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DHIS2: The Tool to Improve Health Data Demand and Use in Kenya

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Abstract. Information garnered from health information systems (HIS) is essential for monitoring health, and for evaluating and improving the delivery of health-care services and programs. Yet the collection, collation, compilation, analysis and reporting of health data in most developing countries is faced with major problems resulting in incomplete, inaccurate and untimely data which is not useful for health decision-making. Increasingly there is growing demand for good quality health information from developing countries as a result of performance based resource allocation by donors. This has led to some initiatives in these countries to reform the existing paper-based systems through computerization. Kenya's development blueprint titled '*Vision 2030: First Medium Term Plan (2008-2012)*' identified the need to strengthen the national HIS to enable it provide timely and understandable information on health. But assessments conducted in the country in the past revealed that despite rising demand for health information, the Kenya HIS was weak and poorly integrated. Recognizing the critical role played by a functional HIS, the country initiated an overhaul of the existing system to replace it with the free and open-source web-based District Health Information Software (DHIS2).

This review study looks at the challenges of implementing HIS in developing countries, and how various countries are attempting to overcome these challenges through computerization. In particular we examine the increasing use of the free and open source DHIS2 as the HIS solution for various developing countries and review the outcome of several cases where DHIS2 has been implemented in Africa. Against this backdrop we address the potential of DHIS2 as a motivator for health data availability and use in Kenya.

It is evident that the DHIS2 system has presented unprecedented potential for Kenya to move from the era of unreliable and fragmented HIS system to the more ideal situation of availability and use of quality health information for rational decision making. However it is also apparent that implementation of a technically sound system like DHIS2 is not an end in itself in ensuring improved reporting and use of HIS data. The need for acceptance and adequate support from the national and local authorities, and by all targeted users of this system cannot be overemphasized.

Keywords. Health Information Systems; Data Quality; Healthcare Data Demand and Use; DHIS2.

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Introduction

The World Health Organization (WHO) defines Health Information System (HIS) as a system that integrates data collection, processing, reporting and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services (1). A national HIS brings together data from the routine data collection systems as well as information from other sources such as community surveys, clinical studies, health systems research, census, and other periodic or population-based surveys. HIS is also recognized as one the six building blocks of Health Systems Strengthening (HSS) and as such, strengthening a national HIS to generate reliable and accurate public health information is one key approach to support public health reform initiatives in developing countries (2). HIS information is essential for monitoring health, and for evaluating and improving the delivery of health-care services and programs. However the collection, collation, compilation, analysis and reporting of health data in most developing countries is faced with major problems resulting in incomplete, inaccurate and untimely data which is not useful for health management decision-making at any level (3–8). The poor quality data scenario is made worse by lack of adequate ICT knowledge among health workers, as well as under-investment in HIS in developing countries. In the last decade however demand for good quality health information from developing countries has continued to grow as a result of performance based resource allocation by international donors (e.g. GFATM, USAID), which subsequently makes it a requirement to monitor and report on short term health program outputs and outcomes. This demand has led to some initiatives to overcome the HIS challenges in these countries by reforming the existing fragmented and paper-based routine health information systems through computerization (9–11)

Kenya's vision for the health sector is "to provide equitable and affordable quality health services to all Kenyans". To accomplish this, the first Medium Term Plan 2008-2012 of the Vision 2030 identified the need to 'strengthen the national health information systems to enable them provide adequate information for monitoring health goals and empowering individuals and communities with timely and understandable information on health' (12,13). But health assessments conducted in the country over the last decade (between years 2000 and 2010) revealed that despite rising demand for health information, Kenya's HIS was weak and poorly integrated. In particular the routine health information was found to be deficient in quality, timeliness and level of analysis, and hardly accessible to stakeholders for use in decision making (14–17). Having recognized the critical role played by a functional HIS, in 2010 Kenya's HIS Division at the \Ministry of Health was mandated to overhaul of the existing system and replace it with the web-based District Health Information Software (DHIS2). DHIS2 is designed to facilitate generation, analysis and dissemination of quality health information for informed decision making. The role of quality data in enabling informed healthcare decision making cannot be over-emphasized, for instance good quality routine HIS data delivered in a complete and timely manner can be used in surveillance of diseases of public health importance to prevent or control outbreaks, as well to strategize on adequacy of service delivery under the various disease programs. Healthcare practitioners and other professionals can also use this and other HIS data for training and research, and subsequently in production of research to policy briefs to inform national health policies and programs. Yet despite introduction of

DHIS2, recent evidence has shown very low levels of data demand and use by the targeted users in Kenya (18).

Understanding the challenges that cause HIS in developing countries to fail in delivery of the quality information necessary for informed decision making, or alternatively that cause stakeholders to fail to use good quality data generated by the national HIS, is a necessary first step to reversing these negative trends. There are important lessons to be learnt from examining a few cases of implementation of HIS in developing countries, particularly those which elaborate on how good quality data has been used to drive decision making leading to improved healthcare programs and services. Comparing successful cases to the less successful ones will provide further insight into the critical issues to look out for when implementing health information systems in developing countries context. This study examines the role that DHIS2, a system widely implemented in developing countries for provision of routine and non-routine health data, has played as an enabling tool for acquisition, dissemination and use of HIS data. DHIS2 was implemented in Kenya just 2 years ago, and it is important that the range of data and information available in this system be explored so that health managers, researchers and other stakeholders can be challenged to take a more proactive role in use of this data for more informed health decision making and operational research.

2. What is an effective national HIS?

According to WHO's Health Metrics Network (HMN) framework, an effective HIS is made up of 6 essential components which countries need to build on in order to develop their own national HIS in a way that empowers all those who contribute to and benefit from health information (2). These HIS components are grouped into three categories as illustrated in figure1:

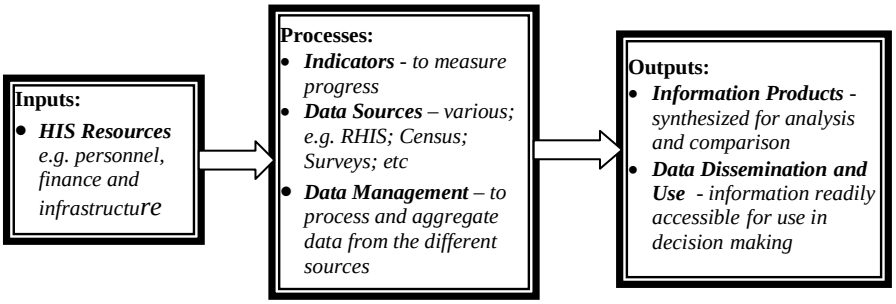

Figure 1: The Health Information Systems Components

As figure 1 illustrates, the ultimate purpose of a HIS then is to produce relevant and quality information which can be used to support evidence-based decision making by various actors at all levels of the health system. Despite the increasing demand for good-quality health information to respond to the performance-based resource allocation for health programs and services, the information products and data

dissemination and use components of developing countries HIS have often been quite inadequate. This is a serious shortcoming that must be addressed if the health systems in these countries are expected to improve. As WHO clearly spells out, *"it is often in countries with the greatest need that reliable and timely information is not available, owing to chronic under-investment in systems for data collection, analysis, dissemination and use"* (2).

In the past the problem of weak HIS in developing countries has been made worse by the overwhelming demand from donors for reports on unrelated indicators, leading to developing of parallel reporting sub-systems. Thus it is encouraging to note that WHO has come together with international partners to form HMN framework, a network which is working to systematically strengthen entire country HIS in developing countries as well as the corresponding country leadership for health information production and use. The creative computerization of various health information functions in these countries can lead to improved efficiencies in planning and delivery of health services, as well as in resource mobilization, data use for M&E and for decision making across the different levels of the health system hierarchy (9,19). Agreeing on the standards for implementation of HIS in these countries is thus an important first step in application of appropriate computer technology to create an integrated health data repository for all stakeholders, eliminating the perennial need to create vertical systems.

3. Evaluating a national HIS

Success of a national HIS needs to be measured not only on the quality of data produced, but also on evidence of the continued use of data to improve health system performance, to respond to emergent threats, and to improve health. Improving HIS in terms of data availability, quality and use often requires interventions that address a wide range of possible 'determinants of performance'. Any framework or tool developed to evaluate the strength or effectiveness of a health system should typically address all the components of the HIS, namely the resources available to the system (inputs), its methods of work and products (processes and outputs) and results in terms of data availability and quality and use (outcomes). HMN acknowledges that such an assessment is complex as the overall system performance depends upon multiple determinants including technical, social, organizational and cultural determinants (2).

Nevertheless HMN has developed a national HIS assessment tool which uses qualitative and quantitative approaches to assess the national HIS resources, indicators, data sources, data management, data quality, and ultimately HIS information dissemination and use. The assessment tool is intended to do more than simply assess the strengths and weaknesses of the elements and operations of a national HIS. In addition the assessment process seeks to reach and engage all stakeholders in the system thus moving them towards a shared and broader vision of a more coherent, integrated, efficient and useful system. The extent to which the HMN assessment tool is applied in any particular country will depend on where the country is at in its implementation of a national HIS, and whether other baseline assessments have already been conducted, in which case the tool will only be applied for monitoring progress

from baseline. The HMN assessment tool has been adapted for application in many developing countries' HIS assessments including those implementing DHIS (20).

Another set of tools developed for assessing HIS systems implementation are the Performance of Routine Health Information System (PRISM) tools, which are based on the PRISM conceptual framework (21). While the HMN tool is intended for evaluation of the entire HIS system, PRISM tools seeks to identify strengths and weaknesses of routine HIS performance by focusing on behavioral, technical and organizational performance determinants. The Routine Health Information Network (RHINO) workshop on *Enhancing the Quality and Use of Routine Health Information in Developing Countries* (22) emphasized the great potential inherent in the use of district-level routine health information in developing countries but noted that despite the substantial improvements in the timeliness, quality, and presentation of information available to provide managerial support in many countries, this had not guaranteed its utilization for improved health-related decisions. Unlike the traditional assessment methods which focused solely on the technical aspects of the health systems i.e. the indicators, data collection tools; and the technology in use, both the HMN and PRISM tools recognize the importance of assessing the environmental/organization as well as the behavioral aspects of implementing health systems.

In partial concurrence with the HMN and PRISM tools, the Tools for Assessment of Levels of Information (TALI) developed by Health Information Systems Project (HISP) as part of the Integrated Health Information Architecture (IHIA) goes a step further to categorize 3 levels of HIS information use which are achieved through a learning process that can take years to attain. The levels used in this tool are categorized by growing maturity in information use. Level 1 of TALI focuses on a technically working information system, emphasizing data completeness; level 2 focuses on analysis, use and feedback of HIS data; while level 3 looks for evidence of impact on decision making based on the HIS data. The IHIA also recognizes that strengthening the quality of information use in a country requires multidimensional efforts focusing on organizational, information system and technical / tools aspects (23, p. 313-314).

4. The Barriers to Implementation of HIS in Developing Countries

Health experts worldwide agree that health information systems in most countries, and especially in developing countries, are woefully inadequate to provide the necessary information to support individual healthcare and public health activities. In fact, poor use of information for evidence-based decision making is implicated as one of the main causes of the current lack of linkages between individual care and public health systems in many developing countries. HIS in many of these countries have evolved in a rather chaotic and fragmented manner, with multiple and overlapping demands from both the vertical disease programs and the national health administrative departments and ministries. The vertical programs usually maintain their own '*vertical'* reporting information systems, existing alongside the national health information system. Over time this results in a multitude of uncoordinated and disintegrated data collection systems and ultimately in a national HIS that is predominantly unreliable, irrelevant,

ineffective and inadequate in providing the much needed data for decision making (24,25).

In most developing countries, each of the HIS stages of collection, collation, compilation, analysis and reporting of HIS data is burdened by major problems ranging from inadequate human resources who mostly do not have the capacity to undertake the assigned tasks; and excessive and uncoordinated reporting requirements. Another problem commonly cited with HIS systems in these countries is the lack of data ownership occasioned by health workers' perception that the purpose of a HIS is simply to enable submission of reports to the higher levels, leading to a situation where there is no incentive for health workers at levels below the national level to analyze, use and interpret health data (7,24,26). The situation is made worse by the health workers minimal skills and competencies in the area of data analysis and interpretation; the lack of training on how to use health information for planning and other decision making; and the complex process usually required to access the processed health data.

Another concern that has been raised by HIS experts is that most developing countries also lack an information culture which would focus on strengthening the supervision, feedback and support aspects for the overall HIS. It is evident that feedback constitutes an integral component of the health information cycle as this is necessary for keeping communication lines open to discuss and resolve problems in the system leading to improvements in the entire HIS. However, health workers collating and transmitting health data in developing countries hardly ever receive any feedback, and when such feedback is received it is mostly of the kind that is negative, long delayed and not very constructive (11,25–27).

5. Overcoming the HIS Challenges in Developing Countries – Computerization?

In the past data collection in developing countries has relied primarily on paper-based routine HIS; however there is currently a gradual move from manual to computerized systems. The benefits expected from introduction of these computer based systems include significant cost reductions as well as timely delivery of health care services in these countries (2,9,28). Other improvements in this area will include rationalizing the amount and types of data that is collected, improving formats and procedures for data recording and reporting. And the ultimate benefit expected from computerizing the data capture processes is that this will allow data to be analyzed at the point of data collection as well as at the subsequent levels. In this way managers and decision makers at higher levels of the data flow hierarchy will also be able to view disaggregated data from the lower levels of the system.

There is however challenges that are faced in the process of introducing ICT based initiatives to transform HIS in developing countries. These are mostly context sensitive challenges which include inadequate financial and infrastructural resources such as computers, poor internet connectivity, lack of electricity; limited human resource capacity to handle the new systems and technologies; fragmented and uncoordinated organizational structures; and the multitude of heterogeneous stakeholders with different data demands (29,30). This means that it is important to consider the

contextual differences in studying acceptance and use of computerized information systems in developing countries.

Another key solution that developing countries are implementing in their efforts to strengthen their national HIS is decentralization of the Health decision making processes to the peripheral levels, especially the districts. This involves getting these levels to play a bigger role in the development and implementation of the national HIS, as well as the subsequent use of the HIS information for informed decision making (5,7,11,31)

It is however important to caution that computerization alone is not the solution to the highlighted HIS challenges. The new national HIS systems in developing countries must also be designed to achieve standardization and integration of the many parallel and fragmented systems introduced to meet demands of different donors and other stakeholders. Comprehensive health information systems with easily available information which is accessible to all stakeholders will create the enabling environment for use of such information for decision making (32). It will also be important for developing countries to build a culture of information use through training of healthcare workers in data analysis and other data management skills; as well as initiate regular review and feedback workshops to address issues of data quality, data use and data dissemination. In addition there is need to decentralize the HIS system as much as possible while carrying out the required infrastructural improvements, and design innovative ways of using new and existing technologies. Braa and Sahay advise that developing countries need to start using the available HIS information rather than waiting for it to become of 'good' quality because only through data use and feedback process will this quality be enhanced (23, p. 247-248).

6. DHIS2: More than a tool for better quality HIS in Developing Countries

The District Health Information System Software (DHIS) is a free and open source database and application for collecting, processing, and analyzing health information, and whose development and implementation was started in 1998 by the Health Information System Programme (HISP) based in South Africa. HISP is a research network which is organized by the University of Oslo and is devoted to the development of HIS in developing countries. It stems from the effort to build a HIS in post-apartheid South Africa in the mid 1990s, but has now spread and includes partners in many parts of Africa and Asia. DHIS is designed to support decentralized decision making and health service management by allowing health care workers to use their data to analyze their levels of service provision, predict service needs, and assess performance in meeting health service targets (33,34).

The HISP network focuses on action research and user participation, especially local participation to customize the health information software with the aim of developing local knowledge and skills in computers, design, data handling and use. DHIS's relative success in South Africa and the fact that the software is highly customizable to suit the local country's context has led to the export of this software and ideas on health management to countries like Mozambique, India, Malawi,

Mongolia, Cuba, Tanzania, Ethiopia, Vietnam and Kenya. The fact that the current version of the software, DHIS2, is based on Free and Open Source Software (FOSS) gives the countries an opportunity to get the software free of charge and to make use of local expertise to customize it according to local needs. Software customization includes mimicking manual health data collection tools to look similar on the software data entry forms, accommodating most routine data elements, and in some cases translating the software into the local language (31).

The overall objective of DHIS2 implementation is to be able to generate, analyze and disseminate health information to facilitate effective policy formulation, management, planning, budgeting, implementation, monitoring and evaluation of health services and program interventions in the health sector. DHIS2 is able to support collection and analysis of routine health services data, as well as non-routine data such as population estimates, facility workload and survey data. Currently this data is collected by means of a paper-based system of registers, tally sheets, and monthly data collation forms at each health facility. The collated monthly data is either entered directly into the web-based DHIS2 or sent to the district level where is entered on to the web-based DHIS2 software, then analyzed in the system. The web-based DHIS2 is intended to capture health facility service delivery data and allow analysis at that level, promoting data use at all levels for decision making.

DHIS2 is configured to allow the generation of reports, which can be either standard or customized to meet the user requirements; and to also carry out data quality analysis and provide a dashboard for monitoring and evaluation of health programs' indicators. The essential reports have already been built into the system and are immediately available for review at all levels i.e. by the health facility, district, province and national health departments. Data quality is addressed through mechanisms incorporated into the data collection process and functions within the DHIS software. Another advantage of the DHIS2 platform is its very modular web interface which allows for easy incorporation of various modules, enabling easier replication of the complex paper reporting formats that are unique to each country of implementation (28,34).

7. Evidence of DHIS2 Use Outcomes in African Countries

The ultimate success of a HIS can only be measured by the level of demand and use of its data by the targeted audience for informed decision making. There is growing evidence that when implementation of DHIS2 is done with both the support of the local health authorities and involvement of all relevant stakeholders in the implementation process, then the chances of achieving a successful implementation are improved. The converse is also true. The following is a summary of a few cases of both successful and the not too successful use of DHIS2 data for decision making in Africa.

7.1 Sierra Leone

Sierra Leone was selected as one of Health Metrics Network's (HMN) pilot countries for health information systems strengthening in 2007, and in early 2008 a project to use DHIS2 as a data warehouse to integrate the various data reporting structures at district

level was initiated. At that time, collection and reporting of health data was characterized by extreme fragmentation and there were no agreed upon data standards across the various health programs. Following a successful pilot, implementation of DHIS2 was scaled up to cover all 13 districts as well as the reporting from the districts to the national level towards the end of 2008. Some aspects of this success is attributed to involvement of all relevant stakeholders in review and integration of data collection formats, complimented by training of donors and other stakeholders on the use and analysis of data from the repository. The success also inspired the autonomous HIV/AIDS program to agree to use DHIS for their data collection, and the subsequent export of aggregated ART, HIV testing, and PMTCT data from the electronic medical record system to DHIS2 leading to the first implementation of the SDMX-HD standard for health data transmission (34).

Another reason given for the successful use of DHIS in Sierra Leone was the improvement of data completeness and quality which was encouraged through the wide dissemination of the districts' data, and ranking the districts performance in 'league tables' which were also widely disseminated through the quarterly health information bulletins. This ranking process was initiated at the district level in 2007 but was soon drilled down to sub-district levels, whose performance was discussed during monthly district review meetings incorporating numerous stakeholders(23, p. 261-266) (34,35).

7.2 Zanzibar

In 2005 the Health Management Information System (HMIS) Unit of the Zanzibar's Ministry of Health, with support from the Danish International Development Agency, launched a process aimed at strengthening the HMIS, improving data reporting and implementing the District Health Information Software (DHIS). A lot of success of this system in Zanzibar is attributed first to the fact that DHIS presented an integrated national data warehouse framework, thus providing an enabling environment in which stakeholders in the health sector could "speak to each other", which is a prerequisite when seeking to improve national health systems. Additionally, regular data-use workshops initiated in 2005 provided health management teams with a conducive environment for self-assessment, peer critique and discussion of the data presented, and were thus a powerful means of building a strong evidence base for HMIS improvements. As a result of these workshops, HIS data collection forms were reviewed and simplified leading to improved data submission rates; previously segregated databases were integrated; quality of reported data improved and capacity for data analysis and interpretation among the health management teams was increased (20,35).

7.3 South Africa

Implementation of DHIS in SA started in 1995 in 3 pilot districts of Cape Town. HISP's intention was to develop and implement shared data standards to counteract the extreme fragmentation of health services and programs which had mushroomed and taken root during the apartheid legacy. The scale up of DHIS implementation to other states was done through intense process of negotiations and consultations to agree on the processes and datasets for implementation. The DHIS in SA has over the years achieved maturing levels of use of information for decision making and improvement of health services, having crossed over the initial hurdle of ensuring acceptable levels of data quality and completeness (36).

A DHIS Case Study done in the Eastern Cape of SA identified some of the enablers for success of DHIS in this state as:

1. The emphasis on a core standard of data with flexibility at each implementation level to add both data elements and derived indicators.
2. Use of open software for processing, and open access to information across the country. In addition the modular design of the DHIS has allowed for incremental expansion to accommodate the many demands of managing the health care system.
3. A large effort in undertaking standardized training, on-site mentoring and communication with hundreds of information officers, more recently extending to the orientation of thousands of managers at all levels of the health system.
4. The realization by health workers of the need to use DHIS data to keep tabs on the rapidly changing health care system e.g. district health workers have been using the system to help monitor priority health problem trends and the coverage of services such a EPI, TB and STI in specific geographic areas. This has allowed allocation of increased resources to those facilities found to be lagging behind. Analysis of certain indicators, such as workload, has also assisted in the reallocation of staff and the determination of new places requiring introduction of health services (25).

For public health professionals and the multi-disciplinary teams involved in developing health management information systems, the South African experience is rich in innovation and lessons learned. Despite this apparent success in use of DHIS in SA, there are still challenges reported with regard to data quality as well as capacity of various health workers to analyze and use DHIS information (37,38)

7.4 Malawi

Malawi has had a relatively successful experience in implementation and use of DHIS. A paper/computerized hybrid system was introduced in 2002 leveraging an older version of DHIS and currently the country is in the process of migrating to DHIS2. Overall, data use has matured to the point where DHIS information is used for generation of graphs to support management decisions. In addition, district and program managers use the data in the formulation of district implementation plans and monitoring implementation, among other applications. Some aspects of this success have been identified as:

- Availability of data at the district level which has promoted decentralization of decision-making.
- The district level data is used in the formulation of district implementation plans and for monitoring their implementation.
- DHIS has produced a health facility comparative analysis tool showing facility performance, which the DHMT use to identify poorly performing facilities in need of support (35)

7.5 Tanzania:

The HISP research project in Tanzania was initiated in 2002 by the University of Dar-es-Salaam and the University of Oslo. The objective of this project was to implement

the DHIS software at district medical offices in Tanzania, and this software was piloted in five districts. Yet despite DHIS being introduced in Tanzania earlier than in most other African countries, the system has not achieved the initial objective of an integrated national computerized health information system providing health data analysis for the various stakeholders. Studies done to determine the adoption of DHIS in the management of health information at both facility and district levels and to evaluate users satisfaction with the performance of DHIS concluded that though the system was rated as accurate and reliable, it was rated poorly in terms of usability and content. Some of the challenges attributed to the failure of DHIS data to be used as initially envisaged include computer illiteracy, lack of skills for data interpretation and utilization, lack of policy guidelines on information and human capacity building, and the inflexibility of the DHIS version implemented in Tanzania (11,19).

The government of Tanzania has since come up with strategies to address the HIS challenges as outline in its Health Sector Strategic Plan III (HSSP III 2009 - 2015). In particular the government intends to support implementation of interventions to harmonize health indicators, streamline data collection and analysis processes, enable more efficient use of healthcare resources, enhance systems integration and encourage collaboration and information sharing among various stakeholders. With technical and financial support from WHO, Netherland, CDC, RTI International and other partners, Tanzania's Ministry of Health and Social Welfare (MOHSW) has in addition developed the National eHealth Strategy (2013 – 2018) to provide clear guidance on use of ICT to support health sector transformation. One of its strategic objectives is to 'strengthen an electronic health management information system (HMIS) to support evidence based healthcare and decision making'. The MOHSW has since adopted DHIS2 as the core HMIS software and started implementation of a strategic initiative to enhance integration of the diverse information systems into DHIS2 to create a common data warehouse (39,40).

7.6 Ethiopia

HISP-Ethiopia was initiated in 2003 as a collaborative project between departments of Information Science, Addis Ababa University and the University of Oslo, Informatics department. The Program initially targeted implementation of DHIS in five regional states: Oromia, Amhara, Tigray, Benishangul-Gumuz, and Addis Ababa. The objective was to change the existing routine paper-based HIS by adapting and implementing DHIS software; collaborating on the development of standardized essential data sets, reporting formats and indicators; and in building capacity through training of health workers and managers at different levels of each region. As in many other developing countries, this introduction was faced with several challenges and problems including: lack of adequate financial, infrastructural and human resources, fragmented and uncoordinated organizational structure and heterogeneity of stakeholders; and political and bureaucratic constraints. Another challenge was the fact that the public health care system in Ethiopia is characterized by differences across regions and between districts and zones within a region in terms of human and infrastructural resources thus presenting contextual challenges in the attempt to introduce DHIS in the different states. Despite the substantial work that was done by HISP in building local capacity of health workers and managers as well as in adapting and implementing DHIS across the five pilot regions, the HISP initiatives was disbanded by the Federal Ministry of Health in

2007 to pave way for another international agency which was given the mandate to undertake all HMIS reform activities both at regional and national levels (10).

In subsequent efforts to address some of the identified challenges, a HMIS National Advisory Committee (NAC) was established with representation from different stakeholders. NAC played a pivotal role in the development and pilot testing of the new country-owned HMIS which was designed with the technical assistance from John Snow, Inc. (JSI). The government of Ethiopia with support from USG, WHO and other development partners is now in the process of implementing the Health Sector Development Program IV (HSDP IV 2011 – 2015) whose mandate includes health systems strengthening. Under HSDP IV rollout of the new HMIS will be scaled up to all the 9 Ethiopia Regions, 2 city administrations and all districts, and the related HR capacities strengthened both in numbers and training levels. Simultaneously regional ownership of HMIS processes has been enhanced for future sustainability (41–43).

7.7 Mozambique

With the recognition that sustained development and successful use of DHIS would depend to a large extent on the available human and institutional capacity, HISP network initiated various training programmes purposed for both health and IT professionals targeted to work in the health sector. One such training was the Masters in health informatics programmes initiated in Mozambique in 2000, and which have since spread to other developing countries. Yet despite this advantage, use of DHIS in Mozambique was not exceptionally successful in the country at the time, partly due to misaligned expectations between the DHIS implementers and the country's health polity makers (36,44).

The poor result of the initial DHIS implementation in Mozambique led to implementation of another system which was paper-based at the peripheral health unit level, but computerized at the district level. Though relatively more successful that the DHIS, the new system had serious technical challenges including limited capacity for scalability and the need for extensive technical support. A HMN supported assessment of the HIS identified the challenge areas and provided valuable input to the development of the new National Health Information System Strategy (2010-2014). Subsequently with support from Canadian IDRC and U.S. CDC, the Ministry of Health engaged the Mozambique Open Architecture, Standards and Information Systems (M-OASIS) programme which has been instrumental in strengthening the country's health systems and the local capacities for managing the systems. M-OASIS has been lauded as a good example of how public-private partnerships can work seamlessly to address national health systems challenges. One of the current M-OASIS projects is the implementation of a health information system for M&E, which is based on DHIS2 (45–47).

8. DHIS: Same System, Different Success Levels

Braa et al (34) emphasize the need for *scalable* and *comprehensive* solutions in order to achieve success of national HIS strategies in Africa. They clarify that scalable refers to the need for rolling out the solutions in a paced manner: 1) vertically "down" the health hierarchy, from national to region, district, facility, and finally to the patient and community levels, as well as 2) horizontally in "scope" of services and functional areas and finally 3) geographically. And *Comprehensive* refers to the need for providing solutions that meet the needs of each service area and level of the health system; from medical records for patient management to aggregated data and indicator repositories supporting district management and national monitoring and evaluation (M&E).

As highlighted by various researchers who have reviewed implementation of DHIS in developing countries, there is also need to address the socio-technical challenges that DHIS implementers are faced with in the developing countries' context, which includes the uncertain and unpredictable environment of their public health care systems, as well as uneven infrastructural development, fragmented nature of HIS and poor human resource competency across different levels. This situation is further complicated by new policies, strategies, and regulations both on public health care and HIS activities that are triggered by the requirements of international agencies, national governments, NGOs supporting vertical programs, and regional authorities. The importance of the attitudes and preparedness of policy-makers and managers towards the change process cannot also be underestimated. Thus the importance of adapting flexible strategies to deal with context-sensitive challenges in the different regions, as well as regular renegotiation and reformulating of such strategies based on emergent trends and problems, new interests, new policies, new actors, and uncertainties from the external environment cannot be over-emphasized (2,3,10,26).

In addition, in countries which have registered apparent success in use of DHIS, there are still challenges reported with regard to data quality as well as capacity of various health workers to analyze and use DHIS information. Thus there will always be continued need for targeted training and development of staff in terms of general computer skills and data analysis concepts, as well as concerted efforts to improve data quality at facility and regional levels. It is also apparent that as the HIS data gets more actively used, the users tend to request for more details and higher quality of the same, implying that implementation of a HIS system will always be a dynamic, maturing process (4,27). Additional challenges which have been identified in countries using DHIS include the fact that fragmentation of systems in the health sector still persists, and even where quality data is present, its use for rationalizing key health decisions is still limited (11,19,32,48).

It is thus apparent that implementation of a technically sound system like DHIS is not an end in itself in ensuring improved reporting and use of HIS data for rational health decision making. There is also the need for acceptance and adequate support from the national and local authorities.

9. The Process of implementing national HIS in Kenya

The Government of Kenya (GoK) decentralized the Ministry of Health's (MoH) decision-making process to the districts in response to the national policy on District focus for Rural Development (DFRD). This led to the establishment of HIS offices in all districts, whereby all Heath data from all health facilities in the district would be processed, which is in line with the WHO resolution calling on all member states to strengthen District Health. It was envisaged that this decentralization would provide the district health managers with access to accurate, reliable and up-to-date information relevant for management at their levels. However, despite the establishment of this decentralized national routine HIS, a number of parallel and mostly donor driven district health information systems started to mushroom all over the country supposedly because the information collected through the national system was incomplete and unreliable thus rendering it unsuitable for analysis and use at any level (5).

A study of some of these parallel systems found that they were characterized by a lack of capacity for integration, and were disjointed with no effective central co-ordination or other mechanisms for information flow to allow sharing of information among stakeholders who needed it (15,16). Over the years several tools and systems have been introduced in the Ministries of Health to try and address the identified gaps in management of the national routine HIS. One of them, the "Kwale Model", which was a District health information system implemented at the Coast province, is considered a phenomenal success in some studies (49,50). The "Kwale model" was however never scaled up as envisaged, and is no longer in use.

The first National Health Sector Strategic Plan (1999 – 2004) articulated the ministry of health's strategy to strengthen its co-ordination function with the private sector and non-governmental organizations in health care delivery, and recognized that proper design and implementation of integrated HIS was critical. However, it was also during the period of its implementation that the country experienced major fragmentation of HIS with various development partners introducing many systems outside of the national HIS. The Kenya health ministries were cognizance of the inadequacy of the existing health information systems, which explains why they were instrumental in the conducting of the various HIS assessments over the last decade. These assessments identified very similar challenges within the Kenya HIS, some of which are listed below (13,15,51,52):

- Gross underreporting under the existing HIS, as well as lack of elaborate feedback at all levels.
- Inadequate capacities of HIS staff in terms of professional knowledge, skills, and even numbers. This included lack of capacity in computer skills and data analysis among staff both at the peripheral and national levels
- Too many data collecting and reporting tools (forms and registers) and lack of integration at the various levels. In addition, too many indicators defined to monitor the sector with inadequate data collection and reporting tools at the data collection points.
- Lack of guidelines and policy to make reporting mandatory from the various source, and inadequate supportive supervision to districts and provinces.

- Data from the private health facilities not incorporated in the national HIS, largely because the private sector did not see the need to submit reports to the national HIS, and neither were they mandated to.
- Unequal distribution of workers across the rural/urban divide, as well as by regions and levels of healthcare, with most of the health workers preferring to work in the larger health institutions commonly found in urban areas.

These assessments also came up with a host of recommendations to enhance the HIS system, some of which included the need to strengthen the overall capacity for data collection, analysis and reporting at the health facility, district and national levels; to develop elaborate, integrated and harmonized data collection tools as well as user friendly data capture systems with adequate linkages to the central data processing unit; and to develop a comprehensive HIS strategic plan to support the HIS and facilitate buy in and support by all stakeholders. It was envisaged that a functional and integrated national HIS would play a crucial role in availing the timely data necessary for evidence-based planning and decision making. Subsequently the government in collaboration with stakeholder formulated the HIS Policy and HMIS strategic plan 2009 – 2014 to guide the interventions needed to strengthen the national HIS and enable it have sufficient capacity to serve all identified health stakeholders' information needs (17,53).

9.1 FTP-Based HIS System

In an attempt to respond to some of the challenges identified in the national HIS, in 2008 the country introduced the use of the File Transfer Protocol (FTP) to transfer data from the district level to the National level. During the initiation of the FTP system, a major revision of reporting forms and registers was carried out. Data from these reporting tools were captured on a monthly basis by health facilities and submitted to the district level. The district would then aggregate all its facilities' data in MS Excel spreadsheets before onward transmission to the national level through the FTP. If the Excel data from the district was transmitted successfully through the FTP system, then the spreadsheet data would be automatically added to a master Excel Workbook maintained at the national level. Where the district was not able to FTP the data, they had the option of sending the Excel Spreadsheet as an email attachment, in which case there was need for manual intervention before the data could be added to the master Excel Workbook. The national level received only district aggregates which could not be disaggregated to show facility specific details, thus making it impossible to do analysis of comparative performance across facilities. Furthermore, it was very difficult to manage the data or get an overview of the data when spread over about 180 worksheets, each representing a district. The continuous splitting up of districts to create new districts further complicated the data management process (14,51,54).

- The 'FTP system' described above served as the official national HIS system for Kenya from 2008 until 2011 but was however plagued by a host of other challenges, the key ones being:
- There was always a major time lag between when data was reported and when it was received at the national level, analyzed and made available to stakeholders for their decision making, thus making the data less useful.

- This system of data transmission and analysis did not have inbuilt error checking and data validation mechanisms, hence the level of reported data accuracy was always suspect.
- In terms of infrastructure, the districts relied mostly on wireless modems which many a times experience low bandwidth availability and yet had to transmit the relatively bulky excel files.
- Sometimes the data files were infected with viruses from the source computers – such files would be rejected by the server at the national level and hence this data was not updated in the master file.

Faced with all those challenges, the FTP system could not solve the problem of multiple parallel HIS systems and the erosion of trust that stakeholders were experiencing with regard to the national HIS. A 2009 critical review of all softwares in use in the Kenya health sector revealed that there were still numerous disparate and un-integrated health softwares (52). The FTP system may thus have been successful in transmitting routine service data from lower levels to the central level; however it lacked adequate features to facilitate analysis and use of information for decision making, or even to assure the quality of data within the system.

9.2 From FTP to DHIS2

Recognizing the inadequacies of the FTP system and the persistent need to strengthen management of health data and information at all levels of service delivery in the Kenya Health system, the Ministry of Health embarked on a process to acquire a web-based database that would facilitate processing of facility level data at all levels. In addition to the requirement to generate aggregate reports for use at regional and national levels, the system's standard output had to include dashboards generated for use at health facilities to assist them in planning, and initiating the interventions required in management of services at their level. The system was also expected to be simple, scalable, user friendly and capable of capturing both community and health facility level data, hence providing the foundation for an integrated national health information system (16). After considering many options, the DHIS2 was found to meet the stated software requirements.

Implementation of DHIS2 in Kenya commenced in year 2010. Following its successful customization to suit the Kenyan context as well completion of the pilot testing phase, the DHIS2 was rolled out to all of the 8 Kenyan provinces between March and December 2011. DHIS2 in Kenya is installed on a central server using the "cloud" based computing infrastructure and as such users are expected to access the system via the internet both for data entry and information use purposes (54). Unlike the FTP system which could not capture individual facility data, DHIS2 data at the district level is captured per facility and entered directly into the web-based central server. This difference is illustrated in figure 2:

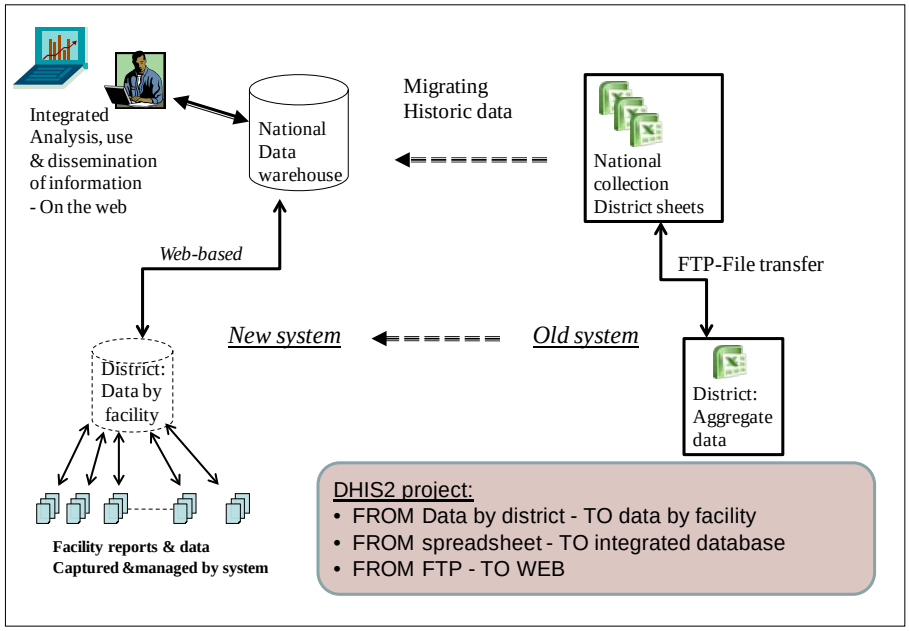

Figure 2: Transition from FTP to DHIS2. Source: Division of HIS (55)

10. DHIS2 in Kenya

10.1 The Challenges and the Innovative Solutions

Kenyan health facilities suffers from the usual infrastructural problems experienced in other developing countries such as inadequate access to computers, internet connectivity, telephone and electricity services. Recognizing this factor, the implementers of the system planned it in such that most of the health facilities would still generate paper-based monthly reports which they would then send to their respective districts for keying into the web-based DHIS2. The majority of these districts have access to computers and internet via mobile provider based modems. The higher level health facilities, namely the district, county and referral hospitals, do however have access to computers and internet and hence were expected to key in their data directly on the DHIS2 system. The use of internet modems was found to work well during the piloting phase, and this led to the decision to go for a central server solution for the DHIS2 implementation in Kenya, rather than deploying offline standalone instances in districts around the country. The Ministry of Health server setup was however not ready for this installation, which is why the implementer resorted to us of an external server in the “cloud computing” infrastructure (54).

Some other challenges that have faced the deployment of the web-based DHIS2 in the country include:

- Connectivity: The strength of Internet connectivity varies widely in Kenya. Some regions also have less access to electricity and mobile telephony. It is

thus difficult to implement direct data entry by health facilities till the infrastructure at these levels in enhanced.

- Capacity: User capacity to use DHIS2 effectively has also been a challenge because of the limited availability of skilled ICT work force in the health sector.
- Stakeholders: There is continuous need to take care of all stakeholders' needs in the system, and at the same time avoid introducing redundant tools that risk overloading the system. This has necessitated the development of standardized tools which take into account the reporting needs of the various stakeholders – a challenging task which is still ongoing.
- Capital: While the project was heavily donor funded, there is need to find ways to blend private and public resources in ways that would be sustainable.
- Onset of Devolved counties – this has slowed down the rollout of training to users which is necessary to ensure ease of system use. Moreover the new structures at the counties means that some of the DHIS2 district champions have had their roles redefined slowing down use even further.

It is interesting to however note that the above challenges have not dampened the process of scaling up use of DHIS2 in Kenya. The issue of staff capacity was mostly alleviated by the widespread training of intended users during implementation of DHIS2 – a training which targeted both the data managers as well as the health decision makers from each district. Interconnectivity via the local GSM service providers has also proved to be ideal for the Kenya set up as this network connectivity solution persists even in the midst of the frequent power black outs experienced in the country. Another solution which has proved indispensable in this infrastructural resource-limited setting is the use of caching feature available in the new HTML5 standard. This feature enables DHIS2 users to store their data offline in their computer browser during periods when internet access in unavailable, and then upload it to the server when network connection is restored (54).

So far implementation of DHIS2 in Kenya has been highly donor funded with the Danish AID Agency, DANIDA, having supported the initial implementation stages including purchase of computers and related infrastructure as well as the essential training of health workers at national and peripheral levels. The core support has since transitioned from DANIDA to USAID through the Afya Info project whose mandate is to assist the Kenya government to establish an integrated, web-based, unified National Health Information System (NHIS) that will serve as the sole source of data for all health sector stakeholders, thus eliminating the need for the existing vertical monitoring and reporting systems. The ministry of health has also received technical and financial support through other USAID support mechanisms, as well as from WHO, DFID, CDC, World Bank, among other development partners (17,55).

10.2 DHIS2 as a motivator for Health Data Use in Kenya: the Potential

The first step on the way to enhancing data demand and use for decision making in healthcare is to ensure that availability of relatively good quality data which is accurate, complete and timely. In addition, there must be an easy way to analyze the data at all levels in order to obtain the relevant information required at those levels. As Manya et

al. (54) explain, the DHIS2 implemented in Kenya is comprehensively addressing the need for quality routine health data in the following ways:

- The inbuilt validation rules and data quality checks have improved overall data quality.
- Use of the cloud-based Central Server ensures that changes made in the system are available immediately to all user, and this setting also ensures that DHIS2 is available on a 24/7 basis.
- Previously some of the HIS data was contained in parallel, mostly donor-sponsored systems which were not easily accessible to potential users; the DHIS2 data is however web-based and all interested users can now use web-browsers to access HIS reports from any location.
- The implementation HTML5 standard allowing for offline data entry has made use of DHIS2 a reality even in rural parts of Kenya with poor internet connectivity.

Overall DHIS2 implementation in Kenya has enabled the undertaking simple, customized data analysis thus encouraging data use for decision making right from the lowest level. The standard reports and the data visualizer are popular with users for making graphs and reports. The system has also allowed for improved dissemination of public health information via the public login option (54,56). Nevertheless there is much more unexplored potential that should continue to be realized from the DHIS2 implementation, including the increased use of the inbuilt mobile application for reporting and viewing of reports; as well as gradual integration of more module (such as modules for human resources management, Health Finance management, and Patient level information) to DHIS2 to build a comprehensive data warehouse of the entire country's health information. It is expected that in addition to all the other outlined benefits, the system will be enhanced to improve efficiency of administrative systems in health facilities as well as in the district, regional and national levels.

Administrative statistics obtained from the system indicated that as at 11 September 2013 a total of 9402 users were registered in the system, out of which 2262 users had logged on to the system over the previous 30 days. This is a substantial increase from the corresponding figures of 1351 registered users and 676 30-day logons recorded in the system on 7th February 2012. This increase in the number of registered users could be partly attributed to the new feature introduced for the Kenya DHIS2 system whereby in addition to users being created and assigned different roles by authorized DHIS2 system administrators, new users are also able to create their own user IDs for viewing information in the system. The categories of DHIS2 users include health workers from public, private and faith-based facilities, national and regional health managers, and the HIS system administrators. Another notable statistic is that as at 11 September 2013, the number of data values entered in the system over the preceding 30-day period was also relative high at 1,254,993, providing data for computation of the 688 indicators defined in the system. This compares well to the 880,600 data values registered in the system during the month of January 2012 (54). This snapshot of information provides proof that interest in DHIS2 continues to grow among users in the country, and that the use of the system to report on various health indicators is growing steadily. Nevertheless this does not provide evidence about the quality of the data recorded or the overall perception of the system by the targeted users.

A more formal evaluation of the acceptance and use of DHIS2 is necessary to enable informed conclusion on the success of the DHIS2 implementation in Kenya, from the intended users' perspective.

11. Conclusion

The ultimate goal a national health information system is to produce good-quality data that is subsequently used to generate relevant information for evidence-based decision making in designing health system interventions (2). The evidence of the continued use of data to improve health system performance, to respond to emergent threats, and to generally improve public health is therefore key in evaluating the performance and success of a health information system. As the proponents of formal HIS evaluation tools point out, the success of a system should be measured on many fronts which include behavioural, technical and organizational aspects of system acceptance and use (23, p.252-253) (2,26).

To enhance the use of health information in developing countries, there is need to enhance health workers sense of data ownership and eliminate the perception that the health worker's role ends when they collect data and transmit it to the next level. Use of computerized data management tools such as the DHIS2 is expected to enhance the capacity for workers at all levels to analyze and interpret HIS data, and if this is coupled with focused training on data use for decision making it will lead to more ownership of the responsibility for data use, analysis and interpretation at all levels. Kenya and other developed countries that have implemented DHIS2 for management of their routine and other health data are therefore strategically positioned to move from fragmented and non-functional HIS to become role models in effective use of HIS data in low resource settings. For Kenya, the introduction of the devolved government which commenced in April 2013 makes the decision to use the district focused DHIS2 even more appropriate.

It is thus evident that the DHIS2 system recently implemented in Kenya has presented unprecedented potential for Kenya to move from the era of unreliable and fragmented HIS system to the more ideal situation of availability and use for quality health information for decision making. There is need to sustain the process of enhancing the system to incorporate all stakeholders requirements and encourage further use of this system in Kenya for the benefit of all citizens as outlined in Kenya's vision 2030. A more formal evaluation process to gauge the level of acceptance and use of DHIS2 by the different categories of targeted users in Kenya would be very useful in providing the empirical evidence that can guide the system implementers in achieving higher success levels. Such evidence would also be useful in identifying any underlying challenges and informing system developers and health policy makers on approaches for successful introduction of health information technologies in the country.

References

[1] WHO. *Health Management Information Systems: A Practical Guide for Developing Countries*. Geneva: World Health Organization; 2004.

[2] Health Metrics Network. *Framework and Standards for Country Health Information Systems*. Geneva; 2008.

[3] Abouzahr C, Boerma T. Health information systems: the foundations of public health. *Bulletin of the World Health Organization*. 2005;**83**:578–83.

[4] Mphatswe W, Mate KS, Bennett B, Ngidi H, Reddy J. Improving public health information: a data quality intervention in KwaZulu-Natal, South Africa. *Bulletin of the World Health Organization*. 2012;**90**:176–82.

[5] Odhiambo-otieno GW. Evaluation of existing District Health Management Information Systems A case study of the District Health Systems in Kenya. *International Journal of Medical Informatics*. 2005;**74**:733–744.

[6] Rumisha SF, Mboera LEG, Senkoro KP, Gueye D, Mmbuji PK. Monitoring and evaluation of Integrated Disease Surveillance and Response in selected districts in Tanzania. *Tanzania Health Research Bulletin*. 2007;**9**(1):1–11.

[7] Kimaro H. Strategies for developing human resource capacity to support sustainability of ICT based health information systems: a case study from Tanzania. *Journal for Information Systems in Developing Countries*. 2006;**26**(2):1–23.

[8] Oak MR. A review on barriers to implementing health informatics in developing countries. *Journal of Health Informatics in Developing Countries*. 2007;**1**(1):19–22.

[9] Wilson R. Using Computers in Health InformationSystems. In: T. Lippeveld, R. Sauerborn CB, editor. *Design and Implementation of Health Information System*. Geneva: World Health Organization; 2000. p. 198–212.

[10] Mengiste SA. Analysing the Challenges of IS implementation in public health institutions of a developing country: the need for flexible strategies. *Journal of Health Informatics in Developing Countries*. 2010;**4**(1):1–17.

[11] Lungo JH. The reliability and usability of district health information software: case studies from Tanzania. 2008;**10**(1):39–45.

[12] Government of Kenya. Kenya Vision 2030: A Globally Competitive and Prosperous Kenya. Nairobi; 2007.

[13] Government of Kenya. Vision 2030: First medium term plan (2008 - 2012). Nairobi; 2008.

[14] Blumhagen D, Khan T, Ndungu M, Settimi S, Health G, Assistance T. USAID / KENYA: Assessment of National Monitoring and Evaluation and Health Management Information. 2010.

[15] Government of Kenya. Report for the Assessment of the Health Information System of Kenya - June 2008. 2008.

[16] Ministry of Health. Division of Health Information Systems: Terms of Reference for Software Acquisition. 2009.

[17] Ministry of Health. Health Sector Strategic Plan for Health Information System 2009-2014. Nairobi; 2009.

[18] Ekirapa A, Mburu E, Kunyanga E, Moreland S. Data Demand and Use in the Health Sector in Central and Eastern Kenya. 2013;

[19] Kimaro HC, Twaakyondo HM. Analysing the hindrance to the use of information and technology for improving efficiency of health care delivery system in Tanzania. *Tanzania Health Research Bulletin*. 2005;**7**(September):189–97.

[20] Braa J, Heywood A, Sahay S. Improving quality and use of data through data-use workshops: Zanzibar , United Republic of Tanzania. *Bulletin of the World Health Organization*. 2012;**90**:379–84.

[21] MEASURE Evaluation. Tools for Data Demand and Use in the Health Sector Performance of Routine Information Systems Management (PRISM) Tools. 2011.

[22] Routine Health Information Network. Second International RHINO Workshop: Enhancing the Quality and Use of Routine Health Information at District Level. 2003.

[23] Braa J, Sahay S. Integrated Health Information Architecture. Power to the Users: Design, Development and Use. 2012.

[24] Lungo JH. Data Flows in Health Information Systems. University of Oslo, Norway; 2003.

[25] Wilson R, Hedbert C, Rohde J, Puchert R, Shaw V. South Africa's District Health Information System: A Case Study from Eastern Cape Province. Second International RHINO Workshop: Enhancing the Quality and Use of Routine Health Information at District Level. 2003. p. 26–41.

[26] Aqil A, Lippeveld T, Hozumi D. PRISM framework: a paradigm shift for designing, strengthening and evaluating routine health information systems. *Health Policy Plan*. 2009;**24**:217–28.
[27] Garrib A, Stoops N, Mckenzie A, Dlamini L, Govender T, Rohde J, et al. An evaluation of the District Health Information System in rural South Africa. *South African Medical Journal*. 2008;**98**(7):549–52.
[28] Braa J, Monteiro E, Sahay S, Staring K, Titlestad OH. Scaling up local learning-experiences from South-South-North Networks of shared software development. Procceeding of IFIP 9.4,. Sao Paulo, Brazil; 2007.
[29] Heeks R. Information Systems and Developing Countries. Failure, success and local improvisations. *The Information Society*. 2002;**18**:101–12.
[30] Chilundo B, Aanestad M. Negotiating multiple rationalities in the process of integrating the information system of disease specific health programmes. *Journal on Information Systems in developing Countries*. 2004;**20**(2):1–28.
[31] Braa J, Hedberg C. The Struggle for District-Based Health Information Systems in South Africa. *The Information Society*. 2002;**18**(2):113–27.
[32] Galimoto M. Integration of Health Information Systems: Case Study from Malawi. University of Oslo; 2007.
[33] Braa J, Monteiro E, Sahay S. Networks of action: sustainability health information systems across developing countries. *MIS Quarterly*. 2004;**28**(3):337–62.
[34] Braa J, Kanter AS, Lesh N, Crichton R, Jolliffe B, Sæbø J, et al. Comprehensive Yet Scalable Health Information Systems for Low Resource Settings: A Collaborative Effort in Sierra Leone. AMIA 2010 Symposium. 2010. p. 372–6.
[35] Lubinski D, Perin N, Anderson R, Bernson J, Mwanyika H, Makafu C. The Health Information Systems Programme: Final Report Submitted to the Norwegian Agency for Development Cooperation. 2011.
[36] Braa J, Hanseth O, Heywood A, Mohammed W, V S. Developing Health Information Systems in Developing Countries: The flexible standards strategy. *MIS Quarterly*. 2007;**31**:381–402.
[37] Masilela T. Key Issues in Routine Health Information in South Africa. 2012.
[38] Rohde JE, Shaw V, Hedberg C, Stoops N, Venter S, Venter K, et al. Information for Primary Health Care. South African Health Review 2008. Durban, South Africa: Health Systems Trust; p. 195–210.
[39] Ministry of Health and Social Welfare [Tanzania]. Health Sector Strategic Plan III July 2009 – June 2015. Dar es Salaam; 2015.
[40] Ministry of Health and Social Welfare [Tanzania]. Tanzania National eHealth Strategy June, 2013 – July, 2018. Dar es Salaam; 2012.
[41] MEASURE Evaluation/HMIS Scale-up Project. USAID HMIS Scale-up Project Ethiopia. 2011.
[42] WHO and HMN. Strengthening monitoring and evaluation practices in the context of scaling up the IHP+ compact and Country Health Systems Surveillance ETHIOPIA. 2009.
[43] Federal Democratic Republic of Ethiopia. Ministry of Health. Health Sector Development Program IV (HSDP) 2010 - 2015.
[44] Kimaro HC, Nhampossa JL. The challenges of sustainability of health information systems in developing countries: comparative case studies of Mozambique and Tanzania. *Journal of Health Informatics in Developing Countries*. 2007;**1**(1):1–10.
[45] Soumbey W, Boerma T, Low-Beer D, Louis MS. Development of a comprehensive M&E component of the national health plan 1 MOZAMBIQUE. 2010.
[46] Campione A, Seebregts C, Nhampossa JL, Baloi C, Hazelton P. Strengthening health information systems to address the HIV / AIDS epidemic: A public-private NGO model in Mozambique.
[47] Jembi Mozambique. Jembi Health Systems: Annual Report 2012-13.
[48] Chaulagai C, Moyo C, Koot J, Moyo H, Sambakunsi T, Khunga F, et al. Design and implementation of a health management information system in Malawi: issues , innovations and results. *Health Policy Plan*. 2005;**20**(6):375–84.
[49] AKHS Kenya. Community Health Department. Policy Brief No . 5: Best Practices in Community-Based Health Initiatives. Leading the Information Revolution in Kwale District.
[50] HENNET Secretariat. Health Management Information Systems at the Community Level: AKHS Community Health Information System. Documentation of best practices and lessons learned among hennet member organizations. June 2010. 28–33.
[51] Luoma M, Doherty J, Muchiri S, Barasa T. Kenya Health System Assessment 2010. Bethesda, MD; 2010.
[52] Ministry of Health. Health Sector Programme Support - Phase 2. Review of Softwares in the Health Sector. 2009.

[53] Ministry of Health. Health Information System Policy. Nairobi; 2008.
[54] Manya A, Braa J, Øverland L, Titlestad O, Mumo J, Nzioka C. National Roll out of District Health Information Software (DHIS 2) in Kenya , 2011 – Central Server and Cloud based Infrastructure. IST-Africa 2012 Conference Proceedings. 2012.
[55] Ministry of Health. Report for DHIS2 Implementation in Kenya. October 2010 - February 2012.
[56] Braa J, Sahay S. Integrated Health Information Architecture. Power to the Users: Design, Development and Use. Matrix Publishers; 2012. p. 148–9.