped to directly improve the quality of provided health care services. An obvious case was seen in the Kigali University Teaching Hospital where a worrying average length of stay of 23,1 days had been detected in 2008 for femur fracture admissions. Surgical procedures, nursing care and sterilization processes have been reviewed based on the provided metrics feedback, enabling the discovery of a number of sub-optimal practices. An improved femur fracture clinical pathway was then put in place after which average femur fracture admission duration was reduced to 13,91 days in 2009 and 10,13 days in 2010.

Overal mortality rate change in the study population showed an average reduction of 19% in hospitals which implemented the OpenClinic information system, yet this was not statistically significant (single factor ANOVA test) and needs further follow-up.

Using Data Envelopment Analysis (DEA), we analyzed the pre- and post-implementation technical efficiency of a set of 8 hospitals (6 Rwandan, 2 Burundian; 6 public and 2 private) from which a usable set of baseline inputs and outputs could be derived, such as the average number of full-time equivalents of physicians, the average number of nurses, the number of other personnel categories, operational admission beds, out-patient and in-patient case load. The following results were obtained as shown in Table 1:

Table 1 – Technical Efficiency Change

	Technical efficiency		
DMU	PRE	POST	Improvement
CDS	66,68%	100,00%	33,32%
HMK	23,12%	28,54%	5,43%

NYA	17,03%	27,76%	10,73%
CHUK	11,84%	26,85%	15,02%
GIH	12,70%	22,94%	10,24%
CMCK	18,73%	20,78%	2,05%
RWA	9,87%	19,04%	9,17%
NDE	16,67%	17,58%	0,91%
		Mean	10,86%

Technical efficiency had improved systematically after implementing the OpenClinic toolkit. Yet, the average increase of 10,86% appeared not to be statistically significant. Further research on an extended set of OpenClinic-implementing health facilities is needed in order to confirm or reject the obtained results.

Discussion

In the course of our 6 years research, convincing evidence was provided confirming both study hypotheses. The first hypothesis was confirmed by demonstrating that patient identification, financial management and structured reporting improved dramatically after OpenClinic implementation. Furthermore, out-patient case load significantly increased compared to the national average, mean length of stay has been significantly shortened in 15 of 19 health facilities and global hospital mortality decreased. The second hypothesis, which forwarded the relevance of feedback procedures, was confirmed by real-time monitoring of financial management metrics which helped hospitals to quickly identify fraudulent practices and defective invoicing procedures. Also, direct feedback-related quality of care improvement had been demonstrated in a number of health facilities such as the University Teaching Hospital of Kigali where femur fracture length-of-stay had been dramatically reduced.

Hospital workforce-evaluated impact of OpenClinic implementation on local working conditions and quality of care was very positive (based on surveys taken from 165 hospital employees in 2010 and 2012). It has been demonstrated that local sub-Saharan health professionals strongly believe in the importance of health information systems and developed a positive attitude towards the newly introduced technology which they perceived as a major improvement.

Still, many questions and challenges remain. Frequent and sometimes lengthy power outages occurred in all studied countries, often damaging sensitive electronic equipment and hindering users in performing ICT-based routine activities. Adequate information technology knowledge remains scarce in most sub-Saharan countries and most health facilities have trouble finding reliable nearby providers of technical assistance. Also, defective or missing hardware maintenance procedures can heavily compromise information systems' reliability and may preclude user acceptance of technology tools as a trustworthy instrument. The study results showed that health facilities which managed to successfully correct these issues significantly improved their productivity.

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