

The Sierra Leone HIS Case: Towards an Integrated Health Information Infrastructure

Romain-Rolland TOHOURI^{1,2}, Ime ASANGANSI¹

¹University of Oslo, PO Box 1081 Blindern NO-0317 Oslo Norway

Email: romain@tohuri.com, jornbraa@gmail.com, asangansi@yahoo.com, olati@ifi.uio.no

²ICTs Development Center, 92, av Martin L King, Bamako, BP E2468, Mali

Tel: + 223 65014890, Tel/Fax: +223 44900068, Email: romain@tohuri.com

Abstract: In this article we describe and reflect on an ongoing project to develop an integrated Health Information System (HIS) in Sierra Leone. We emphasise the complexity of such an enterprise and on challenges faced while building a Health Information Infrastructure in the context of a developing country. The main contribution of the paper is the design of a change strategy towards an integrated HIS in Sierra Leone which is influenced by the information infrastructure theory. Key elements of the strategy are to facilitate a gradual change process building on the existing systems and practices (the installed base), to bootstrap political will to change through pilot projects and quick wins, and to apply a flexible standardisation approach to integration to smoothen the change experience for users and stakeholders.

Keywords: Sierra Leone, health information system, Information Infrastructure theory

1. Introduction

In this article we describe and reflect on a project to develop an integrated Health Information System (HIS) in Sierra Leone, which has been ongoing since early 2007. Our main focus is on the design of a change strategy towards an integrated HIS which is influenced by the information infrastructure theory[1] which seeks to understand complex systems such as national HIS made up of a diversity of stakeholders at multiple hierarchical levels and across geographical areas who have varying and conflicting interests.

The Health Information System in Sierra Leone consists of a large number of peripheral health units (PHU), Community Health Center (CHC), hospitals, and other health centres shared between facilities, chiefdoms, districts and national level. These are essentially heterogeneous health units that share vital health information as well as report to the government health authorities. The collection of health data is partially computerized but highly fragmented as in many other developing countries [2] due to many parallel data collection systems driven by different donors and programs. An initiative to counter this fragmentation by integrating and strengthening the health Information Systems (HIS) supported by novel ICT solutions to cope with the extreme infrastructural challenges, has been initiated and piloted over the last year. In order to address the fragmentation created by various health initiatives, an integrated district-based data warehouse approach has been followed. The aim of implementing this reformed HIS is to strengthen the national health system by unifying and integrating the various existing systems, thereby standardizing the information system. This project started in four pilot districts and is now scaling to the whole

country, and is raising the interest of the other programs and organizations in terms of integration and capitalization of resources. The outline of the paper is as follows; a description of the method applied, the case study from Sierra Leone, an analysis of the change strategy applied, and finally our conclusion.

2. Methodology

This paper draws on experiences from an ongoing HIS reform project in Sierra Leone and more broadly on a long term action research project called the Health Information Systems Programme [2, 3, 4]. The HISP project was initiated by universities in Cape Town and Oslo in 1995, and now it is present in a number of African and Asian countries. Within each country the projects are comprised of various actors in the health administration (community, sub-district, district, provincial, and national), universities, NGOs, and funding providers. At the global level, with the Norwegian and South African nodes as the major coordinating bodies, HISP has over the last decade been engaged in development and implementation of health information systems with emphasis of facilitating sharing of software and best-practices. In the specific case of Sierra Leone, which is the focus of this paper, the HISP project played a major role in supporting the development of the new HIS.

This research is based on Action Research, a form of participative research where the researcher takes part in the change processes in an organization, actively trying to improve some stated problem [5, 6]. The authors are involved in the HISP project, and two have been involved in the Sierra Leone project. Through in-depth involvement in the HIS development process, field trips to Sierra Leone, and close collaboration with the various stakeholders the authors have gained a good understanding of the context and processes taking place. Instead of a formal interview, which was recommended for this paper, the data sources are a series of informal interviews with stakeholders at all levels through a participatory approach where the authors and stakeholders have discussed and solved problems together.

Two of the authors are among the main implementers of the DHIS application in Sierra Leone HIS and one of them have been part of the M&E officers training process and the districts' technical installation and has participate to some awareness seminars in the field.

3. Theoretical Background

An Information Infrastructure (II) is a *shared, evolving, heterogeneous installed base of IT (information technology) capabilities developed on open and standardized interfaces* [7]. It is the *set of organizational practices, technical infrastructure and social norms that collectively provide for the smooth operation of scientific work at a distance* [8]. Specific to health information systems, an II has been described as being *composed of technological and human components, networks, systems, and processes that contribute to the functioning of the health information system* [2] or it can also be regarded as heterogeneous networks of actors [9]. In an information infrastructure, all components - technical and social - are important and play roles that are interdependent and tightly linked.

The concept of information infrastructure, which was first used in the early 1990s in political settings [10,11], has become very useful in understanding, designing and implementing information systems. This concept can be applied to complex socio-technical systems, such as the National Health Information System in developing countries, to improve the understanding of such systems. An II is designed as extensions to or improvements on the installed base and its successful or unsuccessful implementation depends according to information infrastructure kernel theory [7], on a codification of five design principles which when applied will increase the likelihood of achieving a desired set of system features i.e. managed complexity, openness and growth in the installed base:

- Design initially for usefulness
- Draw upon existing installed bases
- Expand installed base by persuasive tactics
- Make it simple
- Modularize by building separately key functions of each infrastructure, use layering, and gateways

One key principle in the successful implementation of a HIS is the fact that as the number of users grows, the technology tends to get momentum and starts growing through a self-reinforcing process [12]. That is, the network grows independently and motivates other users to become part of the network. “Bootstrapping”, according to the Webster dictionary [13] works “to promote or develop by initiative and effort with little or no assistance” Specifically to developing countries HIS has generally been regarded as being fragmented and of poor quality in terms of data quality and use. They are also not coordinated between different health structures involved with no shared standards, making interoperability difficult [14]. To provide useful information for action to managers at all levels there is a strong need for integration of the fragmented data flows into one common health information system that covers the main important aspects of the various health programmes, limits the amount of data being collected and focuses on the essential data needed to take action [15].

The term “integration” in information systems is often perceived as a technological task which involves many aspects such as politics, social and economic [14, 16]. It is a way to get more control of information in such a context like developing countries where the HIS is often desperately fragmented. The solution proposed by the integration process is not solely to provide software to integrate all information flows, but a broad approach taking the whole information infrastructure into consideration, which comprises both technical and non technical components, and human and non-human actors. However this integration in other hand brings reflexive side effects and leads to less control [17]. It is then a good approach to enable heterogeneity and flexibility in order to counter this.

Flexibility, as in the ability to adapt to emerging changes and new contexts of use is an important criteria for scalability [2]. Standards play an essential role in any health information system, both when it comes to the non-technical data definitions (what is collected and reported), and the technical solutions applied to facilitate computerised data exchange between various stakeholders of the system and on a larger scale between co-existing computerised systems. The definition of a standard is more than designing a technological system. It is the design of a socio-technical network. The standard is just one element linked to other elements, technical and non-technical, in this network [18].

In order to provide scalability these standards must be flexible to change, and rather than applying one complex all-encompassing standard, an approach of many smaller manageable standards and gateways between them is suggested [7].

A gateway can be defined in general terms as a link between different elements. Within computer or telecommunication it is used to denote an object linking two different networks or different communication protocols or standards. It is often used to denote a converter or translator between different formats. Such translation is one task that gateways between different networks or standards have to do. In some cases the term is used in a broader sense where even a standard or a whole network can be seen as a gateway between different computers or applications [18]. We will use the term gateway in a more restricted sense i.e. to denote elements linking together two or more networks implementing different standards.

In the health information system literature, Braa et al [2] identified three general types of gateways in the translation of data within the system: paper to paper, paper to computer, and computer to computer gateways. They argued that the types of gateways change according to the evolution of the context.

4. The Sierra Leone HIS Case

Sierra Leone, a relatively small country in West Africa, is one of the poorest countries in the world and was ravaged by civil war that had lasted for ten year before it was officially declared over in January 2002. The public health system, suffering from a huge loss of both personnel and infrastructure during the war, is slowly rebuilding the capacity to improve the service provision across the country. This effort is supported by the government and the international community through many agencies such as UNAIDS, WHO, UNICEF, GTZ etc. and aims at achieving health millennium development goals. The rapid growth of various health initiatives has created a situation of fragmented information systems, common also in other developing countries[2]. A number of paper based reporting formats and routines are currently in place in Sierra Leone, some of these are also computerized, such as HIV/AIDS reporting, which consists of paper forms reported from the facilities, and a database application called CRIS (from UNAIDS) located in the districts, where the HIV/AIDS reporting forms are captured. The actual fragmented situation is characterized by overlapping data collection tools and data elements. The overlapping rate between two different forms can vary from 0 to 50%. In 2008, each facility reports for about 17 forms.

The Sierra Leone Health Information System is highly heterogeneous, being made up of a number of non identical individuals and groups with varied core interests. Once a decision is made to improve the HIS in Sierra Leone based on the findings of the initial assessment, the MoH, HMN and HISP had organized several meetings during which many questions regarding what the project's success entails were addressed. In doing so, some key actors were identified and enrolled in an alliance of complementary and experienced actors to run the project. Among them the Ministry of Health of Sierra Leone, *Health Metrics Network – HMN* (see www.who.int/healthmetrics/), *Health Information System Program – HISP* (see <http://hisp.info>), *ICT Development Center – IDC* (see <http://idcmali.com>), *Inveneo* (see <http://www.inveneo.org>) and *Health programs*(Mother & Child Health, EPI (immunization), HIV/AIDS, Tuberculosis program, etc.).

From the fragmented HIS described above, the main problem was the inability to provide meaningful and relevant information for decision making and reduce the huge and unnecessary workloads on health workers collecting and reporting the data. To solve these critical problems the suggested way forward was to use the District Health Information Software (DHIS) developed by HISP to integrate the various data flows and data sources and thereby to provide an integrated framework for M&E (Monitoring and Evaluation) and data management. In addition to severe data-related problems, the poor level of the overall technical infrastructure posed challenging issues on the project implementation. The general lack of electricity in the entire country. The public electricity service is unable to cover the need so the use of generators are most of the time the only one way to get power in order to perform some work. As the government is unable to fuel all the generators in use in the public health facilities and offices, most of the time the M&E (Monitoring & Evaluation) officers are paying for it themselves to perform their work. Another big challenge is the problem of computer viruses, making all computers in districts unusable and a major contributor to data loss. The heat and the humidity are also so extreme in some district like Makeni that they have to be taken into consideration while choosing the hardware. In fact we observed a lot of computer overheating and damage in that location due to the extreme climate.

4.1 The Change Strategy Applied in Sierra Leone HIS

The ongoing change process in Sierra Leone follows a 5-step design strategy based on information infrastructure theory. It involves building on a gradual/evolutionary prototyping

philosophy where user interest and momentum for change is built up during a pilot phase and change is carried out in a piecemeal manner. Figure 1 below outlines this 5 step process and below are detailed descriptions for each step. The following section provides details of each step. The steps should be understood as important conceptual elements that are part of an overall continuous change process, more than as strict phases in a linear process. The steps might overlap and iterations between steps are also likely to happen.

4.1.1 Analyse and Assess the Existing System

In Sierra Leone the entry point to the HIS building process was a collaboration initiated between UNAIDS and the Health Information System Program (HISP) team for the integration of the Country Response Information System (CRIS) and the District Health Information System (DHIS) version 2.0, in order to build a system that supports data disaggregation, data analysis, programmatic reporting, local system integration and a more user friendly data entry screen than the one offered by CRIS. But to leverage the government and donors' efforts, it has been decided in consultation with the Ministry of Health and Health Metrics Network (HMN) to extend this integration project to the whole HIS framework in Sierra Leone. The ownership of the project has shifted from UNAIDS-MOH to HMN-MOH as well. The suggested way forward was then to use DHIS version 2 tool to integrate the various data flows and data sources and thereby to provide an integrated framework for M&E and data management. The approach was to design data entry interfaces that are similar to existing ones in order to enter all data in DHIS. But at the same time, data can be imported from existing application into DHIS. So instead of entering overlapping data at district level in many databases, now data will be entered in one application (DHIS) and then exported in appropriate format to other applications. Because of the reduced workload brought on by the implementation of the new tool, M&E officers at the pilot districts were more supportive of the information system. Thus, the project has raised the interest of the other programs and organizations in terms of integration and capitalization of resources.

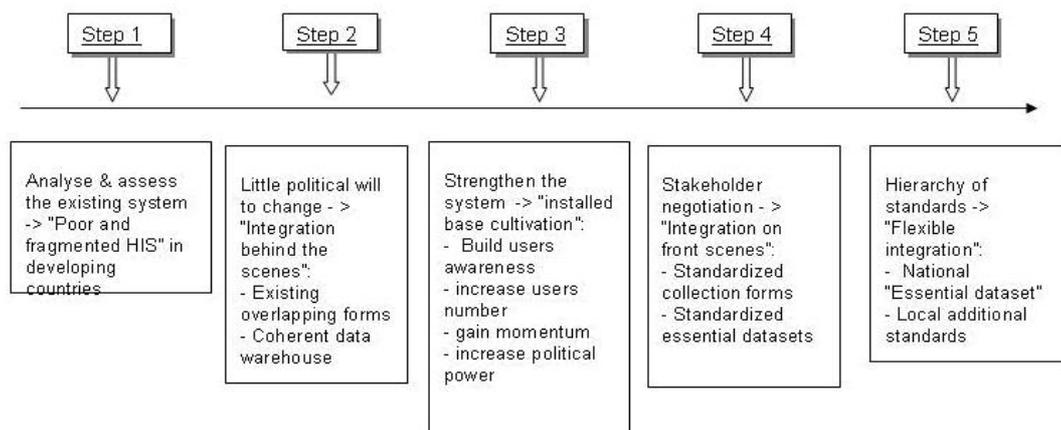


Figure 1 - 5 Step Strategy to Change Towards An Integrated HIS

4.1.2 Provide Integration Behind the Scenes Through Software

Because of the low political capacity and will to change at this earlier stage of the project, attention was devoted to the data warehouse as a starting point. Programs and districts were allowed to be flexible with their choice of data elements. Their paper forms used to collect

data remained as they were while we concentrated on linking the different elements used by different programs within the database.

As a result a coherent integrated data warehouse was built, where one data element in the database can be related to a field in several data collection forms. This integration “behind the scenes” in the data warehouse in one hand and overlapping paper based form in other hand strategy was been adopted to quickly get consensus among all the stakeholders and raise the interest of the first users, while preparing the process for further integration and standardization in later stage of the project.

At the political level the capability of the system to improve the meaning of collected data by allowing cross analysis between data from different sources is raising a lot of interest from the various local stakeholders who understanding the opportunity to improve the quality of the data collected by their own vertical systems. They were therefore willing to be part of the process and are now participating in the negotiation towards a standardised minimum dataset.

4.1.3 Pilot the Tool and New Integrated Solution

The project started with four pilot districts (Moyamba, Kono, Makeni and Western Area) were the new HIS was implemented. The focus was at this stage on the user’s capacity building through “on site” training and later, through country wide M&E officers training. In each district, two monitoring and evaluation (M&E) officers are working to collect, prepare, report, and analyse aggregated data. During six weeks in May-June 2008, extensive training was given to all M&E officers in order to give them the skills to use and customize the system to fit their own local needs and also to allow them to impact the HIS design process by discussing how the system could fit more closely their need and improve the global HIS. The findings from this training and from HMN and Ministry of health were used to improve the system and facilitate the roll out of the project to the whole country.

4.1.4 HIS Reform, Integration in the Open

The standardization of forms was started many months ago by the MOH but was not trivial. Most health programs wanted to keep their data elements and indicators and their definitions. So the compromise was maximal standards where all existing data elements were taken in account and duplicated ones were solved. The standardization process is still an ongoing process and other stakeholders’ meetings are planned to revise the forms and reach a consensus around a standardized dataset and indicators. But this process is very complex and involves negotiation between stakeholders with different interests. HMN and the Ministry of Health and Sanitation wanted a minimalist national dataset and core indicators to reduce the work load at the grass root level and improve the data quality, but the different health specific programs would like to see all their indicators and data elements included in the national set. But there is also a need of specific dataset and indicators locally at the district level. The fact that the project is gaining more and more users and raising more and more interest at both national and international level is impacting the integration process in the good way by inducing more political capacity to change.

4.1.5 Gradual Reduction of Data Collection and Increased Focus on Information Needs at Each Level

At the grass root level, health care providers who are also those producing data had understood the new solution can trigger a process that will lead to harmonization of reporting tools which in turn will diminish the 17 overlapping forms they have to fill at the end of each month. The alignment of interest of actors at all levels made a large alliance of actors that was strong enough to get a momentum in the project and got them very involved and active.

The HISP team, HMN and the Ministry of Health and Sanitation are actively trying to drive the HIS in Sierra Leone towards the South African model of hierarchy of standards (Braa and Hedberg 2002) that allows addressing the different needs of information across contexts and at the different levels, and at the same time a need for a standardised national dataset. In short it allows lower levels of the organisational hierarchy to define their own additional local standards as long as they comply with the standards set by the level above.

A key challenge of an integrated HIS is to manage and coordinate all data when more and more health programs and other data sources are standardised and included in the same data repository. Action-driven data collection and focus on essential data for monitoring and evaluation at all levels are key objectives to work towards and key components of a mature integrated HIS [2]. Standardised essential datasets reducing the amount of data collected are difficult to swallow for many health programs located in the more traditional data-led end of HIS design, but when exposed over time to the benefits of integrated data repositories and indicator driven data analysis, this perception of what is a useful HIS can change.

5. Discussion

The five steps outlined above are discussed below in two parts. The first one discuss the complexity of the system and the obstacles to change and the second one analyse the change strategy through an II lens.

5.1. *The Case Complexity and Obstacles to Change*

Critical issues such as technical infrastructure that the system relies on and human capacity, need to be addressed. In Sierra Leone, the national power supply system is down as many other national infrastructures. The main power source of the existing computerized HIS are generators. As the government is not able to provide fuel regularly to run generators, this reliance on diesel contributes to undermining the system. Human capacity both in terms of data analysis and information use and IT skills is another key issue that has to be tackled.

The heterogeneity of actors involve in the Sierra Leone integration process is in fact a key element to modularisation and flexibility [2] by bringing together all this network of actors using different standards. One needs to build gateways between them to achieve integration while avoiding lock-in. The suggested way to succeed in such a process is to build the II while keeping modularization in mind. But this heterogeneity as reverse side brings complexity in the system which one need to deal with. The different interests of actors involve in the process makes hard the negotiation process to standardization

However this process of standardization involves the resolution of a large number of data elements and indicators, each useful and important to the actors involved. To achieve this, a revision of the data collection tools within an integrated framework is being planned. Indeed this process will not be achieved without some resistance to change and tensions between all the different actors. Standards tend to be evolving through negotiations between actors facilitated through ongoing efforts to develop standards in practice, rather than through early agreements [1,2]. To achieve this, the Ministry of Health and Sanitation of Sierra Leone is planning a revision of the data collection tools within an integrated framework. This will be achieved through a set of meetings involving the various stakeholders taking part of HIS in Sierra Leone. The complexity of this kind of negotiation is based on the fact that all the actors are willing to keep their set of indicators in national indicators set, most of the time even if they are not using them all.

Reaching sustainability of a HIS at a national scale is highly dependent on achieving local sustainability as the global HIS depends on the quality of data coming from the local levels,

which is a result of how successfully the national standards have been adapted and integrated across the different local contexts[3]. This more than true in the case of Sierra Leone where various programs are giving incentive to health workers at grass root level to collect programs specific data and indicators and in the same time huge efforts are deploying at national level to narrow the amount of indicators and data to be collected.

5.2 *An II Analysis of the Change Strategy*

5.2.1 *Analyse and Assess the Existing System*

Given the complexity of a HIS and the importance of taking the installed base seriously into consideration when designing for change, this step was necessary and very decisive to the continuation of the change process. Ideally, the best approach and the desired next step to standardizing health data and integrating different vertical data reporting systems would be to make all actors agree upon a new set of standards and then implement the new standards. However, due to the wide variety of vertical donor initiatives, which all tend to have their own separate reporting requirements, and overall changes in information requirements within and between the various vertical health programs, standardization of health data is a complicated process. Standards tend to be evolving through negotiations between actors facilitated through ongoing efforts to develop standards in practice, rather than through early agreements [1,2]. Steps 2 and 3 outline this gradual change process where trust and political support is cultivated to prepare for the more official reform process introduced in step 4. Given more political support for change at an earlier stage, e.g. as was the case with HISP in Zanzibar [23] it would have been possible to jump directly to step 4 after an initial assessment.

5.2.2 *Integration Behind the Scenes Using Software Tools*

A key point of this phase was to take an important step towards and integrated HIS without disturbing existing data collection processes at the health facilities and districts. Through the use of a flexible software tool the new design of the HIS was hidden through the use of electronic forms as gateways [1] the existing paper based collection process. The electronic forms looked exactly like the existing paper forms, but behind the user interface, black-boxed to hide complexity from the health workers[1] a modular architecture re-linked the data being collected into an integrated data repository without overlaps and fragmentation. Such a technical solution had not been possible without the inherent change flexibility [1] in the software tool which was necessary to reduce complexity (from the user perspective) and avoid lock-ins in the continuously changing and user-influenced prototype [1,2].

5.2.3 *Pilot the Tool and New HIS Integration Approach*

Although the idea of step 2 was to limit the change of data collection and paper forms, the benefits and possibilities of having an integrated data repository introduced new working routines and ways of thinking about data. Furthermore, these benefits all depended on proper use of the newly introduced software tool to manage the data integrated repository. Implementation of the new approach was done in a gradual manner, starting with a few selected health districts, the early adopters, and then by increasing the number of districts in phases. Feedback from the pilot process in the first districts provided an important input to revising the tool developed in step 2, and several cycles between 2 and 3 were necessary before expanding to more districts in what can be described as an ongoing participatory standardisation process. By limiting the implementation of the new approach complexity was reduced, both in terms of size, geographical spread and variety of interests in the user pool, and the chance of acceptance increased. In turn as the first users were satisfied and felt

comfortable with the new approach and software it was much easier to expand to new districts and to gain support among key stakeholders at the national level. Such a prototyping process builds on the bootstrapping principle which is a recommended strategy when designing for II change [20], and in the case of the Sierra Leone HIS reform a necessary process to reach a critical mass of committed stakeholders to move to step 4.

5.2.4 *HIS Reform in the Open*

This step which can be described as long term standardisation process consists of many smaller and interlinked steps that taking place in the background (many of them overlapping with step 3), but the one critical step towards success is the official meeting where paper forms and indicators are revised and agreed upon by key stakeholders. Without such a sanctioning of revised datasets (and change) there is little hope to change the HIS processes at the lower levels. For such a process to succeed, alignment of a critical mass of stakeholders is necessary[1], stakeholders or actors spread around a heterogeneous network involving health programs, donors, and as well as various departments within the central administration of the ministry. For integration to succeed a common set of standards must be agreed upon by at least the key health programs and most likely other programs and actors will join in at a later stage and gradually the standardised infrastructure will grow in a increasingly self-reinforcing process [20] But without an initial push and political will towards integration and change, little will happen, illustrating the importance of step 3. In Sierra Leone, after more than a year of bootstrapping a climate for change (in step 2 and 3) the political willingness for an integrated approach has increased and a major revision meeting is planned for in 2009.

5.2.5 *Gradual Reduction of Data Collection and Increased Focus on Information Needs at Each Level*

This step five is a long term process of upgrading the status of the HIS from acceptable to ideal, and as such an infinite process of improvement. One key challenge is to tackle the complexity of the multi-level nature of the HIS and address the information needs at all levels from local clinics to the Ministry of Health. Although the previous steps are all taking local levels into consideration, especially local participatory design processes in the pilot phase, the major decision-making on health standards take place at the top of the hierarchy. The hierarchy of standards approach described in section 2 follows the principle of flexible standards [2]. Flexibility to change standardised datasets at each level while at the same time complying with the demands of the higher levels minimises global-local tensions [22] and enables local flexibility to make the standards useful for local action.

6. Conclusion

The main contribution of the paper is the design of a change strategy towards an integrated HIS in Sierra Leone which is influenced by the Information Infrastructure theory [1]. Key elements of the strategy is to facilitate a gradual change process building on the existing systems and practices (the installed base), to bootstrap political will to change through pilot projects and quick wins, and to apply a flexible standardisation approach to integration to smoothen the change experience for users and stakeholders.

References

- [1] Hanseth, O., Monteiro, E., & Hatling, M. (1996). *Developing Information Infrastructure: The Tension between Standardization and Flexibility*. *Science, Technology, and Human Values*, 21(4), 407-426.
- [2] Braa, J., Hanseth, O., Mohammed, W., Heywood, A., and Shaw, V. "Developing Health Information Systems in Developing Countries. The Flexible Standards Strategy.," *MIS Quarterly* (31:2) 2007, pp 381-402

- [3] Braa, J., and Hedberg, C. "The Struggle for District-Based Health Information Systems in South Africa," *The Information Society* (18:2), 2002, pp. 113-127.
- [4] Braa, J., Monteiro, E., and Sahay, S.(2004) "Networks of Action: Sustainable Health Information Systems across Developing Countries," *MIS Quarterly* (28:3), 337-362
- [5] Avison, D., et al., *Action Research*. Communications of the ACM, 1999. 42(1): p. 94-97
- [6] Checkland, P. and S. Holwell, *Action Research: Its Nature and Validity*. Systemic Practice and Action Research, 1998. 11(1): p. 9- 21.
- [7] Hanseth, O., and Lyytinen, K. Theorizing about the design of Information Infrastructures: design kernel theories and principles, 2008, Case Western Reserve University, USA. Sprouts: Working Papers on Information Systems, 4(12). Available at <http://heim.ifi.uio.no/~oleha/Publications/ISRinfrastructurefinal05-12-05.pdf>, Accessed October 2008
- [8] Edwards, P.N., Jackson, S.J., Bowker, G.C., and Knobel, C.P. Understanding Infrastructure: Dynamics, Tensions, and Design, 2007, Available at: www.si.umich.edu/InfrastructureWorkshop/documents/UnderstandingInfrastructure2007.pdf, Accessed October 2008
- [9] Bijker, W. E., & Law, J. (1992). *Shaping Technology / Building Society: Studies in Sociotechnical Change*. The MIT Press.
- [10] Bangemann, M. Europe and the Global Information Society – Recommendations to the European Council, European Commission, Brussels, 1994.
- [11] Gore, A., "Remarks by Vice President Al Gore at National Press Club", Dec 21. 1993
- [12] Hughes, T. P., Bijker, W. (1987). The Evolution of Large Technological Systems. In *The Social Construction of Technological Systems - new directions in the sociology and history of technology* (pp. 51-82). Maple-Vail Inc.
- [13] Webster dictionary [13]
- [14] Chilundo and Aanestad 2004)
- [15] Shaw V. 2005, WHO round table discussion on HIS, WHO bulletin, 2005, Geneva, Switzerland.
- [16] Puri, Sahay, and Georgiadou 2007)
- [17] (O. Hanseth and Ciborra 2007)
- [18] Hanseth and Monteiro, "Inscribing behaviour in information infrastructure standards, *Accounting, Management & Information Technology*. Vol. 7, No. 4, pp. 183-211, 1997.
- [19] Ole Hanseth. Infrastructures: From Systems to Infrastructures. In K. Braa, C. Sørensen, B. Dahlbom (eds.). Planet Internet. Studentlitteratur, Lund, Sweden, 2000, pages 193 - 212
- [20] Hanseth and Aanestad, "Bootstrapping networks, communities and infrastructures. On the evolution of ICT solutions in health care", in *Methods of Information in Medicine*, 2002.
- [22] Rolland, K.H. and Monteiro, E. 2002. "Balancing the local and the global in infrastructural information systems," *The Information Society*, (18, 2), 2002, pp. 87-100.
- [23] Sheikh and Titlestad 2008, "Implementing Health Information System in Zanzibar: Using Internet for communication, information sharing and learning", IST Africa 2008, Windhoek, Namibia
- [24] The DHIS wiki. Available: www.hisp.info/confluence/display/DHIS2/Home
- [25] Ole Hanseth and Eric Monteiro (1998). Changing irreversible networks: Institutionalization and infrastructure. In Kristin Braa and eric Monteiro. Proceedings from 20th IRIS. p. 21 – 40